The City of Ferndale

Agenda
City Council Meeting
MONDAY, JULY 13, 2020 @ 7:00 PM
CITY HALL, 300 E 9 MILE, FERNDALE, MI 48220
PLEASE CLICK THIS URL TO JOIN.
HTTPS://US02WEB.ZOOM.US/J/85215297447?PWD=EVLRL3ZKTHNFAGVHS0E4SMNXV05LZZ09
PASSWORD: FERNDALE

OR JOIN BY PHONE:
877 853 5247 (TOLL FREE)
WEBINAR ID: 852 1529 7447
INTERNATIONAL NUMBERS AVAILABLE:
HTTPS://US02WEB.ZOOM.US/U/KLEGQRRGW

1.PLEDGE OF ALLEGIANCE

2.ROLL CALL

3.APPROVAL OF AGENDA

4.ELECTRONIC MEETING PROCEDURES

4.A. Electronic Council Meeting Procedures Update

5.PRESENTATION

5.A. Proclamation Recognizing Sgt. Baron Brown on his Retirement from the Ferndale Police Department

6.CALL TO AUDIENCE

Strict half-hour; excess of half-hour immediately prior to Call to Council.

Time Limitations for Public Comments

· Call to Audience 3 minutes
· Public Hearings 3 minutes
· Regular Agenda Items 3 minutes

7.CONSENT AGENDA

7.A. Approval of Minutes of Regular City Council Virtual Meeting Held June 22, 2020, as

Submitted by City Clerk

7.B. Approval of the Receipt and Acceptance of the Downtown Waste Management Report, as Submitted by Sustainability Planner

7.C. Approval to Purchase Dog Park Play Equipment from GameTime c/o Sinclair Recreation for Wilson Dog Park in the Amount of $6,500, the Expense be Charged to General Fund, Parks, Capital Outlay, Account Number 101-750-977-000, as Submitted by Parks & Recreation Director

7.D. Approval to Renew Membership by Paying Annual Dues to OAKWAY Mutual Aid Group in the amount of $5000.00 from account 101-336-873.000 Memberships and Dues, as Submitted by the Fire Chief

7.E. Approval of Election Services Agreement with Oakland County to Process Ferndale's AV Ballots, Authorization for the City Clerk to Execute the Agreement, and approval to designate City Clerk McGrath and Deputy Clerk MIller as representatives to act as a primary and secondary Points of Contact with County, as Submitted by City Clerk

7.F. Approval of Cost of Living Adjustments for Non-Union Employees Effective July 1, 2020 at a Cost of Approximately $37,432, Recognizing that Merit Increases have Not Been Offered as a Result of the Financial Implications of COVID-19, as Proposed by the City Manager and Human Resources Director

7.G. Approval of Proposal from Three Lyons Creative for Production of "2020 State of the City" Video Series, in the Amount of $4,700.00 to be Charged Evenly to Contractual Services Account #101-173-818 and Special Events 101-803-885.000 Special Programs, as Submitted by Communications Director

7.H. Approval of the Receipt and Acceptance of the Climate Change Vulnerability Assessment for Stormwater Final Report, as Submitted by Sustainability Planner

7.I. Approval of Contract with SeamlessDocs for Three-Year Renewal of Websites and Digital Forms Services for an Annual Amount of $17,775.20, as Submitted by Communications Director

7.J. Approval of the quote from Sound Planning Communications in the amount of $24,932 for Cable Broadcast Equipment Upgrades to support COVID-19 initiaives to be paid from the Cable fund account number 296-000-977-000, as submitted by City Manager

7.K. Approval of the Bills and Payrolls as Submitted by the City Manager's Office and Subject to Review by the Council Finance Committee

8.REGULAR AGENDA

8.A. Consideration of the Contract with Fishbeck for On-Call Environmental Services

8.B. Consideration of a Resolution Declaring a Climate Crisis and Requesting City and Regional Collaboration on an Immediate, Just Transition and Urgent Effort to Restore a Safe Climate

9.CALL TO COUNCIL

10.ADJOURNMENT

3

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Barb Miller

SUBJECT: Electronic Council Meeting Procedures Update

INTRODUCTION
On March 18, 2020, Governor Whitmer signed Executive Order No. 2020-15, which temporarily suspends the Michigan Open Meetings Act (OMA) rules requiring meetings of public bodies to be held at a physical place with a physical presence. This Order, under the Michigan Constitution of 1963 and Michigan law, was issued to mitigate the spread of COVID-19 and protect public health while providing the general public with the opportunity to continue participating in government decision-making.

On March 23, 2020, the Governor signed Executive Order No. 2020-21, designed to further enforce social distancing to limit the spread of the COVID-19 virus.

Accordingly, the Ferndale City Council, in compliance with this Executive Order No.2020-21, has decided to hold the Monday, July 13 Council Meeting electronically.

SUMMARY & BACKGROUND
As always, the public is invited to participate in City Council's July 13 electronic meeting. The procedures are as follows:

ELECTRONIC COUNCIL MEETING ACCESS
Access the electronic meeting in one of the following three ways:

Please copy the link to join the webinar:
https://us02web.zoom.us/j/85215297447?pwd=eVlrL3ZkTHNFaGVHS0E4SmNXV05LZz09

Watch the City Council meeting cablecast on cable WFRN or YouTube

Please do NOT access the meeting using both video conference and phone - it creates significant noise feedback.

ELECTRONIC COUNCIL MEETING PARTICIPATION
The following are the procedures by which persons may contact members of the public body to provide input or ask questions about any business that will come before it at its July 13, 2020 meeting.

To help meeting flow and organization, all public comment, general Call to Audience matters as well as comment on all Agenda items, will be taken at once, during the Call to Audience.

Video conferencing audience: To make a comment, use the "raise your hand" feature or state your name and express your interest when called upon to do so.

Phone-in audience: To make a public comment, state your name and express your interest when called upon to do so.
The time limit for an individual's public comments shall remain 3 minutes.

If you would like to contact City Council about any matter, on the Monday, July 13 agenda or otherwise, please do so via the email addresses below. Please note that emails received will be distributed to Council but will not be read during the meeting. Audience members wishing to speak should attend by phone or video conferencing.

Mayor Melanie Piana: mpiana@ferndalemi.gov
Mayor Pro Tem Raylon Leaks-May: rleaksmay@ferndalemi.gov
Councilmember Greg Pawlica: gpawlica@ferndalemi.gov
Councilmember Kat Bruner James: kjames@ferndalemi.gov
Councilmember Laura Mikulski: lmikulski@ferndalemi.gov

ACCESS & PARTICIPATION FOR PERSONS WITH DISABILITIES
For persons with disabilities who wish to participate in City of Ferndale Council's July 13 meeting:

Keeping with general practice, the meeting will be streamed via YouTube with Closed Captioning (please note that there may be up to a minute lag-time between the live digital meeting and the YouTube stream).

For personal assistance accessing and/or making public comment during the meeting, the City Clerk's Office can provide assistive technology/support; please reach out to them at 248-546-2525, ext. 5, or by email at mmcgrath@ferndalemi.gov.

BUDGETARY CONTEXT

CIP#

ATTACHMENTS

STRATEGIC PLANNING CONTEXT
Organizational and Financial Excellence

RECOMMENDED ACTION
Articulate the electronic meeting rules prior to conducting City Council business.

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Joseph Gacioch

SUBJECT: Proclamation Recognizing Sgt. Baron Brown on his Retirement from the Ferndale Police Department

INTRODUCTION
Sergeant Baron Brown will retire from the Police Department after 33 years of distinguished public service. The City Manager and City Council have prepared a resolution of gratitude for Sergeant Brown's commitment to community and service.

SUMMARY & BACKGROUND
Sergeant Baron Brown has served in a leadership role in the Police Department, pioneered the area of 21st century communications and social media engagement for law enforcement professionals by establishing the @FerndalePD Twitter account in 2012, assumed the mantle of change agent while becoming the Police Department's first community engagement officer, and has undertaken the daunting task of quality assurance as the police department's first professional standards officer.

BUDGETARY CONTEXT
N/A

CIP#

ATTACHMENTS
Baron Brown Resolution.docx

STRATEGIC PLANNING CONTEXT
Safe, Protected, Engaged Community

RECOMMENDED ACTION
Reading of proclamation

FERNDALE

Resolution Honoring the Public Service of Police Sergeant Baron Brown

At a Regular meeting of the City Council of the City of Ferndale, Oakland County, Michigan, held virtually on the 13th day of July 2020, the following resolution was moved, and supported unanimously:

On July 15, 2020, Sergeant Baron Brown will retire from the City of Ferndale Police Department after 33 years of dedicated public service to the community and city of Ferndale. Sgt. Brown not only retires as a distinguished leader for the Police Department, but also as a community ambassador for city officials and an agent of positive change for city leadership.

In 2016, Sgt. Brown was appointed as the Police Department's first Community Engagement Officer. In this role, Sgt. Brown cultivated, nurtured, and developed relationships with the community and its visitors. He served as a keeper of values for the Police Department and the community, and fundamentally supported and accelerated the Police Department's cultural shift toward community-focused policing.

In 2019, Sgt. Brown was appointed as the first Professional Standards Officer. In this final role, he has been solely accountable for helping the Police Department fulfill and prove over 105 professional standards to become one of few departments across the State of Michigan to achieve accreditation. He has done so with great passion and focus, working to leave a legacy of excellence in policing worthy of his career and the Ferndale Police Department.

Baron Brown was promoted to Sergeant in 2002. He was hired by the police department as a patrol officer in 1995. Prior to his work with the Police Department, Sgt. Brown began his career working summers for the Department of Public Works and code enforcement.

Therefore, be it resolved, that Mayor Melanie Piana, on behalf of the Ferndale City Council, extends the City's congratulations to Sgt. Baron Brown on the occasion of his retirement. Baron is a credit to this community, the police department, and the city government, and it is with heartfelt appreciation that we celebrate his achievement.

I, Marne McGrath, the duly appointed City Clerk of the City of Ferndale, Oakland County, Michigan, do hereby certify that the foregoing is a true and complete copy of a resolution duly adopted by the City Council of the City of Ferndale at a virtual meeting held on July 13, 2020, the original of which is on file in the City Clerk's Office.

IN WITNESS WHEREOF, I have hereunto affixed my official signature on this 13th day of July 2020.

Marne McGrath, City Clerk

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Barb Miller

SUBJECT: Approval of Minutes of Regular City Council Virtual Meeting Held June 22, 2020, as Submitted by City Clerk

INTRODUCTION
Approval of minutes of regular City Council virtual meeting held June 22, 2020.

SUMMARY & BACKGROUND
Approval of minutes of regular City Council virtual meeting held June 22, 2020.

BUDGETARY CONTEXT
NA

CIP#
NA

ATTACHMENTS
2020 06 22 Virtual Council Minutes

STRATEGIC PLANNING CONTEXT
Organizational and Financial Excellence

RECOMMENDED ACTION
Approve the minutes of regular City Council virtual meeting held June 22, 2020, as submitted by City Clerk.

FERNDALE

MINUTES
City Council MEETING
June 22, 2020
Held virtually via Zoom
7:00 PM

1) PLEDGE OF ALLEGIANCE

2) ROLL CALL

COUNCIL PRESENT: Kat Bruner James
Raylon Leaks-May
Laura Mikulski
Greg Pawlica
Melanie Piana

COUNCIL ABSENT: None

3) APPROVAL OF AGENDA

Moved by Raylon Leaks-May, Seconded by Kat Bruner James to approve the agenda as amended to move Consent Agenda item 8Q (Budget Adjustments) to 9E, and Consent Agenda item 8B (Juneteenth Resolution) to 9G..

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

4) ELECTRONIC MEETING PROCEDURES

4.A Electronic Council Meeting Procedures Update

Cover Page

City Attorney Christ noted the remote meeting order has been extended to July 30 and summarized the electronic meeting procedures.

5) PRESENTATION

5.A Ferndale Accessibility and Inclusion Commission Celebrates 30 Years of the Americans with Disabilities Act

Mayor Pro Tem Leaks-May introduced FAIAC Chair Alan Hejl who gave a presentation on the ADA 30 year celebration.

5.B Presentation of the June Beautification Awards

FBC Chair Yelverton presented the June Beautification Awards.

5.C Ferndale Police Department MACP (Michigan Association of Chiefs of Police) Accreditation Process Update

Sgt. Brown summarized the accreditation process noting the department had completed all the necessary steps.

6) CALL TO AUDIENCE

Garo Boyagian, who lives near The dot construction, expressed concern about screening installation overlooking his property.

Mike Flores cited transparency concerns about additions to the agenda and suggested the Juneteenth proclamation be amended to celebrate the holiday on June 19 rather than the third Saturday in June.

7) PUBLIC HEARING

7.A Consideration of approval of State of Michigan Drinking Water Revolving Fund Project Plan for Lead Service Line Replacement

DPW Deputy Director Antosik introduced the item and requested that those attending the meeting sign in using the link provided in his staff report.

Mayor Piana opened the public hearing at 8:50pm

Mike Flores noted he had difficulty accessing the link to the presentation and asked for clarification of the length and terms of the loan.

Bruce Jarvie asked about how the horizontal drilling would be addressed.

Mayor Piana closed the public hearing at 8:58pm

Moved by Laura Mikulski, Seconded by Greg Pawlica to approve the Drinking Water Revolving Fund Project Plan for lead service line replacement.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

8) CONSENT AGENDA

8.A Approval of Minutes of Regular City Council Virtual Meeting Held June 8, 2020, as Submitted by City Clerk

8.C Approval of the appointment of Representative and Alternate to SOCRRA Board of Trustees, as submitted by DPW Deputy Director.

8.D Approval of Michigan Municipal League membership renewal and dues in the amount of $7,977.00, charged to City Council Membership and Dues, 101-101-958, as submitted by City Clerk

8.E Approval of the Recommendation for the Mayor to Sign the Contract Between Dorsey Emergency Medical Academy and Ferndale Fire Department to Allow EMS Students and Fire Department Employees to Perform Clinical Rotations with the Fire Department to Obtain a Paramedic License as submitted by Fire Chief

8.F Approval of payment to Tri-Country International Trucks for emergency truck repair in the amount of $3,942.22, the expense to be charged to General Fund, Motor Pool, Repair and Maintenance, Account Number 101-443-775, as submitted by DPW Deputy Director.

8.G Approval of Payment to Woodsman Services for Emergency Tree Removal in the Amount of $4,200.00, the Expense to be Charged to General Fund, Public Services, Contractual Services, Account Number 101-441-818, as Submitted by DPW Deputy Director

8.H Approval of Data Migration Invoice from Granicus for Past Council Meeting Agenda Packets and Minutes Files in the Amount of $16,000.00 to be Charged to City Clerk Contractual, 101-215-818, as submitted by City Clerk

8.I Approval to Upgrade the Department of Public Works Time Clock to NOVATime in the Amount of $4,595.00, the Expense to be Charged to General Fund, Public Services, Contractual Services, Account Number 101-441-818, as Submitted by DPW Deputy Director

8.J Approval to Extend the Michigan Natural Resources Trust Fund Agreement for the Grant Funds Awarded to the City of Ferndale for the Geary and Wanda Park Improvement Projects, and Execute the Michigan Natural Resources Trust Fund Agreement Amendment, as Submitted by the Parks & Recreation Director

8.K Approval of the Water Main Easement Agreement for the Iron Ridge Development, as Submitted by the Planning Manager

8.L Approval of the Storm Water Drainage Facility Maintenance Agreement for the Iron Ridge Development, as Submitted by the Planning Manager

8.M Approval of Renewing the Transportation Improvement Association Membership in the Amount of $6,510.00, Charged to Major Streets, Memberships & Dues, Account Number 202-000-958, as Submitted by the DPW Deputy Director

8.N Approval of the Agreement and Resolution for CARES Act Distribution Between Oakland County and The City of Ferndale as submitted by City Manager

8.O Approval of the Attached Changes to the Collective Bargaining Agreement Between the City of Ferndale and the Ferndale Clerical and Technical Employees' Union, AFSCME 998, for the Period of July 1, 2020 Through June 30, 2022, as Submitted by HR Director

8.P Approval of the Attached Changes to the Collective Bargaining Agreement Between the City of Ferndale and the Ferndale Fire Fighters Association, I.A.F.F., Local 812, for the Period of June 28, 2020 through June 30, 2022, as Submitted by the HR Director

8.R Approval of the Bills and Payrolls as Submitted by the City Manager's Office and Subject to Review by the Council Finance Committee

Moved by Kat Bruner James, Seconded by Greg Pawlica to approve the Consent Agenda as presented.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

9) REGULAR AGENDA

9.A Consideration to Confirm Appointments for Boards and Commissions

Moved by Kat Bruner James, Seconded by Laura Mikulski to approve to Confirm the Mayoral appointment of Anne Galligan to the Beautification Commission for term ending December 31, 2022; and Confirm the Mayoral appointment of Maryanne Wessels to the Arts & Cultural Commission for term ending December 31, 2021; and Confirm the Mayoral appointment of Dustin Hagfors to the Planning Commission for term ending December 31, 2021.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

9.B Consideration of the Resolutions for Temporary Outdoor Seating and Sales for COVID-19 Pilot Programs

Moved by Kat Bruner James, Seconded by Laura Mikulski to approve the resolutions for temporary outdoor seating and sales for COVID-19 pilot programs and to adopt the fees and rental rates as outlined in the presentation, as submitted by Community and Economic Development Director.

There are three resolutions that City Council will need to consider and approve to allow for these temporary measures, which would remain in effect through December 31, 2020:

1. Resolution allowing for temporary use of off-street parking areas for outdoor seating and sales.

2. Resolution allowing for temporary use of parking spaces on city streets, sidewalks, alleys, and parking spaces.

3. Resolution allowing for temporary permits to licensed mobile vendors (including food trucks).

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

9.C Consideration of partnership contract with the Ferndale Area Chamber of Commerce for Business Support Services in an amount not to exceed $20,000, charged to Community Programs, Account Number 101-371.818-000 as submitted by the Community and Economic Development Director.

Moved by Greg Pawlica, Seconded by Laura Mikulski to approve the partnership contract with the Ferndale Area Chamber of Commerce for Business Support Services in an amount not to exceed $20,000, charged to Community Programs, Account Number 101-371.880-000.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

9.D Consideration of the Resolution Authorizing an Interfund Loan to the Auto Parking Fund from the General Fund in an Amount Not to Exceed $2 Million

Moved by Greg Pawlica, Seconded by Kat Bruner James to approve the resolution authorizing an interfund load to the Auto Parking Fund from the General Fund in an amount not to exceed $2 million, to be repaid over a term of five years at 1% interest rate.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

9. E E) Approval of the Year-End Budget Amendment for Fiscal Year 2019-2020

Moved by Kat Bruner James, Seconded by Laura Mikulski to approve the year-end budget amendment for Fiscal year 2019-2020, as submitted by Finance Director.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

9.F Consideration to Renew the City's Coverage with the Michigan Municipal Risk Management Authority at a Cost of $776,146

Moved by Kat Bruner James, Seconded by Laura Mikulski to approve the renewal of the City's coverage with the Michigan Municipal Risk Management Authority at a cost of$776,146, to be charged to account 101-940-914.000, then spread to appropriate funds, and to authorize the City Clerk to execute the Michigan Municipal Risk Management Authority Coverage Proposal and Stop Loss Participation Agreement, as submitted by City Clerk.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

9.G Approval of Resolution Honoring Juneteenth, a Commitment to Liberty and Equality, and Recognizing the Third Saturday in June as 'Juneteenth National Freedom Day,' as Submitted by Special Events Director

Moved by Greg Pawlica, Seconded by Kat Bruner James to approve the resolution honoring Juneteenth, a commitment to liberty and equality; and recognizing the 19th of June as 'Juneteenth National Freedom Day,' as submitted by Special Events Director.

For: Kat Bruner James, Raylon Leaks-May, Laura Mikulski, Greg Pawlica, Melanie Piana
Against: None
Abstain: None
5 - 0 - 0

MOTION CARRIED

10) CALL TO COUNCIL

Mayor Pro Tem Leaks-May read the 30 year ADA proclamation.

City Clerk McGrath announced that AV ballots would be available soon and in the mail by the beginning of July.

Finance Director Stubblefield tax bills hitting mail stream July 1and the coupons will be going out a couple of days later.

Fire Marshal Barr provided an update on burn permit inspections and fireworks.

Parks and Recreation Director Wheler announced the donation of 100 play kits per week in July.

DPW Deputy Director Antosik announced the curbside waste pickup program was proceeding as normal.

City Manager Gacioch announced the restoration of public access to City Hall starting Monday, July 6 with temporary hours of 10am - 3pm Monday through Thursday operating under new public health requirements.

Mayor Pro Tem Leaks-May expressed concern about temporary outdoor recreational uses and ADA compliance, thanked council for being so involved and have open conversations about race and holidays to celebrate the Black community, that as the mother of children who are African-Americas the progress means a lot to her and wished everyone a safe and happy Fourth of July.

Council Member James noted people have told her they've been uncomfortable about the lack of physical and social distancing downtown and urged people to keep distancing to keep COIVD in check for everyone's safety and noted Citizens for a Fair Ferndale were distributing Black Lives Matter signs for donations of $5 or more.

Council Member Pawlica wished everyone a Happy Independence Day and to stay safe by social distancing.

Mayor Piana expressed her thanks to Rep. Andy Levin for leading the HEROES act which offers to pair up mayors with mayors of opposing political parties for conversations about their viewpoints and encouraged people to continue with social distancing for everyone's safety.

11) ADJOURNMENT - 11:23pm

_____
Melanie Piana, Mayor

_____
Marne McGrath, City Clerk

FERNDALE

July 13, 2020 Community & Economic Development

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Erin Quetell

SUBJECT: Approval of the Receipt and Acceptance of the Downtown Waste Management Report, as Submitted by Sustainability Planner

INTRODUCTION
Formal approval of the adoption of the Downtown Waste Management Report prepared by RRS.

SUMMARY & BACKGROUND
RRS was the selected firm to conduct the Downtown Waste Management assessment to optimize downtown waste operations and provide recommended guidelines to improve level of service. RRS previously presented the final findings to City Council in March 2020. The original budget for the study was not to exceed $63,627 and was completed on time.

The purpose of this report is to guide city staff in improving level of service to businesses and community members in the downtown concerning landfill waste, recycling, and organic waste. As a direct recommendation out of this report, there were initial capital investments made which include:
*Sanitation infrastructure upgrades at an initial $200,000 for FY 20-21 and $45,000 subsequent years (dumpsters, compactors, recycling bins, access management etc.)
*Organic compost pilot $45,000 each year FY20-FY23
*Cardboard compactor replacement at $35,000 FY 21-22
*Creation of a green ambassador position to facilitate downtown sustainable practices

These efforts will immediately improve services in the downtown area, and provide opportunities for community and business education and engagement in the improved waste management. Other highlights include recommendations for fats, oils, and grease (FOG) optimization, improvements to waste management in the four corners of downtown, and improved pedestrian receptacle upgrades which include landfill and recycling options.

BUDGETARY CONTEXT
Sanitation infrastructure Upgrades at an initial $200,000 for FY 20-21 and $45,000 subsequent years (dumpsters, compactors, recycling bins, access management etc.), Organic Compost Pilot $45,000 each year FY20-FY23, years, Cardboard Compactor Replacement at $35,000 FY 21-22, and a Green Ambassador position to facilitate downtown sustainable practices as recently approved in the Capital Improvement Plan and all funded through 226-000-977.00 Sanitation Fund.

CIP#
N/A

ATTACHMENTS
Ferndale Downtown Waste Reduction and Recycling Master Plan Final - 07012020-merged.pdf

STRATEGIC PLANNING CONTEXT
Supported Infrastructure

RECOMMENDED ACTION
Approve the Resolution to adopt the Downtown Waste Management Report.

WASTE REDUCTION AND RECYCLING MASTER PLAN FOR FERNDALE DOWNTOWN

PREPARED BY:

RRS | recycle.com

COMMISSIONED BY:

FERNDALE

EXECUTIVE SUMMARY

Overview of the Waste Reduction and Recycling Master Plan

The City of Ferndale initiated a planning process to determine future needs and evaluate potential solutions to create a long-term sustainable plan for waste and recycling in the downtown/central business district. Cities with thriving downtowns face multiple challenges regarding solid waste and recycling management such as space constraints, cleanliness, frequency of service needs, and successfully incorporating recycling collection. Through the development of a waste reduction and recycling master plan, the City of Ferndale can explore potential opportunities and solutions to ensure the waste and recycling needs of the central business district are being met and accommodated into the future.

The plan serves as the roadmap for the City and its stakeholders over the next twenty years (2020-2040) and will include recommendations for implementation and measurement of progress over the implementation period to address immediate operational needs and desires of the community in a financially sustainable manner. Specifically, the plan responds to:

- Ongoing operational needs and costs related to the City's current waste reduction and recycling management programs in the downtown/central business district; and
- The desire of the community to enhance or expand its current solid waste and recycling services to provide a higher level of service and reduce the quantity of waste disposed downtown/central business district.

The plan document includes:

- Data from the desktop waste characterization, walk-through and stakeholder interview summary as the background data to provide the foundation of the plan activities;
- A description of the regional infrastructure in use and available (map included);
- The summary memo prepared for Task 4 describing considerations regarding best practices, emerging trends and technology, and policy implications for future waste and recycling management;
- An overview of the projected waste stream analysis;
- A summary of the evaluation and recommendations for waste and recycling management in the downtown central business district; and
- Plan implementation recommendations and metrics.

Waste Reduction and Recycling Master Plan Process

The Master Plan development began in November 2019 with the City's assignment of a staff stakeholder group to oversee the planning process and contracting of an expert consulting team to lead the research, analysis, and public engagement aspects of the planning process. Work on the plan concluded in April 2020 with presentation of this report to the City of Ferndale Waste Reduction and Recycling Master Plan Stakeholder group, City Council and the Downtown Development Authority (DDA).

The plan was developed through a comprehensive process and activities included:

- Review of current operational costs, services contracts and waste and recycling data;
- Research of solid waste, waste reduction and recycling management best practices and emerging technologies in peer communities across the U.S.;
- Analysis of options to improve operations, enhance or expand current programs and services, and add new programs and services to meet the City's objectives;
- Business community engagement through targeted meetings, interviews and surveys of participants in one-on-one stakeholder interviews, downtown business focus group members, and input from the City staff to obtain input and feedback from the community on current and future needs/interests as well as support for options under consideration;
- A gap analysis;
- Development of a financial model to compare baseline current conditions of program operations to options of improved operations, enhanced or expanded programs. This model assumes full funding of the proposed recommendations through the use of fund balance and increased special assessment revenue to cover new costs and rebuild fund balance;
- Recommendation development and review with stakeholders and City staff; and
- Presentation of the Master Plan Findings and Recommendations to the stakeholders and City staff.

Waste Reduction and Recycling Master Plan Recommendations

The recommendations contained in this plan will assist the City in future efforts to achieve their long-term recycling and sustainability goals.

The key recommendations for enhancing the waste reduction and recycling in the City's Downtown Business District Area are presented in the main report in Section 4 and restated below.

- **Set Metrics for Success** – The City of Ferndale should use the data and forecasts in this plan to develop a set of Goals and Targets for the City to measure success. For example, reduce the amount of material landfilled by 50 percent by 2025.
- **Infrastructure Investments** – The City of Ferndale should develop four enclosed collection areas each with new landfill compactors with sensors and single stream recycling compactors with sensors. New technology will allow the City to monitor unique restaurant and business use of the collection area and each type of compactor. The City of Ferndale should also partner with SOCRRA to purchase new landfill and recycling containers for the public use areas of the downtown. The City of Roanoke, Virginia manages downtown waste streams in way that could be a model for Ferndale. Roanoke, Virginia and Lawrence, Kansas both use a tiered payment structure to allocate costs across users who use the system differently.
- **Dedicated Staff Person** – The City of Ferndale should create new position to manage downtown recycling, compost, and landfill programs, educate business employees, manage the Green Business Challenge program, and coordinate with SOCRRA.
- **New Policies and Ordinances** – The City of Ferndale should
  - Develop an ordinance requiring all new construction to include space on-site for sustainable materials management – landfill, recyclables, organics – on-site;
  - Develop a pilot program for pre-consumer commercial organics (compost) collection partnering with SOCRRA or another compost service provider. Start with the 44 restaurants and expand as appropriate;
  - Develop and implement an ordinance requiring operating standards and reporting by restaurants and grease haulers to improve management of fats, oils, and grease (FOG) generated by restaurants;
  - Develop a single hauler franchise for FOG;

- Develop an ordinance requiring recycling for commercial and residential properties;
- Develop an ordinance requiring one waste hauler for the community;
- Develop an ordinance requiring organics collection from key businesses. Expand as appropriate across all commercial and residential properties; and
- Increase data availability and tracking of construction and demolition (C&D) debris as a precursor to establishment of requirements for diversion of C&D materials.

- **Fund and Finance** – The City of Ferndale should develop new models to fund and finance expansion of existing programs and new programs through a combination of cost savings and new revenue from property taxes and special assessments. The current system has little or no financial incentive for businesses to reduce trash. Explore funding partnerships with SOCRRA and the DDA. Use existing downtown funding structures including Business Improvement Zones as necessary.

The RRS Team developed a set of scenarios assuming business as usual diversion (14 percent), strong diversion (40 percent) and stretch diversion (56 percent) programs. This set of scenarios was modeled using current CBD employment and remodeled adding 150 employees over the next five years. These scenarios help Ferndale explore the kind of new infrastructure required to capture additional recycling and organics. The elements of the strong and stretch diversion programs are shown below and described in more detail in the Recommendations section.



Figure 1 - Strong Diversion Program Elements



Figure 2 - Stretch Diversion Program Elements

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This report would not have been possible without the help of key city staff, community partners, and RRS staff. This page acknowledges the staff and local businesses who worked to provide important direction, feedback, data sets, model assumptions, and contributed to developing and editing the final report materials.

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1. BACKGROUND AND CURRENT WASTE AND RECYCLING MANAGEMENT PRACTICES

Statewide Waste and Recycling Rate and Goals

In the past several years, Michigan has invested via grant-funding in diversion programs throughout the state. The investments have paid off with an increase in the overall diversion rate from 15 percent in 2015 to 18.1 percent in 2018. The increased diversion is in part due to improved access for residents with more cart-based collection programs and greater drop-off site infrastructure. The state would like to continue the growth in recycling and composting programs and has set a statewide goal to reach an overall diversion rate of 45 percent. Increasing diversion saves valuable landfill space and will reduce Michigan's greenhouse gas (GHG) emissions. A recent report commissioned by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) found that GHG reductions from tripling the recycling rate would eliminate emissions of an additional 7 million metric ton equivalent of carbon dioxide beyond current diversion practices - equivalent to taking nearly 1.5 million passenger vehicles off the road for one year or conserving the annual energy consumption of more than 760,000 households (approximately 20 percent of Michigan households). The report's main focus was the impact diversion programs play on the state's economy. Tripling the recycling rate to 45 percent would support 138,000 new jobs in Michigan's Recycling, Reuse & Recovery (RRR) Industry, providing $9 billion in annual labor income and $33.8 billion in economic output.

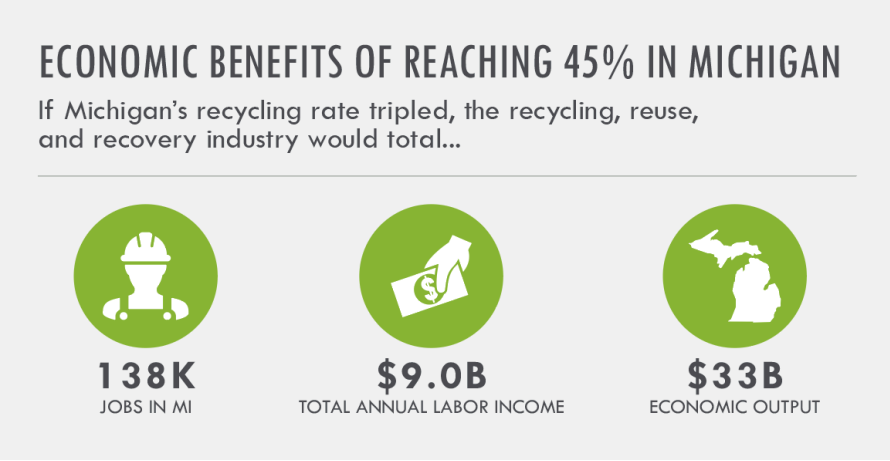


Figure 3 - Economic Benefits of Recycling in Michigan

Regional Waste and Recycling Infrastructure

The City of Ferndale is one of 12 member communities part of the Southeastern Oakland County Resource Recovery Authority (SOCRRA). Founded more than a half-century ago, SOCRRA is one of the oldest waste authorities in Michigan. The other member communities are Berkley, Beverly Hills, Birmingham, Clawson, Hazel Park, Huntington Woods, Lathrup Village, Oak Park, Pleasant Ridge, Royal Oak, and Troy. SOCRRA provides curbside services via private contracts to approximately 283,000 people, and the average diversion rate for member communities is 40 percent. Additionally, the authority owns and operates a transfer station, compost facility, a material recovery facility (MRF), and permanent household hazardous waste (HHW) drop-off site (located at the MRF). Member communities pay a rate cost for service.

Per the membership agreement with SOCRRA, Ferndale agrees to allow SOCRRA to collect and deliver all municipal solid waste, yard waste, and recyclables collected from within Ferndale to SOCRRA's facilities. As a member,

Ferndale benefits from the availability and use of local facilities owned by SOCRRA that help to manage costs in the favor of members. Rather than member communities bidding for services, SOCRRA bundles the communities for bidding. SOCRRA is the contract holder for all community collection services. The service provider for the City of Ferndale including Ferndale's CBD is Car Trucking.

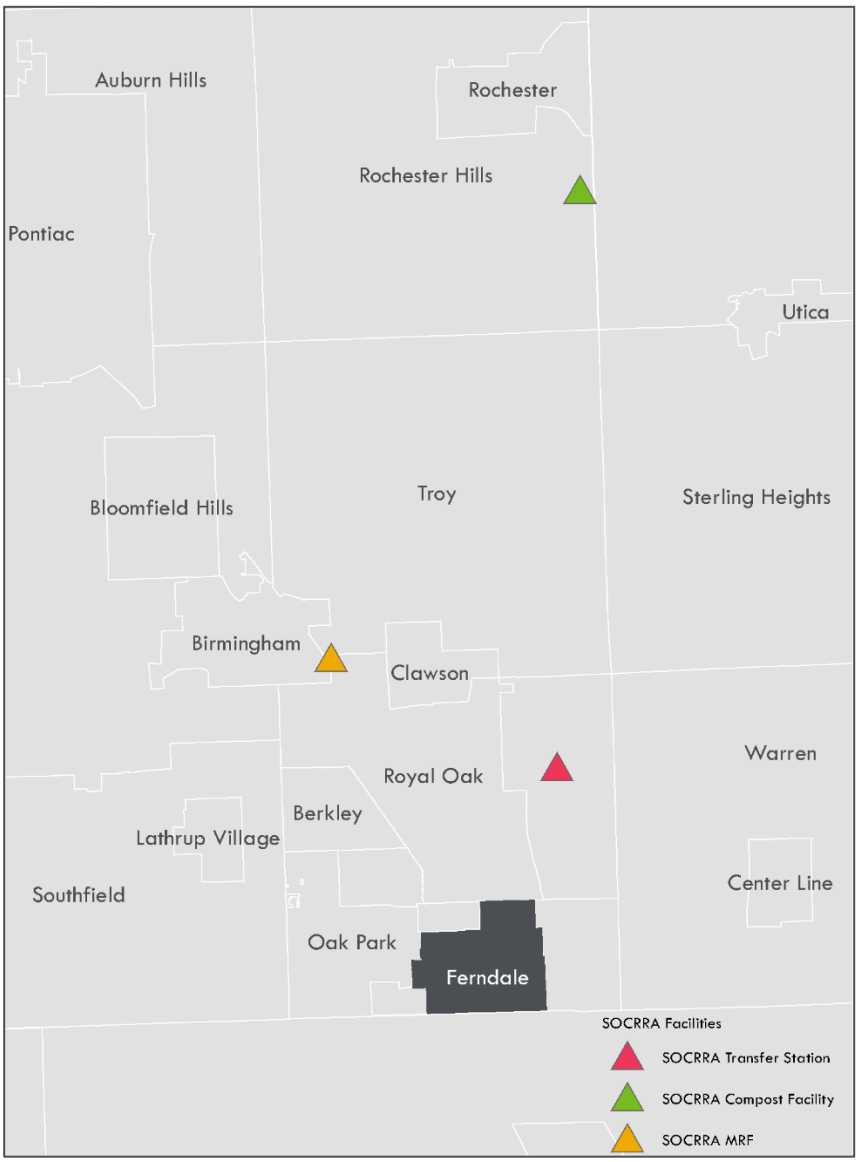


Figure 4 - SOCRRA Facilities Map

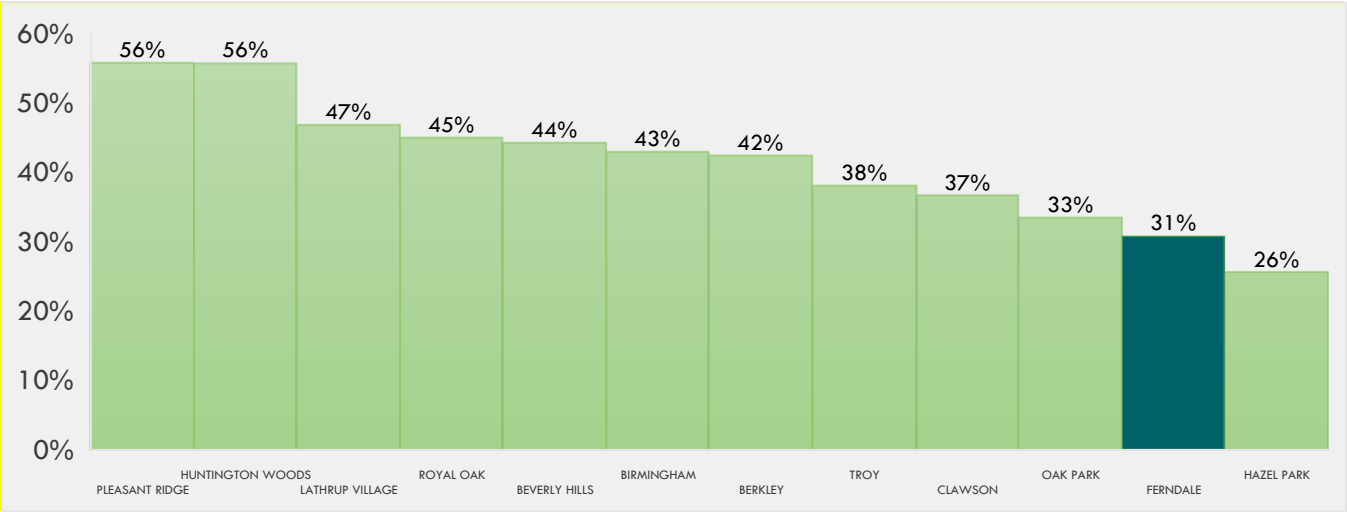


Figure 5 - SOCRRA Diversion Rate by Community

Ferndale's Central Business District Waste and Recycling Infrastructure and Collections

Ferndale's Central Business District (CBD) is centered around the intersection of Woodward Ave and Nine Mile Road. The CBD is a dense area comprised of a mixture of restaurants, bars, retail stores, and professional offices and services. At the time of this report, 46 percent of all employees worked in restaurants. The density of the CBD makes waste collection from individual businesses too challenging due to lack of business and alley space, and so waste collection in the CBD is managed through central collection areas. The City of Ferndale currently has five centralized locations available for commercial waste disposal and recycling, all serviced by Car Trucking. They are currently positioned in a manner that all businesses within the central business district have access to a waste collection area without needing to cross Woodward Ave or 9 Mile Rd. Waste collection areas include four compactor locations (Como's, E Troy, W Troy, Withington) and a single dumpster location (W Breckenridge). A new compactor location is planned as part of The DOT construction, which will replace the current W Troy compactor.



Figure 6 - Ferndale Central Business District Compactor locations: 1: Vester Compactor, 2: E Troy Compactor, 3: Withington Compactor, 4: W Troy Compactor, 5: Dot Compactor (Planned), 6: W Breckenridge Dumpsters

WALK-THROUGH ASSESSMENT

In the centralized waste collection areas, four streams of material are collected: landfill, single stream recycling, cardboard recycling, and FOG collection. To understand these collection areas, the RRS Team performed a walk-through assessment of Ferndale's current central business district waste collection.

The RRS Team visited each of the compactor locations during the initial walk-through. Each location includes a compactor for waste collection, some form of cart or dumpster to collect recyclables, containers for FOG collection, and collection for other material (e.g., bulky items, pallets, etc.)

VESTER COMPACTOR (NORTHEAST AREA OF CBD)

The waste area is in an alley corner south of Vester Ave. The area is located on the north side of the parking lot.



Figure 7 - Vester Collection Area

- The waste area includes a compactor, dumpsters for recycled carboard collection, green 64-gallon carts for recycled plastic, metal, and glass container collection, and a container for FOG collection. Detroit Grease provides the FOG container.
- Pallets stored next to recycling containers appear to have been left out for collection.
- The compactor and other containers are not located in a gated enclosed area (unlike some of the other waste collection locations). A number entry pad for compactor use is located on a pole with security cameras near the compactor. The compactor did not appear to fully close and latch.

E TROY COMPACT (SOUTHEAST AREA OF CBD)

The waste collection area is in the alley from E Troy to 9 Mile.



Figure 8 - E Troy Collection Area

- The waste area includes an enclosed area for a compactor. A number pad for compactor access is located next to door. The compactor enclosure has gates for compactor service.
- The area included open-top, wheel carts to collect cardboard for recycling. The cardboard carts were located on the southside of alley separate from the container recycling carts and compactor enclosure.
- The area had multiple 64-gallon carts for plastic, metal, and glass container recycling. These containers took up a large area of the alley space.
- The waste area included a container from Detroit Grease for FOG collection.

W TROY COMPACTOR (SOUTHWEST AREA OF CBD)

The waste area visited during the initial walk-through is a temporary location for the containers and compactor while the DOT is under construction. This compactor location will move inside the DOT following completion of construction.



Figure 9 - W Troy Collection Area (temporary)

- The area had large, green dumpsters for recycled cardboard collection and green 64-gallon carts for recycled plastic, metal, and glass container collection. Brown containers from Car Trucking were also set in the collection area. It was unclear what these containers were set up to collect.
- The area's compactor is not located within an enclosure but will be in the DOT. The area also included a large roll-off dumpster. It was unclear whether this was being used to collect comingled recycling or refuse.
- The area had two FOG collection containers from Mahoney.

WITHINGTON COMPACTOR (NORTHWEST AREA OF CBD)

The compactor area is located on the north side of the large parking lot area to the south of Withington St. There is an enclosure with a gate for the compactor and some of the recycling containers.



Figure 10 - Withington Collection Area

- Green dumpsters for recycled cardboard collection were located outside the enclosure. Additional brown dumpsters from Car Trucking were also located outside of the enclosure.
- Green 64-gallon carts for recycled plastic, metal, and glass containers were located inside of the compactor enclosure. Two FOG containers from Mahoney were located within the enclosure.
- A large amount of bulky waste that would not fit into the compactor (e.g., pallets, cabinets and counters, drawers) was also stored inside the compactor enclosure.

All of the waste locations visited by the RRS Team included compactors for refuse disposal, dumpsters, carts for recycled cardboard and containers, and FOG collection containers. Two of the four locations housed the compactors in an enclosed area, while compactors in the other two location were in open areas like the other dumpsters and carts. There are different numbers of carts available for the collection of recycled materials, likely due to differing amounts of materials generated based on the waste location. Cardboard was collected in rolling carts at the E Troy location, while cardboard was collected in blue dumpsters at the other three locations. The W Troy and Withington locations had additional brown dumpsters for what appeared to be refuse collection. The W Troy location also had an additional roll-off dumpster. The company providing the container for FOG collection was different based on location, with Mahoney providing containers for two locations (W Troy and Withington), Detroit Grease providing the container at the E Troy location, and the Vester location container did not identify any company information. All the waste locations were generally clear of loose refuse or litter, but some of the locations did have bulk materials and pallets set near the collection containers.

COLLECTION SERVICES

As mentioned earlier, Car Trucking collects all material streams from Ferndale's CBD. Car Trucking entered into a contract agreement with SOCRRA in 2006 for collection services in Ferndale, and that contract was extended in 2016 through July 2027. The table below outlines the agreed upon service levels for Ferndale's CBD.

Table 1 - Ferndale CBD Containers and Collection Frequency

CONTAINER LOCATION	CONTAINER SIZE & TYPE	NUMBER OF CONTAINERS	PICKS PER WEEK OF CONTAINER	USE OF CONTAINER
W Troy	40-yard compactor	1	2	Refuse
	2-yard dumpsters	5	5	Recycling
	64-gallon carts	5	5	Recycling
Withington	40-yard compactor	1	1	Refuse
	2-yard dumpsters	6	5	Recycling
	64-gallon carts	6	5	Recycling
Vester	20-yard compactor	1	2	Refuse
	2-yard dumpsters	2	5	Recycling
	64-gallon carts	3	5	Recycling
East Troy	20-yard compactor	1	1	Refuse
	64-gallon carts	10	5	Recycling

In the past several years, construction projects and specific business requests have resulted in varying container counts within the centralized waste areas. Some businesses have asked for extra recycling carts that they rollout on collection days. Additionally, there have been times where the refuse compactors have gone down and dumpsters have been rolled out in place until compactors are repaired. As a result, the table above may not be representative of containers presently located in the centralized waste collection areas.



Figure 11 - Multiple Dumpster Vendors

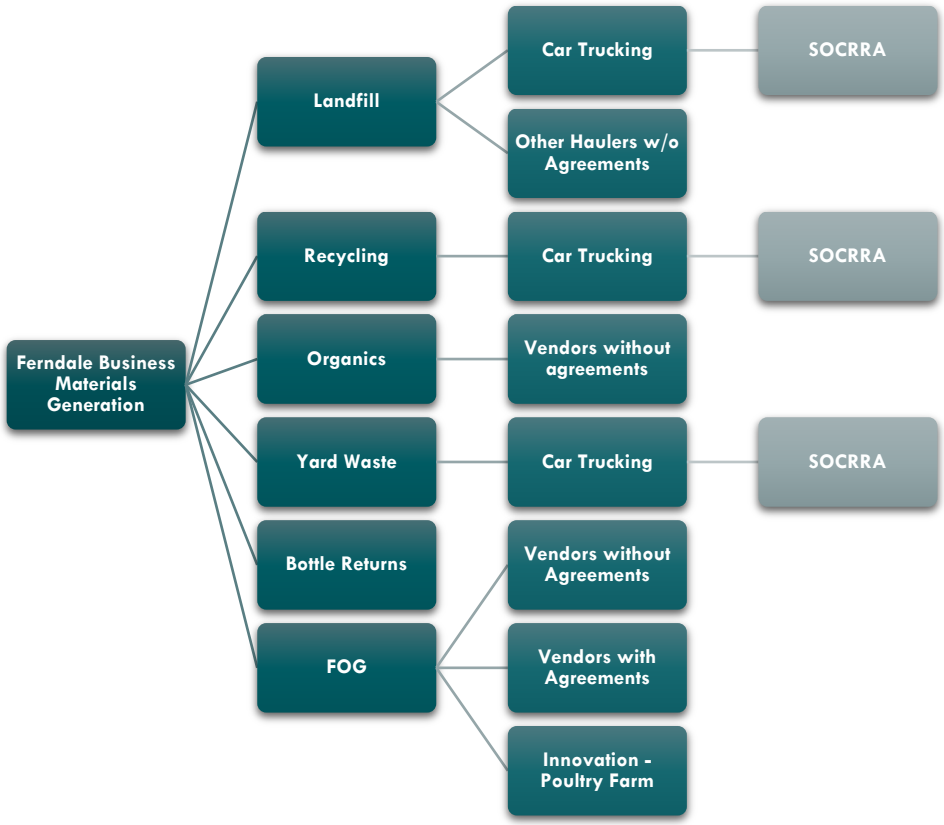


Figure 12 - Summary of Ferndale Collection Streams

Ferndale's CBD Waste Generation and Collection Costs

WASTE CHARACTERIZATION MODEL AND ASSESSMENT

Like many communities, the City of Ferndale does not have perfect information on the weights or volumes of materials within its landfill, recycling, FOG, and organics streams. The city has good landfill data although some businesses use vendors other than Car Trucking and do not report their collections to the City. The city has poor recycling data because downtown recycling is mixed with residential recycling on the route. There is no regular reporting of FOG data to the City. There is no formal organics collection program to collect any data.

To allow the City of Ferndale to plan for the future, the RRS Team built a model using an updated list of the downtown businesses, number of employees, and detailed waste audit information from the 2014 CalRecycle study. This methodology and waste characterization are described in more detail below. The estimates in the model compare favorably with the available waste, cardboard and single stream recycling, and FOG data the RRS Team received from SOCRRA, Car Trucking, and FOG collection providers.

The RRS Team reviewed data from a variety of waste sorts conducted across the country, most notably

- 2014 Generator-Based Characterization of Commercial Sector Disposal and Diversion in California, September 2015;
- Illinois Commodity Waste Generation and Characterization Study Update, March 2015;
- Connecticut 2015 Statewide Waste Characterization Study, March 2016; and
- 2015-2016 Washington Statewide Waste Characterization Study, October 2016.

While all of these sorts include useful data on commercial sector waste streams, the RRS Team determined that the 2014 CalRecycle study was most applicable for estimating waste generation and diversion for Ferndale's CBD. Several factors led to this decision. The CalRecycle study collected samples separately from 16 different industry groups so that, for example, waste from restaurants could be tracked separately from waste from retail. Additionally, the CalRecycle study sorted samples from businesses' disposal and diversion streams, measuring all aspects of the waste stream rather than just focusing on one waste stream. Finally, the CalRecycle study was robust, collecting samples from hundreds of businesses across the state of California. The RRS Team used the detail from the CalRecycle study, in particular the pounds per total employee per year disposal and diversion estimates, to build the model and gather more granular insights into the characteristics of the waste streams in Ferndale's CBD.

BACKGROUND ON 2014 CALRECYCLE GENERATOR-BASED CHARACTERIZATION

In a 2014 study, the California Department of Resources Recycling and Recovery or CalRecycle characterized commercial waste and diversion streams for various market sectors. In order to characterize similar waste streams, this study used the three-digit North American Industry Classification System (NAICS) codes of 837 different businesses to create 16 main industry groups for evaluation. More than 800 disposal samples and 400 diversion samples were hand-sorted into 82 material categories. Diversion streams include curbside recycling, curbside organics, and other diversion methods that include businesses selling their own cardboard or scrap metal directly to recyclers or redeeming beverage bottle deposits. Once all materials were categorized for all waste streams, an analysis was completed based on the number of employees at each individual business.

CBD DESCRIPTION

In order to pull together a picture of the waste stream generated in the CBD, the RRS Team needed an updated list of the type and size of businesses in Ferndale's downtown. A full list of businesses and employee totals was generated for Downtown Ferndale using the LexisNexis database that tracks commercial entities in North American by NAICS

codes and includes information such as type of business, address, number of employees, and estimated sales. The generated list was verified by the RRS Team via an online search of the Ferndale area. Closed businesses were removed from the list while newly opened businesses were added. The employee numbers for recently opened businesses were determined through direct contact and questioning.

With the NAICS codes and employee numbers generated from LexisNexis, each Ferndale business could be categorized into the same industry groups from the 2014 CalRecycle study. Of the 16 industry groups from the study, 13 were relevant for Ferndale's CBD. The largest industry sectors, by employee, in Ferndale's Central Business District include Restaurants (46 percent), Services – Professional, Technical & Financial (10 percent) (includes telecommunications, insurance, real estate, financial investment, etc.), and Services – Repair & Personal (9 percent) (includes all beauty shops, salons, and maintenance). These calculations exclude at least five businesses that the RRS Team identified as open but have been unable to verify employment data. These known missing businesses include one from Arts, Entertainment, and Recreation, one from Education, two from Retail Trade – All Other, and one from Services – Professional, Technical, & Financial sectors.

Table 2 - Ferndale Businesses by Type, Employees, and Percent of Employment

BUSINESS TYPE	NUMBER OF BUSINESSES	NUMBER OF TOTAL EMPLOYEES IN CBD	PERCENT OF TOTAL EMPLOYMENT
Arts, Entertainment, and Recreation	7	28	3%
Durable Wholesale & Trucking	2	17	2%
Education	4	7	1%
Manufacturing - Food & Nondurable Wholesale	5	54	5%
Manufacturing - All Other	5	20	2%
Medical & Health	21	79	8%
Restaurants	44	485	46%
Retail Trade-Food & Beverage Stores	5	52	5%
All Other Retail Trade	20	55	5%
Services – Management, Administrative, Support, & Social	8	29	3%
Services – Professional, Technical & Financial	26	100	10%
Services – Repair & Personal	35	94	9%
Not Elsewhere Classified	3	31	3%
Total	185	1,051	100%*

*Total percent does not add up to 100% due to minor rounding

While the RRS Team used the employment data to estimate Ferndale's overall waste generation via the 2014 CalRecycle Study Data, a co-benefit of this analysis is that the City of Ferndale has a more complete list of downtown businesses and employment estimates for other planning purposes. To the extent possible, this list should be maintained for future planning efforts.

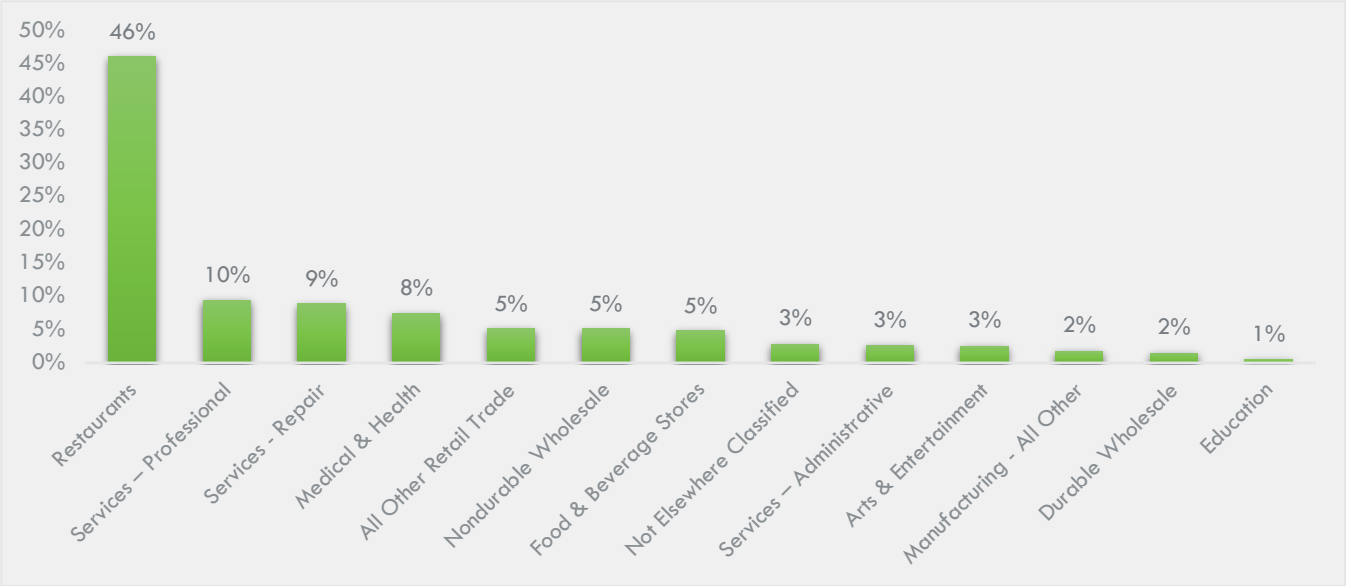


Figure 13 - Employment Percentage by Business Type

CALRECYCLE WASTE ESTIMATION

A breakdown of estimated waste generation per material illustrates that restaurants will have mainly organic waste while repair and personal services will generate mostly organic and paper waste, and professional, technical & financial services generate a large portion of paper, organic, and inerts and other waste. The inerts and other waste group includes pallets, crates, and other wood waste.

Table 3 - CalRecycle Estimated Waste Generation Percentage for Three Largest Industry Groups in Ferndale.

MATERIAL GROUP	RESTAURANTS	SERVICES – PROFESSIONAL, TECHNICAL, & FINANCIAL	SERVICES - REPAIR & PERSONAL
Paper	28.3%*	36.2%	27.8%
Glass	5.3%	1.6%	2.2%
Metal	2.1%	3.9%	15.2%
Electronics	0.0%	1.6%	0.4%
Plastic	11.0%	11.8%	10.8%
Organic	51.6%	22.3%	28.9%
Inerts and Other	1.0%	20.8%	11.5%
Household Hazardous Waste	0.0%	0.2%	1.6%
Special Waste	0.5%	1.4%	1.3%
Mixed Residue	0.1%	0.1%	0.3%

*Percentages are based off sample weights.

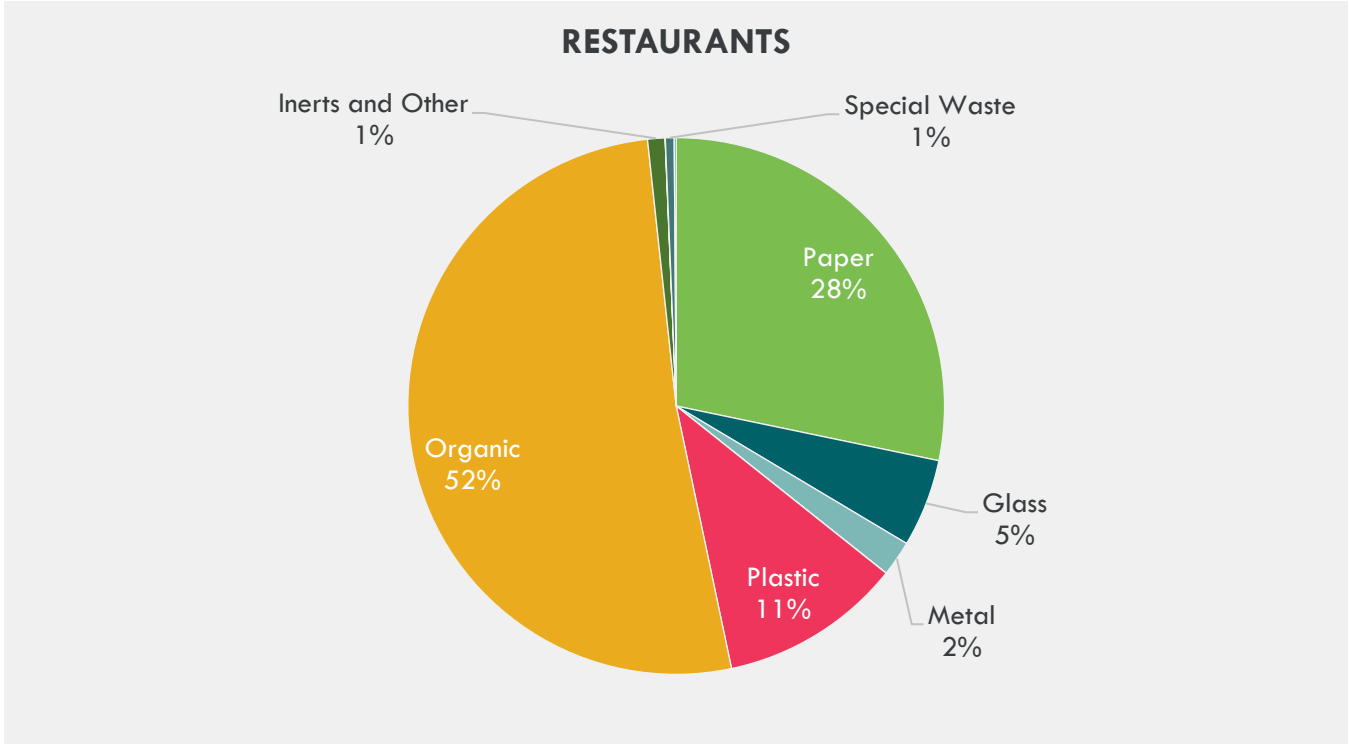


Figure 14 - Restaurant Waste Generation by Material Stream (Weight)

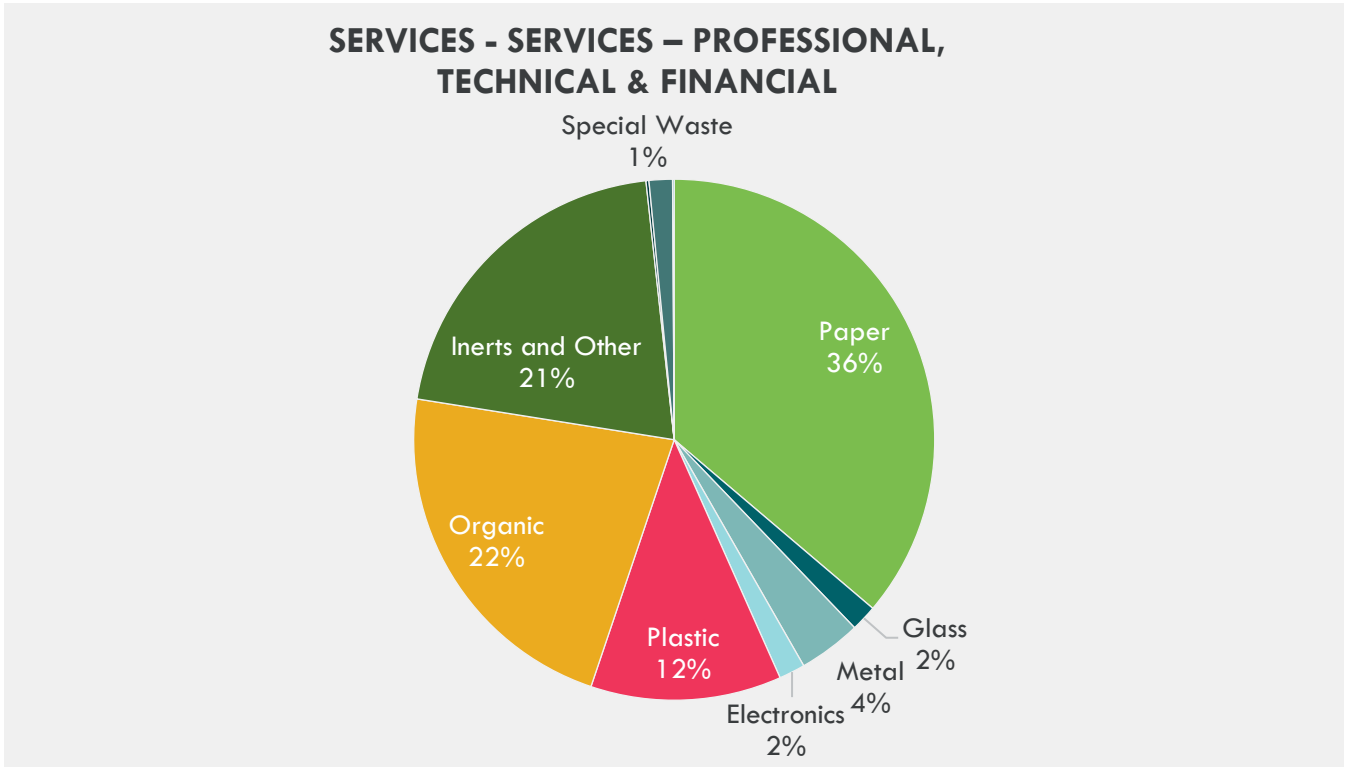


Figure 15 - Professional Services Waste Generation by Material Stream (Weight)

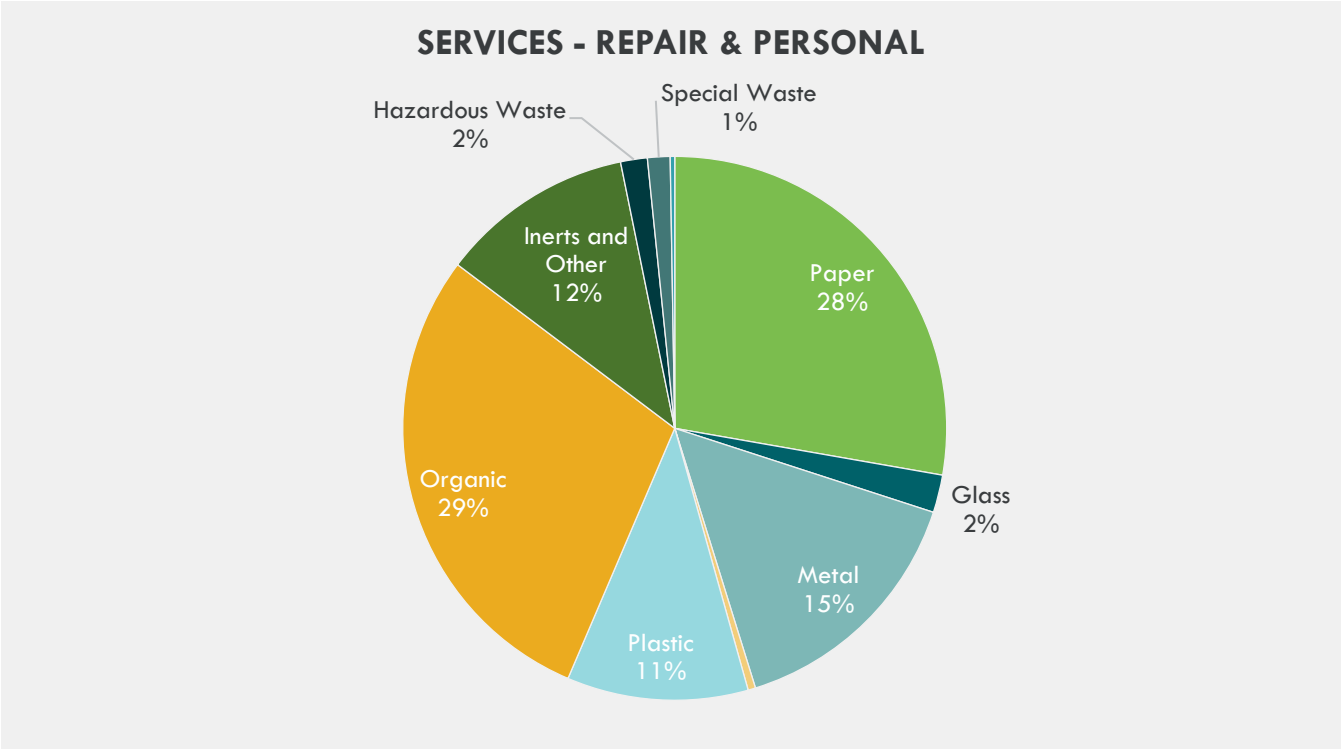


Figure 16 - Repair Services Waste Generation by Material Stream (Weight)

WASTE GENERATION AND COMPOSITION ESTIMATE FOR FERNDALE CBD

The RRS Team used the researched business types and employment data to estimate total waste generation per sector based on the CalRecycle tons per total employee per year disposed, recycled, composted, or other diversion activities, including businesses selling their own cardboard or scrap metal directly to recyclers or redeeming beverage bottle deposits.

Using the 2014 CalRecycle tons generated per employee per year, businesses in the Ferndale CBD are estimated to generate:

- 2,000 tons per year of waste;
- 1,366 tons to landfill;
- 158 tons to single stream recycling;
- 107 tons to composting; and
- 370 tons to other diversion activities.

It should be noted that these data are constantly in flux in a downtown area, because businesses come and go in this market and employee numbers are ever changing. The information provided here is intended as a current point in time example to draw inferences on the state of Ferndale's waste stream and create a baseline to measure progress.

Table 4 - Estimated Tonnage Per Year of All Disposal and Diversion Streams for Ferndale CBD Businesses Based on the 2014 CalRecycle Study

DESCRIPTION	TOTAL EMPLOYEES	DISPOSE	RECYCLE	ORGANICS	OTHER	TOTAL
Arts, Entertainment, and Recreation	28	54	3	1	6	65
Durable Wholesale & Trucking	17	10	3	0	37	49
Education	7	3	0	0	0	3
Manufacturing - Food & Nondurable Wholesale	54	66	3	1	27	97
Manufacturing - All Other	20	9	2	0	19	29
Medical & Health	79	45	3	0	1	49
Restaurants	485	761	87	58	29	936
Retail Trade-Food & Beverage Stores	52	49	6	5	205	265
All Other Retail Trade	55	96	4	0	8	108
Services – Management, Administrative, Support, & Social	29	17	3	14	0	34
Services – Professional, Technical, & Financial	100	161	30	8	4	203
Services - Repair & Personal	94	80	12	20	16	128
Not Elsewhere Classified	31	14	1	0	18	34
Total Estimated	1,051	1,366	158	107	370	2,000

COMPARISON OF CALRECYCLE ESTIMATES TO AVAILABLE CBD WASTE DATA

Car Trucking supplied RRS with the total amount of landfill material hauled from the four Downtown areas from January 2012 through December 2019, providing a means to ground truth the CalRecycle estimation. In January of 2016 the Breckinridge compactor was relocated to Vester, increasing the amount of refuse in this compactor. Overall, the compactor on West Troy receives the most amount of material. This area also had a large spike in disposal from July of 2015 through December of 2017. This spike may have been due to city efforts to get local businesses to use the compactors instead of the dumpsters. In 2018, Car Trucking reported disposing of 878.8 tons of material from Ferndale's CBD compactors. In 2019, disposal from the CBD was slightly greater at 945.9 tons. The CalRecycle disposal estimate is approximately 1.4 times greater than the total 2019 disposal reported by Car Trucking. It should be noted however, that the disposal estimate from CalRecycle includes a category referred to as 'Inerts and Others' that comprises pallets, crates, and other wood waste. It is the RRS' team opinion that those items being generated by Ferndale's CBD may not be disposed of in the compactors directly, and thus not included in the tonnage estimates from Car Trucking. According to the CalRecycle study 'Inerts and Others' category can range from one to 21 percent of a business's waste stream depending on the sector. Additionally, Michigan has a robust bottle redemption program for beer and other carbonated beverages, and redemption rates in Michigan have long been 10 to 30 percent greater than California redemption rates. Containers returned for redemption are not currently captured in this assessment. Finally, RRS has heard that some businesses within the CBD do not use the centralized disposal areas, and it is not currently known how many businesses may be using other means for disposal and

recycling. We know that some businesses in the CBD use dumpsters from landfill haulers that do not report to the City. RRS does not have data on materials sent for disposal collected outside the compactors.

In addition to the disposal data, Car Trucking provided RRS with an estimate of cardboard collected from Ferndale's CBD. The tonnage data provided to the RRS Team included all corrugated cardboard collection in Ferndale plus one additional stop in the City of Clawson. To estimate the tons of cardboard recycling in Ferndale separately, the RRS Team used the known dumpster sizes located at the stop in Clawson along with estimations on percent filled per dumpster and volume to weight conversion estimates specific for cardboard. From there, the RRS Team subtracted the estimated Clawson tonnages from the total tonnages. The table below outlines the estimated cardboard recycling tonnages for Ferndale only.

Finally, the RRS Team analyzed single stream recycling data for Ferndale's CBD. During a conversation with Car Trucking, the RRS Team learned that Car Trucking does not have specific data for the downtown area because the cart recycling collection in downtown Ferndale happens along the same routes as residential recycling. In lieu of specific data, the RRS Team estimated that approximately 96 tons of single stream recycling is collected from the CBD per year. This estimate was made based on the standard service in the compactor area agreed upon with Car Trucking along with estimates of the density of average single stream recycling and percent fullness of each cart at pick-up. The RRS Team also approached the recycling estimate by calculating the proportion of total single stream recycling tonnage collected for each sector – single family, multi-family, and business – and arrived at a similar estimation for CBD recycling. A more granular look at how recycling may have changed from year to year is not obtainable with this estimate.

YEAR	DISPOSE TONNAGE	CARDBOARD RECYCLED TONNAGE	ESTIMATED RECYCLED TONNAGE
2012	582.3	30.9	
2013	717.2	42.2	
2014	796.5	83.0	
2015	840.5	55.2	
2016	1,131.9	68.5	
2017	1,163.8	61.3	
2018	878.8	29.5	
2019	945.9	55.5	96

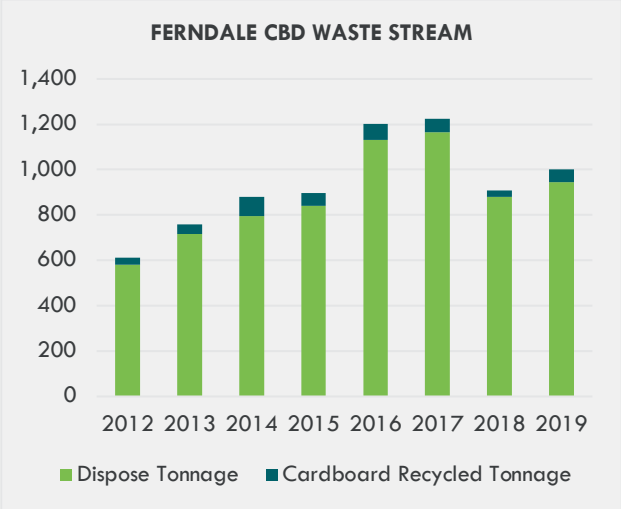


Figure 17 - Total tons of trash, cardboard, and recycling (estimated) hauled from Downtown Ferndale

In total, the RRS Team estimates that approximately 151 tons of recycling was diverted from disposal in 2019 based on data obtained from Car Trucking. According to the 2014 CalRecycle estimate, Ferndale's CBD recycled 158 tons per year, which tracks well with the actual data. Overall this provides for a 14 percent diversion rate for the downtown. Currently Ferndale does not have a robust organics diversion program for downtown businesses, and as such a minimal amount of food waste is diverted from the disposal stream. This contrasts with more established organics diversion for California businesses, as such the estimated organics diversion from the 2014 CalRecycle study (107 tons per year) does not track with actual organics diversion in Ferndale but could be viewed as a potential diversion goal with the development of a organics collection program (approximately a 13 percent capture rate of

food waste for diversion). Finally, RRS has no insight into other recycling that may be going on in Ferndale's CBD such as businesses directly selling cardboard to recyclers or container redemptions.

In sum, the tons per employee per year generation of Ferndale data and the estimates from the 2014 CalRecycle data are comparable.

Table 5 - Comparison of Tons Per Employee Per Year Generation Between Ferndale Data and the 2014 CalRecycle Study

STREAM	FERNDALE DATA - TONS PER EMPLOYEE PER YEAR	2014 CALRECYCLE – TONS PER EMPLOYEE PER YEAR
Disposal	0.90	0.93
Recycling	0.14	0.12
Organics	0	0.10

FATS, OILS, AND GREASES

During the walk-through assessment, grease containers serviced by Mahoney Environmental and Detroit Grease were identified and RRS reached out to those companies for collection data. However, the RRS Team understands that the following additional companies provide downtown restaurants with grease collection services: Alpha Proteins, DAR Pro Solutions, and Kelly's Rendering Service. From our business interviews, we found that one restaurant sends its FOG to a local poultry farm to heat the coops. Detroit Grease maintains two containers ranging from 150-280 gallons, while Mahoney Environmental maintains seven 264-gallon containers in five locations. Ferndale's contract with Detroit Grease is to not only collect yellow grease from containers, but to ensure the grating on the containers remains unclogged to prevent spillage. Since grease spills have been an issue, Ferndale has placed cameras near the containers and fines any business that spills excess grease. More detail on FOG management is in the Best Practices memo from January 2, 2020. RRS has identified regional grease collection providers and mapped those providers main locations in the regional facilities map (see below).

To understand a more complete picture of the CBD FOG waste stream, the RRS Team has estimated FOG generation based on the results from the 1998 Urban Waste Grease Resource Assessment funded by the National Renewable Energy Laboratory. While this study was conducted over 20 years ago, this assessment is still considered to be the most comprehensive assessment of restaurant FOG generation because no other study has researched FOG generation in such depth. The study collected data on yellow and trap grease disposal from restaurants in 30 different metro-regions across the US. Restaurants were found to generate an average of approximately 6,400 pounds of yellow grease per year and approximately 9,000 pounds of trap grease per year. This estimation of yellow grease was substantiated based on the yellow grease collection data from Mahoney Environmental and Detroit Grease, which showed the average restaurant production to be 6,200 lbs. per year. There are an estimated 44 restaurants located within the Central Business District of Ferndale, so that total generation per year in Ferndale's CBD is 340 tons per year of FOG.

Table 6 - Ferndale FOG Estimates

	YELLOW GREASE	TRAP GREASE	TOTAL GREASE
Total Pounds Per Year	283,269	397,222	680,491
Total Tons Per Year	142	199	340

OVERVIEW OF FERNDALE FINANCING OF MATERIALS MANAGEMENT

The City of Ferndale funds its sanitation program from a combination of property tax and special assessments. All residential and commercial parcels pay the property tax. Businesses that choose to use other waste providers do not pay the special assessments. The city is allowed to levy a property tax of up to 3 mills to manage its sanitation programs. Because of the Headlee amendment, the millage is currently reduced to 1.92 mills and brings in approximately $1.2 million per year. The Sanitation Fund budget is approximately $3 million per year and the City uses a special assessment program for commercial and residential property owners to make up the $1.8 million dollar difference. The assessment rates in place and proposed for future years are shown below.

Table 7 - Sanitation Fund Special Assessment Rates

	FYE 2019	FYE 2020	FYE 2021	FYE 2022	FYE 2023
Single Family	166	168	169	171	173
Multi Family	146	147	149	150	152
Commercial	280	283	286	289	292

Revenue Summary

- Property Tax Sanitation millage TY18 = $1,169,102
- Special Assessments TY18 = $1,762,221
    - 9933 parcels in the special assessment budget
- 19 businesses do not pay the special assessment, and all appear to be outside CBD

Expense Summary

- SOCRRA is paid at $80,000 every two weeks to cover:
    - 10093 weekly refuse pick ups
    - 10114 recycling pick ups
    - 9543 compost pick ups
- SOCRRA was paid $2,085,147.53 in FY18-19
- The city spends $1 million in staff, contract services, and equipment rental for leaf collection

Car Trucking submits their expenses to SOCRRA and SOCRRA rebills Ferndale for any “special charges” including landfill compactor collection in the CBD. The special charges for including landfill compactor collection is approximately $60,000 per year.

The DDA captures $479,108 from Tax Increment Financing (TIF) capture.

- $26,403 of the $479,108 is captured from the sanitation millage. These funds are not required to be spent on sanitation as part of DDA TIF capture but may be a revenue source to consider as new programs are developed.

2. REGIONAL FACILITY INFRASTRUCTURE

The RRS Team analyzed regional waste, recycling, and composting infrastructure within 25 and 50 miles of Ferndale. Overall, there is adequate regional capacity to manage disposal and recycling from Ferndale's CBD. However, while there are abundant composting facilities in the region, there are no facilities within 25 miles of Ferndale currently accepting post-consumer food waste. There are three facilities within 50 miles of Ferndale that are accepting post-consumer food waste. Presently, the SOCRRA composting facility does not accept food waste but has indicated the facility could process back-of-house pre-consumer food waste collected from Ferndale's CBD.

Table 8 - Regional Waste, Recycling, and Compost Facilities

	WITHIN 25 MILES OF FERNDALE	WITHIN 50 MILES OF FERNDALE	SOCRRA FACILITIES
Material Recovery Facilities	5	5	MRF in Troy
Transfer Stations	20	21	Waste transfer in Troy and Madison Heights
Landfills	8	13	
Compost Facilities	15+	30+	Compost Facility in Rochester Hills
Compost Facilities Currently Accepting Food Waste	0*	3	
Anaerobic Digesters	2	4	
FOG Facilities	2	2	
EWaste Recyclers	12	14	
HHW Facilities	6	7	

*SOCRRA compost facility does not currently accept food waste but has indicated being able to process back-of-house food waste collected from Ferndale's CBD

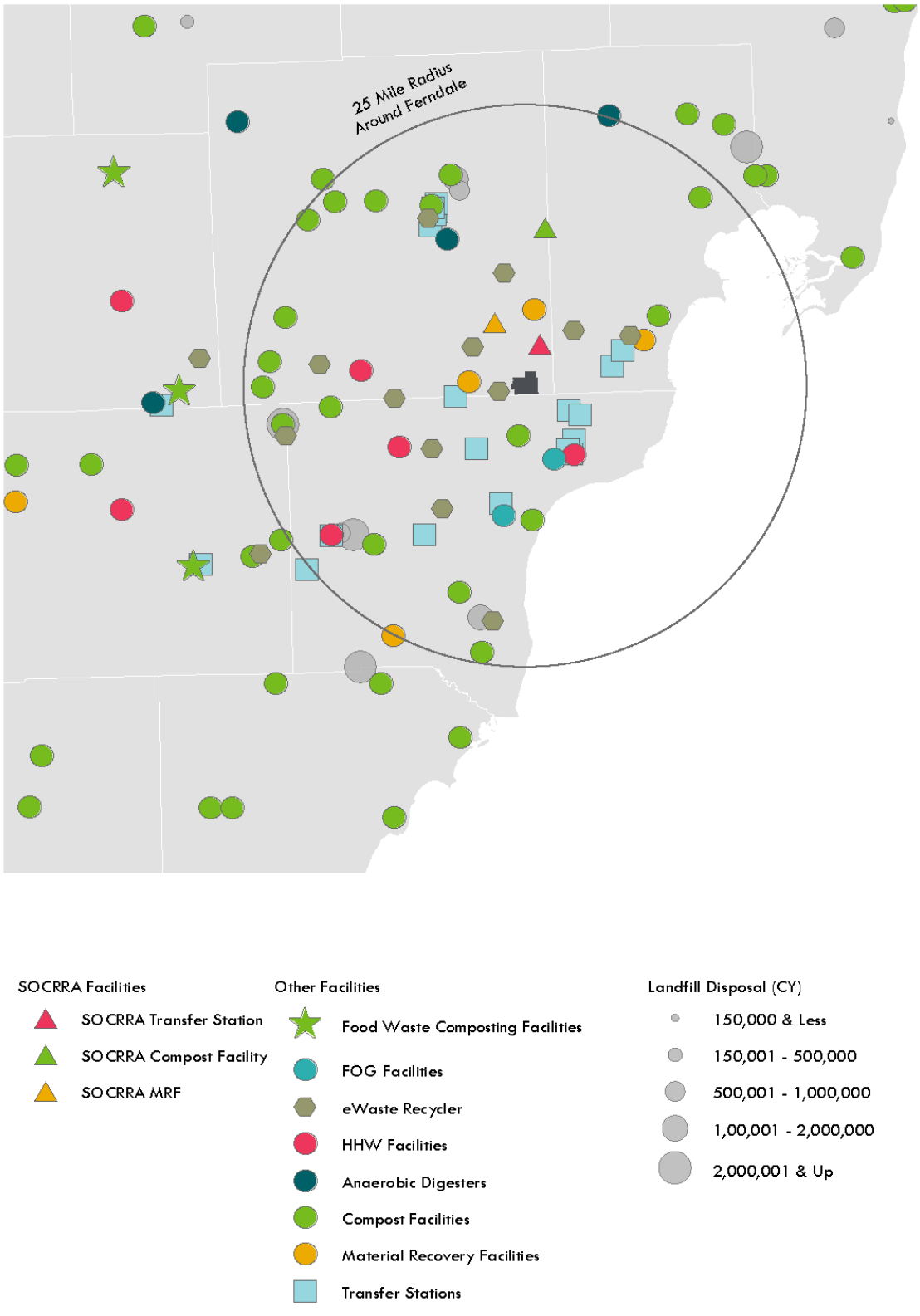


Figure 17 - Map of Regional Facilities

3. CURRENT WASTE PROGRAM STRENGTHS, GAPS AND OPPORTUNITIES

Background and Strengths

The RRS Team has identified six best practices for successful recycling programs. These are:

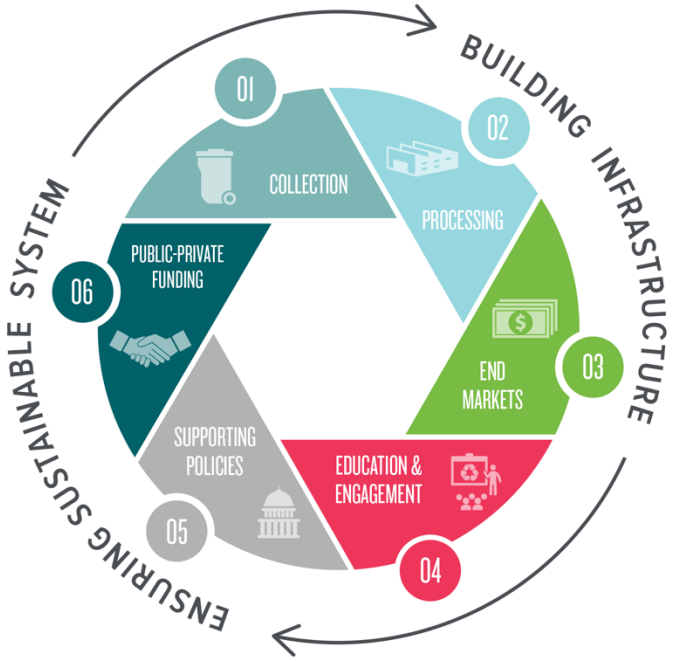


Figure 18 - Best Practices

- Collection
- Processing
- End Markets
- Education and Engagement'
- Supporting Policies
- Public Private Funding

Ferndale has strong elements of many of these areas and is potentially well prepared to improve the current program and leverage new funding from the State of Michigan, South Oakland County Regional Recycling Authority, and partnerships (e.g., The Recycling Partnership). Regional collaboration through SOCRRA provides Ferndale with the scale to reduce costs to residents and leverage opportunities to improve the local programs.

Ferndale's collection program is working well based on business feedback. The RRS Team heard from several businesses that the City is responsive and providing some of the best service seen by long-time building owners. Ferndale's relatively small government helps to improve communication across departments and limit silos. Ferndale's DDA provides an opportunity to leverage the existing engagement with the downtown business community and potentially leverage DDA interest in downtown improvement with capital investments. Current sustainability and DPW staff are responsive to business concerns and have developed a deep understanding of the current system and potential for priority investments to improve the programs.

- **Collection**: Adding collection for organics will help to remove this material from the landfill stream (and future methane generation) and create compost that helps to build better soil. Condensing each collection stream to one hauler allows for better coordination, better data reporting, and fewer vehicles competing for limited downtown collection spaces.
- **Processing:** Ferndale is already part of SOCRRA - a regional authority - and in this current recycling market is in a much better position than communities working on their own to ensure that their recyclable materials are processed and reused.
- **End Markets:** Ferndale could learn more from SOCRRA about the end markets of their recyclables and share this information with the downtown business community.

- **Education and Engagement:** The current education and engagement with the business community is not consistent and none of the following recommendations are likely to be successful without consistent investment in education and engagement.
- **Supportive Policies:** With additional supportive policies, Ferndale can improve the collection of organics and recyclables and reduce contamination in recycling. Ferndale could also set policies that obtain better data from certain haulers that currently operate in the City without any reporting requirements. Better reporting and data will help Ferndale build a stronger program.
- **Public Private Funding:** Ferndale has a stable funding mechanism for the current program and will likely need to identify additional resources to grow the program. With this analysis that provides a new list of businesses, a model of the material streams, and a baseline to measure progress, Ferndale is in a better position to leverage local funds with private and state funding.

The Ferndale Master Plan[1] section on City Services, Facilities, and Infrastructure has identified several goals that align with the RRS Team detailed recommendations that follow. The Ferndale Master Plan goals that are relevant to this set of recommendations include:

- GOAL 2: INCREASE RECYCLING OPTIONS.
  - C2.1 Add recycling to public trash receptacles Downtown, at public facilities, at public events, and in parks.
  - C2.2 Increase business recycling through code requirements and/or incentive programs.
  - C2.3 Create a coalition of communities to work with regional authorities to increase access to recycling.
  - C2.4 Create a drop-off program at the DPW Yard for less common recycling items.
  - C2.5 Create a Zero Waste Event planning guide with a variety of tools and best practices.
- GOAL 5: IMPROVE COMMUNICATION RESOURCES AT CITY HALL.
  - C5.1 Improve communication efforts to residents, businesses, and visitors to promote events, recent achievements, and Ferndale's best assets.
  - C5.2 Improve the user experience of the City's website to be an efficient resource for information, transparency, and basic functions.

This report makes recommendations that support Goals C2.1, C2.2, C2.3, and C2.5. Goal C2.3 is met with participation in SOCRRA and we believe this relationship could be stronger and help to leverage additional state and regional funds. Education and Engagement Recommendations will help to meet Goals C5.1 and C5.2.

[1] https://drive.google.com/file/d/0B9KwUo1cVgfxdm5fRElBTnR3cTg/view

Gaps and Opportunities

The RRS Team identified ten areas of waste management in Ferndale's CBD with gaps and opportunities:

- Data
- Maintenance of Shared Waste Areas
- Education
- Policy and Ordinance
- Funding
- Staffing
- Organics Diversion Program
- Fats, Oils, and Grease Management
- Public Space Collection Bin
- Zero Waste Events
- Construction and Demolition (C&D)

Detail on each area is outlined below. Generally, the first five items identify more general gaps that apply to the entire waste stream. For example, gaps in data apply to all divertible waste streams – recycling, yard waste, organics, and FOG. Rather than call out data as a gap for each waste stream, RRS identified improved data gathering as a key opportunity for waste stream tracking that is needed for Ferndale to set baselines, realistic diversion goals and measure progress. The later five items areas call out gaps and opportunities specific to certain waste streams or activities. Combined, the list of gaps and recommendations is a snapshot to the materials management system in Ferndale's CBD as it stands now and provides direction to improve and streamline material collections moving forward.

DATA

The Gap: Currently, Ferndale's downtown businesses separate their waste into four streams. Landfill goes into the trash compactors in four central collection areas, cardboard goes into dumpsters, single stream recycling goes into 64-gallon carts, and FOG is collected in central collection containers. Car Trucking collects compactors, dumpsters, and carts weekly and tracks disposed tons from Ferndale's CBD at least on a monthly basis and reports these data to SOCRRA. The RRS Team was able to easily obtain a well-organized spreadsheet of disposal data broken down by month going back to 2012. Additionally, Car Trucking tracks tons of cardboard collected from Ferndale's CBD on a weekly basis also going back to at least 2012. However, the Ferndale cardboard collection route includes one stop in Clawson so that the reported tonnage is not exclusive to Ferndale's CBD. As a result, the RRS Team used a volume to weight estimate to establish the proportion of reported recycled cardboard tons that could be attributed to Ferndale CBD alone. Finally, the single stream recycling collected via 64-gallon carts by Car Trucking is on concurrent routes with residential collections. Due to the combination of residential and business recycling routes, the RRS Team could not obtain specific data on recycling for Ferndale's CBD. To estimate single stream recycling from Ferndale's CBD, the RRS Team used a volume to weight estimate similar to the cardboard estimate. More detail is available in the Waste Characterization memo.

The Opportunity: The Ferndale Sustainability Team could work to collect CBD specific recycling data and conduct regular recycle sorts and capture rate studies. Recycling sorts measure prevalent contaminants in the recycle stream, providing important information for targeted education campaigns to reduce unwanted items in the stream. Capture rate measures the proportion of a specific recyclable item such as aluminum cans, cardboard, water bottles, etc. in the recycling stream as opposed to the disposal stream measuring the effectiveness of the recycling program by material type. Regularly tracking data on disposal and recycling in Ferndale's CBD would provide a baseline for

current activities and a grounding point for any future diversion goals. SOCRRA may be able to assist with obtaining estimates from CAR Trucking on recycling volumes in the CBD.

BUSINESS SPECIFIC DATA

The Gap: Individual business use of the waste collection areas is not tracked. Two of the waste collection areas are enclosed requiring input of a code into a keypad to gain entry, however all businesses using those waste collection areas are provided with the same code. The remaining two waste collection areas are not enclosed so that anyone has access to the disposal and recycling areas.

The Opportunity: Obtaining more business specific data, tracking disposal and diversion activities and potential contamination issues, would allow Ferndale to tailor education to meet their businesses needs and reward businesses working hard to reduce waste and divert more. Enclosing all central locations and providing unique entry codes (or fobs) to businesses would improve data collection and help identify staff needing training. Greater monitoring of the collection areas would also help Ferndale address contamination and illegal dumping issues at a per business level as needed. Covering these enclosures with Green or solar roofs would reduce illegal dumping and trash tossed in the areas. Business level data begins to provide Ferndale with the granular level data needed to create incentives for moving materials from landfill to recycling and organic streams.

SHARED COLLECTION AREAS

The Gap: The City of Ferndale currently owns four compactors that are shared among businesses within the central business district, which are serviced two times per week by Car Trucking. The compactors, manufactured by Contract Welding, are in both enclosed areas and unenclosed areas and have key code access for use. The enclosures are not kept locked and the key code is the same for all compactors and users, so maintenance of the area and tracking of data is challenging for the City. These compactors are old and in need of replacement. The city has expressed an interest in moving to a lease program to manage compactors. Businesses and building tenants have expressed concern with the proximity of compactors to businesses. Further, businesses have cited issues with odors from the compactors (especially during summer), trash being set next to the container, the compactors impeding alleys and being a general eyesore, pest issues, and garbage liquids leaking into sewer drains[2]. Businesses have also expressed concerns about the shared compactors, dumpsters and recycling carts filling up over the weekend while there is no collection service.

The Opportunity: Design four enclosed areas – the DOT and three new enclosures to contain all waste streams. Moving to four enclosed areas with compactors and sensor technology to monitor which businesses are using the collection areas and refuse and single stream compactors would improve the look of the areas, reduce liquids leaking from the areas, and begin to provide granular data on business use of the systems. With more granular data, Ferndale can design a pricing structure that creates incentives for reducing landfill materials and increase recycling and organics collection. There is an opportunity to rethink the location of some of these collection sites. A combination of a new staff position, a clear alleys program and alley captain program, along with installation of monitoring technology has the potential to provide incentives for businesses to keep shared waste areas clean and divert more material from disposal.

[2] RRS understands that Ferndale sewers are part of a combined sewer system. These sewers flow to a central treatment facility and can overflow to rivers during heavy rains. Business education may support the regions stormwater permit goals to reduce illicit discharges into the system.

EDUCATION

The Gap: Ferndale does not have a consistent business outreach campaign about waste, recycling, FOG, and composting. Education regarding the waste areas is provided ad hoc to businesses when they initially move into the CBD, and information regarding diversion opportunities and benefits is not continually provided. With business turn over and the need for reminders, education cannot be one and done but rather needs to be conducted regularly.

The Opportunity: Ferndale has a blank slate to create a unified education campaign for downtown businesses. Once developed, this education campaign could be deployed to other Ferndale businesses located outside the downtown area and potentially across other SOCRRA communities by neighboring governments. Developing and maintaining a Green Business Certification program would allow Ferndale to stay in closer touch with businesses and their employees to meet their training needs and better monitor changing materials management needs in the community. The scope of the recommended Green Business Program is broader than just waste management and would likely reduce the cost of doing business in Ferndale by reducing business energy waste and water use. There may be an opportunity to partner with the Oakland County stormwater program to get education credit for the region's MS4 permit.

POLICY AND ORDINANCE

The Gap: Ferndale does not have any ordinances in place to encourage or require Ferndale businesses to reduce waste generation, divert waste from the landfill, or engage in sustainable purchasing programs. There are no requirements for new buildings to plan for managing waste within the property footprint. Businesses that are invested in sustainability are taking some initiative, but these efforts are voluntary, not widely shared across the business community, and unlikely to scale independently. Additionally, businesses engaging in diversion activities do not reap any financial or public perception benefit from reduced disposal and improved diversion. When businesses have no financial benefit or regulatory encouragement to divert waste from the landfill, the challenges of day to day operations may lead business owners to be content if the waste simply goes away. Businesses have reported a desire for additional recycling, viewing the City of Ferndale as an excellent environment to push for increased recycling and waste reduction. However, a lack of weekend collection has been reported as an issue for businesses and tenants within the CBD generate higher volumes of recycling during their weekend operations. This requires many recycling carts to be made available to ensure businesses have the capacity and space to store materials.

The Opportunity: The City of Ferndale could develop new policies and ordinances to help drive waste diversion and obtain business level data that support incentives for diversion activities. These data can also quantify cost saving opportunities for businesses. By doing this, Ferndale's CBD could become a model for recycling and compost activities in a downtown area. Ordinances and single hauler franchises are often used in the highest performing programs improve data collection, reduce collection vehicle traffic, to demonstrate the community commitment to successful diversion. These are most effective when coupled with strong local government support via education, business recognition, and financial incentives.

FUNDING

The Gap: The City of Ferndale Sanitation millage currently funds 40 percent of the community costs for refuse, recycling, and yard waste collection and disposal. The City uses special assessments to fund the difference between the total program costs and the millage funds (60 percent). Several businesses contract waste collection from a hauler other than Car Trucking and they do not pay the special assessment[3]. There is no ordinance requiring one hauler over another.

[3] Approximately 19 based on conversations with Finance staff

The property tax millage is a little less than two mills because of Headlee rollbacks and could be as high as three mils under statute. Currently the millage generates approximately $1.2 million. The City uses a special assessment formula to make up the difference between the Sanitation Fund program budget and the funds generated through the millage. Special assessments can be applied to properties that do not pay property tax (e.g., schools, churches) and share costs with all service users. The costs for business service and residential, institutional, and multi-family services are not disaggregated under the current funding system.

The Opportunity: The City could establish a rate structure with businesses that improve cost allocation across service users based on how they use the system and provide financial and other incentives to reduce waste disposal and increase diversion. The business list and waste model created as part of this project allows the City to estimate waste production and allocate special assessments based on how businesses use the system. New funding for staff and education could be shared across CBD businesses or shared across all city properties recognizing that all residents benefit from a well-managed downtown business area[4].

STAFFING

The Gap: Ferndale does not have a staff person dedicated to monitoring the waste collection areas or connecting with businesses using those areas. Without a specific role, committing time to ensuring waste collection areas are being utilized appropriately is challenging for staff balancing other roles and commitments, and as a result diversion programs in the CBD to take a back seat to other pressing needs.

The Opportunity: A new position could be created within the City organization (e.g., Sustainability, DPW, DDA) to fulfill the role of managing the program progress using data and metrics and developing new programs as grant opportunities and other funding becomes available. By creating a new position, the City has the blank slate to draft a forward-looking job description to address downtown sustainability that anticipates future growth and materials management needs in the downtown. This position could also manage a Green Business Challenge program, help with business employee education, coordinate with SOCRRA, and assist with Zero Waste Event coordination.

ORGANICS DIVERSION PROGRAM

The Gap: The City of Ferndale does not currently have a coordinated food waste compost collection program for businesses but has explored options to begin organics collection (food prep waste and post-consumer food waste) and processing using anaerobic digestion. SOCRRA currently accepts yard clippings and vegetative waste (garden or kitchen vegetative waste), but not the full range of commercial organics (post-consumer food waste) that is typically collected from restaurants. During interviews and discussions with the City, businesses within the Central Business District (CBD) and Downtown Development Authority (DDA) have expressed interest in organics collection. Some businesses have elected to contract with private haulers for food waste collection on a year-round basis, as expressed during the business interviews (Greenspace Café used Midtown Compost to collect their food waste weekly for a $45/month fee). Other businesses may be managing their food waste, but information on costs and diversion for other businesses participating in the private open market is not currently available to the City. There is no organized organics diversion program for businesses in the downtown. A business wanting to divert food scraps would have to setup a collection program themselves and would not realize any potential cost savings from decreased disposal.

The Opportunity: Organics was identified as a major waste stream for Ferndale's CBD, accounting for approximately 40 percent of all waste generated. Additionally, organics tend to be heavy containing a lot of water such that their

[4] The DDA TIF captures some of the Sanitation millage funds – estimated at $30,000/yr.

disposal makes up a significant portion of tons hauled to landfill. Any robust diversion program is going to need to address organic waste to reduce both wasted food (food that could have been consumed) and divert food waste such as vegetables peels from disposal. Diverting food waste from landfill is also a key component to reducing GHG emissions.

FATS, OILS, AND GREASE MANAGEMENT

The Gap: The vast majority of restaurants and eating establishments generate fats, oils, and greases. FOG are broken into two categories, yellow or brown grease. Yellow grease consists of high value cooking oils while brown grease is 90 percent water and is captured using grease traps or interceptors, routinely pumped using a vacuum truck and then generally disposed of. All FOG requires proper disposal and should be kept out of the sewage system. The City of Ferndale does not currently have a formal system in place for the management of FOG. Issues include lack of usage data, an inability to monitor whether participating restaurants are following regulations, and a lack of information on fee structure, organization structure, and any existing contractual relationships. Further, restaurants have expressed displeasure with the current FOG collection system, citing issues with pests and methods used for transporting FOG to the alley collection containers. During the walk-through assessment, grease containers serviced by Mahoney Environmental and Detroit Grease were identified and RRS reached out to those companies for collection data. However, the RRS Team understands that the following additional companies provide downtown restaurants with grease collection services: Alpha Proteins, DAR Pro Solutions, and Kelly's Rendering Service. From our business interview, we found that one bar/restaurant sends its FOG to a local poultry farm to heat the coops. Detroit Grease maintains 2 containers ranging from 150-280 gallons, while Mahoney Environmental maintains 7 264-gallon containers in 5 locations. Ferndale's contract with Detroit Grease is to not only collect yellow grease from containers, but to ensure the grating on the containers remains unclogged to prevent spillage. Since grease spills have been an issue, Ferndale has placed cameras near the containers and fines any business that spills excess grease.

The Opportunity: A formalized system such as a franchised collection company for Ferndale's downtown has the potential to reduce costs, improve service, and provide continuity in data collection for better understanding of grease generation in Ferndale's restaurants. A franchise could generate revenue for the City as well.

PUBLIC SPACE COLLECTION BINS

The Gap: The City of Ferndale currently has seven public locations in the DDA area parking lots with paired Big Belly units for trash and recycling. One pair is a high capacity/compacting, solar unit and the other six pairs are standard (non-compacting) bins. City of Ferndale DPW Sanitation staff manages the collection of material from Big Belly's as needed. The lease payment for the units is split between the parking and sanitation funds and the pilot program has two more years remaining. The cost to lease the units from the vendor is significant and the $/ton has yet to be calculated to determine the diversion and cost impacts of the units. Car Trucking picks up sidewalk bins (@60) once a week and the DDA is responsible for managing the bins the rest of the week. The DDA contracts with the City DPW to collect waste and very limited recycling with a pickup truck as needed. The overall program for public space bins does not target recycling to its maximum potential. The RRS Team has heard that some small businesses use the public containers for office waste. The RRS Team does not have any information on quantities of waste managed in the public containers.

The Opportunity: There is an opportunity for Ferndale to purchase new waste and recycling bins for the public spaces. Coordination with DPW, SOCRRA and CAR Trucking staff on design is important to ensure efficient collection. A before and after survey of businesses and public space users could help in identifying measurable improvements. SOCRRA has offered to discuss cost sharing with the City for new public waste and recycling containers for the Ferndale downtown. This investment could be shared by the DDA as well as a downtown infrastructure investment.

Ferndale should explore opportunities to leverage container design to educate residents on broader community sustainability efforts.

ZERO WASTE EVENTS

The Gap: The City of Ferndale does not have a Zero Waste event program. Car Trucking can provide trash and recycling roll-offs as well as cleanup efforts, but often the roll-offs are too contaminated for SOCRRA to accept as recycling. Event planners sometimes use the shared downtown containers. If Car Trucking or other City-approved contractor is involved, the City director of special events would have access to the details of costs and volumes from the invoice sent to the City.

The Opportunity: Zero Waste events are an opportunity for recycling and other staff to interact directly with residents, visitors, and business leaders and provide recycling and composting education to the community. Zero Waste events also require more upfront planning, coordination, and often staffing by paid and volunteer staff. Once the event is over, metrics on waste disposed and diverted can be shared with the community to highlight the community commitment to recycling and composting programs. These events become much easier over time as organizers and vendors understand requirements. A new downtown sustainability staff person could help to coordinate these events and provide SOCRRA with a central point person at the City. Better coordination will likely result in Ferndale taking advantage of what SOCRRA has to offer and to improve communication, grant, and partnership opportunities.

CONSTRUCTION & DEMOLITION

The Gap: Construction and demolition waste generated from building-related projects is not currently an element of the City's materials management system. While discussions with staff suggest that there is limited new development in the downtown, it is likely that a significant amount of C&D waste is hidden – generated as businesses move in and out of existing spaces and new buildouts occur. It is unlikely that much of this waste is measured in the current system. C&D waste typically is collected and either recycled or disposed of by private haulers through open market arrangements between haulers and property owners or construction contractors. The City currently does not require construction contractors to track waste during construction projects and the City does not accept C&D materials in commercial containers or compactors[5]. It is not clear how well this is enforced. The only current downtown project focused on C&D is the DOT, where the City and the construction contractor are working towards a certification (ParkSmart) specific for parking structures. The City does have an ordinance that provides height incentives for certain sustainability measures. Any building 70 feet tall or greater must be LEED certified, which can provide points for managing C&D wastes.

The Opportunity: There is significant opportunity to reduce and recycle C&D waste, substantially contributing to Ferndale's diversion rates. Many communities have begun to manage C&D waste under voluntary incentive or ordinance requirements. The scale of Ferndale makes it unlikely that a coordinated demolition and salvage operation could be supported by Ferndale alone, however there is an opportunity to use regulation and incentives to support material recovery programs in the SE Michigan region.

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[5] "The city shall collect and dispose of all solid waste, ashes, bulk refuse, garbage, combustible and noncombustible refuse, rubbish, yard waste, yard waste compost, recyclables, except builder's or contractor's refuse, production or processing refuse, when properly prepared and placed for collection according to the regulations of this chapter and those promulgated pursuant thereto." Ferndale City Code Section 10-2

Table 9 - Summary of Gaps

SUMMARY OF GAPS	
Data	CBD Diversion data and business level recycling and organics data are not available
Shared Collection Areas	Lack of enclosures for all material streams; limited monitoring of waste collection areas; business concerns about odor and overflow
Education	Lack of unified education campaign
Policy and Ordinance	No set of policies or ordinances in place to encourage or require waste diversion activities for CBD
Funding	No financial incentive to reduce landfill materials and increase diversion; Businesses do not pay for waste services based on quantity of waste disposed
Staffing	Current staff do not have time dedicated to waste diversion in the CBD
Goals Targets and Metrics	No explicit targets for waste diversion
Organics Diversion Program	Organics collection is not available for businesses in CBD
FOG Management	Informally organized FOG collection resulting in collection inefficiencies
Public Space Collection Bin	Limited public bin recycling
Zero Waste Events	Zero waste events are not encouraged or required by the City in downtown
Construction and Demolition	No requirement that C&D waste streams are managed, measured, reused or recycled

4. WASTE REDUCTION AND RECYCLING PLAN RECOMMENDATIONS

The RRS Team worked with Ferndale's Sustainability Team to identify priority recommendations and estimate a rough timeline for recommendations to address gaps and opportunities outlined above. Specific new budget allocations, cost partnerships, and grant opportunities may allow Ferndale to shift this timeline. These recommendations are organized into five core areas: Metrics; Infrastructure; Staff; Policies and Ordinances; and Funding and Incentives.

- Set Metrics for Success
- Infrastructure Investments
    - Four Enclosed Collection Areas
    - New Disposal Compactors – with Sensors
    - New Combined Single-Stream Recycling Compactors
    - Public Containers with Recycling
- Dedicated Staff Person
    - Education and Green Business Challenge Program
- New Policies & Ordinances
    - Organics Waste Pilot with SOCRRA/Other Partner
- New Funding & Incentives

Table 10 - Draft Implementation Matrix

	NEAR-TERM YEAR 1	MID-TERM YEAR 2	LONG-TERM YEAR 3-5
High Priority	**Funding-Staffing-Education** Metrics, Goals, and Baselines Enclosures and Compactors FOG Franchise New Ordinance Development Alley Captains	**Funding-Staffing-Education** Pilot Organics Mandatory Recycling Mandatory Organics Public Space Receptacles Green Business Program	**Funding-Staffing-Education** C&D Ordinance and Diversion Program Review
Medium Priority	Pilot Organics Green Business Program	Zero Waste Events C&D Ordinance and Diversion Waste Sort	
Low Priority	Public Space Receptacles		

Near Term - Year 1

FUNDING – STAFFING – EDUCATION

To allow any of the plan recommendations to work well, it needs to be someone's job to manage the Green Business Challenges and education program, monitor collection performance and progress, explore grants and other fund leveraging opportunities, and coordinate with SOCRRA and other partners. Monitoring centralized waste areas for cleanliness, addressing contamination, and encouraging participation in a diversion program requires time and a dedicated staff person who can focus on these tasks. A new staff position could be created to:

- Monitor collection spaces and concern tracking – See Click Fix;
- Educate and train business and employees;
- Manage Green Business Challenge program;
- Maintain list of CBD businesses for communication and ensure that businesses are up to date with staff education and training;
- Maintain regular contact with businesses to track progress and identify challenges;
- Assist with Zero Waste Events – Concierge;
- Track data and monitor performance;
- Act as Liaison with DDA and SOCRRA;
- Review new site plans and assess impact of new businesses and downtown growth on material management infrastructure;
- Develop new programs;
- Cross train (and potential co-funding) downtown employees on waste management and stormwater, energy waste, and emergency management;
- Monitor FOG management and grease trap maintenance; and
- Evaluate dumpster and container right sizing issues and optimize collection frequency.

EDUCATION CAMPAIGN

Education is the bedrock of any successful diversion program. While education can feel less critical than infrastructure, even programs with the best laid infrastructure will not thrive without a well thought out education effort. A successful education campaign involves four key elements:

Table 11 - Education Campaign Elements

EDUCATION CAMPAIGN STEPS	STEP EXPLANATION	CARDBOARD RECYCLING EDUCATION CAMPAIGN EXAMPLE
Research	Define goals, target audience, success metrics, and plan how success metrics will be measured.	By breaking down boxes before placing into recycling dumpster, it is anticipated that less cardboard would be placed in the trash compactors because the recycling dumpsters would overflow less. Success metrics could be a measure of cardboard recycling tonnage and visual monitoring of state of boxes in recycling dumpsters.
Planning	How will message be delivered on multiple platforms? Need to weight the cost and reach of different outreach efforts.	How do businesses get key information from the City currently? Are businesses active on social media platforms and if so which ones?
Implementation	Conduct outreach via media, social media, mailings, events, direct engagement with businesses.	Perform outreach campaign to businesses focusing on the breakdown of cardboard boxes.
Evaluation	Was the message successful? Track metrics of intended results.	Are visual inspectors finding cardboard boxes more broken down in dumpsters? Did breaking down boxes more and thus preventing overflow result in more tons of cardboard recycling?

Green Business Challenge[6]

The Green Business Challenge (GBC) is a customizable national model that local governments can use to engage local businesses and commercial property managers in a fun and friendly competition to save money, energy, water, and waste, improving their business's environmental performance. This innovative program in turn helps local governments reach their energy and climate goals.

The GBC arose from a growing need for methods and practical tools that allow local government to engage the business community in climate protection and sustainability. For mutual benefit, businesses want to be recognized socially and environmentally in a positive light and have more economic and regulatory incentives to reduce their carbon footprint. It is about businesses being responsible and responsive to the local community's priorities and about the community providing businesses with opportunities for recognition for their positive actions.

The City should explore developing a tailored program for the Ferndale CBD that supports a broad set of sustainability goals and supports lower costs for doing business in Ferndale through energy waste reduction and reduced water use. Austin, Texas has been running this program for eight years.

[6] ICLEI - https://icleiusa.org/programs/city-business/green-biz/



Figure 18 - Austin Green Business Leaders Program

METRICS, GOALS, AND BASELINES

Working with the Sustainability Commission and City Council, Ferndale should explore setting near term goals that align with the 40 percent diversion goal that the Strong program recommendation is expected to achieve. Ferndale should work with SOCRRA and Car Trucking to identify ways of collecting data on recycling tonnage specific to Ferndale's CBD. If direct data cannot be obtained, organize an agreed upon estimation method to regularly track diversion activities. Our understanding is that Car Trucking provides estimates in other communities. In addition to tonnage data, consider implementing regular recycle sorts and capture rate studies to identify common contaminants and assess where recyclables are ending up in the waste stream. The education program can reinforce common contaminants and improve contamination rates. The hands-on studies could be conducted seasonally or yearly. Waste sorts are often opportunities to engage local non-profits and schools for volunteers and expand the community awareness of recycling program challenges. Downtown employees should be offered the opportunity to participate as part of the Green Business Challenge program.

ENCLOSURES AND COMPACTORS

Changes to the centralized collection areas are near term high priority because they are a very visible part of the system and a foundation step towards gathering baseline data to improve diversion programs. Some of the top recommendation changes include:

- **Shared Compactor and Recycling Systems**
  - Each compactor and (set of recycling carts) are behind closed enclosures and each business has their own card swipe/key code to enter the enclosure and access the compactor hopper
  - Accessible 24 hours a day, 7 days a week
  - Compology is a camera system put into the compactor and dumpsters that uses Artificial Intelligence (AI) to identify contaminants and send an alert when the compactor needs to be emptied
  - Pricing options: Based on square footage of building or on generation volume to share total cost; all charged a minimum fee; food service businesses generate more waste per square foot so are charged more per square foot than the office buildings.
- **Alley Captain Program** – For central business district commercial customers, they receive a credit on their waste bill if they volunteer as an Alley Captain and monitor the area and help clean up waste outside the containers and report any issues to the City.
- **Clear Alleys Program** – Bans public storage of all containers in public right-of-way for designated business district and provide daily trash collection.

- **Staff Monitors** – staff monitor trash compactor services to reduce current issues of overfilling, vermin, and odors. The City can work with the compactor supplier, Contract Welding, to install a monitoring system in the compactors that would notify the hauler that the compactor is almost (typically 75-80 percent full) and requires a pickup. The compactor fee structure is currently based on pickups and any reduction in pickups saves the City money. Recycling containers are free to use to incent recycling and/or support the mandatory recycling ordinance. For shared areas that show a projected volume of commercial cardboard that justify a compactor, the City could replace recycling carts with a cardboard and single stream recycling compactor using the same type of card-access as the trash compactors. This is more common for private commercial or multi-family developments, but SOCRRA is supportive of a pilot program with the City and Car Trucking. The compactor would need to be inside an enclosed area and only accessible to approved users.

Ferndale should develop a plan to fund three new enclosures on public land that are close enough to businesses for ease of use, far enough to reduce any occasional odor issues, and allow for easy access by collection vehicles. In the short term, the City could pilot one new enclosure and compactor set. These enclosures will hide the collection containers and may include artistic elements. Enclosures could be located with curb cuts to allow access from the street as opposed to the parking lot areas. Enclosed collection areas should have sensor technology where key fobs – unique to each business are required to open each enclosure. This will allow the City to monitor how each business uses each enclosure and could be the basis for a tiered rate structure. Examples are illustrated in Figures 19-23.

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Figure 19 - Roanoke, VA Enclosure



Figure 20- Enclosure Example



Figure 22- Green Wall Example



Figure 21



Figure 23 - Public Art Example

Ferndale should explore the model used by Roanoke, Virginia where specialized sealed compactors are leased and placed within each enclosed area. The same unique key fob is used to open each compactor and carts are mechanically emptied into the compactor. These compactors are specially made for Roanoke with a lift arm attachment to ease loading. Based on conversations with SOCRRA, Ferndale should explore both landfill and single stream recycling compactors. This could reduce the overall space for collection containers and reduce the frequency of pickups. Sensor technology that identifies when the compactors are ready for collection will reduce special charges over time, especially when more recyclable material is placed in the recycling containers instead of landfill containers, and provide granular data of business use for planning and rate setting.



Figure 24 - Roanoke, Virginia compactor

FOG FRANCHISE

Ferndale has contracts with two vendors to collect FOG. This review identified other vendors working in the downtown who do not appear to have any contractual relationship with the City. Ferndale should put out an request for proposals (RFP) seeking one vendor to collect all FOG in the City and manage the cleanliness and management of the collection areas. The city may need to develop an ordinance supporting the FOG and any other franchise agreements. A franchise has several benefits including reduced collection vehicle traffic, clear contractual relationships with vendors using the City right-of-way, data reporting to the City, reporting to the City on end markets for the materials, and potentially a revenue stream.

NEW POLICY AND ORDINANCE DEVELOPMENT

Many cities with high diversion rates use policies and ordinances to support community goals. The policies create incentives and/or ordinances require that:

- New construction manages all waste streams on site;
- All properties separate recyclables from the landfill stream; and
- All properties (or certain businesses) separate organics from the landfill stream.

Recycling Ordinance

Require all commercial and larger multi-family properties to have recycling service. Additionally, Ferndale may want to require restaurants and bars to subscribe to Saturday or Sunday collection service[7]. Key components to a successful recycling ordinance:

- Access must be adequate and convenient;
- Recycling must be collocated with trash;
- Minimum number of items must be included in recycling program, for example paper, plastic bottles and tubs, aluminum cans, paper cups, steel cans, cardboard, and glass bottles and jars;
- All containers must be appropriately and clearly labeled to distinguish trash and recycling;
- Hauler contracted to collect recyclables does not commingle recyclables with the disposal stream at point of collection;
- Education material is provided to employees and tenants on how to separate recyclables from trash at least on a yearly basis; and
- Businesses required to report on recycling plan annually.

Implementation could cover all properties or could be phased in over time based on type of business, square feet of establishment and number of dwelling units for multi-family properties to allow for businesses to and property managers to prepare for new program. A Green Business Challenge program with education and recognition would support this ordinance.

FOG Ordinance

A FOG ordinance requires registration and reporting by all FOG haulers and all businesses to insure the proper recycling of fats/oils/greases in the downtown business area and commercial sector throughout the City[8]. This may also provide co-benefits by reducing illicit discharges to storm and sanitary sewers. Oakland County requires

7 Austin, TX; Raleigh, NC; Ann Arbor, MI - from interview with Ann Arbor Resource Recovery Manager
8 Considered by Ann Arbor, MI - from interview with Ann Arbor Resource Recovery Manager

restaurants to install and maintain grease traps or interceptors and have a management plan in place to prevent FOG discharge. The FOG ordinance can also allow for a single-hauler franchise agreement.

A franchised FOG hauler agreement maintained by the City or SOCRRA will allow the City to have one service provider in the City and to track users, cost and diversion. It is anticipated that the City would pass an ordinance acknowledging that the City may use one hauler for FOG management. Based on the RFP responses, the City may share in the revenue generated by the hauler or may charge a fee to users to cover the cost of service, container maintenance and contract management. Fees could be developed based on the number of employees or flat fee to users to share total cost. Consolidating services to one provider typically reduces overall costs to all users. SOCRRA has indicated their willingness to help Ferndale pursue franchised FOG collection. Pursuing this would require drafting an RFP for collection, reviewing responding vendors proposals, and engaging in contract negotiations. Enforcement could be part of a new staff position.

FUNDING

Based on our exploration of other community best practices and current funding streams, Ferndale should explore the following funding opportunities:

- Reduce Expenses
  - Reduce Special Charges from compactor waste pickups
    - Sensor technology to only collect containers when they are full
    - Reduced waste collection due to more materials entering the recycling and organics collection streams
- Increase Revenue
  - Tiered Approach based on business type and/or granular data from enclosure and compactor use
  - Explore special assessment based on business waste generation that creates an incentive to reduce waste
  - Explore increasing Sanitation millage from 1.92 to 3 mils
  - Explore opportunities to leverage DDA operating millage (1.3072)
  - Explore Business Improvement Zone
- Leverage Partnerships
  - Explore DDA support for CBD infrastructure improvements - collection area improvements, compactor equipment, street containers
    - DDA TIF captures $30,000 from Sanitation millage
  - SOCRRA/EGLE grant partnerships

An increase in special assessment revenue could be used to fund expanded or added services.

Grants are increasingly available through the Michigan Department of Environment, Great Lakes, and Energy[9] for implementing zero waste event guides, purchasing public space trash/recycling bins or shared downtown containers, organics collection pilot containers, and providing educational outreach campaigns.

[9] https://www.michigan.gov/egle/0,9429,7-135-70153_69695_76895---,00.html

Mid-Term Year Two

Based on progress in Year One, Ferndale should continue to expand on waste reduction incentives through the Green Business Recognition Program and explore green purchasing programs for businesses to create collective opportunities for businesses to purchase materials that support the City diversion goals. For example, take-out containers that can be recycled or composted.

WASTE REDUCTION INCENTIVES

Overall the commercial sector in Ferndale generates on average 5.7 pounds per employee per day. Reducing this generation even by a small amount can have a big impact on disposal. Incentives to reduce waste should focus first on reducing the use of common hard to recycle items such as Expanded Polystyrene (ESP) and plastic bags because these items often end up going to landfill or worse blowing around in our environment. Businesses can be incentivized to participate in waste reduction and diversion activities through recognition programs that help their customers identify participating organizations. Below are outlined some approaches to encouraging businesses to reduce waste.

- Green Business Challenge/ Zero Waste Business Award Program – businesses participate in program by submitting diversion rate data to City. Top performing businesses are provided recognition, including award/stickers to post in storefront and online recognition, trash service fee reduction/discounts.
- Environmentally Preferable Purchasing (EPP) Policy to strongly demote the use of EPS – EPP policy promotes the procurement of "reusable, compostable, and recyclable" foodservice ware and office supplies in county offices. Purchasing departments were provided education on the program and county purchasing websites highlight/promote items that are reusable, compostable, and recyclable and demotes items such as EPS foodservice ware.

High diversion rates are possible by incentivizing waste reduction programs including:

- The DDA may be interested in exploring Business Improvement Zone (BIZ) options available to Michigan cities to supplement downtown services[10] that is similar to the Clean Community Fee in Austin.
- Fees assessed by the City, allocating costs among all users that considers business type and service need (e.g., a restaurant will be charged a proportionally larger share of costs compared to a professional office).
- Explore voluntary or mandatory recyclable or compostable take-out containers including group purchasing of containers to save costs across businesses.
- Businesses who participate in the Green Business Challenge program could be eligible to participate in a Zero Waste Award Program (with the potential to receive reduced trash service fees). SOCRRA is interested in supporting a Zero Waste Award Program, maybe to pilot in Ferndale and roll out to other communities if successful and can partner with the City to provide educational materials. However, City staff will need to be the primary educator and contact with the businesses.

ORGANICS PILOT

Forty-six percent of the employees in Ferndale's CBD work at restaurants, and nearly half of the 10.5 pounds per employee per day of waste generated is anticipated to be food waste. There is a lot of potential to reduce disposed tons by capturing the organic stream for composting. A new organics program would require behavioral changes for businesses. Before implementing a large-scale organics collection program or requirement, launching a smaller pilot to some interested businesses could help the City understand key components to making the program successful. For example, what types and capacity of collection containers are easiest for employees to manage in a busy restaurant environment? Things to consider in an organics pilot include:

[10] https://www.michiganbusiness.org/4ada83/globalassets/documents/reports/fact-sheets/businessimprovementdistrict.pdf

- Type and size of collection containers both within the restaurants for outside for collection
- Whether compostable liners will be utilized in the program
- Frequency of collection
- How to manage concern of rodents
- Space constraints encountered by businesses and ways to overcome these constraints
- How program could be funded and whether the program would be subsidized at all

PUBLIC WASTE RECEPTACLES

Public on-the-go diversion is challenging anywhere. Contamination is always an issue where non-residents and onetime visitors may be passing through and utilizing public waste receptables. Also, people will only look at which bin to place their item in for a few fleeting seconds before deciding. No public space recycling program will be perfect, however there are clear ways to reduce contamination and improve efficiency. Any trash bins should be paired with a recycling bin with clear signage and collection of the waste and recycling done by a single entity for increased oversight and tracking. The City could take advantage of the EGLE organics infrastructure grant (requires a 20 percent match) to cover the cost of new public space paired bins, possibly through a partnership with SOCRRA – several years ago, SOCRRA offered to cover half of the cost of public space bins to their community members.

- Big Belly trash (compacter)/recycling paired system – the units are located throughout the downtown with the high capacity/solar compacting trash bins to reduce the collection frequency; the units provide room for posters/messaging on all four sides.
- Paired-Bin Public Space Collection – paired refuse, recycling, and organic materials are positioned in various downtown locations for public use. Similar to the Big Belly containers, space on the paired bin system can be utilized for educational or marketing materials.



Figure 24 - Example Public Space Receptacles

Long Term 3 to 5 Years

In order to obtain the highest diversion rates (56 percent) estimated in the Stretch goals, Ferndale will likely need ordinances that require waste diversion including mandatory recycling and organics diversion from the landfill stream.

ORGANICS DIVERSION ORDINANCE

Ferndale could require restaurants and food establishments to divert organic waste from disposal. The city could also make this requirement city-wide and cover residential and commercial properties with a supporting organics program for residents. Many communities have seasonal yard-waste programs that allow pre- and post-consumer organics. Many communities are also moving to year-round collection programs. An ordinance requiring diversion of food waste may be phased in over time, requiring larger restaurants to comply first before smaller restaurants. The ordinance could specify all food waste generated on premises or focus solely on back-of-house (pre-consumer) food waste. Back-of-house collection is considered easier to implement and less susceptible to contamination because it requires only employees to know the components of the program. Front-of-house collection is more challenging because it requires customers as well as employees to understand what is and is not acceptable in the diversion program.

For the ordinance to be successful, it is key that there is accessible, convenient, and frequent collection services available to businesses and that there is regional processing capacity for the food waste.

ZERO WASTE EVENTS

Over the next five years, Ferndale could move from supporting zero waste events to requiring all public events or permitted events on public property to be zero waste events. Ferndale could require City-sponsored and City-permitted events to be zero waste. City-permitted events would be required to provide recyclables and compostables collection in compliance with the City's special events permit requirements. The city would provide guidance on steps to set up waste management for event, how to set up bins, and how to contract with a City-approved hauler, etc. The Washtenaw County program offers any combination of services based on specific event needs and County resource availability such as: pre-event consultation, vendor coordination and education, volunteer coordination and training, Zero Waste Station lending, allocation of Zero Waste Washtenaw staff, as needed, ensured safe disposal of materials, post-event Zero Waste Report, and consultation. The event organizer pays for services and Recycle Ann Arbor/Washtenaw County can provide sort station and staffing, as needed. Washtenaw County received a grant from the Michigan Department of Environmental Quality (now Department of Great Lakes, Environment, and Energy - EGLE) P2 grant project to get the program started. The city could choose to follow the Birmingham example where all special event trash and recycling fees are charged to that event plus a 15-20 percent markup to account for administrative costs.

CONSTRUCTION AND DEMOLITION WASTE DIVERSION ORDINANCE

Ordinance for mandatory recycling for Construction and Demolition projects requires the proper recycling of construction and demolition debris for projects of a certain size in the central business area of the City; contractors/permit holders are required to file a waste diversion report to show compliance and for City tracking of volume diverted from the landfill[11]. In addition to a C&D ordinance, Leadership in Energy and Environmental Design (LEED) for new developments encourages LEED buildings for all developments within the downtown business district. Volumes of current C&D waste is unknown but using a national average of 22 – 26 percent of the waste steam

[11] An example from Seattle, Washington: https://www.seattle.gov/utilities/businesses-and-key-accounts/construction/construction-waste/recycling-requirements

(CalRecycle), we can estimate at least 90 percent of this is possible to be diverted from the Ferndale waste stream with a requirement for large construction projects. The cost of the program, building permit and waste diversion report filing is the responsibility of the contractor and SOCRRA would be willing to provide a roll-off service for large construction projects if the City mandates it. The City will have minimal costs to enter data and conduct inspections as part of the building permit process, and there will be some staff time to enhance the permit format.

5. WASTE PROJECTION

In 2019, Ferndale's CBD had 185 businesses with 1,051 employees. These businesses disposed of 946 tons to landfills and are estimated to have recycled 96 tons via single stream and 53 tons of cardboard for an overall diversion rate of 14 percent, slightly below the state's average diversion rate. To understand how Ferndale could increase the CBD diversion rate, the RRS Team examined the estimated composition of the waste stream for each sector. According to the results of the 2014 CalRecycle study, the proportion of recyclables in the waste stream varies significantly by business type or sector. For example, only 29 percent of the waste stream of Services – Management, Administrative, Support, & Social is comprised of single stream recyclables (e.g., paper, metals, plastics, and glass). In contrast, the waste stream of restaurants is estimated to contain 47 percent single stream recyclables. A similar picture emerges from the 2014 CalRecycle study results for organics in the waste stream. The proportion of single stream recycling and organics estimated to be in the waste stream for each sector sets a threshold of diversion potential since it is not possible to capture more recyclables or compostables from the stream than is generated.

Table 12 - Proportion of Single Stream Recyclables and Organics in the Waste Stream

DESCRIPTION	SINGLE STREAM RECYCLABLES IN WASTE STREAM	INCLUDE IN RECYCLING PROGRAM	ORGANICS IN WASTE STREAM	INCLUDE IN ORGANICS PILOT & PROGRAM
Arts, Entertainment, and Recreation	40%	X	54%	
Durable Wholesale & Trucking	82%	X	11%	
Education	54%	X	43%	
Manufacturing – Food & Nondurable Wholesale	34%	X	53%	X
Manufacturing – All Other	81%	X	6%	
Medical & Health	41%	X	51%	
Public Administration	62%	X	24%	
Restaurants	47%	X	52%	X
Retail Trade – Food & Beverage Stores	64%	X	32%	X
All Other Retail Trade	53%	X	30%	
Services – Management, Administrative, Support, & Social	29%	X	64%	
Services – Professional, Technical, & Financial	55%	X	22%	
Services – Repair & Personal	56%	X	29%	
Not Elsewhere Classified	34%	X	57%	

To project disposal and diversion needs for Ferndale's CBD into the future, the RRS Team created six scenarios. The first three scenarios vary single stream recycling and organics diversion rates based on today's employee counts. The second set of scenarios model the same collection programs with 150 additional employees in Ferndale's CBD. 150 new employees in five years was used in a recent downtown planning document.

Current employment scenarios

- Current diversion program (14 percent)
- Strong diversion program (40 percent)
- Stretch diversion program (56 percent)

Added employment scenarios (150 new employees)

- Current diversion program (14 percent)
- Strong diversion program (40 percent)
- Stretch diversion program (56 percent)

The current diversion program scenarios assume Ferndale's downtown maintains the present 14 percent diversion rate at today's employment and in five years with an additional 150 employees added. These new employees are distributed proportionally across the business sectors. The RRS Team did not make any assumptions that the types of businesses would change. Under the strong diversion program scenarios, overall diversion rate is tripled from the current rate to 40 percent, on par with Michigan's goal to triple the statewide recycling rate. Finally, the RRS Team model a stretch diversion program where the overall diversion rate is quadrupled to 56 percent.

Table 13 - Capture Rate of Recycling and Organics from Disposal

	SINGLE STREAM RECYCLING CAPTURE FROM DISPOSAL STREAM	ORGANICS CAPTURE FROM DISPOSAL STREAM
Current Diversion Program	14%	0%
Strong Diversion Program	50%	25%
Stretch Diversion Program	75%	45%

Moving to the 40 percent diversion rate will require a strong and consistent education program to train business employees on a regular basis and provide appropriate incentives to support these behavior changes. The 14 percent diversion rate means that a lot of recyclable materials are being landfilled. To obtain 40 percent diversion, Ferndale businesses will need to move recyclable materials from the landfill stream into the recycling stream. Our model estimates that businesses will need to move half of the recyclables currently being landfilled. The strong diversion program also assumes that 25 percent of the organic material in the landfill stream is moved to a new organics collection program.

With the development of a strong diversion program, RRS estimates that Ferndale could capture 50 percent of the available single stream recyclables currently in the disposal stream from each business sector. For the Arts, Entertainment, and Recreation sector that would mean capturing half of the single stream recycling estimated to currently be in the disposal stream or 50 percent of the 40 percent of single stream recycling that is available in the stream. The same logic follows for all identified sectors. Capturing 100 percent of the single stream recycling generated is not realistic because for example, some recyclables will be reused by businesses, recycled through other avenues such as bottle redemptions, or simply thrown out for various reasons.

Along with a stronger recycling rate, the RRS Team estimates Ferndale could capture 25 percent of the available organics in the waste stream from just three business sectors generating nearly three-quarters of the total tons of organics in the CBD: Restaurants, Retail Trade – Food & Beverage Stores, and Manufacturing – Food & Nondurable Wholesale. Within restaurants, two-thirds of the food waste is generated back-of-house during food preparation or due to food spoilage. The remaining third is generated from uneaten food on customer's plates[12]. In estimating capture rates for organics, RRS was focused on the portion of food waste generated back-of-house since SOCRRA has indicated they can process organics from back-of-house collection at their current compost facility.

Taken as a complete picture, the overall Ferndale CBD diversion rate becomes the current diverted tons plus the 50 percent of recyclables captured from current disposal and 25 percent of the organics stream from the main food waste generating sectors. Calculated out, that would move Ferndale's CBD diversion rate from 14 percent where it stands today to 40 percent.

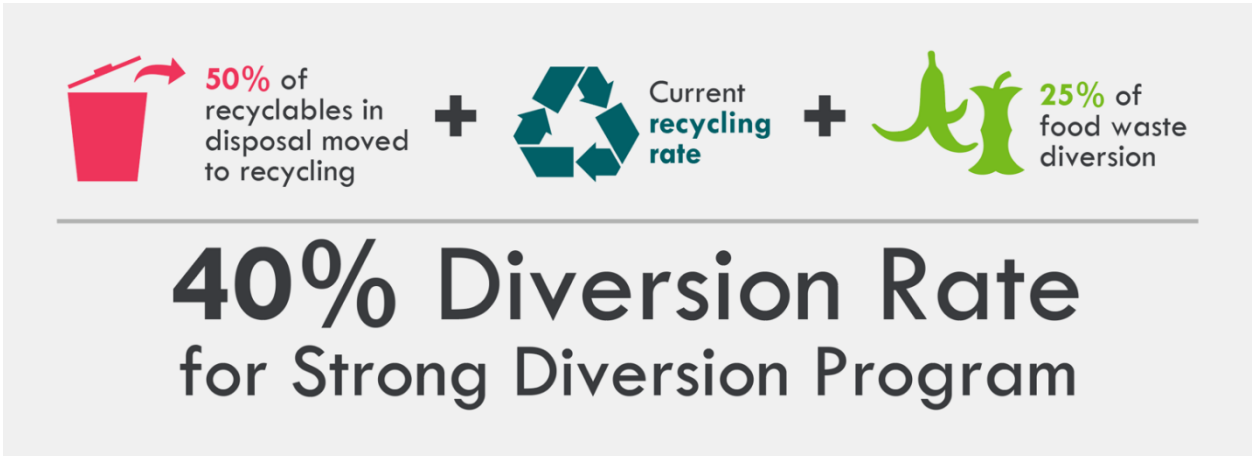


Figure 25 - Strong Diversion Program Elements

At current employment, moving Ferndale's CBD from 14 percent to 40 percent would result in a decrease in disposal from 946 tons to 656 tons or 290 fewer disposed tons per year. In the business as usual model, Car Trucking makes 240 compactor collections each year. This would drop to approximately 166 compactor collections in the Strong Diversion scenario and 125 compactor collection in the Stretch Diversion scenario. Concurrently, recycling tons would increase by 230 tons with 204 tons as single stream recycling and 27 tons as cardboard recycling that could be collected separately or with the single stream materials. An estimated 60 tons of food waste would also need to be collected and processed.

The RRS Team feels a strong recycling program is attainable for Ferndale's CBD by implementing such recommendations as strong education and outreach to the business community, a Green Business Challenge program, and piloting an organics collection program. There is always opportunity to improve programs and to estimate that the RRS Team has created a diversion potential for a Stretch Diversion program. This Stretch Diversion program is still achievable but requires consistent implementation of best practices, stronger financial incentives, ordinances, and continuous monitoring and program adjustments. In the Stretch Diversion scenario, the RRS Team estimates the program could capture 75 percent of single stream recyclables currently headed to the landfill and 45 percent of organics generated from three business types: restaurants; food and beverage stores; and food and nondurable wholesale. The overall diversion rate is estimated at 56 percent for the Stretch Diversion scenario. Generally,

[12] Restaurants take action, Wrap 2015

achieving diversion rates greater than 60 percent is possible but very challenging. In the Stretch Diversion scenario, disposal tons are cut nearly in half from 946 tons currently to 492 tons. Capacity will need to be developed for an additional 350 tons of recycling – single stream and cardboard – through use of compactors and/or increased collection frequencies. Additionally, just over 100 tons of organics would be diverted to composting.

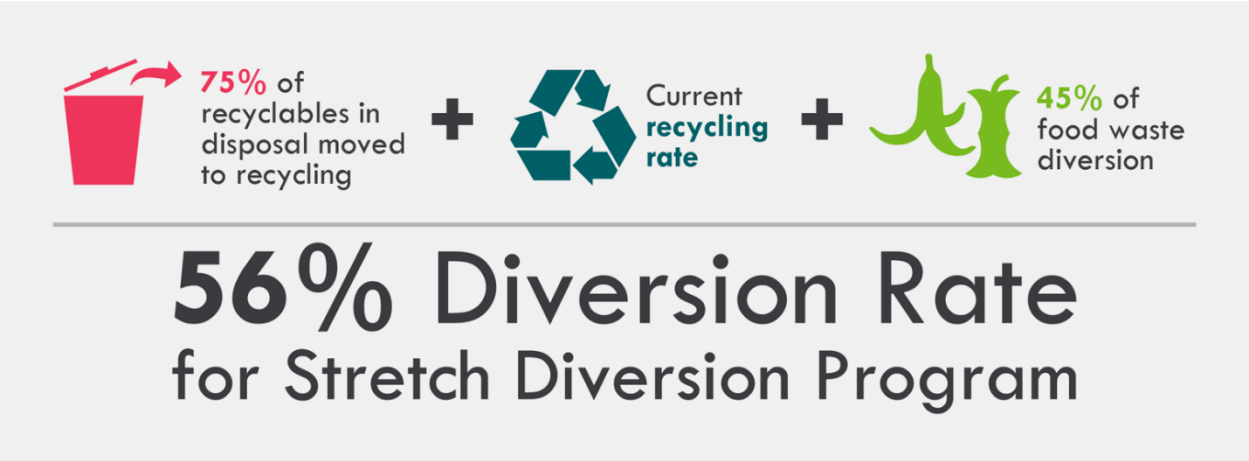


Figure 26 - Stretch Diversion Program Elements

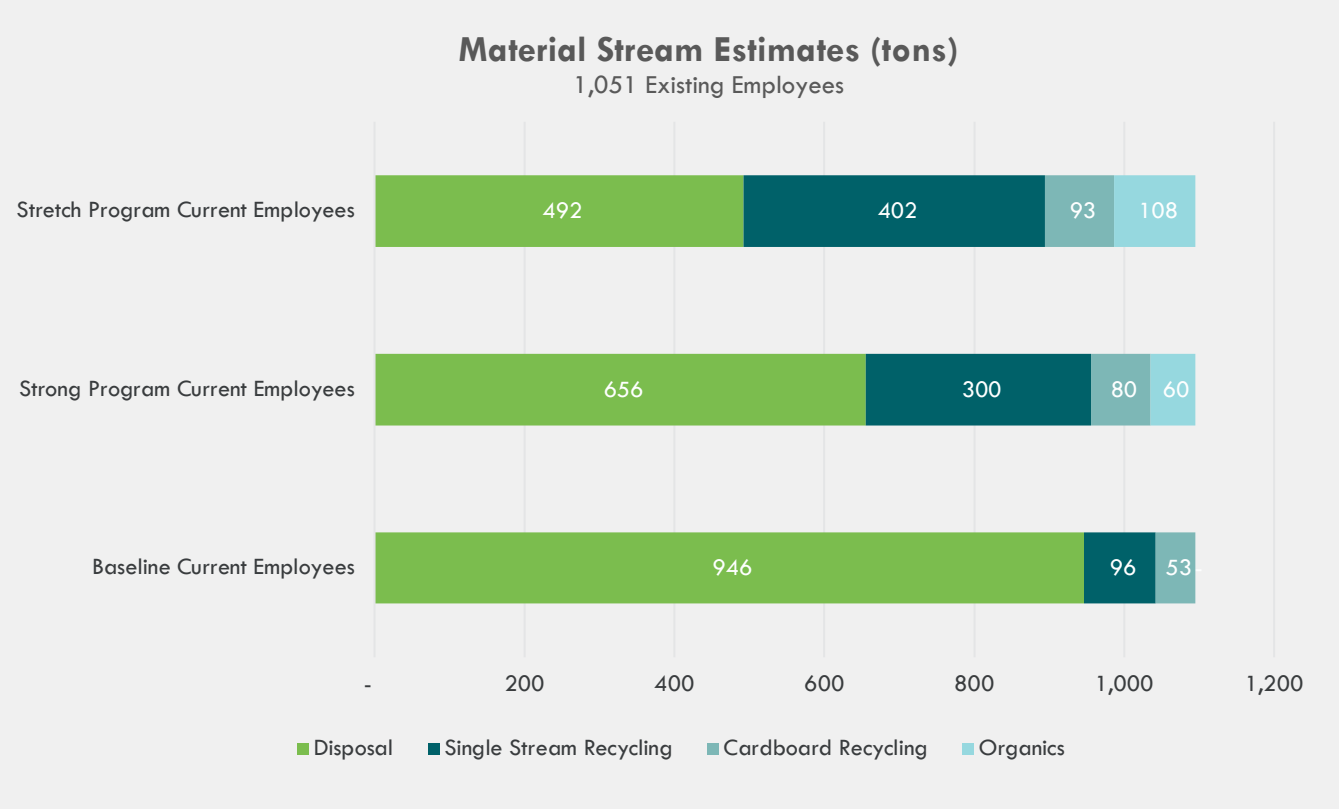


Figure 27 - Material Stream Estimates (Current Employment) for Baseline, Stretch, and Strong Diversion Programs

The RRS Team used previous downtown planning estimates to assume 150 new employees are added to the downtown across all business types. To understand the impact of this growth, the RRS Team repeated the modeling scenarios – current, strong, and stretch diversion program – for a larger CBD employment. If Ferndale adds 150 employees and maintains current diversion rates, an additional 133 tons of disposal would need to be collected adding an increase of 15 percent to the landfill compactor collection special charges. Only marginally more diversion tons would need to be collected. On the other hand, under a strong diversion program scenario, the City of Ferndale could actually decrease disposed tons from current levels even with an additional 150 new employees. The RRS Team estimates that with the implementation of a strong diversion program with 150 new employees, Ferndale would need disposal capacity for 748 tons, nearly 200 fewer tons than current disposal. With this scenario, 433 tons of recycling would be captured per year and 69 tons of organics. Finally, RRS modeled a stretch diversion program with an additional 150 employees, estimating Ferndale would need disposal capacity for 562 tons of waste, a 40 percent reduction from current disposal needs. Nearly equal capacity would be needed for recycling along with 123 tons of organics diversion.

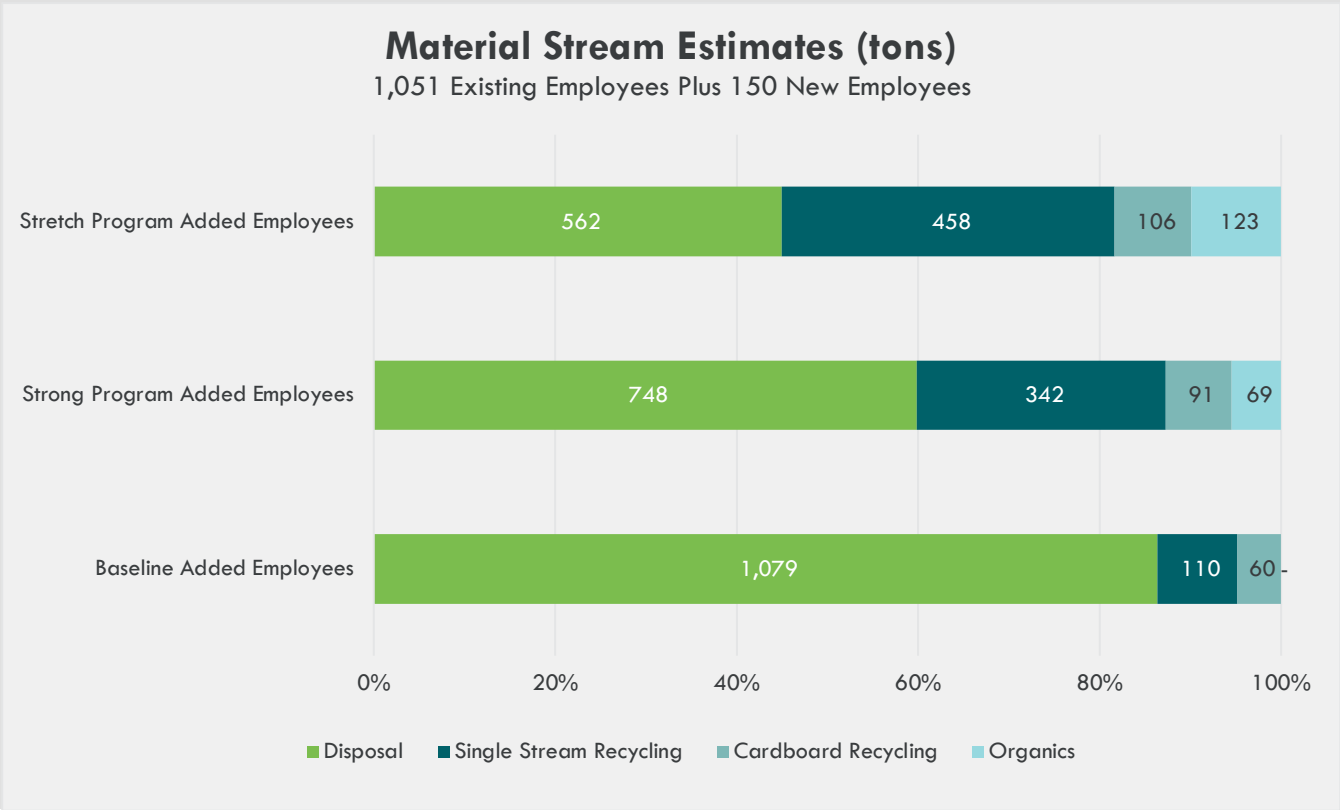


Figure 28 - Material Stream Estimates (150 new employees) for Baseline, Stretch, and Strong Diversion Program

6. GREENHOUSE GAS EMISSION IMPACT

The RRS Team analyzed the impact increased diversion would have on greenhouse gas emissions (GHG) from Ferndale's CBD. While there are many models emerging to calculate greenhouse gas reductions, the most recognized and standard model is the United States Environmental Protection Agency's WARM. The Waste Reduction Model (WARM) was designed to help solid waste planners, municipal leaders, and other stakeholder organizations track and report greenhouse gas emissions reductions. It is a database tool that helps decision makers predict the strategies that most reduce GHG emissions. The WARM calculates GHG emission across six waste management modalities (source reduction, recycling, composting, anaerobic digestion, combustion, and landfilling). Modeling different combinations of waste management practices sees which approach leads to the least GHG entering the atmosphere. RRS used the WARM to calculate a comparison of current waste management practices to alternative waste management scenarios – strong and stretch diversion programs - to determine greatest GHG benefits. RRS did not calculate a comparison among material-specific recyclables since the data provided was not reliable enough.

Background on GHG Emissions

Gases that trap heat in the atmosphere are called greenhouse gases. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20), and fluorinated gases. Each gas's effect on the climate depends on how much is in the atmosphere, how long they stay in the atmosphere, and how strongly they impact the atmosphere. Disposal and treatment of materials results in greenhouse gas emissions from collection, transport, landfill disposal, manufacture, etc.

Many people believe that throwing food scraps and paper products into a landfill is harmless because they biodegrade. However, most people are surprised to learn that when these materials break down in a landfill, they become powerful contributors to greenhouse gas emissions. Compostable materials such as food scraps and paper decompose anaerobically (without oxygen) in a landfill, producing methane (CH_4) which has 23-71 times greater heat trapping capabilities than carbon dioxide. In fact, landfills accounted for approximately 16.4 percent of total U.S. anthropogenic methane (CH_4) emissions in 2017, the third largest contribution of any CH_4 source in the United States[13].

The most common way to measure climate impact of waste management is to state the impact in carbon equivalents. Since waste reduction results in the reduction of several types of greenhouse gases, the conversion to a standard carbon equivalent (CO_2E) measurement allow for a total quantification of the impact. It also provides a standard language for people to compare these actions to others such as transportation and energy conservation efforts. A carbon equivalent CO_2E is simply the amount of CO_2 that would have the same global warming potential as the waste reduction impacts, when measured over a specified timescale. The international reporting standard for CO_2 emissions is metric tons, so carbon dioxide amounts may be reported as $MTCO_2E$, metric tons of carbon equivalent.

Ferndale CBD WARM Results

Presently, Ferndale CBD sends 86 percent of all waste generated to landfill and 14 percent is diverted to single stream recycling. If Ferndale had no diversion program at all, disposal of all waste would emit 286 $MTCO_2E$ annually. Under the current diversion program, Ferndale's CBD recycling activities programs results in a savings of

[13] "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017". USEPA. EPA 430-R-19-001.

emissions of (152) $MTCO_2E$ annually due to prevention of emissions that would happen if nothing was recovered, so that in total (438) $MTCO_2E$ is eliminated from the atmosphere, equivalent of removing 93 passenger vehicles from the road annually. Under a strong diversion program with a 40 percent overall diversion rate, Ferndale's CBD could save (875) $MTCO_2E$ in emissions, for a total of (1,161) $MTCO_2E$ reduction from a no diversion program scenario. This is equivalent to taking 154 passenger vehicles off the road annually. Going further, under a stretch diversion program, (1,541) MTCO2E would be saved compared to a no diversion program scenario which is equivalent to removing 234 passenger vehicles from the road annually. Similarly, the RRS Team calculated reductions in MTCO2E from a no diversion program scenario to current diversion, strong diversion, and stretch diversion programs for a CBD with 150 additional employees. See Tables 14 and 15 for results.

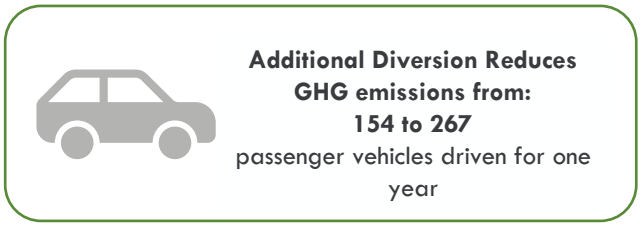


Figure 29 - Additional Diversion Reduction

Beyond the numbers, the key takeaway is that without any diversion, waste activities are $MTCO_2E$ emitters adding to climate change whereas recycling and composting activities conserve natural resources and generate valuable products at a lower emission rate than if all the products were made from virgin materials so that waste can be turned from a carbon source to a carbon sink. With the current diversion programs, Ferndale's CBD is already using their waste to contribute positively to the reduction of GHG emissions, and with greater diversion programs the opportunity to reduce emissions grows.

Table 14 - Total GHG Emissions for Different Diversion Programs & Current Employment

	TOTAL GHG EMISSIONS FOR DIFFERENT DIVERSION PROGRAMS & CURRENT EMPLOYMENT		
Program Type	$MTCO_2E$ = metric tons of carbon dioxide equivalent	Change in $MTCO_2E$ from a no diversion program scenario	Removing annual emissions from passenger vehicles
No Diversion Program (all to disposal)	286	-	-
Current Diversion Programs	(152)	(438)	93
Strong Diversion Programs	(875)	(1,161)	154
Stretch Diversion Programs	(1,254)	(1,541)	234

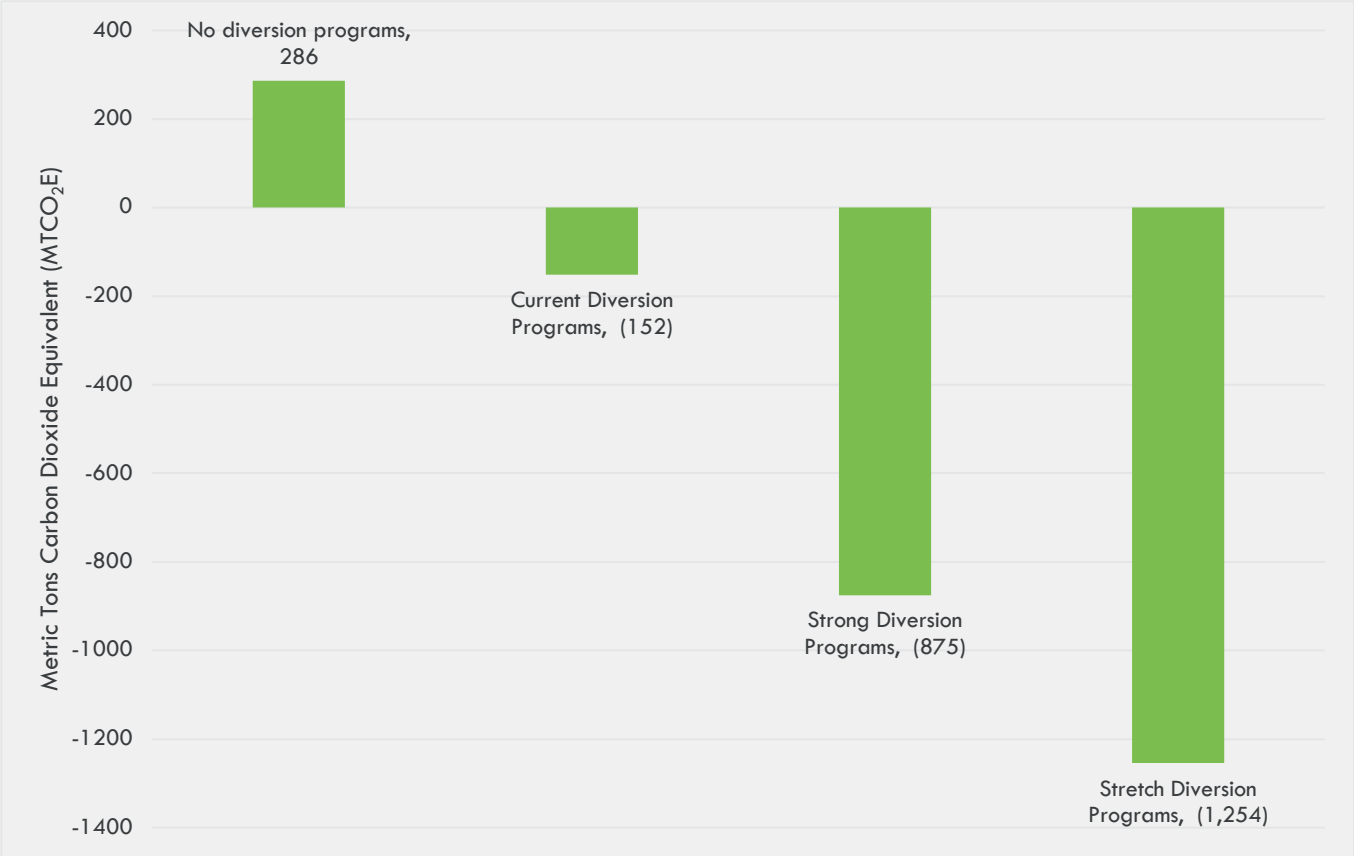


Figure 30 - Comparison of Metric Tons Carbon Dioxide Equivalent (MTCO2E) Emissions for Different Diversion Programs at Current Employment Level

Table 15 - Total GHG Emissions for Different Diversion Programs & Additional 150 Employees

	TOTAL GHG EMISSIONS FOR DIFFERENT DIVERSION PROGRAMS & ADDITIONAL 150 EMPLOYEES		
Program Type	$MTCO_2E$ = metric tons of carbon dioxide equivalent	Change in $MTCO_2E$ from a no diversion program scenario	Removing annual emissions from passenger vehicles
No Diversion Program (all to disposal)	398	-	-
Baseline Diversion Program	(101)	499	106
Strong Diversion Program	(928)	1,326	175
Stretch Diversion Program	(1,357)	1,755	267

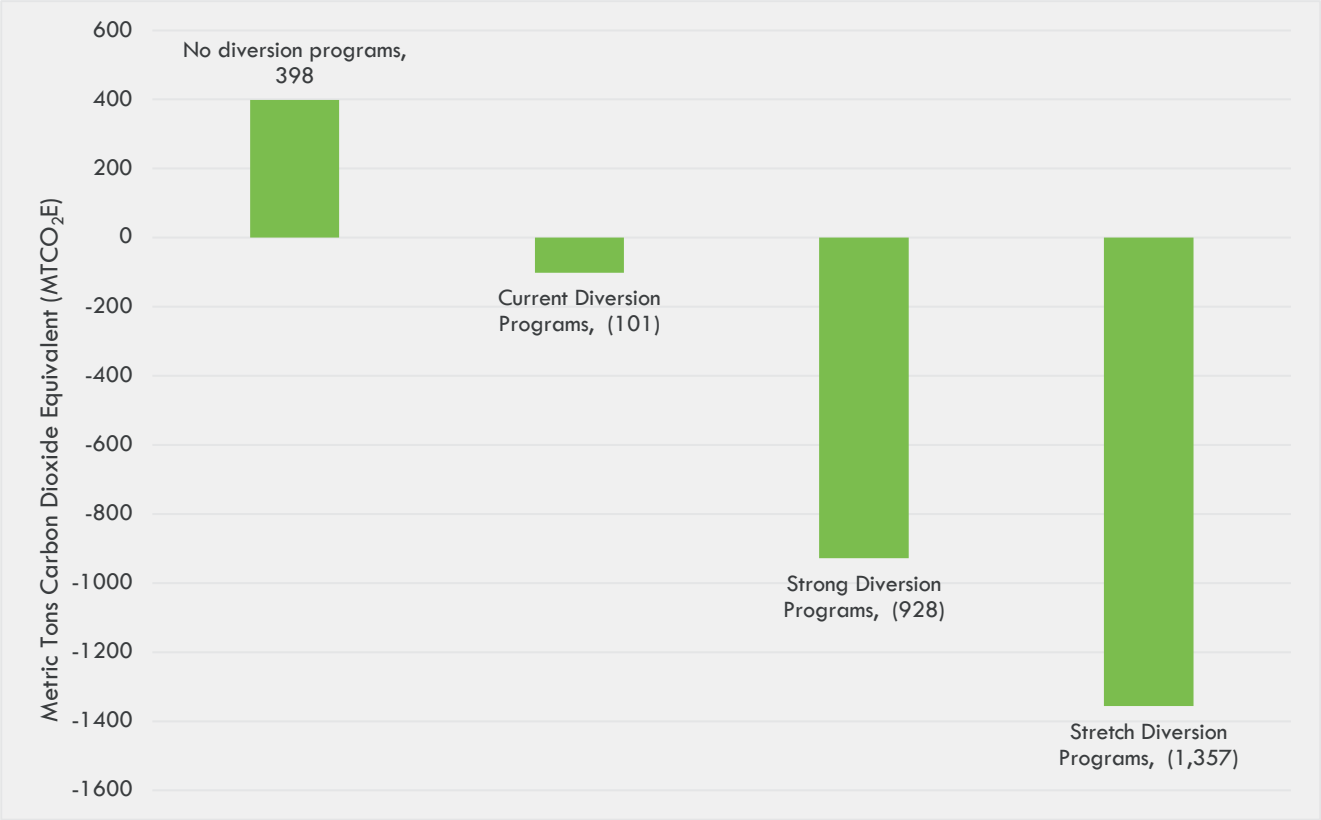


Figure 31 - Comparison of Metric Tons Carbon Dioxide Equivalent (MTCO2E) Emissions for Different Diversion Programs with Additional 150 Employees.

Additional GHG emissions could be avoided if materials are reduced at the source before entering the waste stream to be managed. Rethink Food Waste Through Economics and Data (ReFED)[14] reports consumer education measured in the United Kingdom and elsewhere demonstrate reduced impacts on consumer food waste. Love Food Hate Waste is a national consumer awareness campaign launched by Waste and Resources Action Programme (WRAP). After six months of launching this campaign in six Boroughs of West London Waste Authority, a 14 percent avoidable food waste reduction was tracked.[15] While there is minimal tracking in the U.S. regarding consumer education campaigns, King County, WA and Honolulu County, HI implemented pilot programs testing messages and tools to reduce food waste. Those respective campaigns measured 28 percent and 19.6 percent reduction[16].

[14] https://www.refed.com/solutions/consumer-education-campaigns/
[15] "The Impact of Love Food Hate Waste". http://www.wrap.org.uk/sites/files/wrap/West%20London%20LFHW%20Impact%20case%20study_0.pdf
[16] "Toolkit Implementation Guide for the Food: Too Good to Waste Pilot". July 2013. West Coast Climate and Materials Management Forum. https://westcoastclimateforum.com/sites/westcoastclimateforum/files/related_documents/02_ToolKit_Implementation_Guide_for_the_Good_Too_Good_to_Waste_Pilot.pdf

7. SUSTAINABLE MATERIALS MANAGEMENT IN A CHANGING CLIMATE

Many communities have adopted resolutions declaring a climate emergency. Many have completed Greenhouse Gas Inventories and developed climate action plans to mitigate GHG emission. Fewer cities are using the best available climate science in each and every new planning effort and recognizing the need to plan for and adapt to a changing climate. The following section explores the current best available science on climate change and discusses how these changes may affect the way cities like Ferndale are able to deliver sustainable materials management services.

Where to look for the best available science?

The Great Lakes Integrated Sciences and Assessments (GLISA) Program[17] is a collaboration of the University of Michigan and Michigan State University funded by the National Oceanic and Atmospheric Administration (NOAA). GLISA is part of a national network of NOAA Regional Integrated Sciences and Assessments (RISAs) that focus on adaptation to climate change and variability. GLISA is the NOAA RISA for the Great Lakes region.

Ferndale and GLISA have worked together on a number of projects including the most recent Vulnerability Assessment report looking at the vulnerability of the Ferndale stormwater system to a changing climate. The detailed climate data used in the following section is taken directly from this 2020 report.

In the Southeast Lower Michigan Climate Division, precipitation has increased 18.51% from the 1951-1980 reference period. Changes in spring and winter precipitation have increased 21.14% and 28.43 % respectively.

GLISA developed a climatology for Ferndale in 2018 that measured the following:

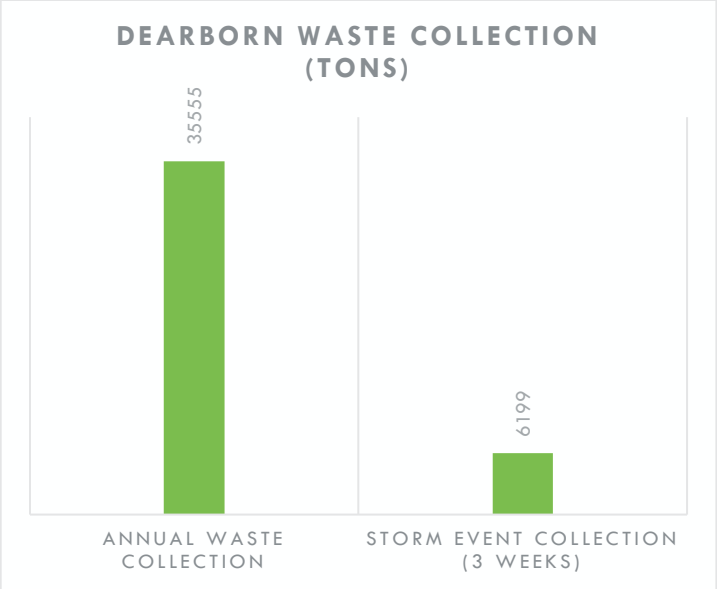
- Average air temperature in Ferndale has increased by 2.7°F.
- Average air temperature is projected to rise 3°F to 5°F by the mid-21st century.
- Total annual precipitation has increased by 25.2%.
- Heavy precipitation (over 1.25" of rainfall in 24hrs) has increased rapidly throughout the region. The amount of rain falling in the most extreme events (heaviest 1% of storms) has increased by 35% and these events have generally become more frequent since 1951.
- The amount of total annual precipitation in Ferndale has increased by 25.2% (8.4") from 1951 to 2017. An increase in precipitation was observed in all four seasons, with the fall seeing the greatest percentage increase of 40% (3.0").
- Total annual precipitation will likely increase in the future, though types of precipitation will vary (i.e., more winter precipitation in the form of rain).

[17] http://glisa.umich.edu/about

How might climate change affect Ferndale's recycling, organics, and waste service delivery in the downtown?

The most obvious problem is that more precipitation is more likely to make the collected materials wet, and less valuable, if dumpster and cart lids are off or open during storms. Investing in training and infrastructure to keep materials less exposed to the elements will improve the quality of collected materials. Covered centralized collection areas is one of the report recommendations along with sealed compactors. Curb carts with robust lids capable of being secured by hooks or cords would also be appropriate. More precipitation will also create more runoff from downtown waste collection areas into the city combined sewer system.

One recent example is the extensive flooding that affected Dearborn in 2014. Dearborn had to contract to collect an additional 6,200 tons of material at a cost of approximately $1,000,000 dollars. This equated to collecting almost 20% of the annual waste in Dearborn in a 3-week period.



GLISA has identified both more precipitation and more extreme storms, which will lead to more flooding and more storm debris.

Climate Challenges

- Increased flooding will affect truck routing and the ability to efficiently collect materials.
- Increased flooding will increase the number of flooded basements and structures that leads to increased costs to collect and dispose of flood damaged materials put at the curb.
- More extreme storms will lead to more urban canopy damage if trees are not trimmed routinely and/or weak tree species are planted.
- Efforts to collect the materials that are not in carts require additional workers.
- Overtime is inevitable in any rapid response. Public works staff will be busy handling waste issues when they could be doing other response activities.
- Special landfill costs may be incurred for waste amounts outside of contracted amounts or materials that are deemed hazardous.
- Additional precipitation as well as increases in heavy rain events on compost facilities could be significant in their ability to manage stormwater coming into contact with compost piles and reduce potential for groundwater impacts.

Climate Opportunities

- Develop incentives to support residents removing household hazardous waste from flood prone areas.
- Develop incentives for urban tree canopy maintenance – consider using Solid Waste enterprise funds if available to subsidize neighborhood "group buys" for tree trimming. There are clear partnership opportunities with Stormwater utility funding to maintain the urban tree canopy.
- Increase the city requirements for locally generated compost for road reconstruction and streetscape improvements to increase the demand for compost.

- Increase the organic content of soil in new construction and incent compost application on residential property to improve stormwater quality and quantity.

Potential approaches cities can use to minimize debris and emergency costs include:

- Build waste and recycling directives into Emergency Response Planning and Training.
- Integrate strong recovery and recycling planning into Emergency Response Plans upfront in order to avoid simply sending material to the landfill.
- An annual and consistent strong education campaign to residents to remove unwanted materials to thrift and reuse stores, limit materials on the basement floors, and remove all hazardous materials from potential flooded areas (e.g., basements and garages)
- An annual and consistent education campaign to residents to trim trees to insure they are less prone to catastrophic damage to structures and overall limb failure.
- A parallel tree maintenance (asset management) program by the municipality to set an example for the urban street tree canopy.
- Municipal budgeting process that includes intentional recognition of climate adaptation benefits of capital investments
- Explicit recognition of potential flood zones and alternative routing predesignated.
- Explicit contract language recognizing the potential for extreme events and the labor, equipment, and disposal charges so that the municipality can budget appropriately.
- Explicit recognition of climate change in municipal All Hazard Plans and inclusion of solid Waste staff in plan development activities and exercises.
- Predestination of compost staging sites for tree and other vegetative waste.

8. IMPLEMENTATION STRATEGY AND IMPACT

As an exercise, the RRS Team worked with Ferndale Sustainability Coordinator to rank how well each of the proposed recommendations improved a set of metrics. None of the metrics were weighted differently. Scoring was on a 1-3-5 scale where 1 was low and 5 was high.

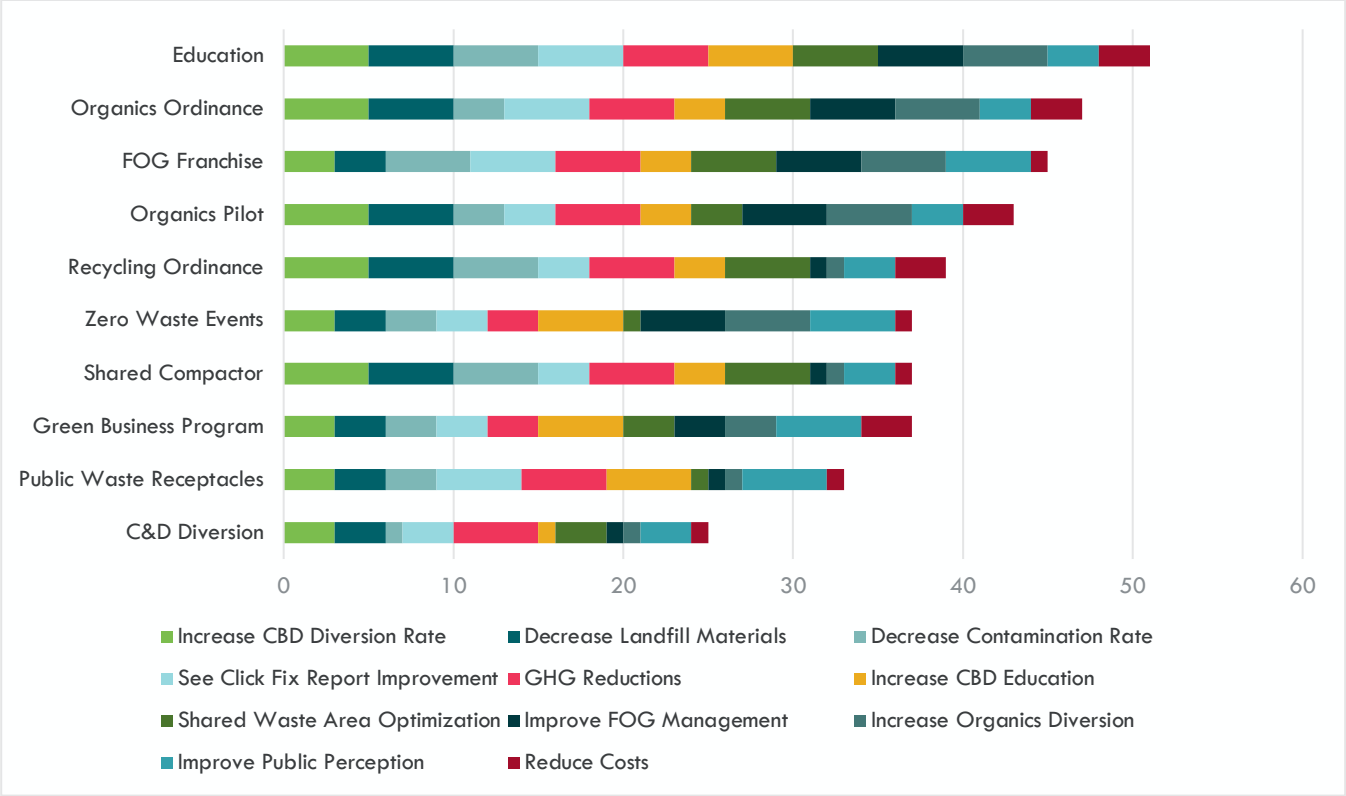


Figure 32 - Qualitative Scoring of Program Benefits for Each Recommendation

ATTACHMENTS

Attachment A - Financial Model

Based on the recommendations developed for the city of Ferndale, the RRS Team developed a financial model in Excel to explore how capital and on-going operational costs could be allocated. In the draft model attached below, RRS made the following assumptions:

- Investments are modeled over 10 years
- All capital investments were made in year 1 and included 3 new enclosures, 4 new waste compactors, 4 new recyclables compactors, 60 street container pairs, zero waste equipment for events and new organics collection carts. The cost assumptions are based on RRS knowledge and inquiries. No formal bids were requested or received.
- Operational costs included a new green business recognition program, downtown employee education, new staff, organics pilot collection costs, and funds for a regular waste sort to monitor progress.
- The current diversion rate of 14% increases to 40% in year 3 and 55% in year 5.
- GHG savings increase with increased diversion
- Special waste collection charges are reduced with increased diversion from $34,000 to $20,000 per year
- Year 6 adds an additional 150 employees to the downtown which increases waste, recycling, and organics and the 55% diversion rate continues.
- There is sufficient fund balance to pay for initial capital investments and first year operational costs.
- Allocating the capital costs of approximately $450,000 across 10,000 parcels would increase the special assessment by $45 or approximately $5 if repaid over 10 years.
- Allocating the operational costs of approximately $200,000 across 10,000 parcels would increase the special assessment by $20 per year.
- The new program could be financed with a $25 increase in special assessments for 10 years that would reduce to $20 in year 11.
- The fund balance would be repaid within the 10-year period.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Phase			Current				Phase 1					Phase 2				
2				2019				2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
3	**Assumptions (Year 2019)**																
4																	
5	Recycling Rebate ($/ton)	$ 10.00	Annual Cost	$ (1,490)		10% increase		$ 10.00	$ 11.00	$ 12.10	$ 13.31	$ 14.64	$ 16.11	$ 17.72	$ 19.49	$ 21.44	$ 23.58
6	Organics Tip Fee ($/ton)	$ -	Annual Cost	$ -													
7	Downtown # of Employees			1051				1051					1201				
8	**Volumes**																
9	Cardboard (OCC) Tons			53				53	53	80	80	93	106	106	106	106	106
10	Recycling Tons			96				96	96	300	300	402	458	458	458	458	458
11	Organics Tons			0				0	0	60	60	108	123	123	123	123	123
12	Landfill Tons			946				946	946	656	656	492	562	562	562	562	562
13	Scenario (BAU, Strong or Stretch)							BAU		Strong		Stretch	Stretch				
14	Diversion Rate (%)							14%		40%		55%	55%	55%	55%	55%	55%
15	GHG Savings (Mtons)							152	152	875	875	1254	1357	1357	1357	1357	1357
16	Social Cost of Carbon	$30						$4,560	$4,560	$26,250	$26,250	$37,620	$40,710	$40,710	$40,710	$40,710	$40,710
17																	
18	**Costs**	**Units**	**Cost**	**Total**	**Life (Years)**	**Annualized Costs**											
19	***New Capital Costs***																
20	Enclosures	3	$ 45,000	$ 135,000	20			$ 135,000									
21	Waste Compactors	4	$ 30,000	$ 120,000	10	$ 12,000		$ 120,000	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333
22	Single Stream Compactors	4	$ 30,000	$ 120,000	10	$ 12,000		$ 120,000	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333	$ 13,333
23	Public Containers	60	$ 1,000	$ 60,000	10	$ 6,000		$ 60,000	$ 6,667	$ 6,667	$ 6,667	$ 6,667	$ 6,667	$ 6,667	$ 6,667	$ 6,667	$ 6,667
24	Zero Waste Equipment	100	$ 100	$ 10,000	10	$ 1,000		$ 10,000	$ 1,111	$ 1,111	$ 1,111	$ 1,111	$ 1,111	$ 1,111	$ 1,111	$ 1,111	$ 1,111
25	Organic Carts	45	$ 75	$ 3,375	10	$ 338		$ 3,375	$ 375	$ 375	$ 375	$ 375	$ 375	$ 375	$ 375	$ 375	$ 375
26	**TOTAL CAPITAL COSTS**							**$ 448,375**	**$ 34,819**	**$ 34,819**	**$ 34,819**	**$ 34,819**	**$ 34,819**	**$ 34,819**	**$ 34,819**	**$ 34,819**	**$ 34,819**
27																	
28	***New Operating Costs***																
29	Green Business Recognition	185	$ 100	$ 18,500		$ 18,500		$ 18,500	$ 18,500	$ 18,500	$ 18,500	$ 18,500	$ 18,500	$ 18,500	$ 18,500	$ 18,500	$ 18,500
30	Employee Education	1051	$ 10	$ 10,510		$ 10,510		$ 10,510	$ 10,510	$ 10,510	$ 10,510	$ 10,510	$ 10,510	$ 10,510	$ 10,510	$ 10,510	$ 10,510
31	Compactor Maintenance	8	$ 1,000	$ 8,000		$ 8,000		$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000	$ 8,000
32	Organics Collection	156	$ 150	$ 23,400		$ 23,400		$ 23,400	$ 23,400	$ 23,400	$ 23,400	$ 23,400	$ 23,400	$ 23,400	$ 23,400	$ 23,400	$ 23,400
33	Waste Sort	1	$ 25,000	$ 25,000		$ 25,000		$ 25,000		$ 25,000		$ 25,000		$ 25,000		$ 25,000	
34	Staff	1	$ 100,000	$ 100,000		$ 100,000		$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
35	**TOTAL**							**$ 185,410**	**$ 195,229**	**$ 220,229**	**$ 195,229**	**$ 220,229**	**$ 195,229**	**$ 220,229**	**$ 195,229**	**$ 220,229**	**$ 195,229**
36																	
37	***Current Operating Costs***																
38	Special Charges							$ 34,080	$ 34,080	$ 23,633	$ 23,633	$ 17,724	$ 20,246	$ 20,246	$ 20,246	$ 20,246	$ 20,246
39	Collections	240	$142					240	240	166	166	125	143	143	143	143	143
40	Savings (annual)								$ -	$ 10,447	$ 10,447	$ 16,356	$ 13,834	$ 13,834	$ 13,834	$ 13,834	$ 13,834
41																	
42	***Total Operating Costs***							**$ 219,490**	**$ 194,490**	**$ 209,043**	**$ 184,043**	**$ 203,134**	**$ 180,656**	**$ 205,656**	**$ 180,656**	**$ 205,656**	**$ 180,656**
43																	
44																	
45	**Revenue**																
46	Special Assessment Increase (Capital Costs)	10000	$ 45	$ 448,375	10	$ 5.00		$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
47	Special Assessment Increase (Operating Costs)	10000	$ 19	$ 185,410	1	$ 20.00		$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000	$ 200,000
48	Recycling Rebate (Recycling Revenue)							$ 1,490	$ 1,639	$ 4,598	$ 5,058	$ 7,247	$ 9,083	$ 9,992	$ 10,991	$ 12,090	$ 13,299
49	Total Revenue							$ 251,490	$ 251,639	$ 254,598	$ 255,058	$ 257,247	$ 259,083	$ 259,992	$ 260,991	$ 262,090	$ 263,299
50																	
51	**Fund Balance**			**$ 1,000,000**				**$ 617,705**	**$ 674,115**	**$ 708,483**	**$ 768,311**	**$ 805,329**	**$ 869,183**	**$ 908,945**	**$ 974,707**	**$ 1,016,567**	**$ 1,084,636**
52																	

recycle.com 83
416 LONGSHORE DRIVE, ANN ARBOR, MI 48105
RRS

Attachment B - Downtown Business Survey

Thank you for taking a few moments to complete the following survey!

The City of Ferndale is embarking on a process to develop a master plan for downtown waste and recycling. As part of the plan development, it is important that the City hear from businesses about services, needs and opportunities regarding waste and recycling. Resource Recycling Systems (RRS) has been retained to assist the city in this process and is conducting the following survey to gather information to contribute to the development of the Master Plan.

If you have any questions, please contact Anna Lynott, Senior Consultant, Resource Recycling Systems, at alynott@recycle.com or (734) 646-5822.

1. Which of the following services does your business use for waste and recycling in Ferndale? (please select all that apply)

- [ ] Waste compactors
- [ ] Waste dumpsters
- [ ] Recycling containers
- [ ] Used Oil Containers
- [ ] Other (please specify)

2. Does the current set-up for waste and recycling meet the needs of your business?

- ( ) Yes, I am good
- ( ) Mostly, but I could use a few more things
- ( ) No, it does not meet my needs.

3. If you answered "**b**" or "**c**", please describe your needs.

4. What components of the services do you like?

- [ ] Cost
- [ ] Convenience
- [ ] Access to recycling
- [ ] Coordination by the City
- [ ] Other (please specify)

5. What would you change about the services?

- [ ] Cost
- [ ] Convenience
- [ ] Access to recycling
- [ ] Coordination by the City
- [ ] Other (please specify)

6. How would you rate the amount your business pays to the value in services you receive?

- ( ) It's a great value
- ( ) Ok
- ( ) I do not believe the cost is equal to the value.

7. Are you interested in additional services? Please select all that apply. You will be asked to provide details ir the following question.

- [ ] Waste
- [ ] Recycling
- [ ] Used Oil Containers
- [ ] Food waste
- [ ] Other

8. Please describe the additional services you are interested in.

9. What materials do you currently recycle?

- [ ] Cardboard
- [ ] Paper
- [ ] Plastic containers
- [ ] Metal containers
- [ ] Glass Containers
- [ ] All of the above
- [ ] None of the above
- [ ] Other (please specify)

10. Do you have any feedback on using the centralized trash and recycling areas (location, cleanliness, etc)?

11. Optional - Please provide your name, business name and contact information.

First and last name	
Business name	
Title/Position	
Email address	
Phone number	

Thank you for completing the survey and contributing to the development of the Downtown Waste and Recycling Master Plan.

If you have any questions, please contact Erin Quetell, Environmental Sustainability Planner, at equetell@ferndalemi.gov or 248-336-4361.

Attachment C - Best Practices and Emerging Technology Options Memo – February 24, 2020

RRS memo

TO: ERIN QUETELL

FROM: RRS TEAM

DATE: JANUARY 3, 2020 (UPDATED FEBRUARY 24, 2020)

RE: BEST PRACTICE AND EMERGING TECHNOLOGY OPTIONS FOR FERNDALE CENTRAL BUSINESS DISTRICT

This memo presents the best practices and emerging technologies researched in other communities across the U.S. and will be considered in development of the Waste Reduction and Recycling Master Plan for the Ferndale's Downtown Central Business District (CBD) to increase diversion and improve the operation of the City's waste and recycling programs and services. The project team identified proven and emerging waste reduction and recycling options based on the input obtained through the stakeholder kick-off meeting as well as research of practices implemented in other communities. The best practices and emerging technologies will be considered and further evaluated for their applicability and financial viability for Ferndale and may be included in the final recommendation for implementation.

The following are the downtown business district best practices and emerging technologies researched:

Central Business District Program Options

- Fats, Oils, and Grease (FOG) Management
- Commercial Organics Collection
- Construction and Demolition (C&D) Waste Diversion
- Shared Compactor, Dumpster and Recycling Cart Utilization
- Waste Reduction Incentives and Mandatory Recycling Participation
- Public Space Collection Bins
- Zero Waste Events
- Funding Options Summary

As the project team develops best practices and current and potential future diversion rates and costs of all options developed as part of the master plan, the emerging technology reasons for consideration will be described in more detail. Below is a summary of considerations with examples of specific best practices from other cities around the U.S. Links to each city's program website are included.

CENTRAL BUSINESS DISTRICT BEST PRACTICES AND EMERGING TECHNOLOGIES

1. Fats, Oils, and Grease Management

Background on Ferndale Current Conditions

The vast majority of restaurants and eating establishments generate fats, oils, and greases. FOG are broken into two categories, yellow or brown grease. Yellow grease consists of high value cooking oils while brown grease is 90% water and is captured using grease traps or interceptors, routinely pumped using a vacuum truck and then generally disposed of. All FOG requires proper disposal and should be kept out of the sewage system. The City of Ferndale does not currently have a formal system in place for the management of FOG. Issues include lack of usage data, an inability to monitor whether participating restaurants are following regulations, and a lack of information on fee structure, organization structure, and any existing contractual relationships. Further, restaurants have expressed displeasure with the current FOG collection system, citing issues with pests and methods used for transporting FOG to the alley collection containers. During the walk-through assessment, grease containers serviced by Mahoney Environmental and Detroit Grease were identified and RRS reached out to those companies for collection data. However, the RRS team understands that the following additional companies provide downtown restaurants with grease collection services: Alpha Proteins, DAR Pro Solutions, and Kelly's Rendering Service. From our business interview, we found that one restaurant sends its FOG to a local poultry farm to heat the coops. Grease maintains 2 containers ranging from 150-280 gallons, while Mahoney Environmental maintains 7 264-gallon containers in 5 locations. Ferndale's contract with Detroit Grease is to not only collect yellow grease from containers, but to ensure the grating on the containers remains unclogged to prevent spillage. Since grease spills have been an issue, Ferndale has placed cameras near the containers and fines any business that spills excess grease.

Best Practices and Emerging Technology

- FOG ordinance – requires the proper recycling of fats/oils/greases in the downtown business area and commercial sector throughout the City (considered by Ann Arbor, MI - *from interview with Ann Arbor Resource Recovery Manager*). This may also provide co-benefits by reducing illicit discharges to storm and sanitary sewers.
- Franchised FOG hauler – allows the City to manage the contract and track users, cost and waste diversion; access swipe card or key code for container usage will be required similar to the shared compactors (considered by Ann Arbor, MI - *from interview with Ann Arbor Resource Recovery Manager*).

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)

Ordinance development for FOG operating standards will require the recycling of yellow grease, and a franchised FOG hauler agreement maintained by the City or South Oakland County Resource Recovery Authority (SOCRRA) will allow the City to track users, cost and diversion. It is anticipated that the City will charge a fee to users to cover the cost of service, container maintenance and contract management that could be based on either number of employees or flat fee to users to share total cost. The best method of cost to users will be evaluated as other options listed below are reviewed in the final recommendations. Consolidating services to one provider typically reduces overall costs to all users.

2. Commercial Organics (Food Waste) Collection

Background on Ferndale Current Conditions

The City of Ferndale does not currently have a coordinated food waste compost collection program for businesses but has explored options to begin organics collection (food prep waste and post-consumer food waste) and processing using anaerobic digestion. SOCRRA currently excepts yard clippings and vegetative waste (garden or kitchen vegetative waste), but not the full range of commercial organics (post-consumer food waste) that is typically collected from restaurants. During interviews and discussions with the City, businesses within the Central Business District (CBD) and Downtown Development Authority (DDA) have expressed interest in organics collection. Some businesses have elected to contract with private haulers for food waste collection on a year-round basis, as expressed during the business interviews (Greenspace Café uses Midtown Compost to collect their food waste weekly for a $45/month fee). Other businesses may be managing their food waste, but information on costs and diversion for other businesses participating in the private open market is not currently available to the City.

Best Practices and Emerging Technology

- Bike-powered collection – City or City-approved private operator provides organics collection by bike on a fee-for-service basis based on level of service (frequency, number of containers); Material collected is tracked, sorted, consolidated and transported to a local compost site, anaerobic digester or community garden (Cleveland, OH; Denver, CO; Traverse City, MI).
- Drop-off center for food waste – City or City-approved private operator manages a centrally located food waste drop-off center where material delivered is tracked, sorted, consolidated and transported to a local compost site, anaerobic digester or community garden (St. Paul, MN).
- Community Garden small-scale compost operation – City or non-profit community garden organization operates a small-scale (less than 200 cy) compost site that receives leaves and food waste year-round from the downtown business district area and composts the material on site for use in the garden; can work in conjunction with the bike-powered collection or drop-off center (New York City, NY).
- Anaerobic Digester – City or City-approved private operator manages an anaerobic digester for recycling food waste and production of compost and electricity or renewable natural gas. Commercial haulers collect food waste as an individual commodity and transport to the digester, where a depackaging unit removes plastic and other inorganic contaminants. Residential organics collection could be included to increase financial feasibility (San Francisco, CA).
- Franchised food waste hauler – City or group of restaurants – possibly coordinated through the DDA - submit an RFP to a private hauler to provide fee-for-service (based on frequency, number of containers) year-round collection and processing of food waste. Business that generate 2 tons of organic waste or more per week are eligible. Businesses can partner to reach tonnage requirement. Consolidating services to one provider typically reduces costs to all users (Chapel Hill, NC).

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)
Any new service provided by the City or a City-approved private hauler must provide monthly volume and cost data reports to the City for tracking costs and diversion rates. A mandatory program (e.g., where food waste is prohibited from the trash) can be phased-in targeting the largest food-waste generators (e.g., 2 tons or more per week) in year one and smaller generators in year two to maximize diversion. Small generators can be incentivized to participate (see **Waste Reduction Incentives** below). Another option is to collect kitchen prep waste and coffee grounds in a first phase and take to SOCRRA, and then expand to full post-consumer food waste when SOCRRA composts site is able to accept a larger range of material. Bike-powered collection and drop-off options can utilize 5-gallon buckets stored inside, whereas a franchised food waste hauler would provide 32-gallon or 64-gallon larger roll carts that can be moved from inside where collection occurs to the alley or central collection point on collection day. SOCRRA is willing to contact Car Trucking for pricing to provide a pilot for 3x/week pre-consumer food prep (vegetative only) year-round collection with carts located at the shared depots. The food

prep waste would be collected with the municipal yard waste during yard waste season. The City could take advantage of the EGLE organics infrastructure grant (requires a 20% match) to cover the cost of the restaurant containers, collected carts, educational material, etc. Food waste collection aims to achieving high waste diversion rate goals where 35-45% of waste from restaurants is food waste.

3. Construction and Demolition (C&D) Waste Diversion

Background on Ferndale Current Conditions

Construction and demolition (C&D) waste generated from building-related projects is not currently an element of the City's waste management system. C&D waste typically is collected and either recycled or disposed of by private haulers through open market arrangements between haulers and property owners or construction contractors. The City currently does not require construction contractors to track waste during construction projects and the City does not accept C&D materials in commercial containers or compactors. The only current downtown project focused on C&D is The DOT, where the City and the construction contractor is working towards a certification (ParkSmart) specific for parking structures.

Best Practices and Emerging Technology

- Ordinance for mandatory recycling for Construction and Demolition projects – requires the proper recycling of construction and demolition debris for projects of a certain size in the central business area of the City; contractors/permit holders are required to file a waste diversion report to show compliance and for City tracking of volume diverted from the landfill (Seattle, WA).
- LEED for new developments - encourages Leadership in Energy and Environmental Design (LEED) buildings for all developments within the downtown business district (City of Northville, MI – *from past list of EGLE grant recipients*).

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)

Volumes of current C&D waste is unknown but using a national average of 22 – 26% of the waste steam (CalRecycle), we can estimate at least 90% of this is possible to be diverted from the Ferndale waste stream with a requirement for large construction projects. The cost of the program, building permit and waste diversion report filing is the responsibility of the contractor and SOCRRA would be willing to provide a roll-off service for large construction projects if the City mandates it. The City will have minimal costs to enter data and conduct inspections as part of the building permit process, and there will be some staff time to enhance the permit format.

4. Shared Compactor, Dumpster and Recycling Cart Utilization

Background on Ferndale Current Conditions

The City of Ferndale currently owns four compactors that are shared among businesses within the central business district, which are serviced two times per week by Car Trucking. The compactors, manufactured by Contract Welding, are in an enclosed area and have key code access for use. The enclosures are not kept locked and the key code is the same for all compactors and users, so maintenance of the area and tracking of data is challenging for the City. Businesses and building tenants have expressed concern with the proximity of compactors to businesses. Further, businesses have cited issues with odors from the compactors (especially during summer), trash being set next to the container, the compactors impeding alleys and being a general eyesore, pest, and garbage

liquids leaking into sewer drains[1]. Businesses have also expressed concerns about the shared compactors, dumpsters and recycling carts filling up over the weekend while there is no collection service.

Best Practices and Emerging Technology

- Clear Alleys Program – Bans public storage of all containers in public right-of-way for designated business district and provide daily trash collection as well as offer prepaid bags through City contractor or private recycler that can be used for customers without storage space for trash/recycling containers in alleys. Bag fees include fee per bag based on size (15-gal - $5.10/33-gal - $7.30) and a monthly account fee (commercial - $28.60); Collection containers for FOG are exempt (Seattle, WA).
- Alley Captain Program – For central business district commercial customers, they receive a credit on their waste bill if they volunteer as an Alley Captain and monitor the area and help clean up waste outside the containers and report any issues to the City (Ann Arbor, MI – *from interview with Ann Arbor Resource Recovery Manager*).
- Shared Compactor and Recycling Systems – each compactor and (set of recycling carts) are behind closed enclosures and each business has their own card swipe/key code to enter the enclosure and access the compactor hopper. Accessible 24 hours a day, 7 days a week. Compology is a camera system put into the compactor and dumpsters; use AI to identify contaminants and sends an alert when the compactor needs to be emptied. Pricing options: 1) Based on SF of building or on generation volume to share total cost; all charged a minimum fee, food service businesses generate more waste per SF so are charged more per SF than the office buildings (Ann Arbor, MI - *from interview with Ann Arbor Resource Recovery Manager*; Chapel Hill, NC); or 2) Invoices based on actual usage. Each business receives two free compactor uses per week. Each additional use costs $1.00. Recycling containers are free to use (Roanoke, VA).

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)
Required trash compactor services 7 days a week may increase costs to the users, but will reduce current issues of overfilling, vermin, and odors. In addition, the City can work with the compactor supplier, Contract Welding, to install a monitoring system in the compactors that would notify the hauler that the compactor is almost (typically 75-80% full) and requires a pickup. A type of Universal Recycling Ordinance that would require all commercial and larger multi-family properties to have recycling service, all food-oriented businesses to have compost collection service and subscribe to Saturday or Sunday trash and recycling collection service and, therefore, would increase diversion rates and reduce trash overfilling over the weekend. This type of ordinance could be funded through fees paid by each property and recycling containers could be free to use. The compactor fee structure will be based on either generation volume (high, medium low), type of business or on actual usage. Recycling containers could be free to use to incent recycling and/or support the mandatory recycling ordinance. For shared areas that show a projected volume of commercial cardboard that justify a compactor, the City could replace recycling carts with a cardboard or single-stream recycling compactor using the same type of card-access as the trash compactors. This is more common for private commercial or multi-family developments, but SOCRRA is willing to pilot it with the City and Car Trucking. The compactor would need to be inside an enclosed area and only accessible to approved users. The prepaid bag program option is worth considering for smaller businesses that are further away from the shared compacter and willing to pay the bag fee but would require the service provider to make additional stops.

[1] RRS understands that Ferndale sewers are part of a combined sewer system. These sewers flow to a central treatment facility and can overflow to rivers during heavy rains.

5. Waste Reduction Incentives and Mandatory Recycling Participation

Background on Ferndale Current Conditions

The City of Ferndale does not currently mandate the recycling of business (commercial) waste. As a member of SOCRRA, the City receives a credit for the sale of any recyclable material collected from residential and commercial sources against the total cost of waste management for the City, incentivizing an increased collection of recyclable materials. Businesses have reported a desire for additional recycling, viewing the City of Ferndale as an excellent environment to push for increased recycling and waste reduction. A lack of weekend collection has been reported as an issue as businesses and tenants within the CBD generate higher volumes of waste and recycling during their weekend operations. This requires many recycling carts to be made available to ensure businesses have the capacity and space to store materials. The City of Ferndale does not currently have programs in place that incentivize the reduction of waste generated by businesses.

Best Practices and Emerging Technology

- Universal Recycling Ordinance – Requires all commercial and larger multi-family properties to have recycling service and all food-oriented businesses to have compost collection service. Funded through fees paid by each property or recycling containers would be free to use. Additionally, require restaurants and bars to subscribe to Saturday or Sunday collection service (Austin, TX; Raleigh, NC; Ann Arbor, MI - *from interview with Ann Arbor Resource Recovery Manager*).
- Clean Community Fee – charge a flat, supplemental fee of $16.50 per month to downtown businesses to support waste reduction and diversion programs (Austin, TX).
- Glass bottle reduction program – Reduces cost of beer license when CBD bars and restaurants voluntarily switch from glass to cans and/or draft. Aimed at reducing health and safety concerns associated with broken glass (Athens-Clarke County, GA).
- Zero waste packaging ordinance for Expanded Polystyrene (EPS) and Plastic Bag Reduction – Requirement for all single-use food packaging used by licensed food establishments be recyclable or compostable (St. Louis Park, MO); Consumer has to pay $0.10 per disposable bag, $0.04 goes to retailer (has to display a sign, # of disposable bags provided, fees charged), $0.06 fee goes to City to fund the education, providing reusable bags, purchase and install collection containers, conduct cleanup events. All grocery stores must record the number of disposable bags provided and the total amount of fees charged on the customer transaction receipt. Six cents of each fee must be remitted to the City quarterly using a return form that is be mailed to each business (Boulder, CO)[2].
- Environmentally Preferable Purchasing (EPP) Policy to strongly demote the use of Expanded Polystyrene (EPS) – EPP policy promotes the procurement of "reusable, compostable, and recyclable" foodservice ware and office supplies in county offices. Purchasing departments were provided education on the program and county purchasing websites highlight/promote items that are reusable, compostable, and recyclable and demotes items such as EPS foodservice ware (Washtenaw County, MI).
- Green Business Recognition/ Zero Waste Business Award Program – businesses participate in program by submitting diversion rate data to City. Top performing businesses are provided recognition, including award/stickers to post in storefront and online recognition, trash service fee reduction/discounts (Boulder, CO; San Francisco, CA; Washtenaw County, MI).

[2] http://www.legislature.mi.gov/documents/2015-2016/publicact/pdf/2016-PA-0389.pdf

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)
High diversion rates of up to 90% are possible by incentivizing waste reduction programs including:

- The DDA may be interested in exploring using Business Improvement Zone (BIZ) options available to Michigan cities to supplement downtown services[3] that is similar to the $16.50 per month per business Clean Community Fee in Austin.
- Fees assessed by the City, allocating costs among all users that considers business type and service need (e.g., a restaurant will be charged a proportionally larger share of costs compared to a professional office).
- Mandating recyclable or compostable take-out containers.
- Providing recycling collection services on a 7-day schedule, with restaurants and bars required to subscribe to Saturday or Sunday collection service through the private hauler and implement mandated container sharing.
- Businesses who pay a fee for a program such as Clean Communities will be eligible to participate in a Zero Waste Award Program with the potential to receive reduced trash service fees. SOCRRA is interested in supporting a Zero Waste Award Program, maybe to pilot in Ferndale and roll out to other communities if successful and can partner with the City to provide educational materials but City staff will need to be the primary educator and contact with the businesses.

6. Public Space Collection Bins

Background on Ferndale Current Conditions
The City of Ferndale currently has seven public locations in the DDA, including parking lots, with double Big Belly units for trash and recycling. One unit is a high capacity/compacting, solar unit and the other six are standard bins. City of Ferndale DPW Sanitation staff manages the collection of material from Big Belly's as needed. The lease payment for the units is split between the parking fund and sanitation and the pilot program has 2 more years remaining. The cost to lease the units from the vendor is significant and the $/ton has yet to be calculated to determine the diversion and cost impacts of the units. Car Trucking picks up non-big belly sidewalk bins (60) once a week and the DDA is responsible for managing the bins the rest of the week. The DDA contracts with the City DPW to collect waste and recycling with a pickup truck as needed and the materials go into trash or recycling rolloff containers at City Hall that Car transports to SOCRRA, but the volume of recycling form this program has not yet been determined. The overall program for public space bins is not efficient and does not target recycling to its maximum potential.

Best Practices and Emerging Technology

- Big Belly trash (compacter)/recycling paired system – the units are located throughout the downtown with the high capacity/solar compacting trash bins to reduce the collection frequency; the units provide room for posters/messaging on all four sides (Raleigh, NC – *from interview with RRS staff*)
- Paired-Bin Public Space Collection – paired refuse and recycling bins are positioned in various downtown locations for public use. Like the Big Belly containers, space on the paired bin system containers can be utilized for educational or marketing materials. Total cost to the Town of Chapel Hill was approximately $20,000 with annual service cost of $1,770 paid to Orange County. Bin cost ranged from $950 - $1,800. (Orange County, NC – *from interview with Orange County Solid Waste Planner)*

[3] https://www.michiganbusiness.org/4ada83/globalassets/documents/reports/fact-sheets/businessimprovementdistrict.pdf

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)
Once the data for the current units are collected, and we are able to compare the efficiency of the compactor units against the units without the trash compacting, future diversion and costs estimates for Big Belly paired units with high capacity/solar compacting trash bins, or an alternative, can be established with a collection system that focuses on efficiency and increased recycling. Any trash bins should be paired with a recycling bin with clear signage and collection of the waste and recycling done by a single entity for increased oversight and tracking. The City could take advantage of the EGLE organics infrastructure grant (requires a 20% match) to cover the cost of new public space paired bins, possibly through a partnership with SOCRRA – several years ago, SOCRRA offered to cover half of the cost of public space bins to their community members.

7. Zero Waste Events

Background on Ferndale Current Conditions
The City of Ferndale does not currently have a zero-waste event program in place and is interested in implementing a program that assists event planners through some type of step-by-step guide and allocation of resources (e.g., staffing, bins, etc.) to set up recycling services for special events. Currently, Car Trucking can provide trash and recycling roll-offs as well as cleanup efforts, but often the roll-offs are too contaminated for SOCRRA to accept as recycling. Event planners sometimes utilize the shared downtown containers. If Car Trucking or other City-approved contractor is involved, the City director of special events would have access to the details of costs and volumes from the invoice sent to the City. SOCRRA is looking to have a point person with the City to be able to make the most out of what SOCRRA has to offer and also to improve communications and partnership opportunities.

Best Practices and Emerging Technology

- Zero Waste Event Program – Requirement for City-sponsored and City-permitted events to be zero waste. City-permitted events must provide recyclables and compostables collection in compliance with the City's special events permit requirements. City provides guidance on steps to set up waste management for event, how to set up bins, and how to contract with a City-approved hauler, etc. (Boulder, CO; Portland, OR).
- Zero Waste Washtenaw and Recycle Ann Arbor (RAA) – The program offers any combination of services based on specific event needs and County resource availability such as: Pre-event consultation, Vendor coordination and education, Volunteer coordination and training, Zero Waste Station lending, Allocation of Zero Waste Washtenaw staff, as needed, Ensured safe disposal of materials, Post-event Zero Waste Report and consultation. Event organizer pays for services, RAA/Washtenaw County can provide sort station and staffing, as needed. Washtenaw County received a grant from Michigan Department of Environmental Quality P2 grant project to get the program started. (Washtenaw County, MI)
- Special Event Cost Allocation – City passes all special event trash and recycling fees directly into that event plus a 15-20% markup to account for administrative costs. (Birmingham, MI – *from project kickoff meeting*)

Viable Options and Possible Impacts on Ferndale Future Conditions (e.g., diversion, operations, costs)
The City could partner with a recycling non-profit in the Ferndale area to build a similar program to the one on Washtenaw County. Once the program is initiated (e.g., RAA/Washtenaw County grant was $19,500) with toolkits, event bins/bags, signage, the program could divert up to 90% of event waste to recycling and composting. In a conversation with SOCRRA, SOCRRA could provide general best practices educational material and work with Car Trucking to support extra pick-ups but does not have the resources to support staffing services

for Zero Waste Events. The City staff would coordinate other community partners who volunteer their time to setup and staff the bins and assist the event organizer to establish collection of the material through a City-approved service provider. Cost of the recycling and composting collection would be the responsibility of the event organizer or the City could establish an ordinance for requirement of zero waste events with costs built into a permit process, or trash/recycling fees (see **Funding Options** below).

8. Funding Options

Background on Ferndale Current Conditions

The City of Ferndale Sanitation millage currently subsidizes business refuse and the City charges commercial businesses the total cost minus the millage and divides it among commercial and multifamily users, but still has a free rider problem since it is divided among the users of the system, not everyone. If the business contracts with a hauler other than Car Trucking, they are not part of the calculation, and there are no taxes that help overcome other costs. Car Trucking offers lower rates than others, but there is no ordinance requiring one hauler over another. The DDA TIF captures some of the Sanitation millage funds – estimated at $25-30K a year. The millage is based on a governmental fund (not enterprise fund) and is a little over 2mils. Currently the millage generates approximately $1.2 million because Michigan cities have been impacted heavily by Headlee rollback[4]. The City uses a special assessment formula to make up the difference between total costs and the Sanitation fund. The City would like to establish a fee or rate type structure with businesses that cover the actual costs for trash and recycling services and provide the appropriate incentives to increase diversion.

Best Practices and Emerging Technology

- An increase in millage and/or special assessment revenue could be used to fund expanded or added services, reduce service fees for commercial customers to balance costs and revenues by sector, and/or support increasing costs related to current services (e.g., recycling processing costs).
- Service fees through the City or franchised hauler based on the level of service selected by customers
- Flat rate trash and recycling fee for downtown businesses - All pay a flat Clean Community Fee and CBD Special Cleaning Service fee. Base rate + volume charge for trash service based on type of business or low, medium, high generator as determined by City. No additional charge for recycling. Business in the service district have access to single stream recycling and trash dumpsters in their alleys (Austin, TX)
- Funding for zero waste program, public space trash/recycling bins and shared downtown containers are funded through special permit/fee process or from a trash tax or Clean Community Fee. The trash tax is an occupation tax on trash haulers serving customers within the City limits and helps fund waste reduction efforts in Boulder. Most haulers pass the tax on to customers as part of their trash service bills. Boulder also has a waste hauling ordinance that applies to all haulers. $0.85 per cubic yard of trash for businesses and multifamily units that use centralized dumpsters. This rate also applies to roll-off containers (Boulder, CO).
- Grants may be available through the Michigan Department of Environment, Great Lakes, and Energy P2 grant project for implementing zero waste event guides, purchasing public space trash/recycling bins or shared downtown containers, organics collection pilot containers, providing educational outreach campaign (Recycle Ann Arbor - Washtenaw County, MI; Emmet County, MI; RRRASOC, MI)

[4] The Headlee Act requires a local unit of government to reduce its millage when annual growth on existing property values are greater than the rate of inflation.

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: LaReina Wheeler

SUBJECT: Approval to Purchase Dog Park Play Equipment from GameTime c/o Sinclair Recreation for Wilson Dog Park in the Amount of $6,500, the Expense be Charged to General Fund, Parks, Capital Outlay, Account Number 101-750-977-000, as Submitted by Parks & Recreation Director

INTRODUCTION
The Parks & Recreation Department manages Ferndale's Wilson Dog Park. Since the park was installed, there has been just one major upgrade: a new entry system in 2018. Over the last two years, the Parks and Recreation Commission (PARC) has engaged our residents in discussions and information gathering (via meetings and surveys) regarding upgrades to the dog park. From these engagements, they've identified a need for the addition of dog play equipment to facilitate more meaningful interactivity between pets (and people).

SUMMARY & BACKGROUND
The Wilson Dog Park was installed in 2016 and consists of large- and small-dog play areas, each with benches and dog waste stations, and a fountain in the common entryway. After gaining feedback from the community, the City's Parks and Recreation Commission (PARC) recommends the addition of dog play equipment to enhance the space and its social interactions. Play equipment will provide opportunities for dog agility training and make the park more appealing to prospective new members.

The Parks & Recreation Department has collected over $18,310 in membership fees over the last three years, which are used to fund programming (such as dog trainings, special events, etc.) and park improvements (such as shade areas, seating, and equipment). To obtain park membership, one must be a Ferndale resident, pay a $40 membership fee (comparable practice to other nearby cities, including Royal Oak, Pleasant Ridge, and Hazel Park), and complete a one-time, hour-long safety course covering proper etiquette, triggers, cautionary measures, and overall dog and owner safety. Based on a recent member survey, users enjoy having the dog park, feel safe while at the park, feel the dog safety course benefited their experience at the park, and are interested in additional educational classes.

The Department and PARC recommend purchasing dog park play equipment from GameTime c/o Sinclair Recreation. Doing so will provide benefits to current members, provide opportunities for the Department to host engaging programming, and attract prospective new members. Membership numbers were 105 in the launch year (2017), rose to 163 in 2018, and dipped a bit to 122 in 2019. Sinclair Recreation participates in the Cooperative Purchasing Program (Sourcewell), a system that allows Michigan cities, townships, villages, counties, school districts, universities, colleges, and nonprofit hospitals to buy pre-bid goods and services from state contracts at a discount. This program eliminates the need for organizations to process bids, as listed prices have already been competitively examined before listing.

BUDGETARY CONTEXT
Funding for improvements to the dog park was approved as part of the FYE2021 budget. Funding was based on the revenues collected from dog park membership fees. The dog park play equipment will be purchased from the General Fund, Parks, Capital Outlay, Account Number 101-750-977-000.

CIP#
N/A

ATTACHMENTS
Dog Park 2020 Survey Results.pdf

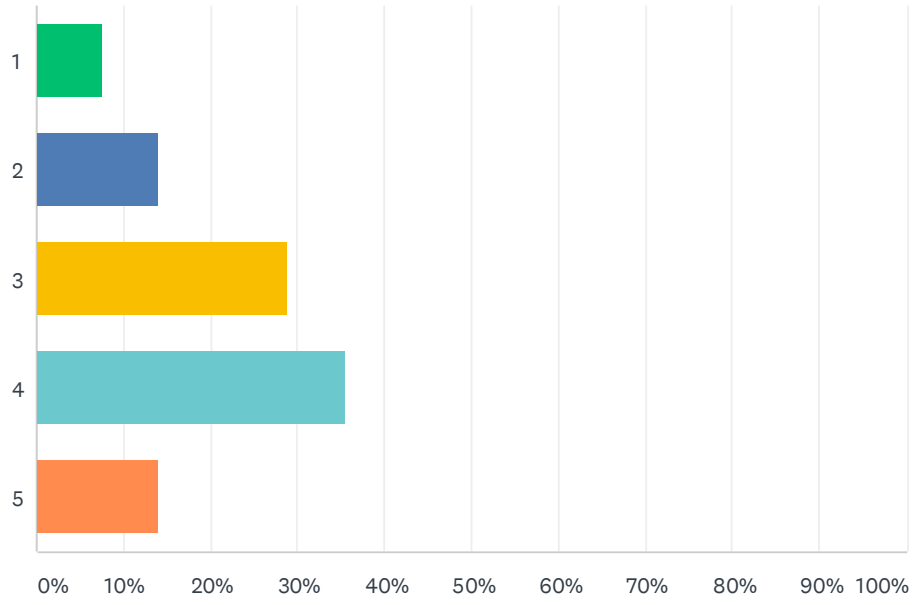
Equipment Quote 6.30.2020.pdf

STRATEGIC PLANNING CONTEXT
Healthy, Connected, and Invested Neighborhoods

RECOMMENDED ACTION
Approval to purchase dog park play equipment from GameTime c/o Sinclair Recreation for Wilson Dog Park in the amount of $6,500, the expense be charged to General Fund, Parks, Capital Outlay, Account Number 101-750-977-000, as submitted by Parks & Recreation Director.

Q1 On a scale between 1 and 5, 5 being the highest, how satisfied are you with the current size of the dog park?

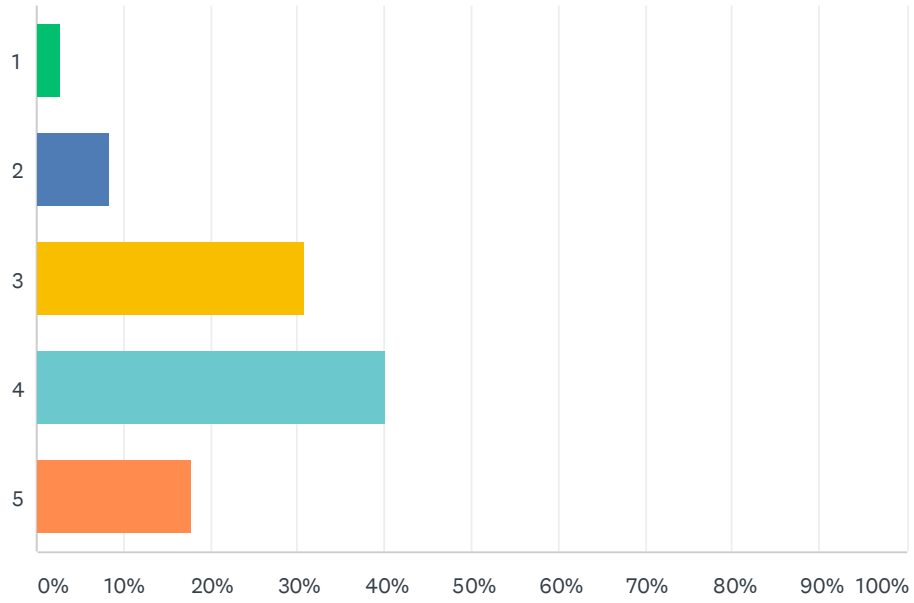
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	7.48%	8
2	14.02%	15
3	28.97%	31
4	35.51%	38
5	14.02%	15
TOTAL		107

Q2 On a scale between 1 and 5, 5 being the highest how satisfied are you with the maintenance and upkeep of the dog park?

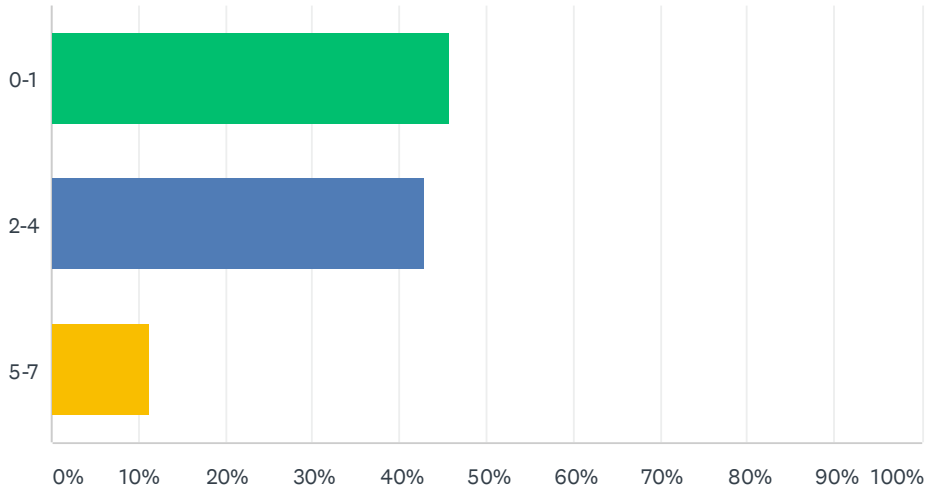
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	2.80%	3
2	8.41%	9
3	30.84%	33
4	40.19%	43
5	17.76%	19
TOTAL		107

Q3 How often do you use the dog park? 0-1 times a week, 2-4 times a week, 5-7 times a week.

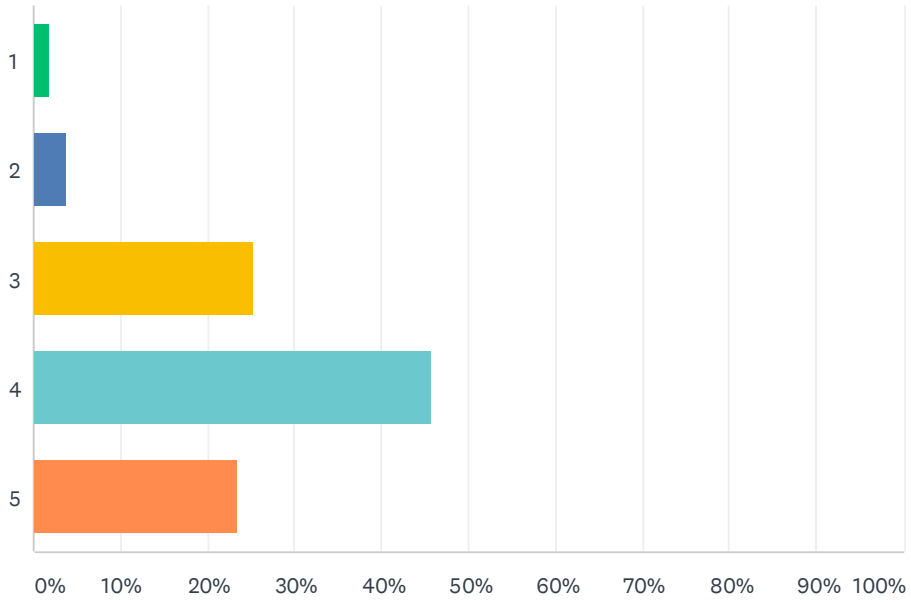
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
0-1	45.79%	49
2-4	42.99%	46
5-7	11.21%	12
TOTAL		107

Q4 As it relates to safety, on a scale between 1 and 5, 5 being the highest, how comfortable are you and your dog around other members and their dogs?

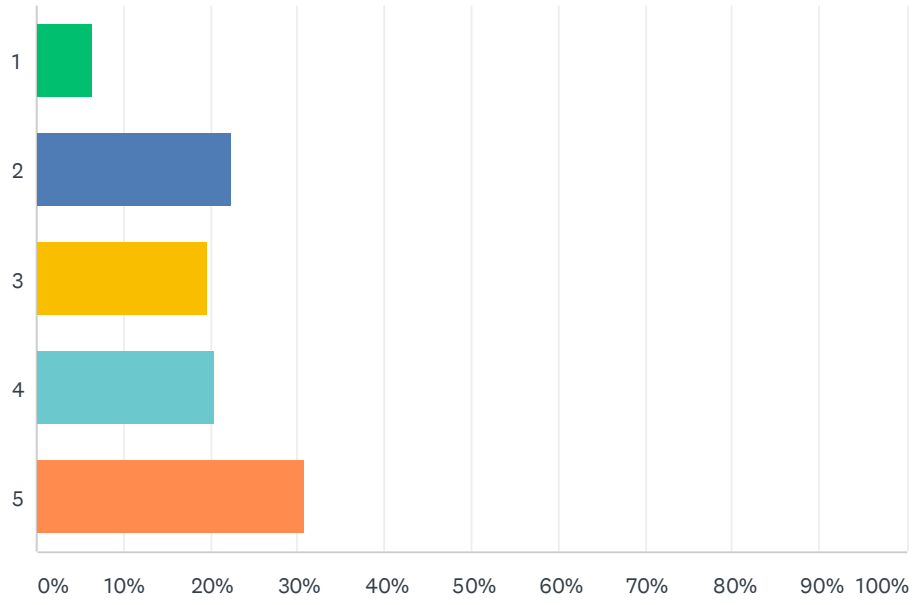
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	1.87%	2
2	3.74%	4
3	25.23%	27
4	45.79%	49
5	23.36%	25
TOTAL		107

Q5 On a scale between 1 and 5, 5 being the highest, how would you rank the need for additional security measures? (i.e. lighting, cameras, etc)

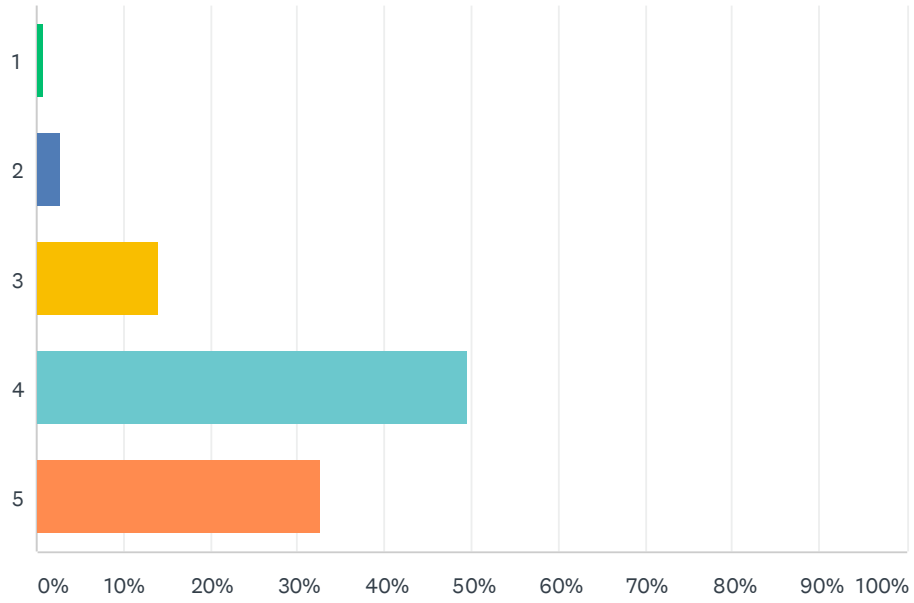
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	6.54%	7
2	22.43%	24
3	19.63%	21
4	20.56%	22
5	30.84%	33
TOTAL		107

Q6 On a scale between 1 and 5, 5 being the highest, how would you rank your interaction with other users at the dog park?

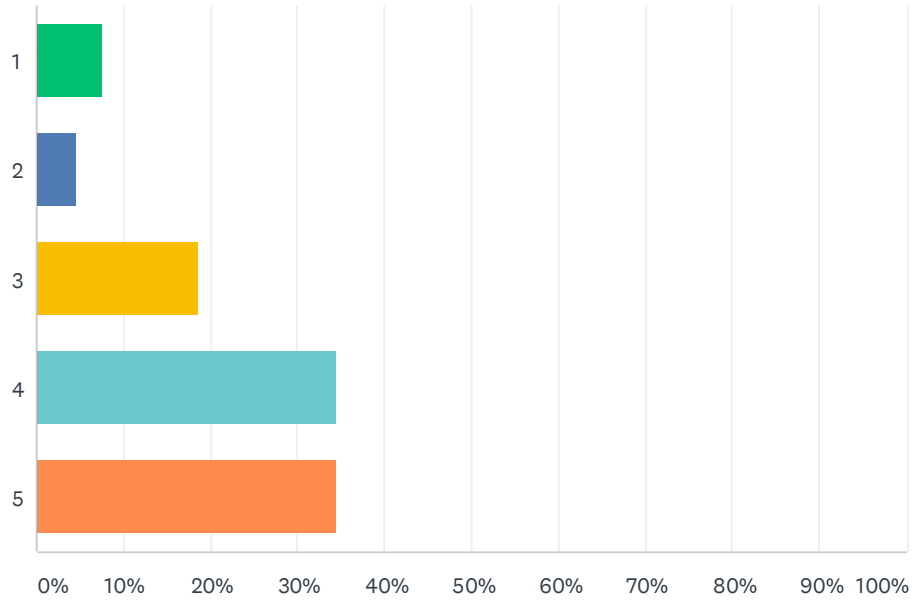
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	0.93%	1
2	2.80%	3
3	14.02%	15
4	49.53%	53
5	32.71%	35
TOTAL		107

Q7 On a scale of 1 and 5, 5 being the highest, how well do you feel our pre-membership class provides adequate education for our members?

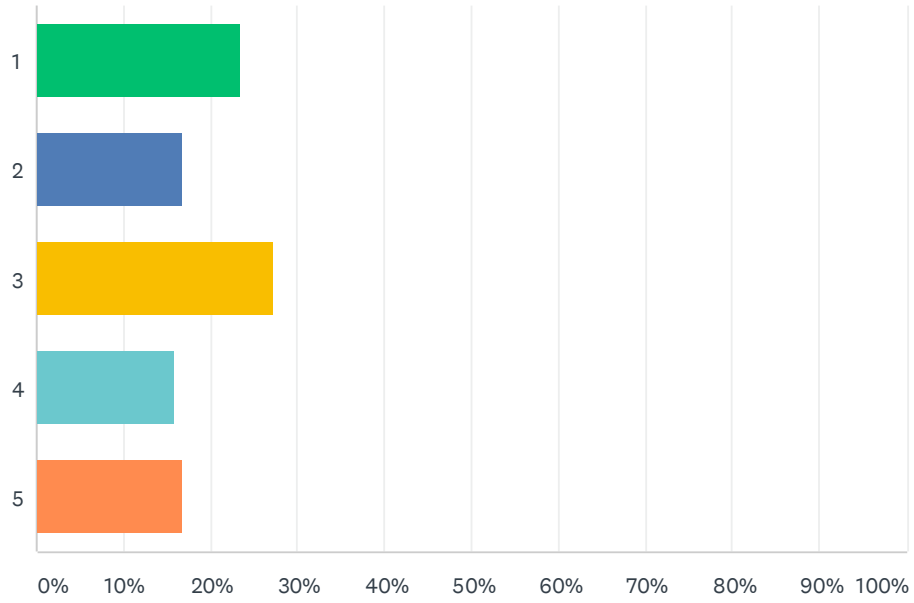
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	7.48%	8
2	4.67%	5
3	18.69%	20
4	34.58%	37
5	34.58%	37
TOTAL		107

Q8 On a scale between 1 and 5, 5 being the highest, would you like reoccurring, education driven classes provided to our members?

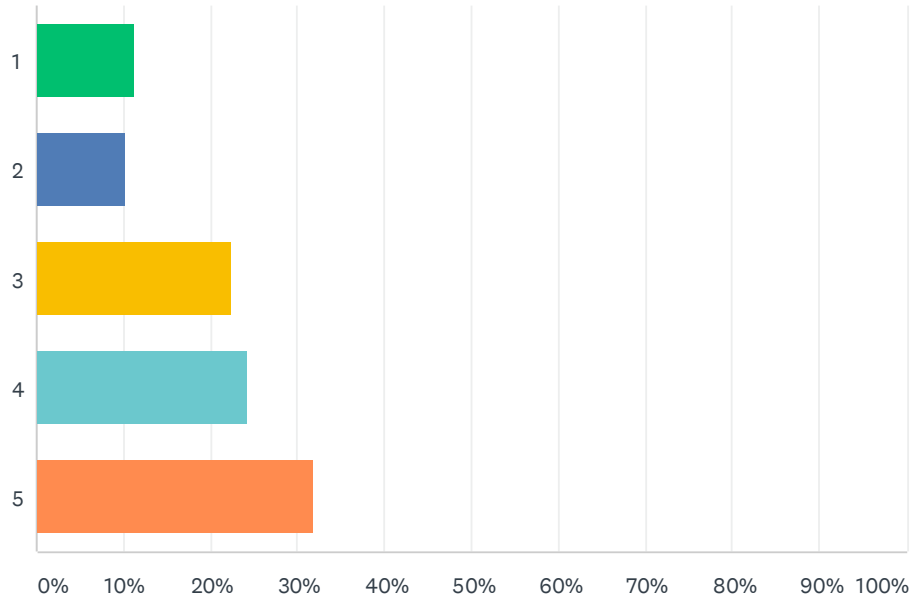
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	23.36%	25
2	16.82%	18
3	27.10%	29
4	15.89%	17
5	16.82%	18
TOTAL		107

Q9 On a scale between 1 and 5, 5 being the highest, do you feel our dog park class benefited your experience at our dog park?

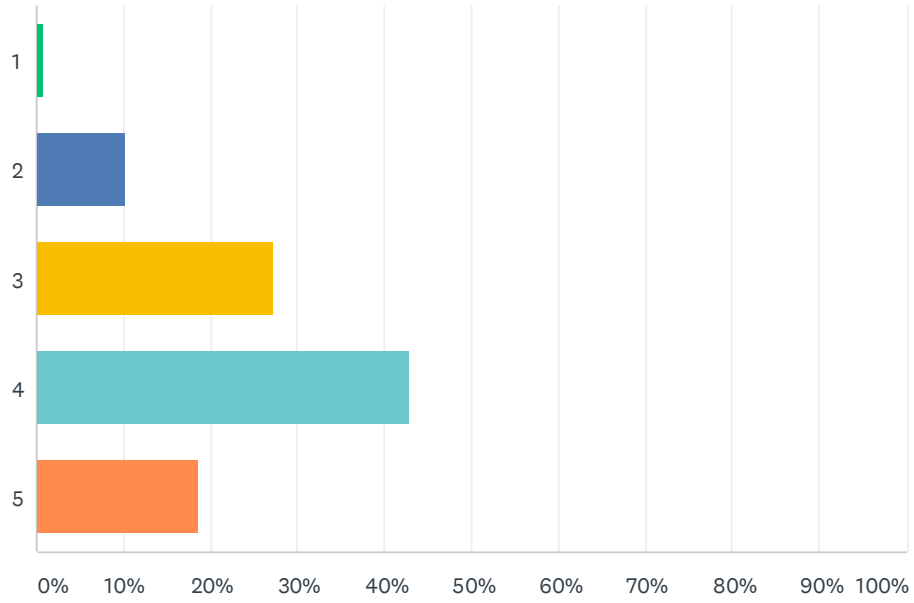
Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	11.21%	12
2	10.28%	11
3	22.43%	24
4	24.30%	26
5	31.78%	34
TOTAL		107

Q10 On a scale between 1 and 5, 5 being the highest, how satisfied are you overall with our dog park?

Answered: 107 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	0.93%	1
2	10.28%	11
3	27.10%	29
4	42.99%	46
5	18.69%	20
TOTAL		107

GameTime c/o Sinclair Recreation
PO Box 1409
Holland, MI 49422-1409
Ph: 800-444-4954
Fax: 616-392-8634

06/30/2020
Quote #100357-01-02

Bark Park-Revised

FERNDALE RECREATION DEPARTMENT
Attn: LaReina Wheeler
1201 LIVERNOIS ST.
FERNDALE, MI 48220
Phone: 248-544-6767 Ext. 501
Fax:248-544-6768
lwheeler@ferndalemi.gov

Ship to Zip 48220

Quantity	Part #	Description	Unit Price	Amount
1	PBARK-400	UltraSite - KING OF THE HILL, INGROUND	$2,900.00	$2,900.00
1	PBARK-450	UltraSite - ROVER JUMP OVER, INGROUND	$1,030.00	$1,030.00
1	PBARK-460	UltraSite - WEAVE POSTS, INGROUND	$1,017.00	$1,017.00
1	PBARK-462	UltraSite - ROOKIE WEAVE POSTS W/ALUMINUM UPRIGHTS, INGROUND	$618.00	$618.00
1	PBARK-470	UltraSite - STEPPING PAWS (Set of 5), INGROUND	$1,321.00	$1,321.00
1	PBARK-471	UltraSite - STEPPING PAWS (Set of 3), INGROUND	$786.00	$786.00
1	TBARK-431	UltraSite - HOOP JUMP - SMALL, INGROUND	$384.00	$384.00
			Sub Total	$8,056.00
			Discount	($2,014.00)
			Freight	$450.00
			Total	**$6,492.00**

This quotation is subject to policies in the current GameTime Playground Catalog and the following terms and conditions. Our quotation is based on shipment of all items at one time to a single destination, unless noted, and changes are subject to price adjustment. Purchases to be supported by your written purchase order made out to GAMETIME C/O SINCLAIR RECREATION.

NOTE: PRICING DOES NOT INCLUDE ANY DAVIS BACON OR PREVAILING WAGE RATES UNLESS SPECIFICIALLY IDENTIFIED ABOVE IN QUOTE.

Pricing: f.o.b. factory, firm for 30 days from date of quotation unless otherwise noted on quotation. Sales tax will be added at time of invoicing unless a tax exemption certificate is provided at time of order entry.

Payment terms: Net 30 days for tax supported governmental agencies. A 1.5% per month finance charge will be imposed on all past due accounts. Equipment shall be invoiced separately from other services and shall be payable in advance of those services and project completion. Retainage not accepted.

Exclusions: Unless specifically included, this quotation excludes all site work and landscaping; removal of existing equipment; acceptance of equipment and off-loading; storage of goods prior to installation; equipment assembly and installation; safety surfacing; borders and drainage provisions.

GameTime c/o Sinclair Recreation
PO Box 1409
Holland, MI 49422-1409
Ph: 800-444-4954
Fax: 616-392-8634

06/30/2020
Quote #100357-01-02

Bark Park-Revised

Acceptance of quotation:

Accepted By (printed): _____ P.O. No: _____

Please make P.O.s out to GameTime C/O Sinclair Recreation

Signature: _____

Title: _____ Date: _____

Facsimile: _____ Phone: _____

Email: _____ Purchase Amount: $6,492.00

REQUIRED ORDER INFORMATION:

Bill To: _____ Ship To: _____

Contact: _____ Contact: _____

Address: _____ Address: _____

Address: _____ Address: _____

City, State, Zip: _____ City, State, Zip: _____

Tel: _____ Tel: _____

(For Accounts Payable) (To call before delivery)

Email: _____ Email: _____

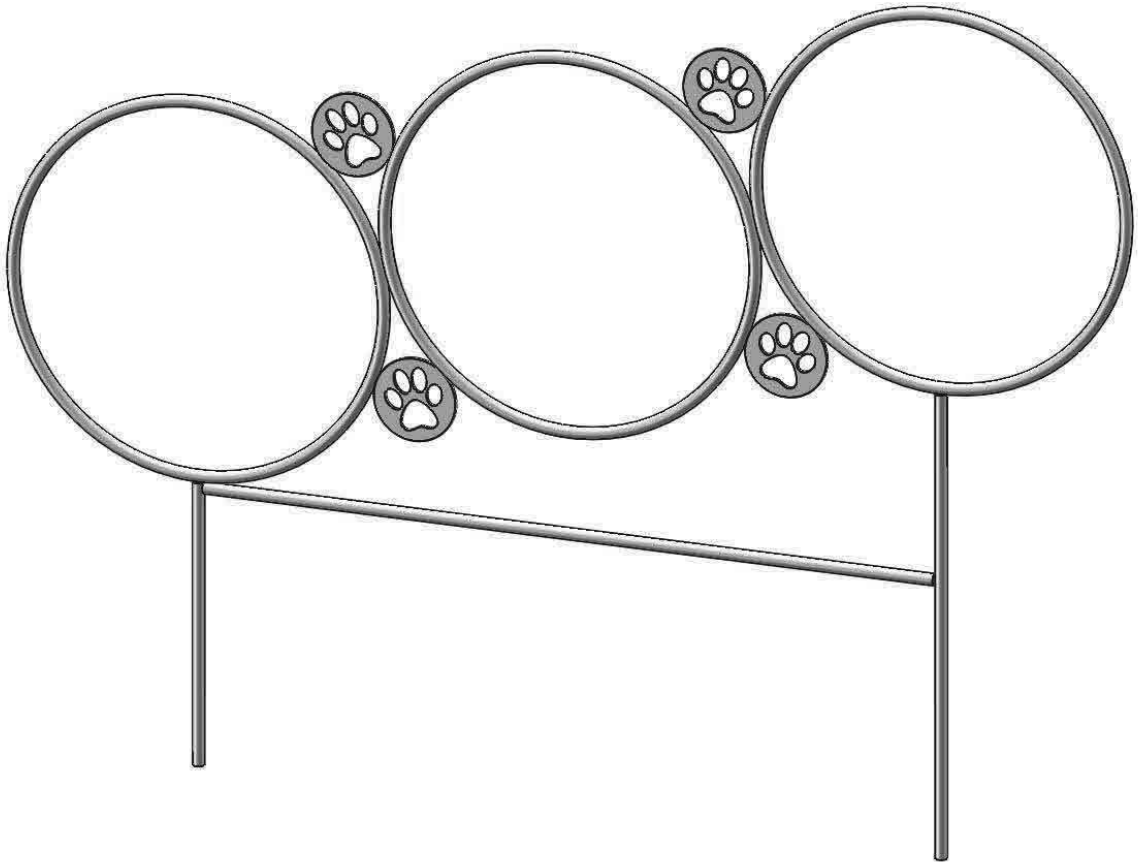
COLOR SELECTIONS: _____

SALES TAX EXEMPTION CERTIFICATE #: _____ (PLEASE PROVIDE A COPY OF CERTIFICATE)

NOTE: PRICING DOES NOT INCLUDE ANY DAVIS BACON OR PREVAILING WAGE RATES UNLESS SPECIFICALLY IDENTIFIED ABOVE IN QUOTE. IF INSTALLATION IS BEING QUOTED, THERE WILL BE A BACKCHARGE FOR THE INSTALLATION TO BE DONE THROUGH FELT, PEASTONE, SURFACING, OR WOODCHIPS. PRICING VALID FOR 30 DAYS FROM THE DATE OF QUOTATION UNLESS OTHERWISE NOTED.

barkpark™

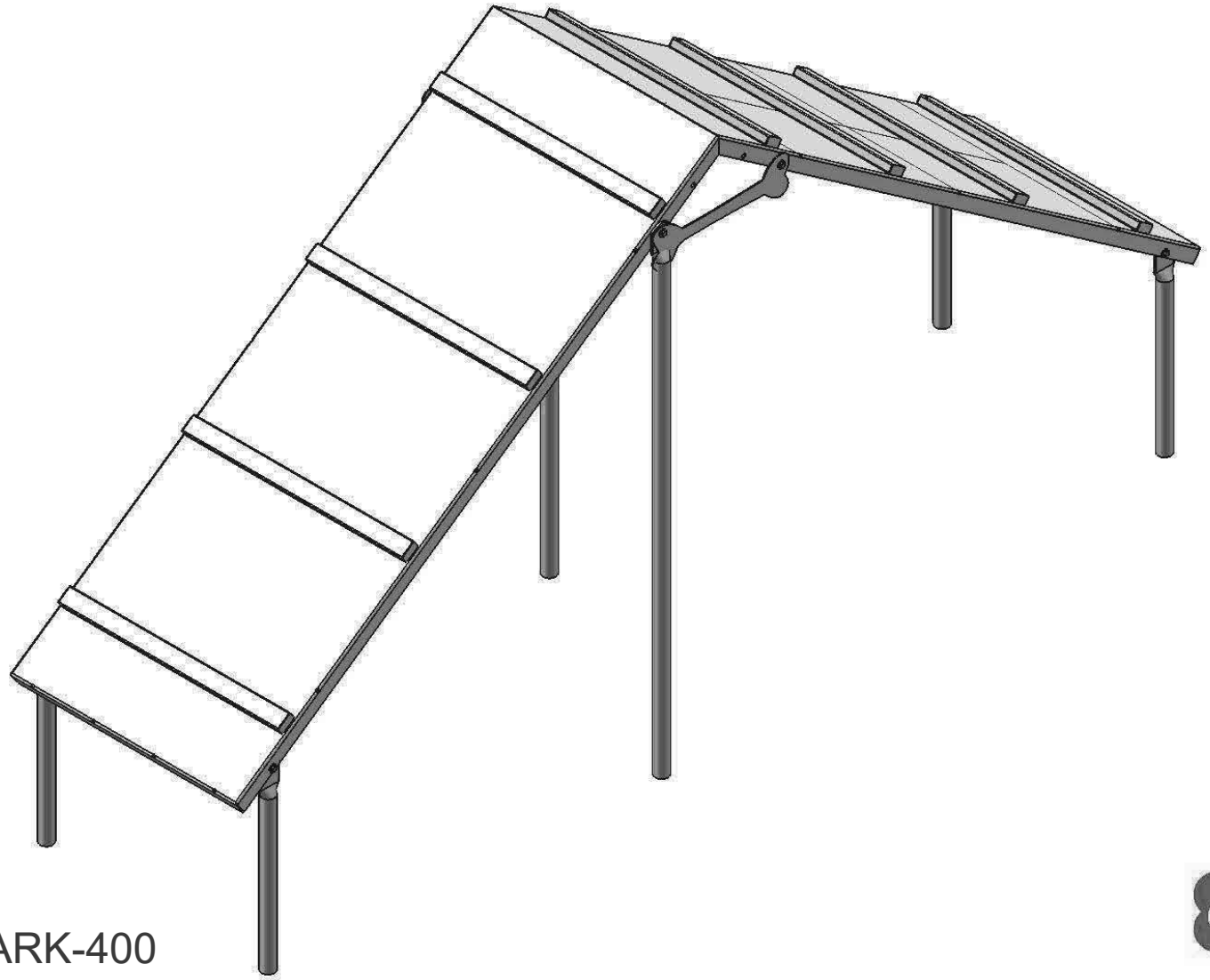
A PLAYCORE Company



Model # BARK-431

barkpark™

A PLAYCORE Company

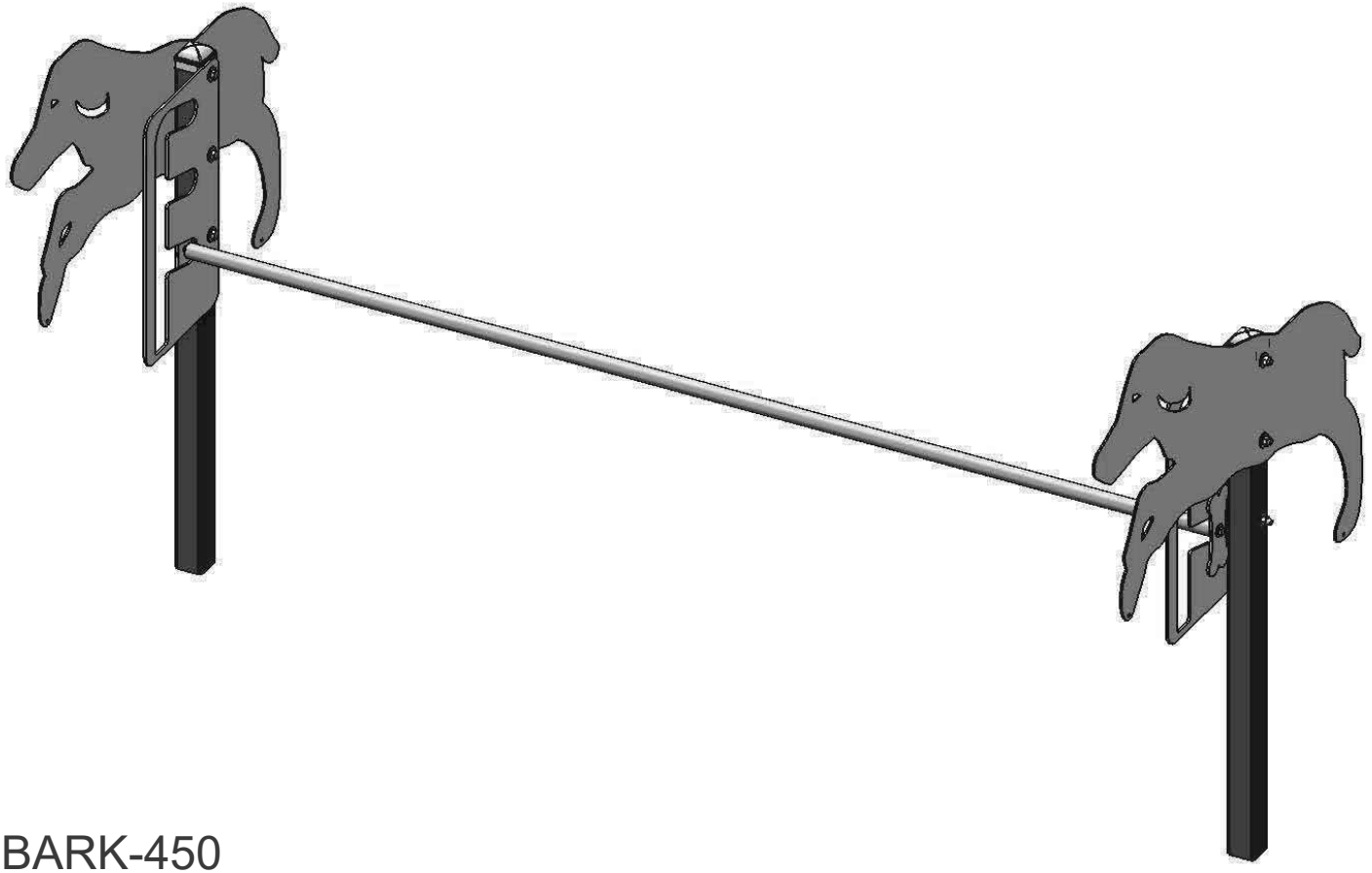


Model # BARK-400

canine coat™

barkpark™

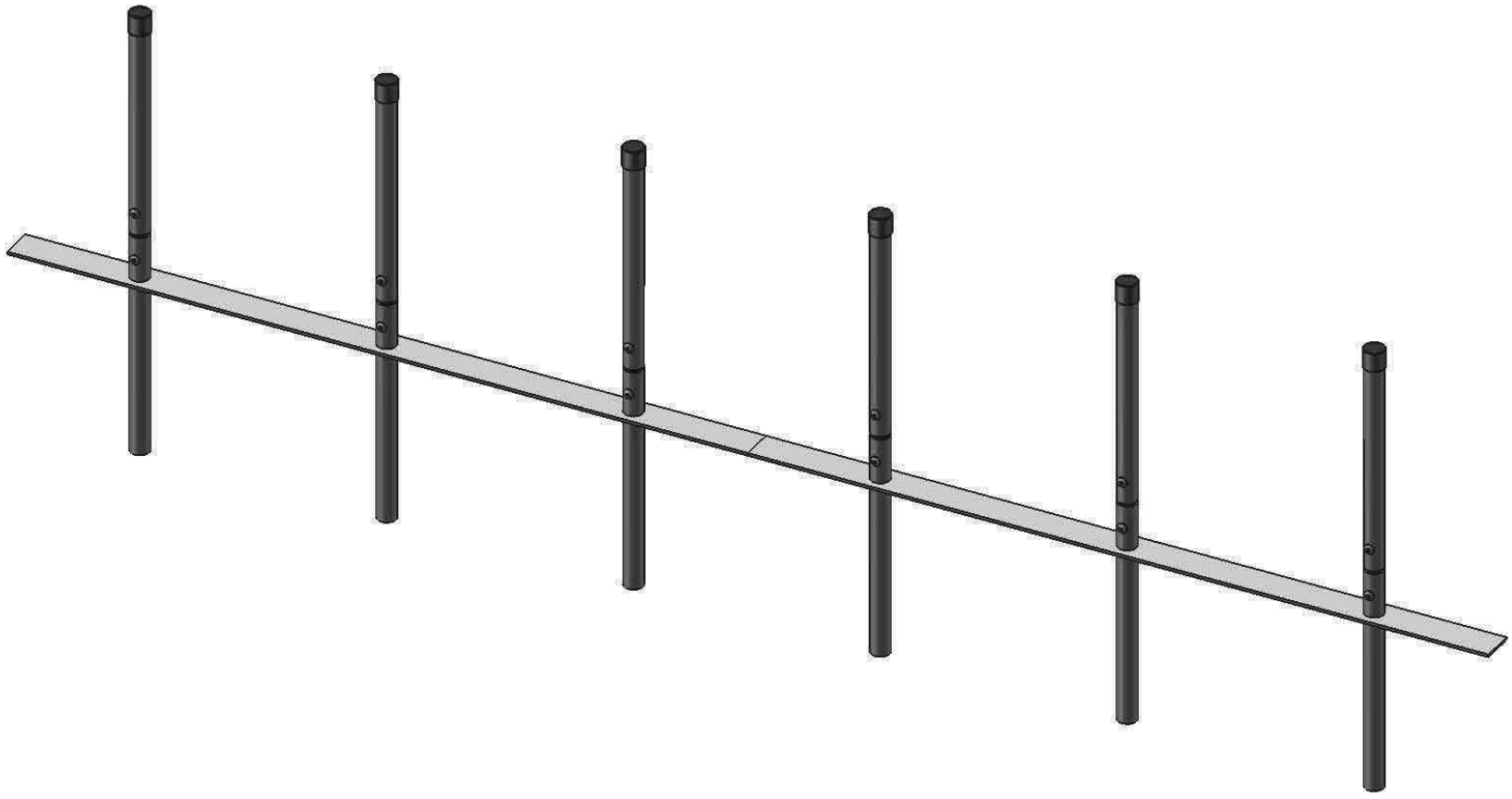
A PLAYCORE Company



Model # BARK-450

barkpark™

A PLAYCORE Company



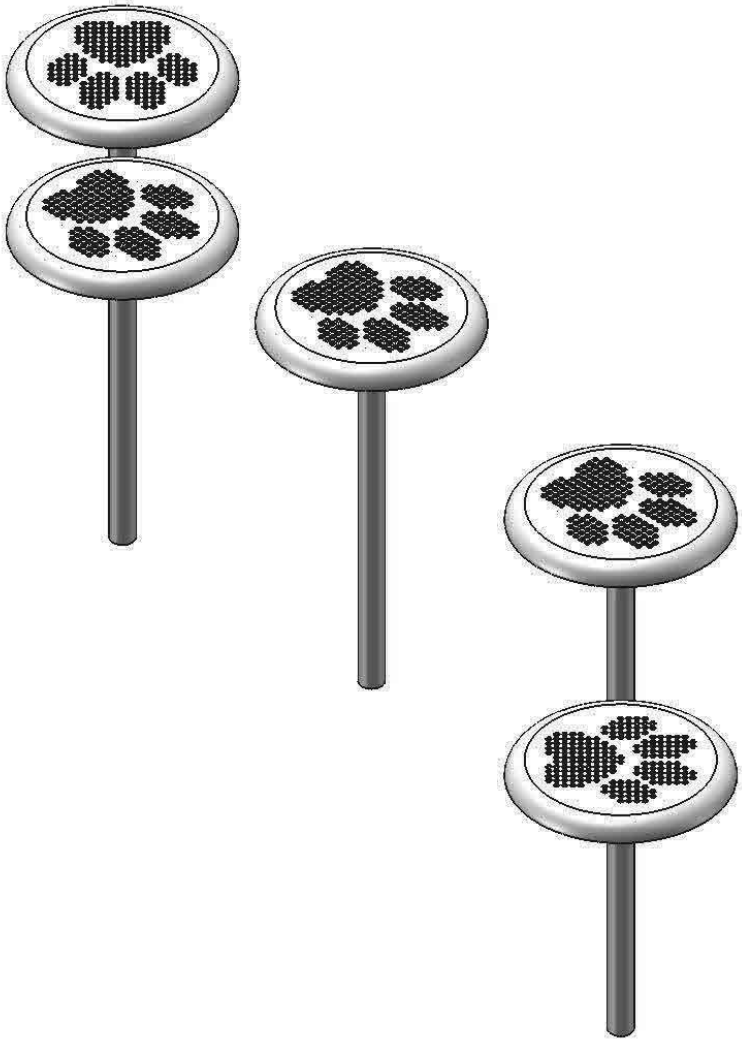
Model # BARK-460



Model # BARK-462

barkpark™

A PLAYCORE Company

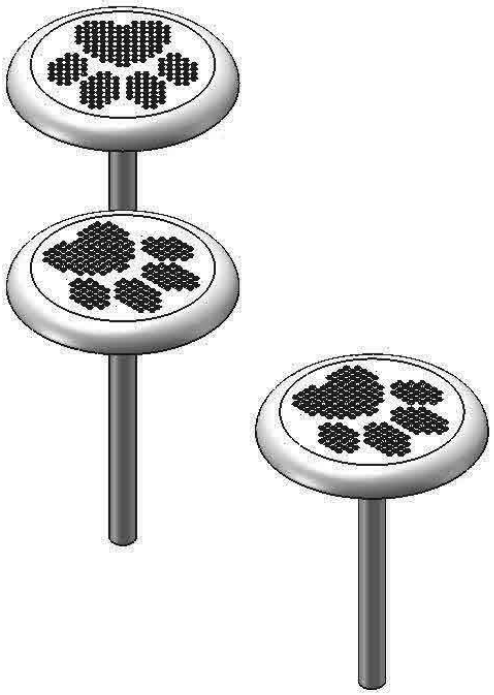


canine coat™

Model # BARK-470

barkpark™

A PLAYCORE Company



Model # BARK-471

FERNDALE

July 13, 2020 Fire Department

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Jack Pesha

SUBJECT: Approval to Renew Membership by Paying Annual Dues to OAKWAY Mutual Aid Group in the amount of $5000.00 from account 101-336-873.000 Memberships and Dues, as Submitted by the Fire Chief

INTRODUCTION
Ferndale Fire Department belongs to the OAKWAY Mutual Aid Group, a collective between ten Oakland County fire departments: Ferndale, Royal Oak, Madison Heights, Birmingham, Southfield, Bloomfield Township, West Bloomfield, Waterford-Pontiac, Rochester Hills, and Farmington Hills. The group offers critical mutual aid service in fire and EMS calls, training, technical rescue, hazmat, and other special teams, ensuring that necessary coverage of emergencies within our ten cities are met.

SUMMARY & BACKGROUND
Ferndale Fire Department belongs to the OAKWAY Mutual Aid Group, a collective between ten Oakland County fire departments: Ferndale, Royal Oak, Madison Heights, Birmingham, Southfield, Bloomfield Township, West Bloomfield, Waterford-Pontiac, Rochester Hills, and Farmington Hills. The group offers critical mutual aid service in fire and EMS calls, training, technical rescue, hazmat, and other special teams, ensuring that necessary coverage of emergencies within our ten cities are met.

OAKWAY, named for Oakland and Wayne Counties (Wayne County was a part of the group at its forming but left some years ago), also offers several other benefits including HazMat, Tech Rescue, EMS, critical incident stress debriefing, and discounted professional training. OAKWAY also has its own Mi-MABAS (Michigan Mutual Aid Box Alarm System) number, allowing the group to be called upon to provide assistance in the event of a large-scale situation or emergency within the State by outside our region; likewise if a large-scale event happens in our district, the favor is returned by other regions in the State. Annual membership dues of $5,000 are required by each department.

BUDGETARY CONTEXT
$5,000.00 to be paid from account 101-336-818.000 Membership & Dues.

CIP#
N/A

ATTACHMENTS
OAKWAY Dues 2020.docx

STRATEGIC PLANNING CONTEXT
Strong Regional Partnerships

RECOMMENDED ACTION

Approve membership renewal by paying OAKWAY Mutual Aid Group annual dues in the amount of $5000.00 from account 101-336-873.000 Memberships and Dues, as submitted by the Fire Chief.

OAKWAY MUTUAL AID ASSOCIATION

INVOICE

OAKWAY Mutual Aid Association
Attn: Chief Paul A. Wells
572 S Adams
Birmingham, MI 48009

DATE: JULY 1, 2020

TO Ferndale Fire Department
1070 E. Nine Mile Rd.
Ferndale, MI 48220

SALESPERSON	JOB	PAYMENT TERMS	DUE DATE

QTY	DESCRIPTION	UNIT PRICE	LINE TOTAL
1	2020 Membership Dues	$5,000	$5,000
		SUBTOTAL	$5,000
		SALES TAX	
		TOTAL	$5,000

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Marne McGrath

SUBJECT: Approval of Election Services Agreement with Oakland County to Process Ferndale's AV Ballots, Authorization for the City Clerk to Execute the Agreement, and approval to designate City Clerk McGrath and Deputy Clerk MIller as representatives to act as a primary and secondary Points of Contact with County, as Submitted by City Clerk

INTRODUCTION
Public Act 95 of 2020 was approved by the Governor on June 23, 2020. This new legislation allows municipalities to partner with the County to provide Absentee Voter Counting Board (AVCB) services for municipalities that opt in. At this time, the County anticipates providing this service at no cost to communities. The City won't pay for AVCB precinct inspectors, tabulation services, or rent for the facility, which presents a potentially valuable cost savings.

SUMMARY & BACKGROUND
The prospective partnership with Oakland County for shared Absentee Voter Counting Board (ACVB) services presents several key benefits, and it is mu recommendation that Ferndale participate.

HOW IT WORKS
1. On the day before each election, Oakland County will pick up and securely transfer all returned AV (absentee voter) ballots for processing in one location by the County on Election Day.
2. All ballots received after this will be taken to Ferndale's precincts by specially designated inspectors in batches throughout Election Day. They will be securely tabulated on site.
3. All AV ballots will be accounted for by precinct inspectors, via the end-of-night ballot summary, and finally by a Receiving Board review. =

WHY IT'S VALUABLE
Absentee Voter Counting Boards have traditionally been conducted onsite at City Hall, with the City Clerk's staff splitting time between assisting them and the other nine precincts. With more people voting AV, the Clerk's staff devotes a huge amount of time assisting same-day AV voters on Election Day. Taking AVCBs offsite will allow staff to devote their time and efforts to assisting precincts and serving same-day voters.

The executed agreement needs to be returned to Oakland County via email on July 13 to be eligible for the August 4 Primary, so as soon as this item is approved the Clerk will sign it and forward it to the County. The Clerk administration will serve as the two designated representatives to act as a primary (McGrath) and secondary (MIller) Points of Contact with County to direct coordination and interaction with County staff and communication with the general public when appropriate.

BUDGETARY CONTEXT

FERNDALE

July 13, 2020

City Clerk

N/A

CIP#

ATTACHMENTS
2020 07 13 Interlocal Agreement Election Services

STRATEGIC PLANNING CONTEXT
Organizational and Financial Excellence

RECOMMENDED ACTION
Approval of Election Services Agreement with Oakland County to Process Ferndale's AV Ballots, Authorization for the City Clerk to Execute the Agreement, and approval to designate City Clerk McGrath and Deputy Clerk MIller as representatives to act as a primary and secondary Points of Contact with County, as Submitted by City Clerk

AGREEMENT FOR ELECTION SERVICES BETWEEN
OAKLAND COUNTY AND
CITY OF FERNDALE

This Agreement for Election Services Agreement (the "Agreement") is made between Oakland County, a Municipal and Constitutional Corporation, 1200 North Telegraph Road, Pontiac, Michigan 48341 ("County"), and the City of Ferndale ("Public Body") 300 East Nine Mile Road, Ferndale, MI 48220. In this Agreement, the County shall be represented by the Oakland County Clerk, in her official capacity as a Michigan Constitutional Officer. County and Public Body may be referred to individually as a "Party" and jointly as "Parties".

PURPOSE OF AGREEMENT. County and Public Body enter into this Agreement pursuant to the Michigan Election Law, 1954 Public Act 116, MCL 168.764 *et seq.*, for the purpose of County providing Ballot Counting Services for Public Body.

In consideration of the mutual promises, obligations, representations, and assurances in this Agreement, the Parties agree to the following:

1. **DEFINITIONS**. The following words and expressions used throughout this Agreement, whether used in the singular or plural, shall be defined, read, and interpreted as follows:

   1.1. **Act** means the Michigan Election Law, 1954 Public Act 116, MCL 168.764 *et seq.*

   1.1. **Agreement** means the terms and conditions of this Agreement and any other mutually agreed to written and executed modification, amendment, Exhibit and attachment to this Agreement.

   1.2. **Claims** mean any alleged losses, claims, complaints, demands for relief or damages, lawsuits, causes of action, proceedings, judgments, deficiencies, liabilities, penalties, litigation, costs, and expenses, including, but not limited to, reimbursement for reasonable attorney fees, witness fees, court costs, investigation expenses, litigation expenses, amounts paid in settlement, and/or other amounts or liabilities of any kind which are incurred by or asserted against County or Public Body, or for which County or Public Body may become legally and/or contractually obligated to pay or defend against, whether direct, indirect or consequential, whether based upon any alleged violation of the federal or the state constitution, any federal or state statute, rule, regulation, or any alleged violation of federal or state common law, whether any such claims are brought in law or equity, tort, contract, or otherwise, and/or whether commenced or threatened.

   1.3. **Confidential Information** means all information and data that County is required or permitted by law to keep confidential, including records of County's security measures, security plans, security codes and combinations, passwords, keys, and security procedures, to the extent that the records relate to ongoing security of County as well as records or information to protect the security or safety of persons or property, whether public or private, including, but not limited to, building, public works, and public water supply designs relating to ongoing security measures, capabilities and plans for responding to violations of the Michigan Anti-terrorism Act, emergency response plans, risk planning documents, threat assessments and domestic preparedness strategies.

   1.4. **County** means Oakland County, a Municipal and Constitutional Corporation, including, but not limited to, all of its departments, divisions, the County Board of Commissioners,

elected and appointed officials, directors, board members, council members, commissioners, authorities, committees, employees, agents, volunteers, and/or any such persons' successors.

1.5. **Day** means any calendar day beginning at 12:00 a.m. and ending at 11:59 p.m.

1.6. **Election Services** means the following individual Election Services provided by County's Clerk's Elections Division, if applicable:

1.6.1. **Absentee Ballot Counting** means processing, including, but not limited to, opening, tabulating and reporting absentee ballots and related results.

1.7. **Exhibits** mean the following descriptions of Election Services which are governed by this Agreement only if they are attached to this Agreement and incorporated in this Agreement under Section 2 or added at a later date by a formal amendment to this Agreement:

☐ Exhibit I: Absentee Ballot Counting Services

1.8 **Local Clerk** means the local elected or appointed Clerk for Public Body or their designee.

1.8. **Public Body** means the City of Ferndale which is an entity created by state or local authority or which is primarily funded by or through state or local authority, including, but not limited to, its council, Board, departments, divisions, elected and appointed officials, directors, board members, council members, commissioners, authorities, committees, employees, agents, subcontractors, attorneys, volunteers, and/or any such persons' successors. For purposes of this Agreement, Public Body includes any Michigan court, when acting in concert with its funding unit, to obtain Election Services.

1.9. **Public Body Employee** means any employees, officers, directors, members, managers, trustees, volunteers, attorneys, representatives of Public Body, licensees, concessionaires, contractors, subcontractors, independent contractors, agents, and/or any such persons' successors or predecessors (whether such persons act or acted in their personal, representative or official capacities), and/or any persons acting by, through, under, or in concert with any of the above who use or have access to the Election Services provided under this Agreement. "Public Body Employee" shall also include any person who was a Public Body Employee at any time during the term of this Agreement but, for any reason, is no longer employed, appointed, or elected in that capacity.

1.10. **Points of Contact** mean the individuals designated by Public Body and identified to County to act as primary and secondary contacts for communication and other purposes as described herein.

2. COUNTY RESPONSIBILITIES.

2.1. County, through its County Clerk Elections Division, will provide the Election Services described in Exhibit I which is attached and incorporated into this Agreement. County is not obligated or required to provide any additional services that are not specified in this Agreement.

2.2. County, through its Board of Election Commissioners and authorized representatives, shall take the necessary and appropriate actions to comply with Section 764d(8) of the Act in the appointment of election inspectors to a County absent voter counting board and all other provisions under the Act governing such board.

2.3. County may access, use, and disclose transaction information and any content to comply with the law such as a subpoena, court order or Freedom of Information Act request. County shall first refer all such requests for information to Public Body's Points of Contact for their response within the required time frame. County shall provide assistance for the response if requested by Public Body's Points of Contact, and if able to access the requested information. County shall not distribute Public Body's data to other entities for reasons other than when it is required by law.

3. PUBLIC BODY RESPONSIBILITIES.

3.1. Public Body shall comply with all terms and conditions in this Agreement, including Exhibit I to this Agreement, and the Act.

3.2. Public Body shall deliver the Agreement executed by its authorized representative(s) to County within the time-frame set forth in Section 764d(5) of the Act and, upon County's execution of the Agreement, the Agreement shall be deemed to be filed by Public Body with County in compliance with Section 764d(5) of the Act.

3.3. For each Election Service covered by an Exhibit to this Agreement, Public Body shall designate two representatives to act as a primary and secondary Points of Contact with County. The Points of Contact responsibilities shall include:

3.3.1. Direct coordination and interaction with County staff.

3.3.2. Communication with the general public when appropriate.

3.4. Public Body shall respond to and be responsible for Freedom of Information Act requests relating to Public Body's records, data, or other information.

3.5. Third-party product or service providers may require County to pass through to Public Body certain terms and conditions contained in license agreements, service agreements, acceptable use policies and similar terms of service or usage, in order to provide Election Services to Public Body. Public Body agrees to comply with these terms and conditions. Public Body must follow the termination provisions of this Agreement if it determines that it cannot comply with any of the terms and conditions.

4. DURATION OF INTERLOCAL AGREEMENT.

4.1. This Agreement and any amendments shall be effective when executed by both Parties with resolutions passed by the governing bodies of each Party or other written notice evidencing such Party's governing body's approval, except as otherwise specified below. The approval and terms of this Agreement and any amendments, except as specified below, shall be entered in the official minutes of the governing bodies of each Party. An executed copy of this Agreement and any amendments shall be filed by the County Clerk with the Secretary of State. If Public Body is a court, a signature from the Chief Judge of the court shall evidence approval by Public Body, providing a resolution and minutes do not apply. If Public Body is the State of Michigan, approval and signature shall be as provided by law.

4.2. Notwithstanding Section 4.1, the Chairperson of the Oakland County Board of Commissioners is authorized to sign amendments to the Agreement to add Exhibits that were previously approved by the Board of Commissioners. An amendment signed by the Board Chairperson under this Section must be sent to the Elections Division in the County Clerk's Office to be filed with the Agreement once it is signed by both Parties.

4.3. Unless extended by an amendment, this Agreement shall remain in effect until cancelled or terminated by any of the Parties pursuant to the terms of the Agreement.

5. **PAYMENTS**.

5.1. Election Services shall be provided to Public Body at the rates and for the charges specified in the Exhibits, if applicable.

5.2. If County is legally obligated for any reason, e.g. subpoena, court order, or Freedom of Information Request, to search for, identify, produce or testify regarding Public Body's records, data, or information that is stored by County relating to Election Services that Public Body receives under this Agreement, then Public Body shall reimburse County for all reasonable costs County incurs in searching for, identifying, producing or testifying regarding such records, data, or information. County may waive this requirement in its sole discretion.

5.3. County shall provide Public Body with an invoice/explanation of County's costs for Election Services provided herein and/or a statement describing any amounts owed to County. Public Body shall pay the full amount shown on any such invoice within sixty (60) calendar days after the date shown on any such invoice. Payment shall be sent along with a copy of the invoice to: Oakland County Treasurer – Cash Acctg, Bldg 12 E, 1200 N. Telegraph Road, Pontiac, MI 48341.

5.4. If Public Body, for any reason, fails to pay County any monies when and as due under this Agreement, Public Body agrees that unless expressly prohibited by law, County or the Oakland County Treasurer, at their sole option, shall be entitled to set off from any other Public Body funds that are in County's possession for any reason, including but not limited to, the Oakland County Delinquent Tax Revolving Fund ("DTRF"), if applicable. Any setoff or retention of funds by County shall be deemed a voluntary assignment of the amount by Public Body to County. Public Body waives any Claims against County or its Officials for any acts related specifically to County's offsetting or retaining of such amounts. This paragraph shall not limit Public Body's legal right to dispute whether the underlying amount retained by County was actually due and owing under this Agreement.

5.5. If County chooses not to exercise its right to setoff or if any setoff is insufficient to fully pay County any amounts due and owing County under this Agreement, County shall have the right to charge up to the then-maximum legal interest on any unpaid amount. Interest charges shall be in addition to any other amounts due to County under this Agreement. Interest charges shall be calculated using the daily unpaid balance method and accumulate until all outstanding amounts and accumulated interest are fully paid.

5.6. Nothing in this Section shall operate to limit County's right to pursue or exercise any other legal rights or remedies under this Agreement or at law against Public Body to secure payment of amounts due to County under this Agreement. The remedies in this Section shall be available to County on an ongoing and successive basis if Public Body becomes delinquent in its payment. Notwithstanding any other term and condition in this Agreement, if County pursues any legal action in any court to secure its payment under this Agreement, Public Body agrees to pay all costs and expenses, including attorney fees and court costs, incurred by County in the collection of any amount owed by Public Body.

5.7. Either Party's decision to terminate and/or cancel this Agreement, or any one or more of the individual Election Services identified herein, shall not relieve Public Body of any payment obligation for any Election Services rendered prior to the effective date of any termination or cancellation of this Agreement. The provisions of this Section shall survive the termination, cancellation, and/or expiration of this Agreement.

6. **ASSURANCES**.

6.1. **Responsibility for Claims.** Each Party shall be responsible for any Claims made against that Party by a third party, and for the acts of its employees arising under or related to this Agreement.

6.2. **Responsibility for Attorney Fees and Costs.** Except as provided for in Section 5.6, in any Claim that may arise from the performance of this Agreement, each Party shall seek its own legal representation and bear the costs associated with such representation, including judgments and attorney fees.

6.3. **No Indemnification.** Except as otherwise provided for in this Agreement, neither Party shall have any right under this Agreement or under any other legal principle to be indemnified or reimbursed by the other Party or any of its agents in connection with any Claim.

6.4. **Costs, Fines, and Fees for Noncompliance.** Public Body shall be solely responsible for all costs, fines and fees associated with any misuse of the Election Services and/or for noncompliance with this Agreement by Pubic Body Employees.

6.5. **Reservation of Rights.** This Agreement does not, and is not intended to, impair, divest, delegate or contravene any constitutional, statutory, and/or other legal right, privilege, power, obligation, duty, or immunity of the Parties. Nothing in this Agreement shall be construed as a waiver of governmental immunity for either Party.

6.6. **Authorization and Completion of Agreement.** The Parties have taken all actions and secured all approvals necessary to authorize and complete this Agreement. The persons signing this Agreement on behalf of each Party have legal authority to sign this Agreement and bind the Parties to the terms and conditions contained herein.

6.7. **Compliance with Laws.** Each Party shall comply with all federal, state, and local ordinances, regulations, administrative rules, and requirements applicable to its activities performed under this Agreement.

7. USE OF CONFIDENTIAL INFORMATION

7.1. The Parties shall not reproduce, provide, disclose, or give access to Confidential Information to County or to a Public Body Employee not having a legitimate need to know the Confidential Information, or to any third-party. County and Public Body Employees shall only use the Confidential Information for performance of this Agreement. Notwithstanding the foregoing, the Parties may disclose the Confidential Information if required by law, statute, or other legal process provided that the Party required to disclose the information: (i) provides prompt written notice of the impending disclosure to the other Party, (ii) provides reasonable assistance in opposing or limiting the disclosure, and (iii) makes only such disclosure as is compelled or required. This Agreement imposes no obligation upon the Parties with respect to any Confidential Information when it can established by legally sufficient evidence that the Confidential Information: (i) was in possession of or was known by prior to its receipt from the other Party, without any obligation to maintain its confidentiality; or (ii) was obtained from a third party having the right to disclose it, without an obligation to keep such information confidential.

7.2. Within five (5) business days after receiving a written request from the other Party, or upon termination of this Agreement, the receiving Party shall return or destroy all of the disclosing Party's Confidential Information.

8. **DISCLAIMER OF WARRANTIES**.

8.1. THE ELECTION SERVICES, INCLUDING ANY GOODS, PARTS, SUPPLIES, EQUIPMENT, OR OTHER ITEMS THAT ARE PROVIDED TO PUBLIC BODY AS PART OF THE ELECTION SERVICES, ARE PROVIDED ON AN "AS IS" AND "AS AVAILABLE" BASIS "WITH ALL FAULTS."

8.2. COUNTY EXPRESSLY DISCLAIMS ALL WARRANTIES OF ANY KIND, WHETHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON- INFRINGEMENT.

8.3. COUNTY MAKES NO WARRANTY THAT: (I) THE ELECTION SERVICES WILL MEET PUBLIC BODY'S REQUIREMENTS; OR (II) THE ELECTION SERVICES WILL BE UNINTERRUPTED, TIMELY, SECURE, OR ERROR-FREE.

9. **LIMITATION OF LIABILITY**.

9.1. IN NO EVENT SHALL EITHER PARTY BE LIABLE TO THE OTHER PARTY OR ANY OTHER PERSON, FOR ANY CONSEQUENTIAL, INCIDENTAL, INDIRECT, SPECIAL, AND/OR PUNITIVE DAMAGES ARISING OUT OF THIS AGREEMENT, REGARDLESS OF WHETHER THE OTHER PARTY HAS BEEN INFORMED OF THE POSSIBILITY OF SUCH DAMAGES.

9.2. NOTWITHSTANDING ANYTHING TO THE CONTRARY CONTAINED HEREIN AND TO THE EXTENT PERMITTED BY LAW, THE TOTAL LIABILITY OF COUNTY UNDER THIS AGREEMENT (WHETHER BY REASON OF BREACH OF CONTRACT, TORT, OR OTHERWISE) SHALL NOT EXCEED THE AMOUNT PAID BY PUBLIC BODY TO COUNTY WITH RESPECT TO THE PARTICULAR ELECTION SERVICE GIVING RISE TO SUCH LIABILITY.

10. **DISPUTE RESOLUTION**. All disputes relating to the execution, interpretation, performance, or nonperformance of this Agreement involving or affecting the Parties may first be submitted to County's Director of Elections and Public Body's Agreement Administrator for possible resolution. County's Clerk and Public Body's Agreement Administrator may promptly meet and confer in an effort to resolve such dispute. If they cannot resolve the dispute in five (5) business days, the dispute may be submitted to the signatories of this Agreement or their successors in office. The signatories of this Agreement may meet promptly and confer in an effort to resolve such dispute.

11. **TERMINATION OR CANCELLATION OF AGREEMENT**.

11.1. Either Party may terminate or cancel this entire Agreement or any one of the Election Services described in the attached Exhibit(s), upon eighty-four (84) days written notice, or such other notice period as otherwise required by the Act, to the clerk of the other Party if either Party decided, in its sole discretion, to terminate this Agreement or one of the Exhibit(s), for any reason including convenience. Each Party shall also comply with the requirements under the Act for filing the notice of termination, in which case, Public Body's timely delivery of a notice of termination to County shall be deemed to comply with its filing requirement.

11.2. Early termination fees may apply to Public Body if provided for in the Exhibit(s).

11.3. The effective date of termination and/or cancellation shall be clearly stated in the written notice. Either the County Executive or the Board of Commissioners is authorized to terminate this Agreement for County under this provision. A termination of one or more of the Exhibits which does not constitute a termination of the entire Agreement may be accepted on behalf of County by its County Clerk.

12. **SUSPENSION OF SERVICES**. County, through its County Clerk, may immediately suspend Election Services for any of the following reasons: (i) requests by law enforcement or other governmental agencies; (ii) engagement by Public Body in fraudulent or illegal activities relating to the Election Services provided herein; (iii) breach of the terms and conditions of this Agreement; or (iv) unexpected technical or security issues. The right to suspend Election Services is in addition to the right to terminate or cancel this Agreement according to the provisions in Section 11. County shall not incur any penalty, expense or liability if Election Services are suspended under this Section.

13. **DELEGATION OR ASSIGNMENT**. Neither Party shall delegate or assign any obligations or rights under this Agreement without the prior written consent of the other Party.

14. **NO EMPLOYEE-EMPLOYER RELATIONSHIP**. Nothing in this Agreement shall be construed as creating an employee-employer relationship between County and Public Body. At all times and for all purposes under this Agreement, the Parties' relationship to each other is that of an independent contractor. Each Party will be solely responsible for the acts of its own employees, agents, and servants during the term of this Agreement. No liability, right or benefits arising out of an employer/employee relationship, either express or implied, shall arise or accrue to either Party as a result of this Agreement.

15. **NO THIRD-PARTY BENEFICIARIES**. Except as provided for the benefit of the Parties, this Agreement does not and is not intended to create any obligation, duty, promise, contractual right or benefit, right to indemnification, right to subrogation, and/or any other right in favor of any other person or entity.

16. **NO IMPLIED WAIVER**. Absent a written waiver, no act, failure, or delay by a Party to pursue or enforce any rights or remedies under this Agreement shall constitute a waiver of those rights with regard to any existing or subsequent breach of this Agreement. No waiver of any term, condition, or provision of this Agreement, whether by conduct or otherwise, in one or more instances shall be deemed or construed as a continuing waiver of any term, condition, or provision of this Agreement. No waiver by either Party shall subsequently affect its right to require strict performance of this Agreement.

17. **SEVERABILITY**. If a court of competent jurisdiction finds a term or condition of this Agreement to be illegal or invalid, then the term or condition shall be deemed severed from this Agreement. All other terms, conditions, and provisions of this Agreement shall remain in full force.

18. **PRECEDENCE OF DOCUMENTS.** In the event of a conflict between the terms and conditions of any of the documents that comprise this Agreement, the terms in the Agreement shall prevail and take precedence over any allegedly conflicting terms and conditions in the Exhibits or other documents that comprise this Agreement.

19. **CAPTIONS**. The section and subsection numbers, captions, and any index to such sections and subsections contained in this Agreement are intended for the convenience of the reader and are not intended to have any substantive meaning. The numbers, captions, and indexes shall not be interpreted or be considered as part of this Agreement. Any use of the singular or plural, any reference to gender, and any use of the nominative, objective or possessive case in this Agreement shall be deemed the appropriate plurality, gender or possession as the context requires.

20. **FORCE MAJEURE**. Notwithstanding any other term or provision of this Agreement, neither Party shall be liable to the other for any failure of performance hereunder if such failure is due to any cause beyond the reasonable control of that Party and that Party cannot reasonably accommodate or mitigate the effects of any such cause. Such cause shall include, without limitation, acts of God, fire, explosion, vandalism, national emergencies, insurrections, riots, wars, strikes, lockouts, work

stoppages, other labor difficulties, or any law, order, regulation, direction, action, or request of the United States government or of any other government. Reasonable notice shall be given to the affected Party of any such event.

21. **NOTICES**. Except as otherwise provided in the Exhibits, notices given under this Agreement shall be in writing and shall be personally delivered, sent by express delivery service, certified mail, or first class U.S. mail postage prepaid, and addressed to the person listed below. Notice will be deemed given on the date when one of the following first occur: (i) the date of actual receipt; (ii) the next business day when notice is sent express delivery service or personal delivery; or (iii) three days after mailing first class or certified U.S. mail.

    21.1. If Notice is sent to County, it shall be addressed and sent to: Oakland County Clerk, Election's Division, 1200 N. Telegraph Road, Bldg. 16 East, Pontiac, MI 48341, and the Chairperson of the Oakland County Board of Commissioners, 1200 North Telegraph Road, Pontiac, Michigan 48341.

    21.2. If Notice is sent to Public Body, it shall be addressed to: 300 E. Nine Mile Road, Ferndale, MI 48220.

    21.3. Either Party may change the individual to whom Notice is sent and/or the mailing address by notifying the other Party in writing of the change.

22. **GOVERNING LAW/CONSENT TO JURISDICTION AND VENUE**. This Agreement shall be governed, interpreted, and enforced by the laws of the State of Michigan. Except as otherwise required by law or court rule, any action brought to enforce, interpret, or decide any Claim arising under or related to this Agreement shall be brought in the 6th Judicial Circuit Court of the State of Michigan, the 50th District Court of the State of Michigan, or the United States District Court for the Eastern District of Michigan, Southern Division, as dictated by the applicable jurisdiction of the court. Except as otherwise required by law or court rule, venue is proper in the courts set forth above.

23. **SURVIVAL OF TERMS**. The following terms and conditions shall survive and continue in full force beyond the termination, cancellation, or expiration of this Agreement (or any part thereof) until the terms and conditions are fully satisfied or expire by their nature: Definitions (Section 1); Assurances (Section 6); Payments (Section 5); Use of Confidential Information (Section 7); Disclaimer of Warranties (Section 8); Limitation of Liability (Section 9); Dispute Resolution (Section 10); No Employee-Employer Relationship (Section 14); No Third-Party Beneficiaries (Section 15); No Implied Waiver (Section 16); Severability (Section 17); Precedence of Documents (Section 18); Force Majeure (Section 20); Governing Law/Consent to Jurisdiction and Venue (Section 22); Survival of Terms (Section 23); Entire Agreement (Section 24).

24. **ENTIRE AGREEMENT**.

    24.1. This Agreement represents the entire agreement and understanding between the Parties regarding the specific Election Services described in the attached Exhibit(s). With regard to those Election Services, this Agreement supersedes all other oral or written agreements between the Parties.

    24.2. The language of this Agreement shall be construed as a whole according to its fair meaning, and not construed strictly for or against any Party.

IN WITNESS WHEREOF, Marne McGrath, City Clerk of the City of Ferndale hereby acknowledges that he/she has been authorized by a resolution of the ity of Ferndale, a certified copy of which is attached, to execute this Agreement on behalf of Public Body and hereby accepts and binds Public Body to the terms and conditions of this Agreement.

EXECUTED: _____ DATE: _____
Marne McGrath, City Clerk of the City of Ferndale

WITNESSED: _____ DATE: _____
Barb Miller, City of Ferndale Deputy Clerk

AGREEMENT
ADMINISTRATOR: _____
(IF APPLICABLE) DATE: _____

IN WITNESS WHEREOF, David T. Woodward, Chairperson, Oakland County Board of Commissioners, hereby acknowledges that he has been authorized by a resolution of the Oakland County Board of Commissioners, a certified copy of which is attached, to execute this Agreement on behalf of Oakland County, and hereby accepts and binds Oakland County to the terms and conditions of this Agreement.

EXECUTED: _____ DATE: _____
David T. Woodward, Chairperson
Oakland County Board of Commissioners

WITNESSED: _____ DATE: _____
[insert name, title]

IN WITNESS WHEREOF, Lisa Brown, in her official capacity as the Oakland County Clerk, a Michigan Constitutional Office, hereby concurs and accepts the terms and conditions of this Agreement.

EXECUTED: _____ DATE: _____
Lisa Brown, Clerk/Register of Deeds,
County of Oakland

WITNESSED: _____ DATE: _____

EXHIBIT I

ABSENT VOTER BALLOT COUNTING SERVICES

1. COUNTY RESPONSIBILITIES.

1.1. County, through its Board of Election Commissioners, shall, subject to Public Body's performance of its duties and obligations under this Agreement and the Act, render absent voter ballot counting services in compliance with the Act for absent voter ballots received by the clerk for Public Body prior to 4:00 p.m. on the day before an election. For clarification, County is not providing Election Services for absent voter ballots received by the clerk for Public Body after 4:00 p.m. on the day before an election; pursuant to Section 764d(10) of the Act, Public Body must deliver such ballots to the voting precinct of the elector on election day to be processed and counted.

1.2. Unless otherwise agreed upon in writing by the Parties, County shall cause absent voter ballots, including, the ballot return envelopes, secrecy sleeves, and ballots (collectively the "Ballots"), received by the clerk for Public Body prior to 4:00 p.m. on the day before an election to be picked up from the clerk by 6:00 p.m. that day by an authorized representative of County.

1.3. Upon completing the process for counting the ballots, County shall place the ballots in ballot containers either provided by Public Body that comply with the requirements described below or provided by County, as determined in County's sole discretion, and seal the ballot containers in compliance with all applicable laws. County shall notify Public Body of its decision to require Public Body to provide ballot containers or to provide ballot containers at least sixty (60) days prior to each election for which County is providing Election Services to Public Body under this Agreement.

1.4. County shall retain the sealed ballot containers containing the Ballots for thirty (30) days after the day of the election for which the Ballots were submitted. County shall make arrangements with Public Body for an authorized representative(s) of Public Body to, after the expiration of the thirty (30) day period, pick-up from County the Ballots, mail trails, ballot envelopes, ballot boxes provided by Public Body, qualified voter list, and any other items related to the Ballots transferred by Public Body to County.

2. PUBLIC BODY RESPONSIBILITIES.

2.1. Public Body shall perform its duties and obligations under this Agreement and the Act and take any other action necessary or appropriate to assist, and cooperate with, County in rendering the absent voter ballot counting services under this Agreement.

2.2. Public Body shall, by 4:30 on the day before an election, have available for transfer to County immediately upon arrival of County's representative, the Ballots received by the clerk for Public Body prior to 4:00 p.m. on that day properly organized in mailing trays, ballot containers, unless provided by County pursuant to this Agreement, in good condition and compliant with the required and appropriate sealing procedures, and a reconciled voter list from the qualified voter file that matches the number of Ballots being transferred to County.

2.3. Public Body shall, during any period County is actively rendering Election Services, provide to County access to Public Body's electronic qualified voter file for the sole purpose of County reconciling such list with the number of Ballot envelopes received by County and to make any necessary corrections to the list to reflect the number of Ballot envelopes received.

2.4. Public Body shall make arrangements with County to, no later than three (3) business days after the expiration of the thirty (30) day period described in Section 1.4, cause authorized representative(s) in number necessary to pick-up from County premises the Ballots, mail trays, ballot envelopes, ballot boxes provided by Public Body, qualified voter lists, and any other items related to the Ballots transferred by Public Body to County. At such time and on County premises, if County provided ballot boxes to seal the Ballots in providing the Election Services, Public Body shall bring ballot boxes for its authorized representatives to transfer into the Ballots from the County provided ballot boxes. If Public Body does not pick-up such items as required in this Section, at County's election exercised in its sole discretion, Public Body shall, within thirty (30) days of receiving an invoice from County, pay to County $100_____for each day beyond the three (3) period set forth above that County remains in possession of such items and/or County may have its authorized representatives deliver such items to Public Body on such date and at such time during Public Body's clerk's regularly scheduled office hours County determines, in which case Public Body shall deemed to have accepted possession of all such items.

2.5. Upon the earlier to occur of the expiration of the three (3) period set forth in Section 2.4 and the transfer of items to Public Body under Sections 1.4 and 2.5, above, Public Body shall be deemed to be responsible for all such items.

3. **PAYMENT; EXPENSES AND FEES**.

3.1. Except as otherwise provided in Section 5 of this Agreement, until such time as County notifies Public Body otherwise, County shall provide the Election Services to Public Body for each election at no cost to Public Body.

3.2. At such time County determines it will require the payment of a fee and/or reimbursement for costs and expenses by Public Body for County's Election Services for an upcoming election(s), County shall provide written notice to Public Body in advance of such election(s) with sufficient time for Public Body to terminate this Agreement in accordance with its terms setting forth in detail such fees, costs, and expenses and Public Body shall pay such amounts in accordance with the terms of this Agreement for Election Services rendered by County.

FERNDALE

July 13, 2020 City Manager

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Dan Jacey

SUBJECT: Approval of Cost of Living Adjustments for Non-Union Employees Effective July 1, 2020 at a Cost of Approximately $37,432, Recognizing that Merit Increases have Not Been Offered as a Result of the Financial Implications of COVID-19, as Proposed by the City Manager and Human Resources Director

INTRODUCTION
During the month of May, the City Manager's office sent a directive to all non-union staff that suspended merit pay increases for fiscal year end 2021 (July 1, 2020-June 30, 2021). Many of of our collective bargaining units also agreed to accept similar concessions through contract negotiations and adjustments. Additionally, a hiring freeze for all new full-time non-union/union positions is in place until further notice. These concessions were difficult, but were a critical component of a series of proactive decisions that were made in response to potential economic disruptions by the COVID-19 pandemic.

Given these concessions, I strongly support maintaining a modest 2% cost of living baseline adjustment for fiscal year 2021. Our workforce has maintained their focus on providing quality services with heightened availability. Staff's ability to embrace and run with the challenges of transitioning an entire workforce across all departments into a mobile-first workforce over a single weekend in March is astounding. By remaining engaged in the dynamism of their roles and focused on not letting down our efforts, they have maintained the vital services and spirit that make this community, this City, a special place.

SUMMARY & BACKGROUND
In late 2016, City Council approved the implementation and administration of the City of Ferndale’s Compensation Policy. This policy governs wage schedules, merit increases, and accountability associated with the ongoing adherence to the Compensation Policy.

In an ordinary year, we would recommend that non-union employees who have demonstrated strong performance, as indicated by their directors on their performance reviews and as approved by the City Manager, receive merit (step) increases. However, we have set the expectation that all non-union employees forgo the opportunity for merit (step) increases due to the financial burdens put on the City due to the COVID-19 epidemic.

Despite the suspension of merit increases, I strongly support maintaining a modest 2% cost of living baseline adjustment for fiscal year 2021. Our workforce has maintained their focus on providing quality services with heightened availability. It is my recommendation that City Council approve an across-the-board increase for non-union employees of 2%. This recommendation is:
*In line with all unions
*In line with other local government organizations
*Consistent with the City’s Compensation Policy

These increases were included in the City's budget adopted on April 27, 2020. The total cost to the City for these increases will be approximately $37,432. The savings to the City with the removal of the merit incentives for non-union staff is approximately $53,627. Additional union concessions and hiring freezes/suspensions are also estimated to make positive impacts on cost avoidance.

BUDGETARY CONTEXT
These amounts have been approved in the current budget as distributed via full time line items across all departments.

CIP#
NA

ATTACHMENTS

STRATEGIC PLANNING CONTEXT
Organizational and Financial Excellence

RECOMMENDED ACTION
Approve a 2% cost of living adjustment for non-union employees effective July 1, 2020 at a cost of $37,432, as proposed by the City Manager and Human Resources Director.

FERNDALE

July 13, 2020 Communications

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Kara Sokol

SUBJECT: Approval of Proposal from Three Lyons Creative for Production of "2020 State of the City" Video Series, in the Amount of $4,700.00 to be Charged Evenly to Contractual Services Account #101-173-818 and Special Events 101-803-885.000 Special Programs, as Submitted by Communications Director

INTRODUCTION
Mayor Piana's 2020 State of the City Address, originally scheduled to be delivered live to the public on May 5 at the Rust Belt Market, was cancelled this year due to the COVID-19 pandemic. Rather than risk rescheduling the event for public delivery during this unpredictable time, the Mayor and staff have worked to re-imagine this year's address as a series of short videos.

SUMMARY & BACKGROUND
The Mayor's State of the City is an annual update delivered to Ferndale's residents and community. The event, typically held in mid-to-late spring, is delivered as a live speech and presentation covering programs and initiatives, recent city events, department-specific news, budget and strategic planning, and other critical updates. It is the Mayor's key opportunity to communicate to citizens about City Council's values, priorities, and goals for moving forward.

With the pandemic and social distancing requirements this year, many of the services we deliver have required re-imagining or innovative new solutions, and the State of the City is no different. Rather than attempt to reschedule for live delivery—which requires the reservation/renting of space and a public gathering of people—the Mayor and staff have worked to reformat this year’s content for video. With City addresses generally being relatively lengthy (30 minutes+), we’ve decided to break it into six shorter videos that will be shared over the course of a week.

The Communications Director sought recommendations for local videography/production companies, and based on portfolios, interviewed three. Three Lyons Creative offers the style and quality of work we’re seeking at a dramatically lower price than anyone else we researched. The videos will be recorded in the coming weeks with a plan of releasing to the public by early August.

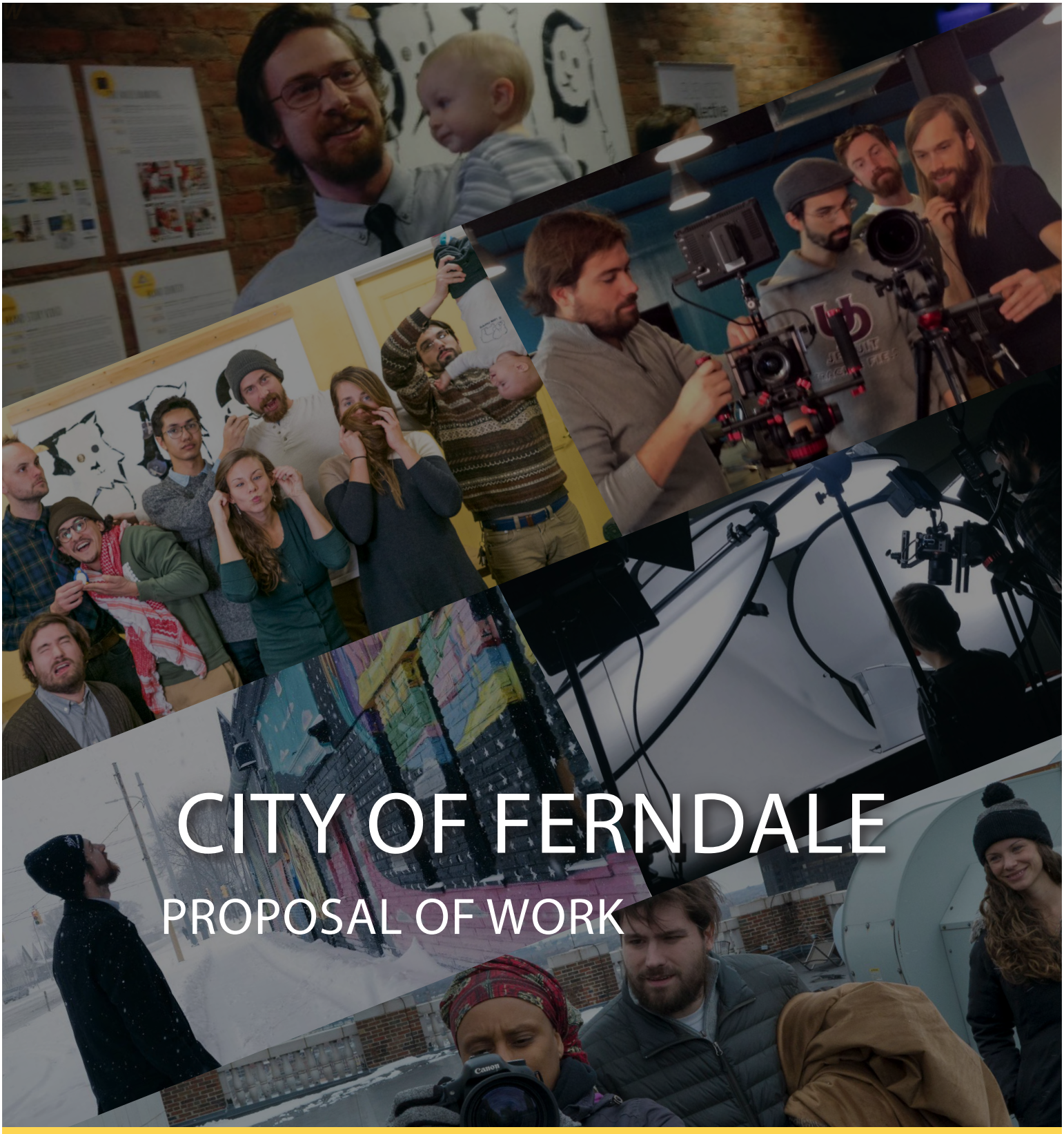
BUDGETARY CONTEXT
$4,700.00 to be Charged evenly to Contractual Services Account #101-173-818--the Communications Department keeps this account for videography/photography needs and #101-803-885.000 Special Events Department's Special Programs held for City Events.

CIP#

ATTACHMENTS
20200617_ThreeLyonsCreative_CityofFerndale_VideoProposal-pages-deleted.pdf

STRATEGIC PLANNING CONTEXT
Safe, Protected, Engaged Community

RECOMMENDED ACTION
Approve the proposal from Three Lyons Creative for production of "2020 State of the City" video series, in the amount of $4,700.00 to be charged evenly to Contractual Services Account #101-173-818 and Special Events 101-803-885.000 Special Programs, as submitted by Communications Director.



CITY OF FERNDALE

PROPOSAL OF WORK

threelyonscreative

threelyonscreative

SCOPE OF WORK

PROJECT

Edit and deliver six unique videos, each approximately two minutes in length. Filming of interviews and B roll will take place during one shooting day within two weeks of contract approval.

Three Lyons Creative will produce opening and closing bumpers for each video consistent with the City of Ferndale's current visual style, including fonts, colors, logos, etc.

threelyonscreative

BUDGET

FERNDALE STATE OF THE CITY VIDEO SERIES

ITEM	PRICE
1 Full Day Production - three person crew	$1,400.00
Post Production	
Video Editing	$1,500.00
Audio Editing	$600.00
Graphic Creation	$1,000.00
Account management	$200.00
Total project cost	**$4,700.00**

FERNDALE

July 13, 2020 Community & Economic Development

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Erin Quetell

SUBJECT: Approval of the Receipt and Acceptance of the Climate Change Vulnerability Assessment for Stormwater Final Report, as Submitted by Sustainability Planner

INTRODUCTION
Resolution to Adopt the Climate Change Vulnerability Assessment for Stormwater Final Report

SUMMARY & BACKGROUND
In late 2018, Ferndale was selected to participate in the Adapting Great Lakes Stormwater Systems to Climate Change through a grant awarded to the Great Lakes Integrated Sciences and Assessments (GLISA) organization and partners the Huron River Watershed Council (HRWC), the Great Lakes Climate Adaptation Network (GLCAN), and the City of Ann Arbor. The project consisted of 12 local governments in the Great Lakes Region completing a customized vulnerability assessment for stormwater management. Ferndale received the in-person workshop in early 2019. Throughout the year-long project, city staff and contractors worked together to complete the vulnerability assessment for our stormwater system. The final report consists of the vulnerability assessment on stormwater system assets in the City of Ferndale. Staff intends to utilize this report in the greater climate adaptation and resiliency planning for the City, and request the formal adoption of the vulnerability assessment from Council.

BUDGETARY CONTEXT
N/A

CIP#
N/A

ATTACHMENTS
FINAL-Climate-and-Socio-Economic-Vulnerability-Assessment-for-Stormwater-FERNDALE-06.02.20.pdf

Project Overview for Adapting Great Lakes Stormwater Systems to Climate Change Pilot Project.pdf

STRATEGIC PLANNING CONTEXT
Supported Infrastructure

RECOMMENDED ACTION
Approve the resolution to adopt the Climate Change Vulnerability Assessment for Stormwater Final Report.

PREPARING FOR CLIMATE CHANGE





FERNDALE

CLIMATE CHANGE VULNERABILITY ASSESSMENT FOR STORMWATER

CITY OF FERNDALE

EXECUTIVE SUMMARY

The climate in Ferndale is changing, and these changes are causing immediate threats to our citizens, our health, our economy, and our community's overall vitality. We know that over the last several years we have experienced a 2.7ºF increase in average annual temperature, with spring experiencing the greatest amount of warming (a 3.1ºF increase). Nighttime temperatures are rising, and the number of cold days (< 32ºF) are declining. Annual precipitation is changing too: in the last several decades Ferndale has experienced a 25.2% increase in annual precipitation, with the greatest change happening in fall (40% increase, amounting to roughly an extra 3.0 inches). In addition, we have seen an increase in the frequency and intensity of severe storms, with the City experiencing a 6% increase in the number of heavy precipitation events (heaviest 1% of storms) annually. These are just some of the changes that have led to serious impacts to our community's infrastructure, economy, social networks, cultural identity, and safety. These impacts are likely to be more extreme as the climate continues to change.

In light of this, the City of Ferndale has decided to plan for climate change, making sure we are considering what changes are projected to take place in the future and integrating that information into how we, as a City, operate. Guiding this work is a commitment to ensuring the health, safety, and general welfare of all Ferndale's residents – especially the frontline communities that are already experiencing a disproportionate share of the impacts associated with a changing climate. This Stormwater Vulnerability Assessment is one important component of our City's efforts to create a more equitable and resilient community for all Ferndale residents – ensuring every resident is prepared for the current and future risks associated with a changing climate.

Within the pages of this report, readers will find more information about how changes in weather and long-term climate have already impacted Ferndale and details about projected changes in climate relevant to the City. Further, the report provides insights into what those changes might mean in terms of on-the-ground impacts to our stormwater systems, an assessment of Ferndale's overall stormwater-system vulnerability to these changes, and which segments of the community may be most vulnerable. Finally, this report provides some initial suggestions on what we, as a community, can do to prepare our stormwater system and those it serves for climate-related impacts.

At a high level, we anticipate that climate change will exacerbate or create the following major impacts to stormwater in Ferndale:

- Total precipitation is increasing (frequency and intensity are critical elements)
    - Causing an increase in the demand on Ferndale's stormwater system
    - Reducing the capacity of pipes, and accelerating the deterioration of the stormwater system
    - Increasing the need for more green infrastructure to manage increased precipitation
    - Residents will experience greater impacts from surface flooding
    - City Facilities will need more maintenance and upkeep to become better prepared

- Rising temperatures
  - Unseasonably warmer weather while the ground is still frozen will exacerbate the reduction in capacity of the stormwater pipes
  - Increased temperatures increases the vulnerability of outdoor workers
  - Establishing green infrastructure becomes more difficult in extreme temperatures
  - Increased health risks for residents associated with increased temperatures

In response to these projected changes and local impacts, the City of Ferndale has initially identified the following actions:

- Plan and budget early for Green Infrastructure and maintenance
- Educate and communicate with city staff, the community, and developers about the need for green infrastructure and flooding
- Plan and budget for updates to existing city facilities and communicate the existing challenges with city facilities to explain to the community why upgrades are necessary

Implementing these and other actions to effectively and efficiently address our community's climate and socio-economic vulnerabilities will require an "all hands on deck" approach. That is why we invite you to join us as we move forward with creating a more resilient, thriving, and sustainable Ferndale for all.

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1. WHAT IS A VULNERABILITY ASSESSMENT

As the climate continues to change, communities across the U.S. and the world are asking, "How are these changes already affecting my community?" and "What local impacts might we experience from future changes in climate?" To help answer these questions, communities are using a tool called a vulnerability assessment. A vulnerability assessment helps stakeholders identify:

1. What changes in climate are projected to happen and what those changes could mean in terms of local **impacts**,
2. The level of **exposure** the community has to potential changes,
3. How **sensitive** the various city and community systems are to projected changes in climate, and
4. What **capacity** those systems have to adapt.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014).

Sensitivity: The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC, 2014).

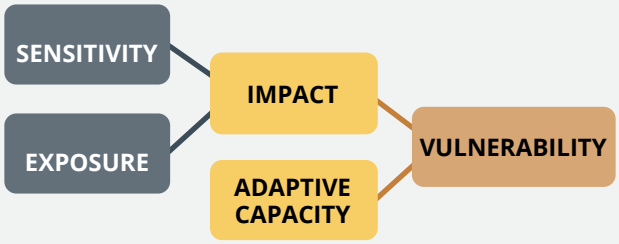
Impact: Effects on natural and human systems such as lives, livelihoods, health, ecosystems, economics, societies, cultures, services, and infrastructure (IPCC, 2014).

Adaptive Capacity: The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2014).

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

Figure 1 provides a graphical depiction of how exposure, sensitivity, impacts, and adaptive capacity all combine to create vulnerability.

Figure 1: Graphical depiction of the various elements of vulnerability

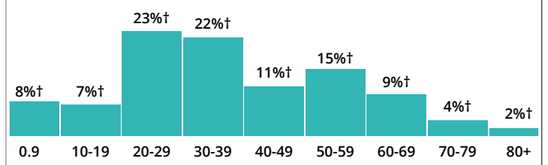


Once completed, the results of a vulnerability assessment can be used to inform the types of actions a community should take to reduce vulnerabilities or seize on potential opportunities.

Currently, most existing vulnerability assessment guidance and tools have either limited or no discussion regarding the important role that a community's social and economic characteristics play in determining local vulnerability. Because of the critical importance social dynamics play in shaping our local community, the City of Ferndale partnered with fellow Midwestern cities, the Huron River Watershed Council, the Great Lakes Integrated Sciences and Assessment (GLISA), and Headwaters Economics to develop a revised vulnerability assessment template that assesses our community's social, physical, cultural, economic, and environmental vulnerability to climate change. The document you are currently reading is a spinoff of this work, focused explicitly on understanding the vulnerability of Ferndale's stormwater system to climate change, socio-economic considerations, and local landscape features. We will use this document to help ensure that all our residents are safe, resilient, and thriving both today and in a climate-altered future.

2. SOCIO-ECONOMIC PROFILE OF FERNDALE

Section Summary[1]

Population by age range	Age	Income	
	34.7 Median age	$37,332 Per capita income	$61,060 Median household income

Ferndale is a unique, progressive city. The population is slightly greater than 20,000 people located within about a four square-mile area. Sharing a border with the City of Detroit, Ferndale offers a variety of community amenities including a vibrant downtown, parks and recreation opportunities, and a growing non-motorized network.

While Ferndale promotes diverse ideals, the demographics of Ferndale are less so. Ferndale is a predominantly white community, with 84.2% of Ferndale residents identifying as White, 6.7% identifying as Black/African American, 5.4% identifying as Multi-racial/other, 2.8% identifying as Hispanic, and 0.8% identifying as Asian or Pacific Islander.

Furthermore, the number of rental households in Ferndale has increased by approximately 30% since 2010. Within the renter population, 4 out of 10 households, approximately 41%, have an annual income below $35,000. Nearly half, approximately 49%, of Ferndale households have an annual income of less than $60,000 a year.

In order to fully understand how the City of Ferndale is resilient or vulnerable to climate change, we need to take a deep look at the social characteristics that make up our community. Using the Socio-Economic Data Mapper (Data Mapper) tool from Headwaters Economics, we analyzed ten characteristics that help explain our local vulnerability:

A. Percent of population over 65

B. Percent of population under 5

C. Percent of community in poverty

D. Percent of population with limited English proficiency

E. Percent of non-white population

F. Percent of households receiving public assistance

G. Percent of households where mortgage is greater than 30% of household income

H. Percent of disabled

I. Percent of renters

J. Percent of population without a high school diploma

A. Percent of population over 65

As of 2017, the City of Ferndale had 20,159 residents, 8.5% (1,720) of which were 65 years or older[2]. This is lower than the U.S. national average for residents over 65, which is 14.9%. Of this population, approximately 0.7% (145) are 80 years or older. This figure is important because elderly populations are at increased risk of compromised health related to environmental hazards and climate change. In fact, age is the single greatest risk factor related to illness and death from extreme heat[3] and the elderly are more likely to have pre-existing medical conditions or compromised mobility, which reduces their ability to respond to extreme heat and extreme weather events[4] - which are both likely to become more frequent due to climate change. Finally, the increased likelihood of chronic disease[5], combined with the fact that older adults are more susceptible to air pollution, which is expected to become worse due to climate change, makes them a uniquely vulnerable population.[6]

All of these factors combined mean that the elderly require unique and/or additional services compared to younger residents. As such, understanding our community's age profile helps us determine the appropriate types of services and resources needed to ensure all of Ferndale's residents are able to survive and thrive in a climate-altered future.

B. Percent of population under 5

As of 2017, 4.9% (986) of the City of Ferndale's population was under 5 years of age. This is lower than the national average (6.2%)[7]. Knowing what percentage of our residents are under the age of five and where they reside, is important because children's developing bodies are particularly sensitive to health problems and environmental stresses[8], including those associated with climate change. Children also spend more time outside and have faster breathing rates than adults, so they are more at risk for respiratory problems related to things such as ground level ozone, airborne particulates, and allergens:[9] all of which can be exacerbated by climate change. Moreover, because their immune systems are not fully developed, children are more susceptible to infectious diseases[10], including those that spread during natural disasters.

Focusing our efforts on reducing youth vulnerability makes sense for a number of reasons, including the fact that childhood lays the foundation for lifelong health, meaning that poor health during childhood can significantly increase the likelihood of problems throughout adulthood.[11] With the rising cost of health care in the U.S., ensuring that we have a healthy, productive community is pivotal to not only our wellbeing, but also our social structure and our economy.



Figure 2: Census Tracts in Ferndale where 8% or more of the population is 65 years of age or older (14.9% is the national average).

As we seek to ensure our youth are resilient to climate change, we need to pay particular attention to youth that are living in poverty, as children living in poverty are less likely to receive high-quality health care, meaning that they may be especially sensitive to changes in climate and the ensuing health impacts.[12] Children living in poverty are also more likely to live in vulnerable areas, including areas that have poor air quality, limited transit options, and homes that are less resilient to changing weather patterns. As we move forward with building community-wide resilience, care must be taken to ensure that children, especially those in poverty, are prioritized.

C. Percent of community in poverty

As of 2017, 2,902 City of Ferndale residents were living in poverty; 1,289 were classified as living in deep poverty (meaning they earn less than ½ of the federal poverty level). This represents 14.4% of the City's population that is living in poverty and 6.4% that is living in deep poverty. In addition, data shows that 0.7% of the City's residents (147) are both living in poverty and over the age of 65. All of these numbers are similar to US national averages.[13]

The above information focuses on the number of individuals living in poverty. In addition, we also analyzed the number of families living in poverty. As of 2017, 387 families (10.3 %) in Ferndale lived in poverty. Of these, 337 had at least one child residing in their household, and 157 were households with a single mother (4.2% of all households). This rate of family poverty is slightly lower than the national average (10.5% for families in poverty and 4.8% for single mother families in poverty).

Understanding the percent and location of those living in poverty is critical because low income is one of the strongest predictors of compromised health as well as an individual's ability to recover from disasters.[14] Moreover, we know that natural disasters disproportionately impact low-income people because of things such as inadequate housing, social exclusion, a diminished ability to evacuate, lack of property insurance, and more acute emotional stress.[15] In addition, research has shown that low-income



Figure 3: Census Tracts where in Ferndale where 5.2% or more of the population is under 5 years of age (6.2% is the national average).

people are more likely to be overlooked during the emergency response period following a disaster.[16] Low-income populations are also more likely to live or work in areas with greater exposure to environmental hazards, including working in jobs that require outdoor labor.[17]

Income inequality within a community is also associated with poor health outcomes. Residents in low-income neighborhoods tend to have higher incidences of asthma, depression, diabetes, heart conditions, and emotional stress compared to higher-income neighborhoods.[18] Low-income households also have to make lifestyle compromises in order to make ends meet, such as choosing unhealthy foods, less food, substandard housing, or delayed medical care.[19] Having limited income may also mean that it is simply too expensive to run fans, air conditioners, or heaters to manage indoor living temperatures, not to mention that many low-income residences are located in high crime areas, meaning that residents may feel unsafe opening their windows.[20] Finally, low-income individuals are least likely to have health insurance, which further exacerbates their vulnerability to the negative health impacts associated with climate change such as deteriorating air quality, higher incidences of asthma, and increased allergens.[21]

D. Percent of population with limited English proficiency

According to the US Census Bureau, in 2017, 0.2% of the Ferndale community had low English proficiency (32 people). This is lower than the national average (4.5%).[22] Understanding the percentage and location of people with limited English proficiency is important because many, if not most, aspects of life in the US require basic proficiency in English. For example, knowing about and then accessing emergency services, learning about poverty reduction programs, or accessing health care all necessitate basic English proficiency. Research has found that limited English proficiency can:

- Limit a person's ability to effectively act during emergencies;[23]
- Make it harder to follow directions and interact with agencies, thereby limiting the amount of support available to respond to and recover from disasters of all types;[24]
- Make it harder for people to get higher wage jobs;[25] and
- Result in isolation from other segments of the US population, and social isolation can be a serious health risk. [26]

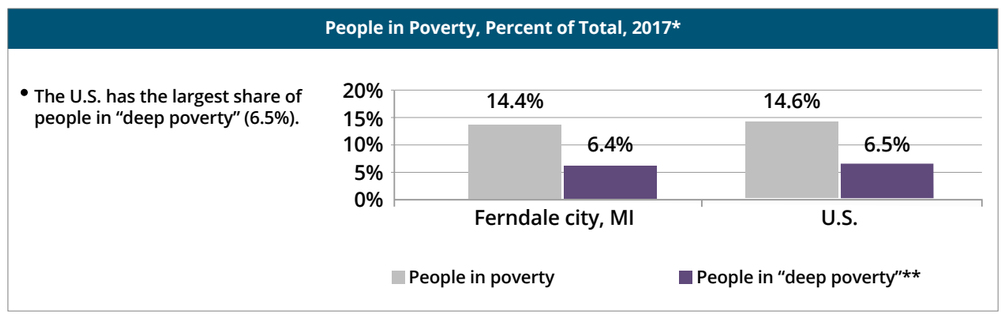


Table 2: Percentage of residents living in poverty. This table was taken from the Populations at Risk Tool created by Headwaters Economics (accessible here).



Figure 4: Census Tracts in Ferndale where 9% or more of the families are living in poverty (10.5% is the national average).

Because of these factors, it is important that we identify who within our population has limited English proficiency and work with trusted partners to ensure these populations have access to the information, tools, and resources they need to build resilience.

E. Percent of non-white population

As of 2017, 13.5% of the population in Ferndale (2,730) identified as non-white. This is lower than the national average (27.0%). Of this population, 6.9% (1,384) identified as Black or African American, 2.8% (561) identified as Hispanic[27], 0.6% (128) identified as American Indian, and 6.0% (1,218) identified as "Other Races".[28]

This information is important because race and ethnicity strongly correlate with disparities in health, exposure to environmental pollution, and vulnerability to natural hazards, including climate-related natural hazards.[29] More specifically:

- Research consistently finds race-based environmental inequities across many variables, including the tendency for minority populations to live closer to noxious facilities and Superfund sites, and to be exposed to pollution at greater rates than whites. [30]
- Across races, the rates of preventable hospitalizations are highest among black and Hispanic populations. Preventable hospital visits often reflect inadequate access to primary care. These types of hospital visits are also costly and inefficient for the health care system.[31] Relative to other ethnicities and races, Hispanics and blacks/African-Americans are less likely to have health insurance: but rates of uninsured are dropping for both groups.[32]
- Compared to other races, blacks/African-Americans have higher rates of infant mortality, homicide, heart disease, stroke, and heat-related deaths.[33]
- Hispanics have higher rates of diabetes and asthma, compared to other ethnicities.[34]
- Minority communities often have less access to parks and nutritious food, and are more likely to live in substandard housing, all of which can negatively impact health outcomes.[35]
- Minorities tend to be particularly vulnerable to disasters and extreme heat events. This is due to language differences, housing patterns, variations in the quality of housing, community isolation, and cultural barriers.[36]
- Blacks and Hispanics, two segments of the population that are currently experiencing poorer health outcomes, are an increasing percentage of the U.S. population and our local community.[37]

Given these realities, it is important that the City of Ferndale ensures that we effectively integrate the needs, perspectives, and lived realities of our population into our efforts to enhance resilience.

F. Percent of households receiving public assistance

As of 2017, 1,139 households within Ferndale (11.5%) received Food Stamps/SNAP assistance. This rate of Food Stamp/SNAP assistance is lower than the national average, which is 12.6% of all U.S. households.[38] While this isn't the only form of public assistance, we have



Figure 5: Census Tracts in Ferndale where 15% or more of the population identifies as non-white (27% is the national average).

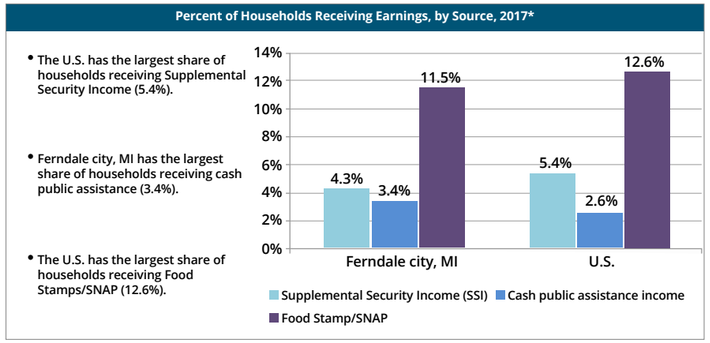


Table 3: Percentage of households in Ferndale and in the U.S. that receive three types of public assistance.

chosen Food Stamps/SNAP assistance as our indicator of public assistance because it is more widely known than the other types of assistance and, as such, there is a higher likelihood that at-need households are getting this assistance compared to the more obscure forms of public assistance.

Understanding the percentage and location of residents receiving public assistance is important because this information is indicative of households living in poverty or households with insufficient resources. For example, in 2011, families receiving public assistance spent, on average, 77% of their household budget to meet the basic necessities of housing, food, and transportation,[39] leaving little to accommodate other important needs including disaster preparedness, response, and recovery.

G. Percent of households where mortgage is greater than 30% of household income

As of 2017, 893 households (19.1%) in Ferndale were paying more than the sustainable 30% of household income towards their mortgage and 1,484 households (42.0%) were paying more than the sustainable 30% of household income towards their rent. Rental costs are slightly below the national average. The reason this is important is because the federal government considers families with housing costs that exceed 30% of their income to be "housing-cost burdened"[40] and therefore have less disposable income to spend on other necessities such as food, heating/cooling, transportation, healthcare, etc. Research also shows that those households living in affordable housing (those spending less than 30% of household income on housing) are more stable and less likely to move frequently. This can enhance community vitality and cohesion, an important element of creating a more resilient Ferndale. In addition, this stability is linked to several positive health outcomes in children and young adults, such as improved emotional and behavioral problems, fewer unplanned pregnancies, reduced drug use, and a lower risk for depression.[41]

As we work to ensure that Ferndale is building resilience, we must be aware of the needs of all residents, including those with limited economic resources.

H. Percent of those with disabilities

As of 2017, 2,469 residents of Ferndale were living with disabilities. This represents 12.2% of our total population; a figure slightly lower than the national average of 12.6%.[42]

People with disabilities are subject to a series of health complications that are often significantly heightened due to environmental conditions. For example, limited mobility and/or being bed ridden raises heat mortality,[43] limited mobility can significantly delay and/or prevent effective evacuation during times of disaster, and extreme weather



Figure 7: Census Tracts in Ferndale where 12% or more of the population has a disability (12.6% is the national average).

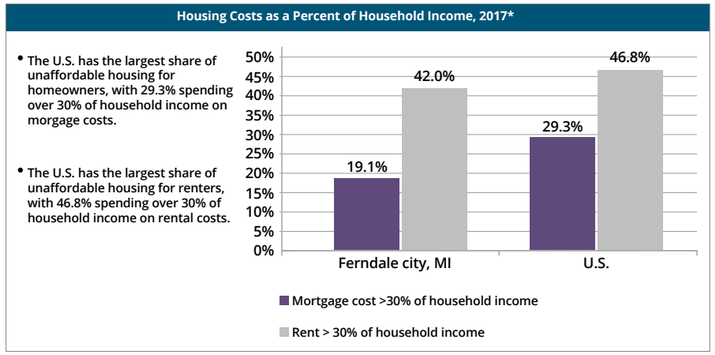


Table 4: Comparison of the percentage of households in Ferndale and the U.S. that spend more than 30% of their income on rental fees or their mortgage.

Percent of Renters Paying 30% or More of Household Income on Gross Rent



Figure 6: Illustrates the percentage of rental households that spend 30% or more of their household income on gross rent (contract rent plus tenant-paid utilities). The greatest percentage of renters that pay at least 30% of their household income on gross rent are located in the residential areas between the east-side of Woodward and west-side of the CN railway.

events can disrupt one's ability to get medical treatment, which can be disastrous for those with compromised health. These are only some of the heightened vulnerabilities faced by people with disabilities. Because of this, Ferndale is determined to incorporate the needs of this population in our attempts to create a more resilient community.

I. Percent of renters

As of 2017, 35.7% of housing units in Ferndale were rentals; an additional 0.3% were mobile homes.[44] This rate is lower than the national average of 36.2% for rentals and the national average of 5.7% for mobile home residences.

The median home value in Ferndale is currently $133,853. This figure represents a decrease in home value of $11,031 based on average home values in 2010.

Understanding what percentage of our population owns a home is important because home ownership contributes to well-being and stability. Home ownership also improves mental health, including increasing self-esteem, creating a heightened sense of control over one's living situation and financial security.[45] On the flip side, the financial stress associated with losing one's home is heightened by people's attachment to place and their neighborhoods.[46]

In terms of renters, studies have repeatedly shown that renters pay a larger proportion of their income in rent. Rental rates have increased over the past 25 years with no sign of abatement.[47] This financial burden is exacerbated by the fact that rental homes are typically not well maintained with conditions such as dampness, mold, and exposure to toxic substances or allergens heightened for those residing in rental units.[48] Because of this, renters may pay even more to heat, cool, or make their rentals more accommodating, further exacerbating the financial impact associated with renting.

J. Percent of population without a high school diploma

As of 2017, 5.0% (772) people in Ferndale did not have a high school diploma. This is lower than the national average (12.7%)[49] , an important statistic because high school completion is a common proxy for overall socio-economic circumstances. In particular, lack of education is strongly correlated with poverty and poor health. For example:

- People without a high school degree are more than twice as likely to live in inadequate housing compared to those with some college education.[50]
- Thirty-eight percent of Americans without a high school degree do not have health insurance, compared to 10 percent with a college degree.[51]
- The rate of diabetes is much greater for those without a high school degree. Incidence of this disease is more than double the rate of those who have education beyond high school.[52]

K. Other Social Vulnerability Determinants

In total, there are 879 people in households that do not have access to the internet via personal computer. Residents located in the Southwest portion of the city (census tract 1733 & 1734) have the greatest percentage of people (431 people total) without access to the internet. The area of the city with lowest percent of people without access is the Northwest region (census tract 1732) with a total of 96 people lacking access to the internet. Understanding who has access to the internet within Ferndale is important when considering how the City distributes information during times of extreme weather conditions and emergencies.

In total, there are 2,136 people in Ferndale that do not have health insurance coverage. The Southwest region of the city (census tracts 1733 & 1734) have the greatest number of people (805 people) without health insurance coverage. This is closely followed by the Northeast region (tracts 1731 & 1730) in which 746 people do not have health insurance. The region that has the fewest number of people without health insurance is the Northwest (tract 1732) where 173 people are without health insurance. Understanding who within the Ferndale population is without health insurance coverage allows us to better determine who will be most vulnerable to drastic changes in climate.

The Southwest portion of the city has the greatest percentage of households with no vehicle available (7.1% and 8.9%), the Northwest portion has the smallest percentage of households with no vehicle (4.5%). Access to a vehicle is an important factor when considering how residents' daily lives will be impacted by increases in flooding and heat. Residents without access to a vehicle will have greater difficulty getting to work, school, or doctors during flooding incidents than those with access to a vehicle. This is why it is also to consider condition and proximity to alternative transporation options such as mass transit.

Cumulative Socio-Economic Vulnerability

Combining the findings from the previous sections, we were able to create a map denoting some of our most socio-economically vulnerable neighborhoods (Figure 12). This figure identifies all the Census Tracts where the City of Ferndale has high averages relative to the rest of the City for all of the following variables: percentage of families in poverty; percentage of people with disabilities; and percentage of population that is non-white.

These findings align with local knowledge of the socio-economic distribution of the City. Ferndale utilizes Community Development Block Grants (CDBG) to provide community services to areas of need, such as minor home repair, housing assistance, and community green



Figure 8: Census Tracts in Ferndale where 36% or more of the housing units were rentals (36.2% is the national average).

infrastructure. Over the past two years, Ferndale has revised the application standards for utilizing this aid to ensure that it is distributed among, and benefitting the greatest areas of need throughout the community. Furthermore, the City is currently evaluating the overall housing affordability and inclusiveness throughout the community. Results from this study will help inform City staff on ways to improve overall housing affordability and inclusiveness in our community.

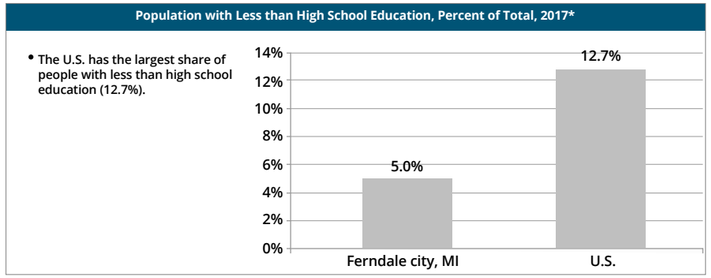


Table 5: Comparison of individuals in Ferndale and the U.S. that have less than a high school education.

Internet Access



Figure 9: Census tracts in Ferndale depicting the percentage of the population that have access to the internet via computer ownership.

Population with No Health Insurance

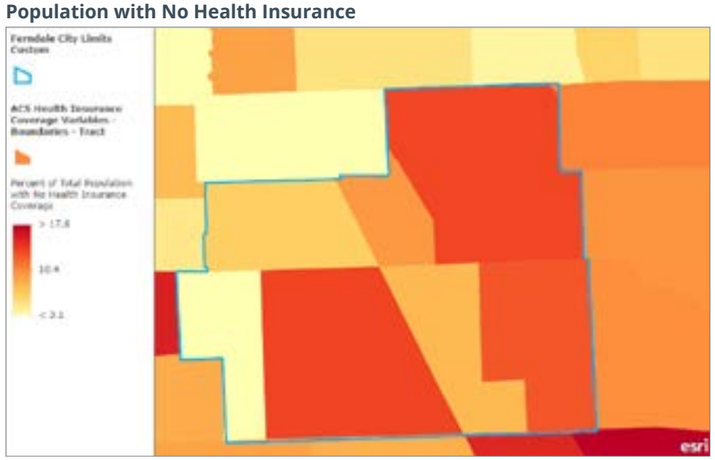


Figure 10: Census tracts in Ferndale depicting the percentage of the population with no health insurance coverage.

Vehicle Availability



Figure 11: Census tracts in Ferndale depicting the percent of households with no vehicle available.



Figure 12: Census Tracts within the City of Ferndale that have the highest overall socioeconomic vulnerability. The map highlights all of the Census Tracts with high averages relative to the rest of the City for: percentage of families in poverty; percentage of people with disabilities; and percentage of population that is non-white.

3. CLIMATE CHANGE IN THE GREAT LAKES REGION AND FERNDALE

In the next section we highlight our exposure to historic, current, and projected futures changes in weather and climate.

Great Lakes Regional Summary

- Average air temperature in the Great Lakes region has increased by 2.3°F
- Average air temperature is projected to rise 3°F to 6°F by the mid-21st century.
- Total annual precipitation has increased by 14% in the region with significant intra-regional variation.
- The total volume of rain falling in the most extreme 1% of events has increased 35%.
- Total annual precipitation will likely increase in the future, though types of precipitation will vary (i.e., more winter precipitation in the form of rain).

A. Climate Change Profile for the Great Lakes Region

The climate of cities throughout the Great Lakes region is already changing. Rising temperatures are leading to more storm activity in our atmosphere, helping to fuel extreme weather and increased precipitation. While heat, drought, and other changes associated with climate change remain a concern for the future, many areas of the region are already facing challenges associated with more total precipitation and more frequent downpours.

Temperature

Average annual temperatures in the Great Lakes region have increased by 2.3°F since 1951, faster than the global and national rates. Most of this warming has been observed during the late spring and early winter, and in overnight low temperatures. The average temperature for the Great Lakes region is projected to increase in the future (3°F to 6°F by 2050), and many of the northern parts of the region will likely experience the most change. The region is projected to see increases in the number of hot and very hot days by the end of the 21st century, with projections indicating the region will see 17 to 42 more days over 90°F in an average year compared to the late 20th century.

Precipitation

The Great Lakes region has experienced changes in the frequency, amount, and form of precipitation. Total precipitation has increased by 14% since 1951 across the region, though this change varies within the region. Therefore, more local data should be used where available. In addition, heavy precipitation (over 1.25" of rainfall in 24hrs) has increased rapidly throughout the region. The amount of rain falling in the most extreme events (heaviest 1% of storms) has increased by 35% and these events have generally become more frequent since 1951. Much of the region is projected to experience more average annual precipitation with total amounts ranging from an additional 2 to 6 inches per year by the end of the 21st century. In addition, the Great Lakes themselves are projected to contribute more water vapor to the air. This increase in moisture combined with rising temperatures, which are necessary for storm formation, will likely produce more intense storms in the future.

Climate change will likely accelerate in the future.

The observed trends in temperature, precipitation, and seasonality are projected to continue or accelerate into the future. The rate of warming has been fastest during the winter, with some locations experiencing twice the annual warming rate of the Great Lakes region. Temperatures will continue to warm at a pace near or faster than the current rate, and precipitation will likely continue to increase, though variability and multi-year dry periods should still be anticipated. By mid-century, summer and spring temperatures may have greater increases compared to fall and winter.

Preparing for the next normal, not a new normal.

The climate system is dynamic and will continue to change rapidly due to greenhouse gas emissions and inherent feedback systems. The challenges, priorities, and risks of the current or next generation climate will continually

change and will affect all sectors. Importantly, climate and weather conditions will not change to a new set of static conditions. This means long-term planning efforts in all departments should regularly evaluate climate and be as flexible and adaptable as possible. Assessing vulnerabilities of a city's assets is a first step toward this goal.

The following table summarizes how various climate risk factors in the Great Lakes region are expected to change in the future. The number and direction of arrows indicate the relative projected trend for mid-century and end of century. A single arrow indicates a projected moderate increase or decrease by mid-century, and two arrows indicate a substantial increase or decrease by end of century.

Climate Change in the Great Lakes Region

Risk	By Mid Century	By End of Century	Summary
Convective Weather (Severe Winds, Lightning, Tornadoes, Hail)	**Uncertain***	**Uncertain***	While extreme precipitation has increased in the region, specific severe weather types (e.g., tornadoes and hail) have remained relatively stable over time.
Severe Winter Weather (Ice/Sleet Storms, Snow Storms)	**Uncertain***	↑	Warmer, shorter winters will reduce the length of winter and winter-related impacts. However, some areas may see more ice, sleet, freezing rain, and wet snow with slightly warmer winter temperatures.
Extreme Heat	↑	↑↑	The number of extremely hot days, those over 95°F and 100°F, will likely increase, though not as fast as in areas farther south. Overnight lows have warmed faster than daytime highs, which may lessen opportunities for relief during heat waves.
Extreme Cold	↓	↓↓	The number of extremely cold days (i.e., days below 10°F) have decreased in the region and are projected to decrease even more in the future.
Dam Failures	↑	↑↑	Stronger and more extreme precipitation events coupled with aging dam infrastructure will increase the probability of dam failure, if appropriate measures are not taken.
Flood Hazards	↑	↑↑	Stronger and more extreme precipitation events will be more likely to overwhelm stormwater infrastructure without appropriate adaptation efforts.
Wildfires	**Uncertain***	↑	Summer drought and the number of consecutive dry days may increase in the future, despite more precipitation annually, increasing the risk of wildfires.
Drought	**Uncertain***	↑	Summer drought and the number of consecutive dry days may increase in the future.
Infestation	↑	↑	With shorter winters and longer growing seasons, conditions may become more suitable for invasive species and pests currently found elsewhere and distribute vector-borne illnesses.

**Boxes labeled uncertain reflect either a lack of available data to discern a trend or no apparent trend from existing data.*

The arrows in this table reflect a qualitative assessment made by the project team based on the best available data for the Great Lakes region. While these trends hold true for projections for most of the region, they should not be assumed to hold true for any particular location. Data used to make this assessment is provided by the NOAA Technical Report NESDIS 142-3 and the Third National Climate Assessment.

B. Ferndale City Summary

Ferndale City Summary

- Average air temperature in Ferndale has increased by 2.7°F.
- Average air temperature is projected to rise 3°F to 5°F by the mid-21st century.
- Total annual precipitation has increased by 25.2%.
- The total volume of rainfall in extreme events (heaviest 1% of storms) has increased by 6%.
- Total annual precipitation will likely increase in the future, though types of precipitation will vary (i.e., more winter precipitation in the form of rain).

The following is a summary of historic as well as projected changes in climate specific to Ferndale. This information is valuable in helping us understand what changes we have already experienced as well as what changes we anticipate.

Historic and Projected Changes in Climate for the City of Ferndale

	Historic (1981-2010)	Mid-Century Projections (High Emissions)	End of Century Projections (High Emissions)	Change Mid-century/ End of century	Percent Change* Mid-century/ End of century
Average Temperature	49.9°F	53 to 55°F	55 to 60°F	3 to 5°F / 5 to 10°F	6 to 10% / 10 to 20%
Winter	27.5°F	30 to 32°F	33 to 37°F	2 to 4°F / 5 to 9°F	9 to 16% / 20 to 35%
Spring	47.7°F	50 to 53°F	53 to 59°F	2 to 5°F / 5 to 11°F	5 to 11% / 11 to 24%
Summer	71.3°F	75 to 77°F	79 to 83°F	4 to 6°F / 8 to 12°F	5 to 8% / 11 to 16%
Fall	52.5°F	55 to 59°F	58 to 65°F	2 to 6°F / 5 to 12°F	5 to 12% / 10 to 24%
Average Low Temperature	41.8°F	45 to 47°F	49 to 52°F	3 to 5°F / 7 to 10°F	8 to 12% / 17 to 24%
Average High Temperature	58°F	60 to 63°F	62 to 68°F	2 to 5°F / 4 to 10°F	3 to 9% / 7 to 17%
Days/Year Greater than 90°F	8.9 days	22 to 38 days	40 to 73 days	13 to 29 days / 31 to 64 days	147 to 327% / 349 to 720%
Days/Year Greater than 95°F	2.8 days	9 to 18 days	Not Available	6 to 15 days / Not Available	221% to 543% / Not Available
Days/Year Less than 32°F	114.4 days	83 to 91 days	Not Available	-31 to -23 days / Not Available	-27% to -20% / Not Available
Total Annual Precipitation	37 in.	37 to 40 in.	38 to 43 in.	0 to 3 in. / 1 to 6 in.	0 to 8% / 3 to 16%

Historic and Projected Changes in Climate for the City of Ferndale					
Winter	7.8 in.	8 to 12 in.	7 to 12 in.	0 to 4 in. / -1 to 4 in.	3 to 54% / -10 to 54%
Spring	9.6 in.	10 to 12 in.	11 to 13 in.	0 to 2 in. / 1 to 3 in.	4 to 25% / 15 to 35%
Summer	9.8 in.	9 to 13 in.	9 to 11 in.	-1 to 3 in. / -1 to 1 in.	-8 to 33% / -8 to 12%
Fall	9.6 in.	9 to 10 in.	10 to 12 in.	-1 to 0 in. / 0 to 2 in.	-6 to 4% / 4 to 25%
Heavy Precipitation Days	3.3 days (> 1.25")	4 to 5.7 days	4.9 to 5.9 days	0.7 to 2.4 days / 1.6 to 2.6 days (> 1")	21 to 73% / 48 to 79%

*Percent change is calculated as the difference between the projected values and the historic average, divided by the observation and multiplied by 100.

Data provided in this table is described in the "About the Data" section for "GHCN", "CMIP3", and "Dynamically Downscaling for the Midwest and Great Lakes Basin."

Temperature and Hot/Cold Extremes

Average Temperature

The average air temperature in Ferndale has increased by 2.7ºF from 1951 to 2017, with the current annual average temperature being 49.9ºF. Average seasonal temperatures have also increased, with spring experiencing the greatest increase of 3.1ºF. Average temperatures in Ferndale are projected to increase 3.0 to 5.0ºF by mid-century under a business as usual (i.e., high emissions) scenario, with summer having the greatest increases of 4.0 to 6.0ºF.

Hot Days

Days with temperature at or above 90°F are common with multiple occurrences in most years and a slight increasing trend over time. Many years on record have experienced 2 to 4 consecutive days over 90°F, with events of 5 to 8 consecutive days occurring less frequently. By mid-century (i.e., 2050), models suggest an increase of anywhere from 13 to 29 more days per year over 90˚F, and an increase of 31 to 64 more days per year over 90°F by end of century. Models are not able, however, to tell us if those days will be consecutive or not.

Days with high temperatures at or above 95ºF have been much rarer, with far less years on record that see occurrences of more than one consecutive day experiencing maximum temperatures over 95ºF. By mid-century (i.e., 2050), models suggest an increase of 6 to 15 days over 95ºF. However, such hot days will not necessarily occur consecutively.

Heat waves can result from a combination of different drivers including high humidity, daily high temperatures, high nighttime temperatures, stagnant air movement, etc. In the future, models project an increase in the number of days experiencing high temperatures that could lead to additional heat waves, especially since air stagnation events are projected to increase. There is greater certainty that summer nighttime low temperatures will continue to increase, thereby making it more difficult to cool off at night during extended heat events. In addition, any periods of future drought will also contribute to extreme heat.

Cold Days

On average, Ferndale experiences 114.4 days per year that fall below freezing (32ºF). Historical records show this number has decreased already. The city is projected to experience fewer nights below 32ºF, with decreases of 23 to 31 days by mid-century.

Days with temperatures at or below 10ºF are very common and have not experienced any clear trends over time. Consecutive days at or below 10ºF are also frequent, and typically last for 2 to 5 days with less frequent occurrences lasting 6 to 13 days. In the future, there are projected to be even fewer very cold days, so this type of event will be even rarer.

Precipitation and Flood/Drought Indicators

Average Precipitation

The amount of total annual precipitation in Ferndale has increased by 25.2% (8.4") from 1951 to 2017. An increase in precipitation was observed in all four seasons, with the fall seeing the greatest percentage increase of 40% (3.0"). Average annual precipitation in Ferndale is projected to increase by up to 3 inches by mid-century and by 1 to 6 inches by the end of the century.

Heavy Precipitation

The frequency and intensity of severe storms has changed over time, with a 2% decrease in the number of extreme precipitation events (heaviest 1% of storms) and a 6% increase in the total volume of rainfall during these events between 1981-2010. Ferndale is projected to experience an increase of up to 2.4 days of heavy precipitation (days with over 1" of rainfall) per year by mid-century and by up to 2.6 days per year by end of century.

Flooding results when rainfall volumes exceed the capacity of natural and built infrastructure to handle precipitation. Stormwater managers look at several different "design storms" (inches falling over a certain length of time) when designing and managing their systems. These design storms are effectively the probability of any given amount of precipitation falling in a set period of time, based on historical experience. Monitoring over time shows that the volumes falling during these "design" storms are increasing. What this means is that the values used to build our existing infrastructure (Bulletin 71 (Huff and Angel, 1992), used data through 1986, and Atlas 14 (NOAA HDSC) added 1987-2011) are dependent on fluctuating estimates of rainfall.

The table below shows precipitation volumes in inches for both Bulletin 71 and Atlas 14 (Bulletin 71/Atlas 14) along with percent change between the two in brackets. This data shows how the "design" storm has changed over time.

In the Great Lakes region, projected changes in seasonal mean precipitation span a range of increases and decreases. In the winter and spring, the region is projected to experience wetter conditions as the global climate warms. By mid-century, some of this precipitation may manifest in the form of increasing snowfall, but projected warmer conditions by end of century suggests such precipitation events will most likely be in the form of rainfall (USGCRP, 2017).

Precipitation events of more than 2" in a day (i.e., 24-hour period) are projected to increase by up to one day by mid-century and up to about 1.5 days by end of century. Precipitation events of more than 3" in a day are projected

This table does not show projections for how the design storm may change in the future due to climate change.

Precipitation Frequencies for the City of Ferndale							
	1-Yr	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
1-hr	0.88 in. / 0.95 in. [8.0%]	1.06 in. / 1.13 in. [6.6%]	1.29 in. / 1.43 in. [10.9%]	1.47 in. / 1.69 in. [15.0%]	1.69 in. / 2.06 in. [21.9%]	1.87 in. / 2.35 in. [10.2%]	2.05 in. / 2.65 in. [28.6%]
12-hr	1.63 in. / 1.79 in. [9.8%]	1.97 in. / 2.05 in. [4.1%]	2.39 in. / 2.51 in. [5.0%]	2.72 in. / 2.94 in. [8.1%]	3.13 in. / 3.57 in. [14.1%]	3.46 in. / 4.10 in. [18.5%]	3.79 in. / 4.67 in. [23.2%]
24-hr	1.87 in. / 2.06 in. [10.2%]	2.26 in. / 2.34 in. [3.5%]	2.75 in. / 2.84 in. [3.3%]	3.13 in. / 3.30 in. [5.4%]	3.60 in. / 3.98 in. [10.6%]	3.98 in. / 4.56 in. [14.6%]	4.36 in. / 5.17 in. [18.6%]

to increase by less than a day by both mid-century and by end of century.

Annual snowfall totals have been variable, with no clear increasing or decreasing trend in the last 40 years. There has been a decreasing trend in days with snowfall (over 0.1" of snowfall in 24 hrs), with varying year-to-year conditions. Warmer temperatures in the future will cause some winter precipitation to transition from snow to rain over time. The projected change in annual snowfall is variable. Annual snowfall is projected to decrease by 7" to 26" by mid-century and by 20" to 40" by end-of century.

Rain Free Periods (3-week events with less than 0.5" of rain)

Drought, defined here as periods of 3 weeks with less than 0.5" of rainfall, has been highly variable year-to-year, with an overall decreasing trend. In the future, even though more annual precipitation is projected overall, more is anticipated to fall in shorter, extreme events. Thus, there will be longer periods of time that experience no rainfall, increasing the potential for drought.

In the following chapter we look at local landscape features that influence our exposure and overall vulnerability to climate change in Ferndale.

About the Climate Change in the Great Lakes Region and Ferndale Data

Coupled Model Intercomparison Project (CMIP) Version 3. The future (mid-century) climate projections for Ferndale are based on the Coupled Model Intercomparison Project Version 3 (CMIP3) A2 emissions scenario, representing "business as usual" high emissions scenario. These data were selected because they were used in the Third National Climate Assessment (Melillo et. al., 2014). More information is available at: https://www.wcrp-climate.org/wgcm-cmip

"Dynamical Downscaling for the Midwest and Great Lakes Basin." Future projections are based on the dynamically downscaled data set for the Great Lakes region developed by experts at the University of Wisconsin-Madison. There are a total of six downscaled models that represent how a variety of different variables are projected to change (mid-century, 2040-2059, compared to the recent past, 1980-1999). The ranges are comprised of the lowest and highest values from all six dynamically downscaled data sets. The regional data are available for download at: http://nelson.wisc.edu/ccr/resources/dynamical-downscaling/index.php.

National Oceanic and Atmospheric Administration National Centers for Environmental Information Global Historical Climatology Network Station Observations (GHCN). More information about this station located in Ferndale, MI from 1981-2010 is available at: https://glisa.umich.edu/station/c00200230

"National Oceanic and Atmospheric Administration ThreadEx Long-Term Station Extremes for America". ThreadEx is a data set of extreme daily temperature and precipitation values for 270 locations in the United States. For each day of the year at each station, ThreadEx provides the top 3 record high and low daily maximum temperatures, the top 3 record high and low daily minimum temperatures, the top 3 daily precipitation totals, along with the years the records were set for the date (NCAR, 2013). ThreadEx data for the Detroit area from 1966 to 2016: http://threadex.rcc-acis.org/

National Oceanic and Atmospheric Administration Hydrometeorological Design Studies Center Atlas 14 Precipitation Frequency Estimates. Data are available at: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

4. LANDSCAPE FEATURES THAT AFFECT FERNDALE'S STORMWATER SYSTEM VULNERABILITY

Summary

- Local landscape features such as floodplain location and extent, elevation, slope, landscape cover, and stormwater asset conditions all influence the vulnerability of our stormwater system as well as local flooding potential.
- By combining the aforementioned factors, we were able to generate a holistic assessment of where in Ferndale landscape features affect our stormwater systems and our community's vulnerability to flooding. Results showed that the Southeast region of the city is most vulnerable to flooding. This is due to its high percentage of impervious surfaces, low percentage of vegetation, and soil composition.
- Local features influence heat impacts, including: impervious surfaces, urban heat island, and vegetation coverage.
- By combining the aforementioned factors, we were able to generate a holistic assessment of where in Ferndale local landscape features may affect our vulnerability to heat. Results showed that the areas that experienced the greatest heat island effects are concentrated in commercial and industrial districts. With the downtown corridor and rail yard being the most vulnerable to heat.

In addition to our socio-economic composition and projected changes in climate, certain features related to the way Ferndale is designed and our physical environment make us more or less vulnerable to climate change. This section explores a number of these landscape characteristics or features that affect the vulnerability of our residents and our systems to flooding. We chose to look specifically at our local vulnerability to flooding because this is one of the largest climate impacts we expect to continue experiencing in a climate-altered future.

Landscape Features that Affect Our Stormwater System and Flooding Exposure

Flooding is one of the most common and pervasive climatological impacts to affect the City of Ferndale. Every year we experience numerous localized flooding events. These events can cause property damage, road closures, economic disruptions, and other issues. Larger events have far reaching implications for our local economy, transportation systems, and health and safety. Nationally, flood deaths are highest in adults over the age of 50 (although 20-30 years old also have a fairly high vulnerability to flooding-related deaths and injuries).[53] Males are notably more vulnerable to flooding-related deaths, particularly those tied to flash flooding events.[54]

Because of the acute vulnerability we have in Ferndale, we want to understand what local landscape features enhance or reduce our local stormwater systems vulnerability as well as our local vulnerability to flooding. The following factors are important elements of understanding these vulnerabilities.

a) Instances of Community Flooding
b) Elevation
c) Slope
d) Land Cover (vegetation and impervious cover)
e) Stormwater Asset Map
f) Soils Hydrologic Group

a) Instances of Community Flooding

Ferndale utilizes the online tool See Click Fix to monitor and respond to non-emergency requests made by residents through the online portal. In an effort to better understand surface flooding in Ferndale, each report of flooding made by residents in the time period of 2018-

Street Flooding Incidents



Figure 13: The rate at which residents have reported street flooding compared with location of catch basins.

2019 was recorded and exported into a GIS map. The data of flooding incidents was layered with a map depicting the location of restricted and un-restricted catch basins.

Ferndale utilizes two types of catch basins in order to direct stormwater – restricted and un-restricted. Restricted catch basins act to slow the flow of water into the stormwater systems, which can cause minor street flooding for a short period of time. By comparing the rate of flood incidents reported with the location of restricted catch basins we can sort out the controlled flooding from uncontrolled.

The Northwest region of the city reported street flooding at a greater rate than other areas of the city when taking in account of restricted catch basins. This finding is interesting because the Northwest region of the city is the least vulnerable area to flooding and heat in the city. The Northwest region is the most affluent area with the greatest access to resources. It is possible that residents living in the Southeast area (most vulnerable to flooding and heat) are not aware of or do not have access to the online portal See Click Fix, causing there to be a discrepancy of flood reporting. Additionally, the Northwest region appears to have greater amount of pipes that are 12", indicating there is a greater lack of pipe capacity in the Northwest compared to the rest of the city.

b) Elevation

Understanding the elevation of various areas of our city helps us to understand which areas might be more prone to future flooding and, therefore, where we may have greater stormwater-related challenges. Recognizing that, we used the Elevation Profile Tool created by developers at ArcGIS to create an elevation profile for Ferndale. Ferndale's elevation is at its peak height of 670 feet on the West side of the city. Beginning around Livernois St the elevation begins to steadily decline by 40 feet until reaching the lowest elevation in the city of 630 feet on the Eastern border of Ferndale. While the change in elevation is not extreme, it may cause there to be an increased rate of flooding on the East side of the city vs. the West.

c) Slope

Slope is the degree of incline or tilt that exists between two points. Understanding slope can help us determine which areas in our community might be particularly susceptible to runoff and erosion from major rain events.



Figure 14: Graphical depiction of elevation from west to east in Ferndale.

Using a Digital Elevation Model raster layer provided by the City's GIS department, we were able to map slope throughout the city. Based on results, we grouped slope into three categories:

1. Areas with less than 12% slope;
2. Areas with slope between 12-18%; and
3. Areas with more than 18% slope.

As shown in Figure 15, The City of Ferndale is considerably flat (less than 12% slope), with very few instances of increased steepness. The lack of differences in slope throughout the City suggests that it is not a determinant of surface flooding.

d) Land Cover

Land cover is an important factor affecting flood potential (as well as heat potential). Impervious surfaces and low vegetative covering are indicators of runoff potential. We know that when precipitation falls on impervious surfaces, such as roads, streets, sidewalks, and buildings, it is unable to infiltrate into the soil and is diverted directly into our grey infrastructure. Conversely, the greater portion of vegetation cover present, the more precipitation may infiltrate the soil, and thus, the less precipitation moves through the city as run-off. Because of this, the City of Ferndale has decided to use impervious surface coverage and vegetation coverage as indicators of local landscape vulnerability to flooding.

Slope Map

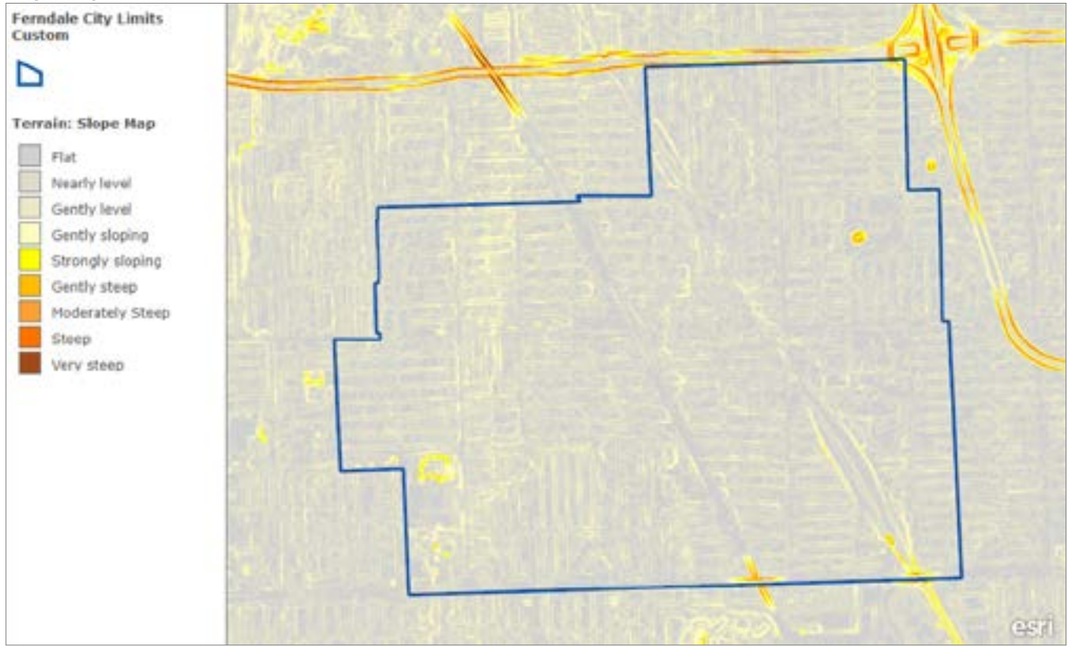


Figure 15: Degree of slope within Ferndale.

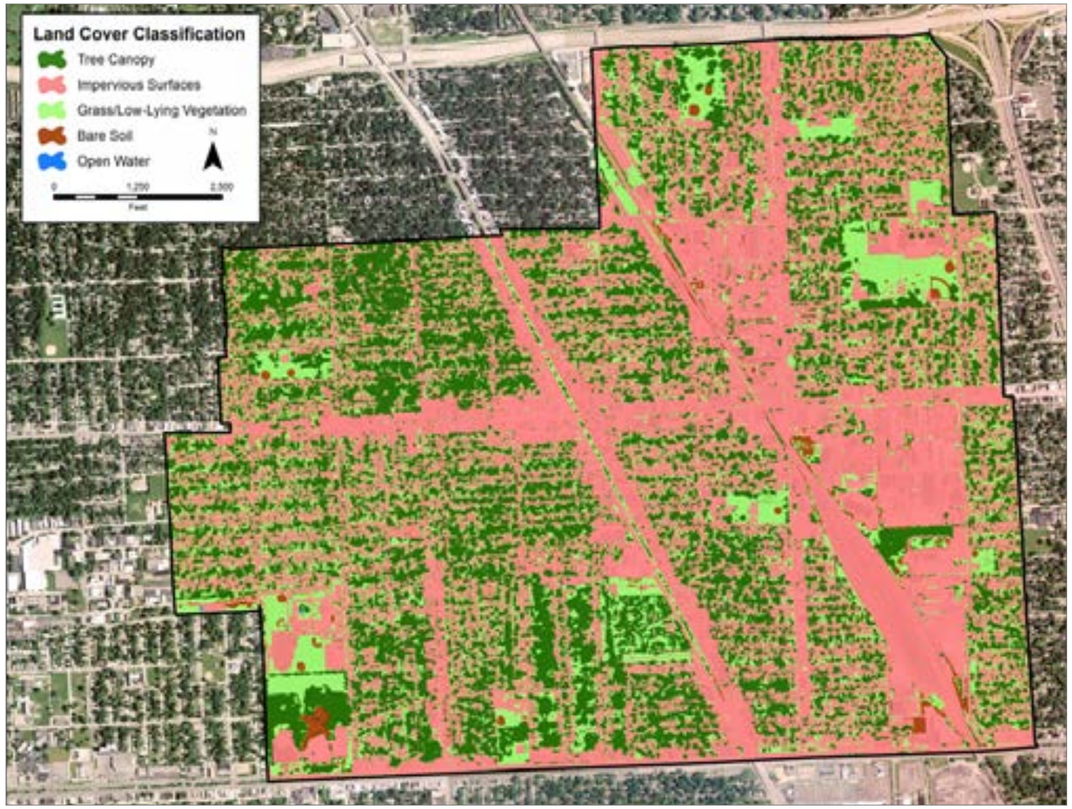


Figure 16: Ferndale land coverage.

To determine the amount and location of vegetation throughout Ferndale we used data from the United States Geological Survey's (USGS) Normalized Difference Vegetation Index (NDVI), which is a measure of "greenness". We downloaded a Landsat 8 aerial image from USGS Earth Explorer and processed it into a NDVI image with ArcMap.[55] The results from this analysis can be found in Figure 16.

As shown in the above figure, there is a great portion of the city consisting of impervious surfaces (49.97%). The highest concentrations of impervious surfaces are located along Woodward, 9 mile, 8 mile, and heavy industrial areas. This corresponds with the zones MXD-2, CBD, C-2, M-1, and M-2. The Southeast region has a tree canopy percent of 21.24%, the lowest percent in the city. Alternatively, the Northwest region has a tree canopy percent of 44.17%

e) Stormwater Asset Conditions

The quality (age, condition, capacity) and design of our city's stormwater infrastructure is another important element that influences our flooding potential. For the purposes of this landscape assessment, we chose to look at the condition of the various elements of our stormwater system, known as our stormwater asset map. Current best practices in our region dictate that all stormwater infrastructure should be built to handle a 10-year storm event. In Ferndale, however, we intend to encourage all developers and staff to begin designing stormwater infrastructure to manage the 100-year storm event. It is important to note that the City of Ferndale is a combined system where sanitary and stormwater flow combine in the same infrastructure. Recognizing that separating our system will be costly and take an enormous amount of coordination, current efforts are to encourage distributed green stormwater infrastructure to help mitigate stormwater from entering the combined system.

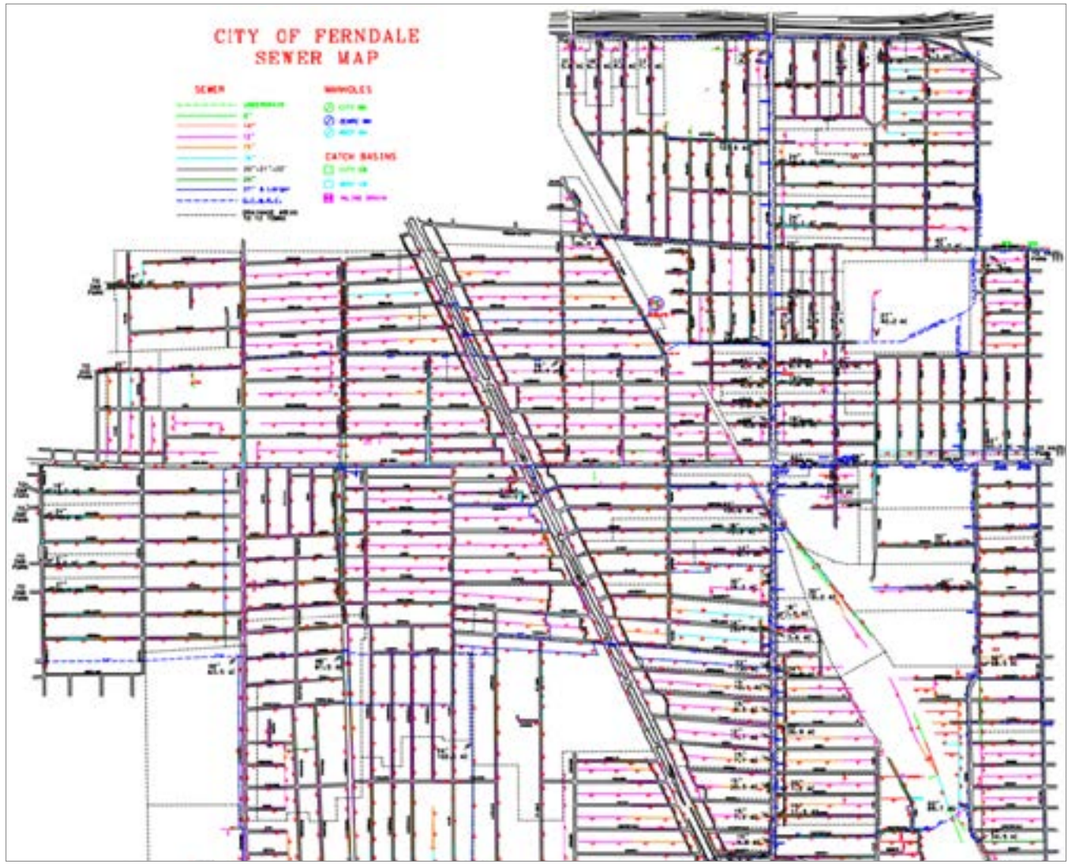


Figure 17: Size and location of the sewer mains, as well as the drainage areas throughout Ferndale as of 2017.

Considering this information, we conducted an analysis to determine what type of storm events our various stormwater assets can handle as well as the overall condition of our stormwater system.

The City is currently in the process of evaluating the condition of its stormwater infrastructure through video analysis of sewer mains.

Results (Figure 17 & 18), show that the majority of watermains throughout Ferndale were installed in 1920, indicating aging stormwater infrastructure as well. The size of the sewer mains throughout the city range from 8" to 27"+, the two most prevalent pipe sizes are 12" and 15". Overall, the system is designed for a 10-year storm event. The northwest region of the city appears to have higher concentration of 12" pipes vs. the southeast which appears to have a more balanced mix of 12" and 15" pipes.

The size of the sewer mains are set, so we need to use alternative methods to increase capacity of the system. By looking at areas within the city that have the highest concentration of smaller pipes, we can determine locations that are more likely to experience surface flooding and implement green stormwater infrastructure.

f) Soils Hydrologic Group

When rain falls over Ferndale, a portion of it runs off into stormwater systems while the remainder infiltrates into the soil or returns to the atmosphere directly through evaporation. The physical properties of the soil in Ferndale affect the rate at which water is absorbed and the amount of runoff that is produced by the storm. Hydrologic soil group provides an index of the rate of water that infiltrates a soil.



Figure 18: Years of installation of Ferndale watermains.

To determine the hydrologic soil groups located within Ferndale we used the ArcGIS map layer "USA Soils Hydrologic Group" which derived the data used from the 2019 version of the gSSURGO 30m (contiguous U.S.) and 10m rasters (all other regions) produced by the Natural Resources Conservation Service (NRCS). The value for hydrologic group is derived from the gSSURGO map unit aggregated attribute table field Hydrologic Group - Dominant Conditions (hydgrpdcd).

The above figure shows that the soil composition of Ferndale consists of four group types: A, B, C, and D. Group A is the most prevalent soil type within the city and is mainly concentrated on the west and north areas of the city. Group A soils consist of deep, well drained sands or gravelly sands with high infiltration and low runoff rates. Group B soils are present in a small concentration in the southeast portion of city, located near the railway and industrial area. Soils in Group B consist of deep well drained soils with a moderately fine to moderately coarse texture and a moderate rate of infiltration and runoff. Group C soils are located in the East portion of the city, they consist of soils with a layer that impedes the downward movement of water or fine textured soils and a slow rate of infiltration. Group D soil types are located primarily in the Downtown Corridor, along Woodward, and in heavy industrial areas of the City. Soils in Group D consist of soils with a very slow infiltration rate and high runoff potential. This group is composed of clays that have a high shrink-swell potential, soils with a high water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.

Ferndale Hydrologic Soils

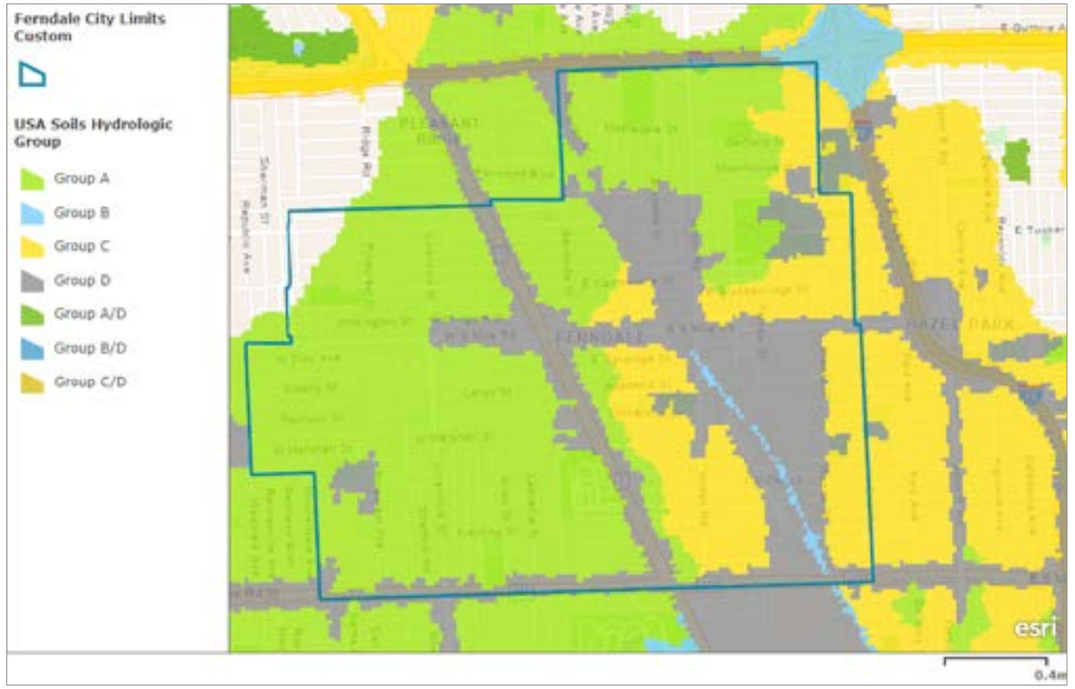


Figure 19: Ferndale Hydrologic Soils

Ferndale's Stormwater and Flooding Vulnerability Map

By combining the above maps,[56] we are able to identify areas of our community that are particularly sensitive to stormwater-related impacts and flooding (Figure 20).

As can be seen from this map, the region that is the most vulnerable to flooding is the Southeast. This portion of the city consists of 62.94% impervious has a tree canopy of 21.24%. The soil composition in the Southeast is primarily soils with a very slow infiltration rate and high runoff potential.

Landscape Features that Affect Heat and Associated Exposure to our Stormwater System

Extreme heat is the number one weather-related killer in the United States.[57] The majority of people who have traditionally died from heat exposure die in their homes, generally in environments with little or no air conditioning. Extreme heat has the most negative impact on adult populations aged 50+, with men being notably more vulnerable to heat exposure and death than women.

Extreme heat can be exacerbated by local environmental conditions, especially the urban heat island. An urban heat island is a phenomenon whereby urban regions experience warmer temperatures than their rural surroundings.[58] Some of the reasons for the localized urban heat island include: reduced vegetation in urban areas; the materials used to build in urban areas; and urban geometry.

Ferndale Flood Vulnerability



Figure 20: Combination of Ferndale land cover and hydrologic soils.

Because of the very real and serious threats posed by extreme heat to Ferndale residents, we have chosen to look at three local landscape indicators that increase our vulnerability to heat.

a) Vegetation Coverage: Normalized Difference Vegetation Index

b) Impervious Land Cover

c) Urban Heat Island Effect

a) Vegetation Coverage: Normalized Difference Vegetation Index

Many urban areas have a lower percentage of green space, compared to rural regions. Since trees and vegetation provide shade, which helps lower surface temperatures, the lower percentage of green space in urban areas can directly translate into higher temperatures compared to more vegetated rural areas. In addition trees and other vegetation help reduce air temperatures through a process called evapotranspiration, in which plants release water to the surrounding air, dissipating ambient heat. In urban areas with limited green space, the value of shading and evapotranspiration is limited, particularly when compared to more rural or less developed regions, thereby contributing to elevated urban surface and air temperatures.

Vegetation



Figure 21: Ferndale Vegetation

To determine the amount and location of vegetation throughout Ferndale we used data from the United States Geological Survey's (USGS) Normalized Difference Vegetation Index (NDVI), which is a measure of "greenness". We downloaded a Landsat 8 aerial image from USGS Earth Explorer and processed it into a NDVI image with ArcMap.[59] The results from this analysis can be found in Figure 21.

The area that has the highest cover of vegetation is the Northwest portion of the city. The areas with the least coverage are located in the Downtown district along Woodward and 9 mile, as well as the heavily industrialized area on the East side of the city following the CN railway. This correlates with data on urban heat islands. In 2016, the City conducted a study on the Tree Canopy in Ferndale to target areas of need for tree plantings. Over 400 trees have been planted since the study was produced, with gaps in the canopy prioritized for further plantings.

b) Impervious Land Cover

In contrast to vegetated areas, we know that impervious surfaces, surfaces made from materials that do not absorb precipitation (e.g., asphalt, concrete, brick) are extremely effective at trapping heat. Given this, the City of Ferndale also mapped the location and percentage of impervious land coverage throughout our community (Figure 22).

Overall, 49.97% of the City is comprised of impervious surfaces. The southeast region has the greatest percentage of impervious surfaces (62.94%), and the Northwest region has the smallest percentage (38.19%). Specific areas in Ferndale that have the greatest percentage of impervious surface are the Downtown District, and heavily industrialized area along the CN railway.

Impervious Surface



Figure 22: Ferndale Impervious Surface

Heat Vulnerability



Figure 23: Ferndale Urban Heat Island

c) Urban Heat Island Effect

Most urban areas consist of roads, roofs, buildings, and other materials that, traditionally, have low solar reflectance and high heat capacity. Solar reflectance (also known as albedo) is the percentage of solar energy reflected by a surface. Darker surfaces, which tend to abound in urban areas, have lower solar reflectance values compared to lighter surfaces meaning that they reflect less and absorb more of the sun's energy. This absorbed heat increases surface temperatures and contributes to the formation of urban heat islands. According to the US EPA, "another important property of building material that influences heat island development is a material's heat capacity, which refers to its ability to store heat. Many building materials frequently used in urban areas, such as steel and stone, have high heat capacities. As a result, cities are typically more effective at storing the sun's energy as heat within their infrastructure."[60] As an example, studies have shown that downtown metropolitan areas can absorb and store twice the amount of heat compared to rural surroundings during the daytime.[61]

Using information from a dataset developed by Descartes Labs API that utilized Landsat 8 imagery band 10 (ground-level thermal sensor) from the summers of 2018 and 2019, we were able to determine the local urban heat island effect throughout the City of Ferndale. This map layer demonstrates where certain areas of Ferndale are hotter than the average temperature for the city as a whole. Severity is measured on a scale of 1 to 5, with 1 being a relatively mild heat area (slightly above the mean for Ferndale), and 5 being a severe heat area (significantly above the mean for Ferndale).

The areas within Ferndale that experience the greatest urban heat island effect are concentrated in the industrial areas on the East side of the city, as well as the Downtown Corridor consisting of Woodward and 9 Mile. These urban heat islands correlate with areas in the city that have the greatest number of impervious surfaces and least amount of vegetation.

Heat Vulnerability

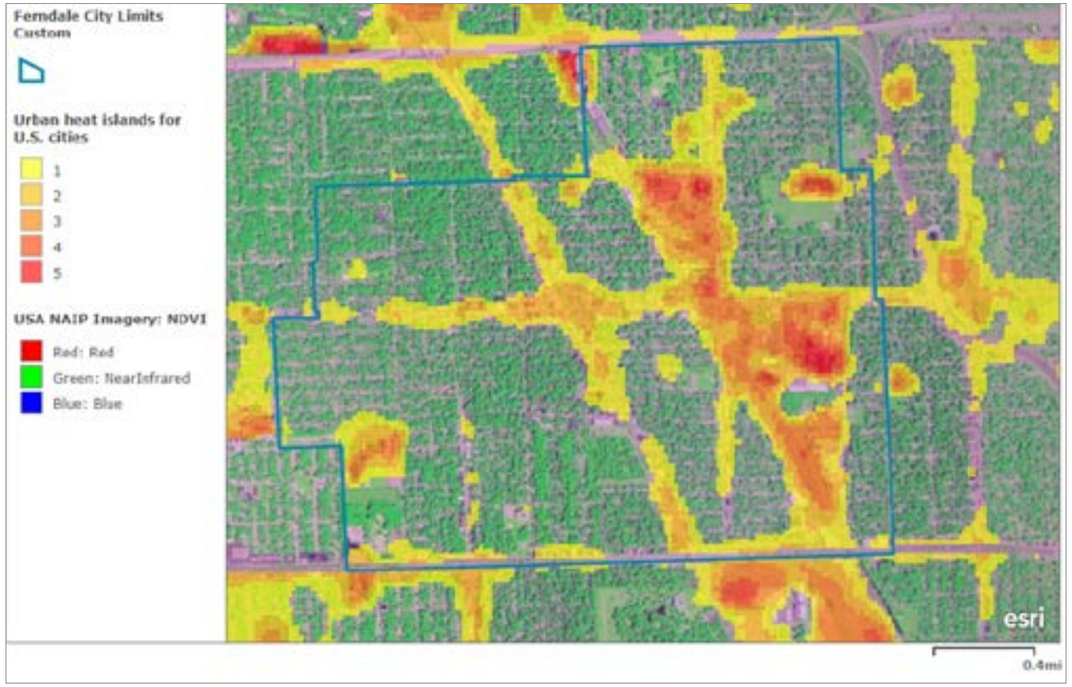


Figure 24: Ferndale Heat Vulnerability

Ferndale's Heat Vulnerability Map

By combining the above maps,[62] we were able to identify the specific areas of our community that are particularly sensitive to heat (Figure 24).

The east side of the city has the highest vulnerability to heat, followed by the Downtown District based on local landscape features. The areas most vulnerable are those in highly industrialized or commercial areas that lack vegetation and have a high rate of impervious surfaces. The areas that have the lowest vulnerability are located in the residential areas on the west side of the city, these areas tend to have increased vegetation and more pervious surfaces.

Summary of Landscape Vulnerability

The results in this section shed light on some of the local characteristics that can reduce or increase our community's vulnerability to flooding and extreme heat. Based on the cumulative results from this section, we know that the southeast area of the city is the most vulnerable to both flooding and extreme heat. This is due to its location between the two major heat islands in the City, the composition of the soil (soils with a layer that impedes the downward movement of water or fine textured soils and a slow rate of infiltration), the amount of impervious surfaces, and the lack of vegetation. Alternatively, the areas that experience the least vulnerability to heat and flooding are in the northwest due to their increased vegetation in relation to the rest of the city and soils that consist of deep, well drained sands or gravelly sands with high infiltration and low runoff rates.

5. FERNDALE'S VULNERABILITY ASSESSMENT RESULTS

In the next section we use all the previous information to complete our vulnerability assessment.

Using the information outlined in the previous sections, the City of Ferndale completed a vulnerability assessment of our stormwater system. A vulnerability assessment helps determine the extent to which our city and its major elements are susceptible to harm from climate change. Our vulnerability assessment helps us understand:

1. What changes in climate are projected to happen and what those changes could mean in terms of local **impacts**,
2. The level of exposure the community has to potential changes and **impacts**,
3. How **sensitive** the various city and community systems are to projected changes in climate, and
4. What **capacity** those systems have to adapt.

As previously identified, this vulnerability assessment is specific to the City's stormwater systems. As such, to undertake our vulnerability assessment we engaged in the following nine steps.

Step 1: Define Scope of Assessment

For the purpose of Ferndale's vulnerability assessment, we chose to focus on our entire stormwater system. The remainder of this section provides a short description of the City's stormwater system and the various components evaluated as part of our vulnerability assessment.

Elements Included in a System-Wide Stormwater Vulnerability Assessment	
Stormwater System Element	Type of System
Demand on Stormwater System	Built System
Capacity of Pipes	Built System
Green Infrastructure	Natural System
Residents Impacted by Surface Flooding	Social Systems and Vulnerable Populations
City Facilities - Buildings	Built System
Condition of Stormwater System	Built System

Municipal Buildings

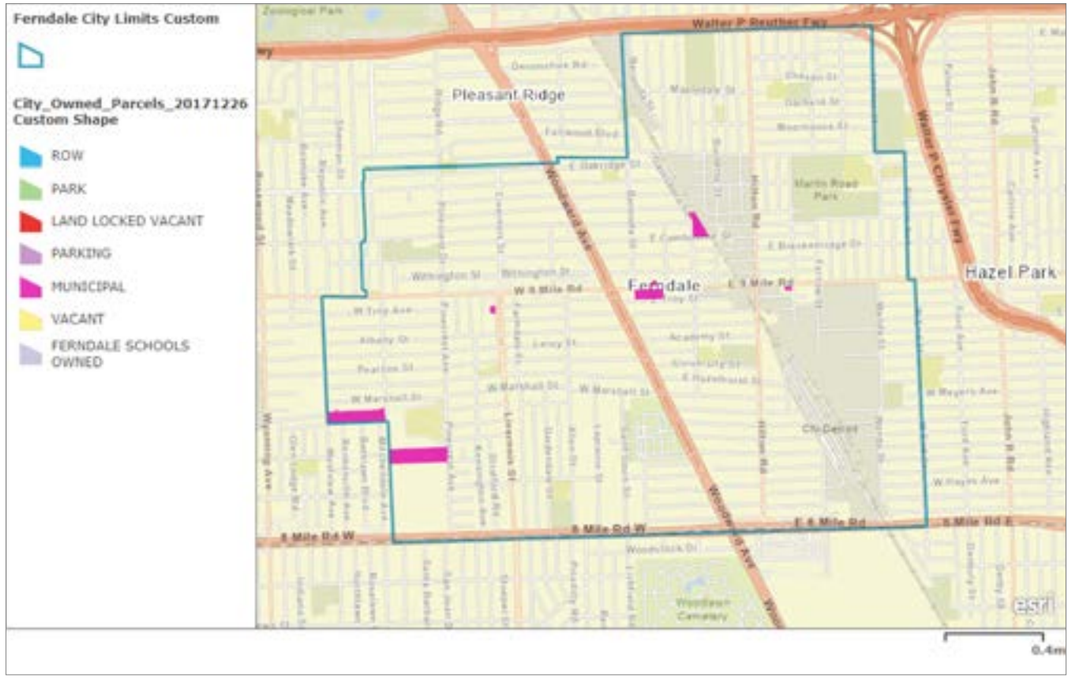


Figure 25: Ferndale City Owned Parcels (municipal buildings highlighted)

Description and Location of Built Elements of the Stormwater System in Ferndale

City Facilities, specifically City Buildings were one aspect of our Stormwater System that we evaluated. The City currently owns and maintains seven municipal buildings.

The capacity of pipes, demand on the stormwater system, and condition of the stormwater system were also evaluated.

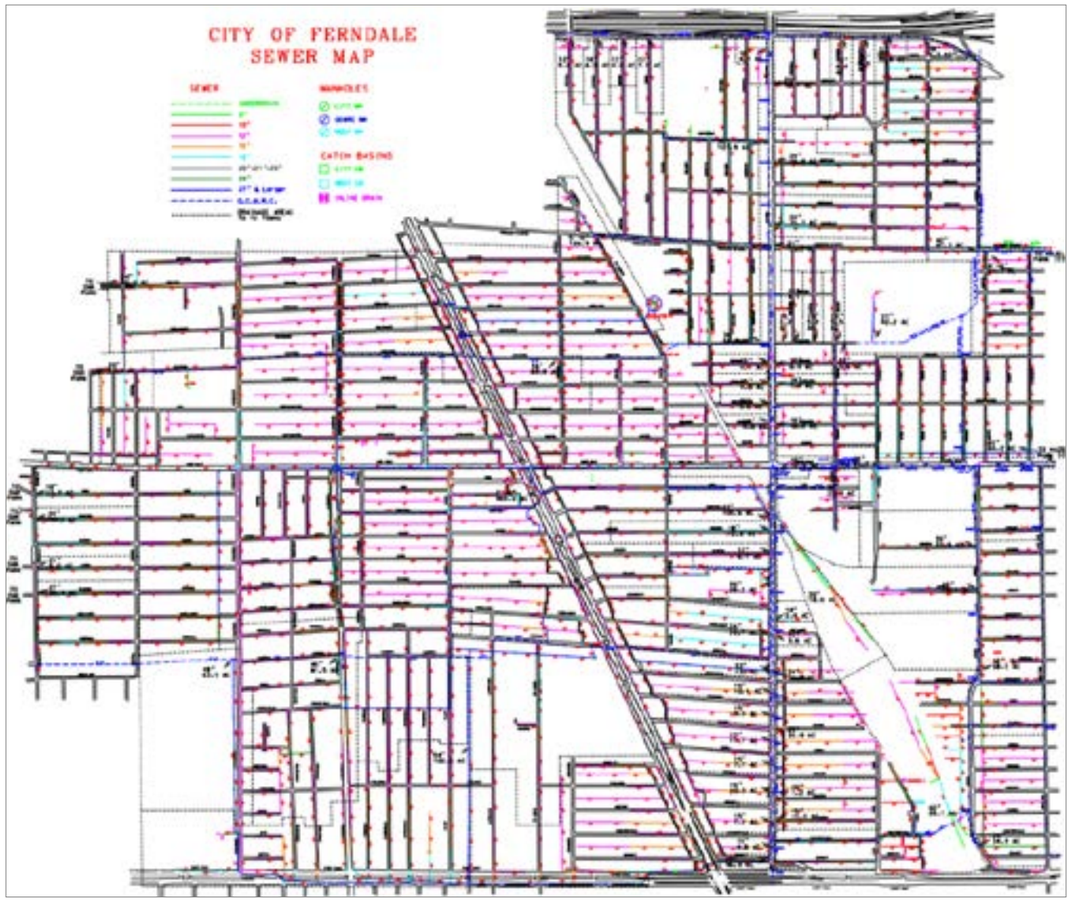


Figure 26: Ferndale Sewer Map

Description and Location of Natural Systems in Ferndale

Green Infrastructure was another component that was evaluated as a part of our stormwater system vulnerability assessment. We specifically looked at what impacts increasing green infrastructure would have on the vulnerability of the City. In the summer of 2019 a skate park that doubles as a stormwater retainer was completed in Geary Park. The City has its first green stormwater infrastructure project planned for Spring 2020 where several bioswales will be installed within the right of way of W. Marshall St. Currently, green infrastructure throughout the city includes city parks, trees, and street medians. In addition, the City has a residential program called Planned Natural Landscape that encourages property owners to install alternative landscapes to replace turf grass. This allows for distributed stormwater infiltration on a property by property basis.

City Parks

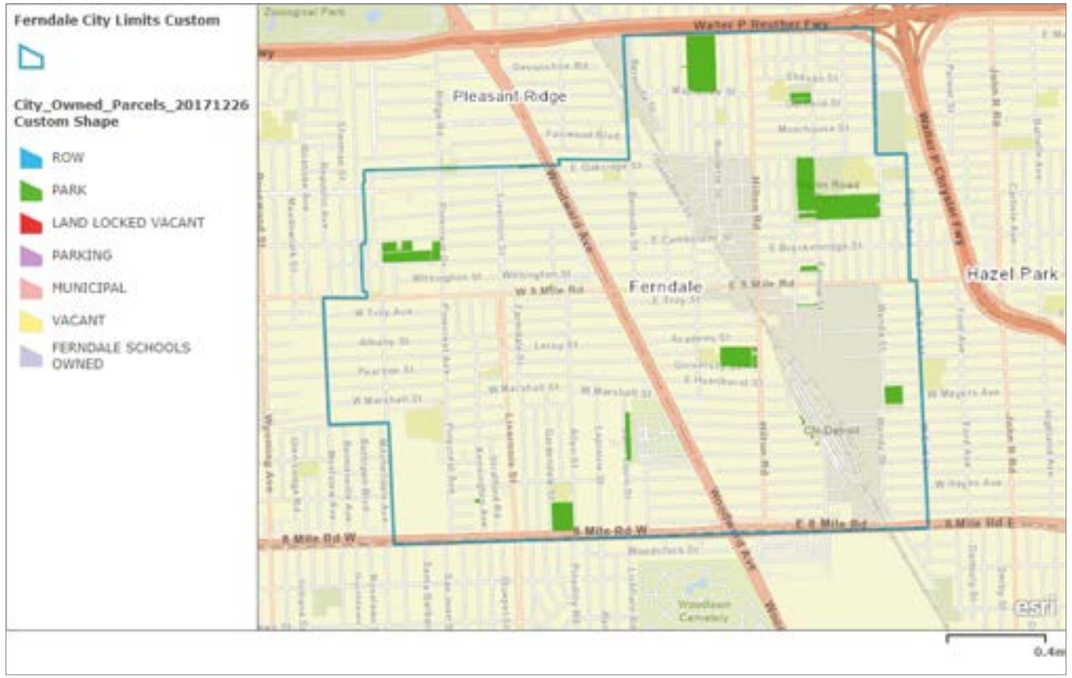


Figure 27: Ferndale City Owned Parcels (parks highlighted)

Description and Location of Social Systems and Vulnerable Populations in Ferndale

As a part of our stormwater system vulnerability assessment we evaluated the impact of surface flooding on all residents of Ferndale. While we evaluated the impacts of surface flooding on all residents, it is important to note that the most vulnerable populations were determined to be located in the southeast region of the city.

To learn more about the geographical location of different populations and rational for including all residents, please view the socio-economic profile of Ferndale.

Cumulative Vulnerability Assessment Scope

In order to begin obtaining an understanding of the effects climate change will have on Ferndale, we evaluated the city's vulnerability to stormwater caused by the increasing rate and severity of storms. We chose to look at how changes in climate will affect the demand on our stormwater system, the condition of our stormwater system, the capacity of our pipes, city facilities – specifically buildings, green infrastructure, and residents impacted by surface flooding.

Table 6 provides a sample of the systems and system elements evaluated as part of the City of Ferndale's stormwater system vulnerability assessment process.

Table 6: Scope of Vulnerability Assesments

Ref#	City	System	System Component	Geographical Distribution System Component (Census Tract, if applicable)
1	Ferndale	Stormwater	Demand on Stormwater System	All Ferndale vs. All Ferndale
2	Ferndale	Stormwater	Capacity of Pipes	All Ferndale vs. All Ferndale
3	Ferndale	Stormwater	Green Infrastructure	All Ferndale vs. All Ferndale
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	All Ferndale vs. All Ferndale
5	Ferndale	Stormwater	City Facilities - Building	All Ferndale vs. All Ferndale
6	Ferndale	Stormwater	Condition of Stormwater System	All Ferndale vs. All Ferndale

Step 2: Socio-Economic Analysis

The second step of our assessment focused on compiling and analyzing socio-economic information, at the pertinent geographical scale, for the various elements evaluated as part of our stormwater-system vulnerability assessment.
To do this, we built upon the data outlined in Chapter 2 to more deeply understand who could be affected by each of the elements evaluated in our vulnerability assessment. Guiding this section were two key questions:

1. How will socio-economic vulnerability influence the elements being evaluated in our vulnerability assessment?
2. How will the elements (i.e., the thing being evaluated as part of our vulnerability assessment) impact (i.e., help or hinder) socio-economic vulnerability?

Table 7 below demonstrates the results from this step of our assessment for a subset of our system.

Project Details					Socio-Economic Vulnerability												
Ref #	City	System	System Component	Geographical Distribution of System Component (Census Tract, if applicable)	% of Population Over 65	% of Population Under 5	% of Community in Poverty	% of Population with Limited English Proficiency	% of Non-White Population	% of Households Receiving Food Stamps/ SNAP	% of Households Where Mortgage is >30% of HH Income	% Disabled	% of Renters	% of Population Without a High School Diploma	Other Social Vulnerability Variables (add any that are relevant)	How Will Socio-Economic Vulnerability Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Socio-Economic Vulnerability?
1	Ferndale	Stormwater	Demand on Stormwater System	All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5		Increased rates to fund system improvements can affect those with less income	Can prioritze increasing capacity on redevelopments since there is already so much impervious
				vs													
				All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5			
2	Ferndale	Stormwater	Capacity of Pipes	All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5		Increased commercial development sometime gets priority over areas that may need it most. NE and south central neighborhoods have high renters and lower incomes	Potential for more basement backups or failures; impacted by downstream system capacity
				vs													
				All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5			
3	Ferndale	Stormwater	Green Infrastructure	All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5		If its on private property, maintainence may be difficult if expense or time are in short supply. High renter population makes GI work more challeging	Access to green space can improve well being.
				vs													
				All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5			
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5		Lack means to install solutions that would prevent flooding. Basement flooding may be difficult to reocver from. Cant afford insurance.	Increased home costs due to flooding means residents will have to spend more money on repairs and insurance, instead of other needs.
				vs													
				All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5			
5	Ferndale	Stormwater	City Facilities - Buildings	All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5		Millage/tax to improve city building	Additional millage could increase tax burden for community.
				vs													
				All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5			
6	Ferndale	Stormwater	Condition of Stormwater System	All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5		As system continues to deteriorate rates will increase; increase rates to repair/maintain sewers and associate infrastructure	Stormwater utility may proportionally distrubute the cost burden for repairs and maintainence
				vs													
				All_Ferndale	8.5	4.9	14.4	0.2	13.5	11.5	19.1	12.2	35.7	5			

Step 3: Exposure Analysis

The third step in our assessment was the compilation and analysis of pertinent climate change information to understand how the various elements being evaluated as part of our stormwater vulnerability assessment could be or already are exposed and impacted by a changing climate.

The intent of this step is to understand responses to two key questions:

1. How will projected changes in climate influence the elements being evaluated as part of our stormwater vulnerability assessment?
2. How will the elements (i.e., the thing being evaluated as part of our stormwater vulnerability assessment) impact (i.e., help or hinder) projected changes in climate?

Table 8 below demonstrates the results from this step of our assessment for a subset of the stormwater system.

Project Details			Climate Vulnerability								
Ref #	City	System	System Component	Variable of Interest	Sub-Variables of Interest		Historical/ Current	Mid-Century Projected Changes	% Change Between Historic and Future; Mid Century % / End Century %	How Will Projected Changes in Climate Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Projected Changes?
1	Ferndale	Stormwater	Demand on Stormwater System	Precipitation	Total Annual Precip	Ferndale-Precipitation-Total Annual Precip	37 in.	37 to 40 in.	0 to 8% / 3 to 16%	Total precipitation is increasing (frequency and intensity is the critical elements) - which could increase demand on the system; overflows could get worse so what are we going to require of our businesses and how will we pay for that? Sized for 10 year storm event (according to Bulletin 71); design in the 1920.	More overflows mean more sewage going into the river; if system is exapnded there will be increased ghg emissions; need to have greater maintenance and increase the capacity to support increased demand on needs; Could lead to challenge/conflict/decisions regarding managing limited resources
				Precipitation	Spring Avg Precip	Ferndale-Precipitation-Spring Avg Precip	9.6 in.	10 to 12 in.	4 to 25% / 15 to 35%		
				Precipitation	Fall Avg Precip	Ferndale-Precipitation-Fall Avg Precip	9.6 in.	9 to 10 in.	-6 to 4% / 4 to 25%		
				Precipitation	Heavy Precipitation Days(>1.25")	Ferndale-Precipitation-Heavy Precipitation Days(>1.25")	3.3 days (> 1.25")	4 to 5.7 days	21 to 73% / 48 to 79%		
				Temperature	Spring Avg Temp	Ferndale-Temperature-Spring Avg Temp	47.7°F	50 to 53°F	5 to 11% / 11 to 24%		
2	Ferndale	Stormwater	Capacity of Pipes	Precipitation	Total Annual Precip	Ferndale-Precipitation-Total Annual Precip	37 in.	37 to 40 in.	0 to 8% / 3 to 16%	Reduces the capacity (intensity and frequency); might require more maintenance over time and if we can't keep up with maintenance, capacity could decrease (might want to look at asset maps)	Possibiliy of more CSO's could lead to more nutrients in Lake St. Clair and we have high heat, you have elevated nutrient loading
				Precipitation	Spring Avg Precip	Ferndale-Precipitation-Spring Avg Precip	9.6 in.	10 to 12 in.	4 to 25% / 15 to 35%		
				Precipitation	Fall Avg Precip	Ferndale-Precipitation-Fall Avg Precip	9.6 in.	9 to 10 in.	-6 to 4% / 4 to 25%		
				Precipitation	Heavy Precipitation Days(>1.25")	Ferndale-Precipitation-Heavy Precipitation Days(>1.25")	3.3 days (> 1.25")	4 to 5.7 days	21 to 73% / 48 to 79%		
				Temperature	Avg Annual Temp	Ferndale-Temperature-Avg Annual Temp	49.9°F	53 to 55°F	6 to 10% / 10 to 20%		

Project Details			Climate Vulnerability								
Ref #	City	System	System Component	Variable of Interest	Sub-Variables of Interest		Historical/ Current	Mid-Century Projected Changes	% Change Between Historic and Future; Mid Century % / End Century %	How Will Projected Changes in Climate Influence This System Component?	How Will This System Component Impact (e.g., help or hinder) Projected Changes?
3	Ferndale	Stormwater	Green Infrastructure	Precipitation	Total Annual Precip	Ferndale-Precipitation-Total Annual Precip	37 in.	37 to 40 in.	0 to 8% / 3 to 16%	Hopefully increase the amount of green infrastructure to help manage increased PPT; enhanced filtration; we'll have increased runoff but GI can help with pollution prevention; GI is a huge environmental education opportunity for residents and businesses to understand how they can play a role; GI might be harder to establish if there are more extreme events and might be less effective; may necessitate the changing of species being planted;	Unless you have more resources coming in, you'll need to balance how you are financing and maintaining green infrastructure; more trees and more GI needs more maintenance - overtime budget; additional employees; If we use volunteers they need to have training, supplies, equipment, etc. (which still has a very clear cost and capacity need); GI can help with urban heat island effect; GI can help with carbon sequestration; GI can help with water quality and quantity
				Precipitation	Spring Avg Precip	Ferndale-Precipitation-Spring Avg Precip	9.6 in.	10 to 12 in.	4 to 25% / 15 to 35%		
				Precipitation	Fall Avg Precip	Ferndale-Precipitation-Fall Avg Precip	9.6 in.	9 to 10 in.	-6 to 4% / 4 to 25%		
				Precipitation	Heavy Precipitation Days(>1.25")	Ferndale-Precipitation-Heavy Precipitation Days(>1.25")	3.3 days (> 1.25")	4 to 5.7 days	21 to 73% / 48 to 79%		
				Temperature	Avg Annual Temp	Ferndale-Temperature-Avg Annual Temp	49.9°F	53 to 55°F	6 to 10% / 10 to 20%		
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	Precipitation	Total Annual Precip	Ferndale-Precipitation-Total Annual Precip	37 in.	37 to 40 in.	0 to 8% / 3 to 16%	More flooding; Limited ability to pay for more repair and mitigation that has to happen; property loss; possibility of a spiral with more and more events pushing them past adaptive capacity; seconary effects associated with social vulnerability might be geographically relevant - we should check	Communicating to the city when they have issues (there is a communication mechanism that doesn't have to be centered around complaints but more reporting); some sort of response plan in place if replacing the infrastructure isn't feasible, we need to be able to respond in the event of overflows; Limited capacity to do the adaptation strategy
				Precipitation	Spring Avg Precip	Ferndale-Precipitation-Spring Avg Precip	9.6 in.	10 to 12 in.	4 to 25% / 15 to 35%		
				Precipitation	Fall Avg Precip	Ferndale-Precipitation-Fall Avg Precip	9.6 in.	9 to 10 in.	-6 to 4% / 4 to 25%		
				Precipitation	Heavy Precipitation Days(>1.25")	Ferndale-Precipitation-Heavy Precipitation Days(>1.25")	3.3 days (> 1.25")	4 to 5.7 days	21 to 73% / 48 to 79%		
				Temperature	Avg Annual Temp	Ferndale-Temperature-Avg Annual Temp	49.9°F	53 to 55°F	6 to 10% / 10 to 20%		
5	Ferndale	Stormwater	City Facilities - Buildings	Precipitation	Total Annual Precip	Ferndale-Precipitation-Total Annual Precip	37 in.	37 to 40 in.	0 to 8% / 3 to 16%	Impacts of climate change could affect city facilities that need maintenance or are not prepared for the future.	Updated city facilities could be designed to be more resilient to impacts of climate change; an updated or new city facility could be designed to temporarily house residents if a major weather event occurred.- provide relief during crisis
				Precipitation	Spring Avg Precip	Ferndale-Precipitation-Spring Avg Precip	9.6 in.	10 to 12 in.	4 to 25% / 15 to 35%		
				Precipitation	Fall Avg Precip	Ferndale-Precipitation-Fall Avg Precip	9.6 in.	9 to 10 in.	-6 to 4% / 4 to 25%		
				Precipitation	Heavy Precipitation Days(>1.25")	Ferndale-Precipitation-Heavy Precipitation Days(>1.25")	3.3 days (> 1.25")	4 to 5.7 days	21 to 73% / 48 to 79%		
				Temperature	Avg Annual Temp	Ferndale-Temperature-Avg Annual Temp	49.9°F	53 to 55°F	6 to 10% / 10 to 20%		
6	Ferndale	Stormwater	Condition of Stormwater System	Precipitation	Total Annual Precip	Ferndale-Precipitation-Total Annual Precip	37 in.	37 to 40 in.	0 to 8% / 3 to 16%	Increase in rainfall burden sytem and may accelerate the deterioation of the system; especially in instances of poor condition	Could cause failures in the system; infiltration into the system; sinkholes; other infrastructure
				Precipitation	Spring Avg Precip	Ferndale-Precipitation-Spring Avg Precip	9.6 in.	10 to 12 in.	4 to 25% / 15 to 35%		
				Precipitation	Fall Avg Precip	Ferndale-Precipitation-Fall Avg Precip	9.6 in.	9 to 10 in.	-6 to 4% / 4 to 25%		
				Precipitation	Heavy Precipitation Days(>1.25")	Ferndale-Precipitation-Heavy Precipitation Days(>1.25")	3.3 days (> 1.25")	4 to 5.7 days	21 to 73% / 48 to 79%		
				Temperature	Avg Annual Temp	Ferndale-Temperature-Avg Annual Temp	49.9°F	53 to 55°F	6 to 10% / 10 to 20%		

Step 4: Landscape Analysis: Flooding

The fourth step in our vulnerability assessment focused on compiling and analyzing pertinent information needed to understand how the various elements in our stormwater system already are exposed to flooding. To do this, we collected information, to the extent available, elevation; whether or not the system was in the floodplain; slope; percent impervious land cover; and the storm event capacity and condition of infrastructure in the region. Where possible, we used data on the census tract level. When not available, we used citywide data.

Once data was compiled we used two questions to guide our assessment of each stormwater element's vulnerability to flooding:

1. How do local landscape features influence the element's vulnerability to flooding?
2. How will each element exacerbate or reduce landscape vulnerability to flooding?

Table 9 below demonstrates the results from this step of our assessment for the demand on the stormwater system, capacity of pipes, green infrastructure, residents impacted by surface flooding, city facilities – buildings, and the condition of the stormwater system.

Project Details				Landscape Vulnerability: Flooding							
Ref #	City	System	System Component	Geographical Distribution of System Component (Census Tract, if applicable)	Landscape Variables That Could Affect Your Community's Local Vulnerability to Flooding -add any locally available data. (see Template for more info)					How Do Local Landscape Features Influence This System Component's Vulnerability to Flooding?	How Does This System Component Exacerbate or Reduce Landscape Vulnerability to Flooding?
1	Ferndale	Stormwater	Demand on Stormwater System	All_Ferndale	Elevation	In Floodplain (Y/N)	Slope (e.g., less than 12%; between 12-18%; over 18%)	Percent Impervious Land Cover	Storm Event Capacity of Infrastructure (e.g. 10-yr event; 20-yr event)	High imperviousness results in higher demand on system with larger rainfall events. Redevelopment provides an opportunity for increased detention capacity. Parking lots are oversized is there an opportunity to reduce the footprint or increase infiltration. WIll people migrate to this area and increase population in a way we do not expect?	More detention planned will decrease flooding.
					9-12 feet below	N	less than 12%	49.97	10 yr flood		
2	Ferndale	Stormwater	Capacity of Pipes	All_Ferndale	Elevation	In Floodplain (Y/N)	Slope (e.g., less than 12%; between 12-18%; over 18%)	Percent Impervious Land Cover	Storm Event Capacity of Infrastructure (e.g. 10-yr event; 20-yr event)	Capacity is pipes is set. They will not be increased in size. A lot of the pipe has been fortified already with plans to do more. Where there are trees, roots become a problem.	Increase rainfall could reduce capcity of pipes increaasing the changes of surface flooding
					9-12 feet below	N	less than 12%	49.97	10 yr flood		
3	Ferndale	Stormwater	Green Infrastructure	All_Ferndale	Elevation	In Floodplain (Y/N)	Slope (e.g., less than 12%; between 12-18%; over 18%)	Percent Impervious Land Cover	Storm Event Capacity of Infrastructure (e.g. 10-yr event; 20-yr event)	Soils in east half of city are clay. Infiltration capacity low. Higher imperviousness of the city leaves little opportunity for GI until a redevepment occurs. A lot of the parks have these clay soils as well	Future GI already planned and funded. Master planning for parks where they are incorporating sustainable practices. SEMCOG doing an analysis of policy and design recommendations for GI
					ground level	N	less than 12%	49.97	10 yr flood		
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	All_Ferndale	Elevation	In Floodplain (Y/N)	Slope (e.g., less than 12%; between 12-18%; over 18%)	Percent Impervious Land Cover	Storm Event Capacity of Infrastructure (e.g. 10-yr event; 20-yr event)	Commercial industrial (high impervious) plus clay makes this area more vulnerable to flooding. Water flows from West to East. This combined with clay soils. makes this area problematic. Railroad is a large landowner in this tract as well limiting control over what is done on the land	Recently there was significant investment in tree canopy in these areas. Residents help id maintainence needs through complaint calls.
					ground level	N	less than 12%	49.97	10 yr flood		
5	Ferndale	Stormwater	City Facilities Building	All_Ferndale	Elevation	In Floodplain (Y/N)	Slope (e.g., less than 12%; between 12-18%; over 18%)	Percent Impervious Land Cover	Storm Event Capacity of Infrastructure (e.g. 10-yr event; 20-yr event)	There should be an inventory completed by the City to understand the existing landscaping features around city facilities to understand how new facilities could limit/eliminate future flooding.	New city facilities could be designed to limit impervious surface, reduce flow to the stormwater system, add tree canopy, and other ways to reduce vulnerability to flooding.
					ground level	N	less than 12%	49.97	10 yr flood		
6	Ferndale	Stormwater	Condition of Stormwater System	All_Ferndale	Elevation	In Floodplain (Y/N)	Slope (e.g., less than 12%; between 12-18%; over 18%)	Percent Impervious Land Cover	Storm Event Capacity of Infrastructure (e.g. 10-yr event; 20-yr event)	Infiltration of tree roots may impact condition of the system causing more infiltration of system which could lead to more back ups due to reduced flow	If system is in poor condition it will not funciton properly; GI/reduction of impervious land reduces flows and vulnerability to flooding
					9-12 feet below	N	less than 12%	49.97	10 yr flood		

Step 5: Cumulative Impacts

The fifth step in our analysis combined the information and analysis done in steps 2-4 to gather a holistic sense for the different ways each element evaluated as part of our stormwater system vulnerable assessment was impacted by socio-economic considerations, changes in climate, and local landscape features. Once we had combined all of this information, we then asked the following question:

1. How will the element affect socio-economic, climate, and landscape features?
2. How will socio-economic, climate, and landscape features affect the element?

Table 10 below demonstrates the results from this step of our assessment on the demand on the stormwater system, capacity of pipes, green infrastructure, residents impacted by surface flooding, city facilities – buildings, and the condition of the stormwater system.

Project Description				Socio Economic Analysis Results		Climate Change Analysis Results		Heat Analysis Results		Flooding Analysis Results		Cumulative Impacts
Ref #	City	System	System Component	How Will Socio-Economic Vulnerability Influence What Is In Column D?	How Will What Is In Column D Impact (e.g., help or hinder) Socio-Economic Vulnerability?	How Will Projected Changes in Climate Influence What Is In Column D?	How Will What Is In Column D Impact (e.g., help or hinder) Projected Changes?	How Do Local Landscape Features Influence Column D's Vulnerability to Heat?	How Will What Is In Column D Exacerbate or Reduce Landscape Vulnerability to Heat?	How Do Local Landscape Features Influence Column D's Vulnerability to Flooding?	How Does Column D Exacerbate or Reduce Landscape Vulnerability to Flooding?	Based On All Analysis Completed So Far, Summarize How This System Component: 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.
1	Ferndale	Stormwater	Demand on Stormwater System	Increased rates to fund system improvements can affect those with less income	Can prioritze increasing capacity on redevelopments since there is already so much impervious	Total precipitation is increasing (frequency and intensity is the critical elements) - which could increase demand on the system; overflows could get worse so what are we going to require of our businesses and how will we pay for that? Sized for 10 year storm event (according to Bulletin 71); design in the 1920.	More overflows mean more sewage going into the river; if system is exapnded there will be increased ghg emissions; need to have greater maintenance and increase the capacity to support increased demand on needs; Could lead to challenge/conflict/decisions regarding managing limited resources	0	Reducing impervious land cover reduces demand on the system	High imperviousness results in higher demand on system with larger rainfall events. Redevelopment provides an opportunity for increased detention capacity. Parking lots are oversized is there an opportunity to reduce the footprint or increase infiltration. WIll people migrate to this area and increase population in a way we do not expect?	More detention planned will decrease flooding.	Increase the demand on the system and if we have an increased frequency and intensity of heavy rainfall events we have problems. Residents more prone to flooding will increase. Residents could be impacted by increasing rates to improve the system or deciding where to place the improvements (and some of these might have disproportionate effects on socio-economically vulnerable populations). Improvements in our ordinance and development practices may decrease the stress for demand due to increased detention. To a certain extent the ongoing maintenance and repairs we have been doing to the system are beneficial and we aren't far behind on the curve in terms of preparing.
2	Ferndale	Stormwater	Capacity of Pipes	Increased commercial development sometime gets priority over areas that may need it most. NE and south central neighborhoods have high renters and lower incomes	Potential for more basement backups or failures; impacted by downstream system capacity	Reduces the capacity (intensity and frequency); might require more maintenance over time and if we can't keep up with maintenance, capacity could decrease (might want to look at asset maps)	Possibiliy of more CSO's could lead to more nutrients in Lake St. Clair and we have high heat, you have elevated nutrient loading	Over capacity if we get warm weather rain while ground is still frozen. Freeze/ thaw events --do these result in more main breaks. Main break mixed with high heat increases vulnerability of outdoor workers	0	Capacity is pipes is set. They will not be increased in size. A lot of the pipe has been fortified already with plans to do more. Where there are trees, roots become a problem.	Increase rainfall could reduce capcity of pipes increaasing the changes of surface flooding	Similar to demand, our maintenance and repair has been done well and we have a plan for continuing into the future. Capacity of the pipes is fairly set so to increase the capacity of the system it has be paired with detention or retention. As a regional, more significant rainfall will all need to go to the treatment facility and does that facility have the capacity to handle? This necessitates the need to think and work regionally on stormwater solutions (includes working with upstream communities to help manage system as well as with downstream communities).

Project Description				Socio Economic Analysis Results		Climate Change Analysis Results		Heat Analysis Results		Flooding Analysis Results		Cumulative Impacts
Ref #	City	System	System Component	How Will Socio-Economic Vulnerability Influence What Is In Column D?	How Will What Is In Column D Impact (e.g., help or hinder) Socio-Economic Vulnerability?	How Will Projected Changes in Climate Influence What Is In Column D?	How Will What Is In Column D Impact (e.g., help or hinder) Projected Changes?	How Do Local Landscape Features Influence Column D's Vulnerability to Heat?	How Will What Is In Column D Exacerbate or Reduce Landscape Vulnerability to Heat?	How Do Local Landscape Features Influence Column D's Vulnerability to Flooding?	How Does Column D Exacerbate or Reduce Landscape Vulnerability to Flooding?	Based On All Analysis Completed So Far, Summarize How This System Component: 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.
3	Ferndale	Stormwater	Green Infrastructure	If its on private property, maintainence may be difficult if expense or time are in short supply. High renter population makes GI work more challeging	Access to green space can improve well being.	Hopefully increase the amount of green infrastructure to help manage increased PPT; enhanced filtration; we'll have increased runoff but GI can help with pollution prevention; GI is a huge environmental education opportunity for residents and businesses to understand how they can play a role; GI might be harder to establish if there are more extreme events and might be less effective; may necessitate the changing of species being planted;	Unless you have more resources coming in, you'll need to balance how you are financing and maintaining green infrastructure; more trees and more GI needs more maintenance - overtime budget; additional employees; If we use volunteers they need to have training, supplies, equipment, etc. (which still has a very clear cost and capacity need); GI can help with urban heat island effect; GI can help with carbon sequestration; GI can help with water quality and quantity	It is more difficult to establish GI with more extreme temps. Trees will be more vulnerable to pests.	GI could reduce impervious surface and increase tree canopy on City streets and lessen the urban heat island effect.	Soils in east half of city are clay. Infiltration capacity low. Higher imperviousness of the city leaves little opportunity for GI until a redevopment occurs. A lot of the parks have these clay soils as well	Future GI already planned and funded. Master planning for parks where they are incorporating sustainable practices. SEMCOG doing an analysis of policy and design recommendations for GI	Overall green infrastructure can be beneficial in reducing the impacts of climate change but it has to be done in a way that is intentional, holistic, and strategic. Because of that, we hope to increase the amount of green infrastructure practice and/or make it more of a priority in our infrastructure improvements. That will mean identifying appropriate funding mechanisms to make this happen. Consideration of design in terms of what gets planted, where, etc in terms of increased temperatures, greater rainfall,and soil conditions. Need to consider the spatial disparity in these equations. Making sure whatever we have, we have education and outreach developed guidelines.
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	Lack means to install solutions that would prevent flooding. Basement flooding may be difficult to reocver from. Cant afford insurance.	Increased home costs due to flooding means residents will have to spend more money on repairs and insurance, instead of other needs.	More flooding; Limited ability to pay for more repair and mitigation that has to happen; property loss; possibility of a spiral with more and more events pushing them past adaptive capacity; seconary effects associated with social vulnerability might be geographically relevant - we should check	Communicating to the city when they have issues (there is a communication mechanism that doesn't have to be centered around complaints but more reporting); some sort of response plan in place if replacing the infrastructure isn't feasible, we need to be able to respond in the event of overflows; Limited capacity to do the adaptation strategy	Power outages coupled with flooding, sump pump failure, higher mold issues, etc. Higher health care costs - emergency response costs. Getting necessary health care for those with disabilities. Transportation channels can be shut down and impede people getting places	Residents impacted by flooding could reduce impact landscape vulnerability by limiting impervious surfaces on their properties, plant more trees, etc.	Commercial industrial (high impervious) plus clay makes this area more vulnerable to flooding. Water flows from West to East. This combined with clay soils. makes this area problematic. Railroad is a large landowner in this tract as well limiting control over what is done on the land	Recently there was significant investment in tree canopy in these areas. Residents help id maintainence needs through complaint calls.	If we continue doing what we are doing, residents that flood are going to continue to be impacted by flooding at greater intensity and frequency. Important to map all the flooding areas to see if there is a systematic reason why it continuously floods. Need to understand basement flooding versus surface (backyard) flooding. Not all flooding is created equal so many need to think about unique strategies to handle different kinds of flooding. There are real concerns about how has the capacity to manage the flooding (i.e., income and other socio-economic considerations).
5	Ferndale	Stormwater	City Facilities Building	Millage/tax to improve city building	Additional millage could increase tax burden for community.	Impacts of climate change could affect city facilities that need maintenance or are not prepared for the future.	Updated city facilities could be designed to be more resilient to impacts of climate change; an updated or new city facility could be designed to temporarily house residents if a major weather event occurred.- provide relief during crisis.	There should be an inventory completed by the City to understand the existing landscaping features around city facilities to understand how new facilities could improve vulnerability to heat.	New city facilities could be designed to limit impervious surface, reduce flow to the stormwater system, and other ways to reduce vulnerability to heat.	There should be an inventory completed by the City to understand the existing landscaping features around city facilities to understand how new facilities could limit/eliminate future flooding.	New city facilities could be designed to limit impervious surface, reduce flow to the stormwater system, add tree canopy, and other ways to reduce vulnerability to flooding.	New or updated city facilities would improve resiliency to climate change by designing and planning for vulnerability to heat, flooding, and other impacts. However, an additional millage could be a financial stress on the community.
6	Ferndale	Stormwater	Condition of Stormwater System	As system continues to deteriorate rates will increase; increase rates to repair/maintain sewers and associate infrastructure	Stormwater utility may proportionally distrubute the cost burden for repairs and maintainence	Increase in rainfall burden sytem and may accelerate the deterioation of the system; especially in instances of poor condition	Could cause failures in the system; infiltration into the system; sinkholes; other infrastructure	0	High heat may stress GI in areas throughout City; high heat may also impact soil conditions and permeability	Infiltration of tree roots may impact condition of the system causing more infiltration of system which could lead to more back ups due to reduced flow	If system is in poor condition it will not funciton properly; GI/reduction of impervious land reduces flows and vulnerability to flooding	Increased rainfall events will impact condition of the system; must pay close attention to correct species when installing GI; locations of GI must consider underground conditions and infrastructure; increase in rainfall events will impact residents, expecially in poor system conditions

Step 6: Sensitivity Assessment

The sixth step of our assessment focused on the sensitivity of each element evaluated in the stormwater system to the impacts identified in the previous step. Sensitivity is the degree to which a system and its constituent parts (e.g., built, natural, human,) can be or are affected by changes in climate conditions or specific climate impacts. For example, a building built in the 500-year floodplain with flood-proofing measures is much less sensitive to a flood than one in the 100-year floodplain with no flood proofing measures.

To determine how sensitive each of our stormwater elements were, we answered three questions:

1. What, if any existing stresses affect this element?
2. How might demand for this element change given impacts identified in Step 5?
3. What, if any, limiting factors does this element have that make it more sensitive?

We answered these questions for each of the Elements included in the scope of our assessment. The responses to these three questions were used to assign a sensitivity score for each element. We used the qualitative evaluation criteria provided in Figure 28 to assign sensitivity scores.

Figure 28 Sensitivity Levels

S0	Element will not be affected by the climate-related impact
S1	Element will be minimally affected by the climate-related impact
S2	Element will be somewhat affected by the climate-related impact
S3	Element will be largely affected by the climate-related impact
S4	Element will be greatly affected by the climate-related impact

Results from this analysis found that we have a particularly high sensitivity (scores of S3-S4) for the Capacity of our Pipes (S4), and the Residents Impacted by Surface Flooding (S4). When looking at the capacity of the pipes within Ferndale, it is important to recognize that the capacity is set, so any changes done to increase capacity of the system has to be done using detention and retention of the stormwater. Additionally, we need to look at the capacity of the pipes as a regional issue. If our regional neighbors do not invest in retention and detention of increased stormwater, it will flow into Ferndale, further reducing capacity on our end. In addition, it is important to consider the capacity of the water treatment facility downstream of Ferndale, and if it will be able to handle an increase in stormwater flow.

When examining residents impacted by surface flooding, it must be noted that if the City to use the same methods to tackle flooding, residents that currently experience flooding are going to continue to experience it and at increasing frequency. One way in the which the City can begin to tackle surface flooding is to ensure that all residents have the same access to and knowledge of the tools provided to residents to report flooding (ex: See Click Fix). If the City is able to implement sufficient green infrastructure and detention systems, it is possible that the rate of surface flooding for residents would decrease, further highlighting the importance of addressing the effects of climate change on a local level. The elements of our system that showed moderate sensitivity (S2) were the Demand on the Stormwater System, Green Infrastructure, City Facilities (specifically City Buildings), and the Condition of the Stormwater System.

Table 11 below demonstrates the results from this step of our assessment for a subset of the stormwater system.

Project Description				Cumulative Impacts	Sensitivity Assessment			
Ref #	City	System	System Component	Based On All Analysis Completed So Far, Summarize How This System Component: 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.	What, If Any Existing Stresses Affect This System Component?	How Might Demand For This System Component Change Given Impacts Identified in Columns E?	What, If Any, Limiting Factors Does This System Component Have? (e.g., think about how projected impacts might influence the System Component's operational thresholds)	How Sensitive is This System Component to Projected Changes in Climate? (e.g., Sensitivity Score)
1	Ferndale	Stormwater	Demand on Stormwater System	Increase the demand on the system and if we have an increased frequency and intensity of heavy rainfall events we have problems. Residents more prone to flooding will increase. Residents could be impacted by increasing rates to improve the system or deciding where to place the improvements (and some of these might have disproportionate effects on socio-economically vulnerable populations). Improvements in our ordinance and development practices may decrease the stress for demand due to increased detention. To a certain extent the ongoing maintenance and repairs we have been doing to the system are beneficial and we aren't far behind on the curve in terms of preparing.	Potential new development	Without climate change, we'd expect demand on the system to decline. With climate change (without the detention capacity), we'd expect it to increase. We need more information on how the efforts to increase retention and how the impacts of increased PPT combine to effect demand.	Space, capital improvements and competing priorities; budget; adding more work needs more workers; what happens upstream and downstream	S2 - System will be somewhat affected by the climate-related impact
2	Ferndale	Stormwater	Capacity of Pipes	Similar to demand, our maintenance and repair has been done well and we have a plan for continuing into the future. Capacity of the pipes is fairly set so to increase the capacity of the system it has be paired with detention or retention. As a regional, more significant rainfall will all need to go to the treatment facility and does that facility have the capacity to handle? This necessitates the need to think and work regionally on stormwater solutions (includes working with upstream communities to help manage system as well as with downstream communities).	Fixed space for any future expansion of capacity; overall condition	If upstream storage capacity is increased and if overall flow is decreased it may decrease stress on our system	Fixed space; funding; opportunities for retention or detention are limited; regional partnerships	S4 - System will be greatly affected by the climate-related impact
3	Ferndale	Stormwater	Green Infrastructure	Overall green infrastructure can be beneficial in reducing the impacts of climate change but it has to be done in a way that is intentional, holistic, and strategic. Because of that, we hope to increase the amount of green infrastructure practice and/or make it more of a priority in our infrastructure improvements. That will mean identifying appropriate funding mechanisms to make this happen. Consideration of design in terms of what gets planted, where, etc in terms of increased temperatures, greater rainfall,and soil conditions. Need to consider the spatial disparity in these equations. Making sure whatever we have, we have education and outreach developed guidelines.	Increase in impervious surfaces	Demand could increase if urban heat island effect and rainfall increases.	Space, capital improvements and competing priorities; budget; adding more work needs more workers; what happens upstream and downstream; soil conditions	S2 - System will be somewhat affected by the climate-related impact
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	If we continue doing what we are doing, residents that flood are going to continue to be impacted by flooding at greater intensity and frequency. Important to map all the flooding areas to see if there is a systematic reason why it continuously floods. Need to understand basement flooding versus surface (backyard) flooding. Not all flooding is created equal so many need to think about unique strategies to handle different kinds of flooding. There are real concerns about how has the capacity to manage the flooding (i.e., income and other socio-economic considerations).	Spending 30% of income or more on housing; Slightly more renters - less likely to have opportunities to make improvements; renters aren't accumulating equity/ wealth	Likely an increase in the number of residents experiencing flooding - depending on how well the city does with implementing GI and detention, it might actually decrease.	Money; soils (clay); ownerships of homes; lack of insurance (possibly)	S4 - System will be greatly affected by the climate-related impact
5	Ferndale	Stormwater	City Facilities Building	New or updated city facilities would improve resiliency to climate change by designing and planning for vulnerability to heat, flooding, and other impacts. However, an additional millage could be a financial stress on the community.	Additional tax burden on the community, existing building limitations.	An increase in climate change related events could make the community understand the need to update city facilities; a large climate related event could create demand for a shared facility that could be shelter for the community.	Rising construction costs and limited labor pool to building or update city facilities.	S2 - System will be somewhat affected by the climate-related impact
6	Ferndale	Stormwater	Condition of Stormwater System	Increased rainfall events will impact condition of the system; must pay close attention to correct species when installing GI; locations of GI must consider underground conditions and infrastructure; increase in rainfall events will impact residents, expecially in poor system conditions	Increased rain events; increase in impervious surface; maintenance cycle - ability to invest in system	system backups and failures	maintenance and funding	S2 - System will be somewhat affected by the climate-related impact

Step 7: Adaptive Capacity Assessment

The seventh step of our assessment focused on the adaptive capacity of each element to the impacts identified in the previous step. Adaptive capacity is a measure of the ability of an element (e.g., institutions, humans, infrastructure, species) to adjust to potential damage, to take advantage of opportunities, or to cope with consequences. Some of the most important factors influencing the adaptive capacity of an element are access to and control over natural, social, physical, and financial resources. This includes things such as knowledge (or access to knowledge), good health, financial resources, ability to migrate (e.g., resources, space, lack of competition), redundant systems, access to social safety nets, and overall social connectivity.

To determine the adaptive capacity each of the elements evaluated in our stormwater system vulnerability assessment have, we answered five questions:

1. Does the element currently have what it will need to adapt to the impacts identified?
2. Can the element accommodate projected climate impacts with minimum disruption or costs?
3. If not, what does the element need to help it adapt to the identified impacts?
4. What is needed in order to help the element adapt to identified impacts?
5. Is the element already stressed in ways that will limit its ability to accommodate identified impacts?

Responses to these questions were then used to assess how adaptive each of the elements evaluated were to projected changes in climate. We used the qualitative evaluation criteria provided in Figure 29 to assign these adaptive capacity scores. Figure 29 provides a sample of our results from this element of our analysis.

Figure 29 Adaptive Capacity Levels

AC0	Element is not able to accommodate or adjust to projected changes in climate
AC1	Element is minimally able to accommodate or adjust to projected changes in climate
AC2	Element is somewhat able to accommodate or adjust to projected changes in climate
AC3	Element is mostly able to accommodate or adjust to projected changes in climate
AC4	Element is able to accommodate or adjust to projected changes in climate in a beneficial way

Results from this analysis found that we have a particularly low adaptive capacity (scores of AC0-AC1) for our Demand on Stormwater System (AC1), the Capacity of Pipes (AC0), Green Infrastructure (AC1), Residents Impacted by Surface Flooding (AC1), and City Facilities – specifically City Buildings (AC1). These results indicate that all but one element (Condition of Stormwater System (AC2)) evaluated are minimally or not able to accommodate to the projected changes in climate. To increase the adaptative capacity of each of these elements, significant funding and support from the community and region will be vital.

Table 12 below demonstrates the results from the adaptive capacity assessment.

Project Description				Cumulative Impacts	Adaptive Capacity Assessment					
Ref #	City	System	System Component	Based On All Analysis Completed So Far, Summarize How This System Component : 1) Will Be Affected By and 2) Will Affect Socio-Economic, Climate, and Landscape Features.	Does The System Component Have What It Will Need to Adapt to The Impacts Identified in Column E?	What Does The System Component Need To Help it Adapt To The Impacts Identified in Column E?	What Would You Need In Order To Provide What The System Component Needs To Adapt To The Impacts Identified in Column E?	Can The System Component Accommodate Projected Impacts Identified in Column E With minimum Disruption or Costs?	Is The Project or System Component Already Stressed In Ways That Will Limit Its Ability To Accommodate Impacts Identified in Column E?	How Adaptive Is The System Component To Projected Impacts in Column E? (e.g., adaptive capacity score)
1	Ferndale	Stormwater	Demand on Stormwater System	Increase the demand on the system and if we have an increased frequency and intensity of heavy rainfall events we have problems. Residents more prone to flooding will increase. Residents could be impacted by increasing rates to improve the system or deciding where to place the improvements (and some of these might have disproportionate effects on socio-economically vulnerable populations). Improvements in our ordinance and development practices may decrease the stress for demand due to increased detention. To a certain extent the ongoing maintenance and repairs we have been doing to the system are beneficial and we aren't far behind on the curve in terms of preparing.	No	Spend more money to increase green infrastructure, maintenance activities, capacity; solicict resident input when events happen	Money; political support; resident support; regional support and collaboration; education; developers and private property owners using updated standards	Somewhat - CSOs are pretty rare	Space. We can handle smaller events - we can't handle the bigger events and an increased frequency of the bigger events	AC1 - System is minimally able to accommodate or adjust to projected changes in climate
2	Ferndale	Stormwater	Capacity of Pipes	Similar to demand, our maintenance and repair has been done well and we have a plan for continuing into the future. Capacity of the pipes is fairly set so to increase the capacity of the system it has be paired with detention or retention. As a regional, more significant rainfall will all need to go to the treatment facility and does that facility have the capacity to handle? This necessitates the need to think and work regionally on stormwater solutions (includes working with upstream communities to help manage system as well as with downstream communities).	No	Larger infrastructure; funding; regional partnerships and coordination of entire regional system	Funding; political support; regional support; separation of sanitary and storm system	No - but TBD based on future funding and partnerships	yes, the system is at the peak design flow	AC0 - System is not able to accommodate or adjust to projected changes in climate
3	Ferndale	Stormwater	Green Infrastructure	Overall green infrastructure can be beneficial in reducing the impacts of climate change but it has to be done in a way that is intentional, holistic, and strategic. Because of that, we hope to increase the amount of green infrastructure practice and/or make it more of a priority in our infrastructure improvements. That will mean identifying appropriate funding mechanisms to make this happen. Consideration of design in terms of what gets planted, where, etc in terms of increased temperatures, greater rainfall,and soil conditions. Need to consider the spatial disparity in these equations. Making sure whatever we have, we have education and outreach developed guidelines.	No	Spend more money to increase green infrastructure, maintenance activities, capacity; solicict resident input when events happen; find ways to promote green infrastructure investment on private property	Money; political support; resident support; regional support and collaboration; education; developers and private property owners using updated standards	Yes to a degree	The stormwater system is stressed for large events. Some old growth trees are in poor condition in the City and tree canopy needs replenished in some areas.	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate
4	Ferndale	Stormwater	Residents Impacted by Surface Flooding	If we continue doing what we are doing, residents that flood are going to continue to be impacted by flooding at greater intensity and frequency. Important to map all the flooding areas to see if there is a systematic reason why it continuously floods. Need to understand basement flooding versus surface (backyard) flooding. Not all flooding is created equal so many need to think about unique strategies to handle different kinds of flooding. There are real concerns about how has the capacity to manage the flooding (i.e., income and other socio-economic considerations).	No	Spend money to increase green infrastructure; map areas with consistent flooding; reduce impervious surfaces.	Money; political support; resident support; regional support and collaboration; education; developers and private property owners using updated standards; data to understand areas in need.	No	Residents that are experiencing flooding continue to do so, which puts a stress on their finances	AC1 - System is minimally able to accommodate or adjust to projected changes in climate
5	Ferndale	Stormwater	City Facilities Building	New or updated city facilities would improve resiliency to climate change by designing and planning for vulnerability to heat, flooding, and other impacts. However, an additional millage could be a financial stress on the community.	No	A millage to fund potential updates to city facilities; more feedback from the community on priority updates to city facilities; political support.	Money; political support; resident support; education; data to understand areas in need; plans.	No, initial evaluations of city facilities show that the costs to update facilities are costly	Yes, certain parks have flooding, buildings have heating and cooling needs, space is limited in some facilities.	AC1 - System is minimally able to accommodate or adjust to projected changes in climate
6	Ferndale	Stormwater	Condition of Stormwater System	Increased rainfall events will impact condition of the system; must pay close attention to correct species when installing GI; locations of GI must consider underground conditions and infrastructure; increase in rainfall events will impact residents, expecially in poor system conditions	Yes, but assuming we have funding and capability for maintenance	more storage capacity; more retention capacity; distribution of pervious versus impervious area	more storage capacity; more retention capacity; distribution of pervious versus impervious are	no, continual funding for maintenance and upgrades is needed	yes, space constraints and capacity constraints; condition continues to decline without proper maintenance or upgrades	AC2 - Systems is somewhat able to accommodate or adjust to projected changes in climate

Step 8: Calculating Vulnerability

The final step in our vulnerability assessment was combining the sensitivity and adaptive capacity scores into a vulnerability score. Using Figure 30 below, we were able to determine which elements within our stormwater system were the most vulnerable (red) and which were the least vulnerable (green).

Figure 30 shows the results for our citywide vulnerability assessment.

This stormwater system vulnerability assessment found that our most vulnerable elements are the Capacity of the Pipes, followed by Residents Impacted by Surface Flooding.

The Capacity of the Pipes was found to be the most vulnerable element of our stormwater system. This is due in part to the fact that the capacity of pipes is set, so focusing on increasing the overall system capacity is needed to combat the increasing amount of stormwater expected. In order to effectively increase the capacity of the stormwater system, a regional approach is necessary, as the stormwater infrastructures of neighboring cities are integrated.

The southeast region of the city has been determined to be the most vulnerable to both surface flooding and the effects of increased heat. The vulnerability of this area is further compounded by the social vulnerability of the residents within this area. The southeast region was found to have the highest socioeconomic vulnerability compared with the rest of Ferndale. In relation to the rest of the city, those located in the southeast are more likely to be spending at least 30% of their household income on gross rent, 9% or more of families are living in poverty, 15% or more of the population identify as non-white, and 12% or more have a disability. As the effects of climate change increase, residents that have experienced surface flooding in the past will see an increase in the rate and amount of flooding in their area. As residents in this area experience higher socioeconomic vulnerability than the rest of the city, it makes their ability to combat increased surface flooding all the more difficult.

		Sensitivity: Low to High				
		S0	**S1**	**S2**	**S3**	**S4**
Adaptive Capacity	**AC4**					
High	**AC3**					
Low	**AC2**			• Green • Condition of Stormwater System Infrastructure		
	AC1			• Demand on Stormwater System • City Facilities - Buildings		• Residents Impacted by Surface Flooding
	AC0					• Capacity of Pipes

Figure 30. Results for our citywide vulnerability assessment.

6. NEXT STEPS

This document represents an important step in building resilience to climate change in Ferndale. To truly prepare, however, we need to implement actions that will reduce our local vulnerability and enhance our resilience. Through the course of this stormwater system vulnerability assessment, we identified a handful of initial actions that can lay the foundation for longer-term adaptation planning and action. These actions include:

- Plan and budget early for green infrastructure and maintenance
- Educate and communicate with the community, staff, and developers about green infrastructure and surface flooding
- Map areas that have consistent flooding issues
- Plan and budget for updates to existing city facilities
- Educate and communicate with the community about the existing challenges with city facilities and why updates are necessary
- Refining city ordinances and policies to reflect stormwater standards and green infrastructure improvements

These, however, are just initial actions. We know far more thought and planning are needed to design a cohesive strategy for enhancing local resilience to climate change. In our quest to create a more resilient Ferndale, we are prepared to immediately undertake the following actions:

1. Present this vulnerability assessment to City Council and seek formal adoption.
2. Initiate a formal adaptation planning process that includes a diversity of community stakeholders.
3. Align our vulnerability reduction efforts with our community's multi-hazard mitigation planning and disaster risk reduction efforts.
4. Align our vulnerability reduction efforts with other relevant community planning and action initiatives, including the updated Master Land Use Plan, Complete Street Ordinances, and Ferndale Moves.
5. Annually report on progress implementing the strategies identified in this plan and others related to reducing local vulnerability.
6. Every 5 years, revise this assessment based on new information (e.g., changes to climate science) and any relevant changes to community priorities. As part of this review process, include metrics that denote how our community's overall vulnerability to climate change has evolved. This may take the form of revising our community's landscape vulnerability as well as our socio-economic vulnerability to see if there have been notable changes. We may also identify, through public input processes, a number of other key metrics we'd like to track to measure reductions in vulnerability. To the fullest extent possible, we will regularly track and report on these metrics so that we can demonstrate how our community's vulnerability is changing.
7. Begin and/or enhance collaboration with peer communities in the region in order to foster greater regional resilience towards climate change and natural disasters.
8. Share successes and lessons learned with our peers to help foster greater resilience not only in our community but also in the region, across the state, and throughout the nation.

Conclusion

Preparing for climate change is a process, not an outcome. This plan represents an important step in that process for the City of Ferndale. Our success in preparing for climate change will depend on whether the strategies identified in this plan and those developed through a formal adaptation planning process are implemented, and whether an iterative process is established to frequently revisit this plan and all the other plans and programs used to manage the way we live, work, play, and operate in our city. We, as a City, are committed to working with all residents, business, and interested stakeholders to make sure we build a thriving, sustainable, and resilient Ferndale. It's time to get to work!

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54 For more information, see: http://www.nws.noaa.gov/om/hazstats/flood16.pdf.

55 For a detailed review of our analysis, please see page 34 of this document.

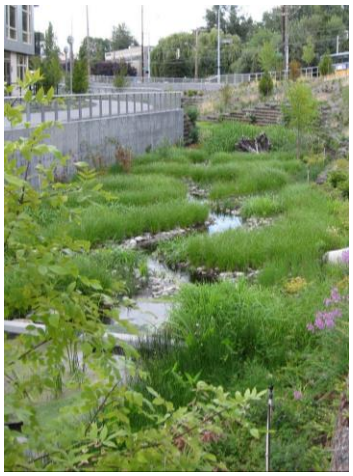
56 For more details on our methodology to combine maps, please see page 43 of this document.

GLISA
A NOAA RISA TEAM

Adapting Great Lakes Stormwater Systems to Climate Change

Project Overview

What: The Great Lakes Integrated Sciences and Assessments (GLISA) received a grant from the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office's Sectoral Applications Research Program (SARP) to customize a template for stormwater management for 12 cities in the Great Lakes. The 1-year project aims to advance the resilience of stormwater management systems in the project cities while also assessing whether the boundary chain model can reduce transaction costs for scaling-up sustained stakeholder engagement by testing different models of engagement. Project partners include the Huron River Watershed Council (HRWC), the Great Lakes Climate Adaptation Network (GLCAN), and the City of Ann Arbor.



How: The project team will recruit and engage directly with 12 local governments in the Great Lakes region. Each city will complete a customized vulnerability assessment template for stormwater management in their city, with support & training from the project team via three test engagement methodologies: face-to-face, webinar assisted, and written/self-guided.

Outcomes: The project will produce an integrated, co-produced vulnerability assessment methodology and training package that allows Great Lakes cities to mainstream adaptation for stormwater management as well as social vulnerability into city-wide and sectoral planning and action. The sustained engagement process will identify best practices of sustained interaction, lower transaction costs, (i.e., human, technical, financial resources, trust-building and legitimacy) and can be replicated and disseminated throughout the GL region and other regions of the US. Outcomes will advance the resilience of stormwater management in the 12 project cities and the science of knowledge usability in the context of boundary organizations.



Background: Annual precipitation, extreme rainfall events, and flooding have increased in the Great Lakes region during the last century, and these trends are expected to continue. Small and mid-sized cities in the region have limited resources and lack of access to climate information, which impedes them from implementing hazard- and climate-related actions to increase their resilience. Recognizing this, HRWC and the City of Ann Arbor, in partnership with GLISA and Headwaters Economics and GLCAN, developed a comprehensive vulnerability assessment template in 2017 for five Great Lakes cities to incorporate climate and socioeconomic information into existing planning processes. There remains a significant need to support the integration of climate information into stormwater management at the municipal level, and to develop a tested strategy for sustained engagement that can be scaled up to other cities, sectors, and regions at lower cost.



FERNDALE

July 13, 2020 Communications

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Kara Sokol

SUBJECT: Approval of Contract with SeamlessDocs for Three-Year Renewal of Websites and Digital Forms Services for an Annual Amount of $17,775.20, as Submitted by Communications Director

INTRODUCTION
Since 2017, the City has used SeamlessDocs for creation, hosting, and high-level maintenance of our suite of websites and digital forms services. With the contract renewal due, after careful research and consideration, the Communications Department recommends renewing the three-year contract with SeamlessDocs for continued service of the City's websites and digital forms.

SUMMARY & BACKGROUND
Since 2017, the City has used SeamlessDocs for creation, hosting, and high-level maintenance of our suite of websites and digital forms services:
- City of Ferndale website, www.ferndalemi.gov
- ParkFerndale website, www.parkferndale.com
- Ferndale Moves mobility plan website, www.ferndalemoves.com
- More than 250 digital web and document forms: provides digital versions of once-static PDF forms, allowing users to complete and submit online and the City to easily collect and use the data

In making the decision about whether to renew our service agreement with SeamlessDocs, we considered the performance of our current digital assets, the company's customer service, and cost (including local benchmarking).

PERFORMANCE OF CURRENT DIGITAL ASSETS
Between July 2019 and June 30, 2020, the City website served just shy of 140,000 users over 215,390 sessions. Users spent an average of 1 minute, 46 seconds per web session—just south of the industry standard of 2 minutes. Our users favored mobile/tablet usage at 54% versus 46% desktop.

These percentages are all up from the previous year (2018-19), and continue to grow/improve annually. From 2018-19 to 2019-20 we saw a 5% rise in users, 3% increase in sessions, and—most notably—a 5% increase in mobile/tablet traffic versus desktop, which is a trend we expect to continue and which our SeamlessDocs websites are designed to accommodate. Our websites continue to perform as designed and promote/support the growth of traffic and users.

CUSTOMER SERVICE
The City has had zero customer service issues with SeamlessDocs in three years. Website and digital forms services come with their own personal customer service representatives—not a team "ticketing system." Requests are acknowledged same-day and solutions are typically delivered in under one business day. This is a critical asset that many larger web companies lack; for example, when the City requested a new service

section be added to the homepage in response to the COVID-19 pandemic, the update was processed and delivered in less than an hour.

COST
The Communications Department worked with SeamlessDocs to deliver a contract that ensures continued service levels with zero service-cost increase. The cost breakdown for this contract is:

	Current	2017-19
City website	$4,000 annual	$4,000 annual
Park Ferndale website	$4,000 annual	$4,000 annual
Ferndale Moves site:	$2,500 annual	$2,500 annual
Unlimited digital web and document forms:	$7,175.20* annual	$6,000* annual

*increase only due to added user licenses, not service increase

We also benchmarked SeamlessDocs' prices compared to other local cities. Example City 1 uses CivicPlus and pays $18,062.25 annually for two websites + digital forms. Example City 2 uses Revize and pays approximately $14,000 annually for websites only. SeamlessDocs comes in less than both.

BUDGETARY CONTEXT
101-173-818.140 Contractual Services- Website
- City Website www.ferndalemi.gov, $4,100 annually, $12,300 three-year
- FerndaleMoves, $2,500 annually, $7,500 three-year
- "Digitize" SeamlessDocs Forms service, $7,175.20 annually, $21,525.60 three-year

585-000-818.140 Contractual Services- Website
- ParkFerndale $4k annually, $12k total three-year

CIP#

ATTACHMENTS
Ferndale__MI_2020_1M7bOg6MIper7d.pdf

STRATEGIC PLANNING CONTEXT
Safe, Protected, Engaged Community

RECOMMENDED ACTION
Approve the contract from SeamlessDocs for three-year renewal of websites and digital forms services for an annual amount of $17,775.20, to be charged to Account #101-173-818.140 Contractual Services – Website ($13,775.20) and Account #585-000-818.140 Contractual Services – Website ($4,000), as submitted by Communications Director.

Ferndale, MI Renewal 2020-2023

Prepared By
Michael Brunwasser
Partner Success

Sent To
Joseph Gacioch
Village Manager

Quote Summary Table

QTY	PRODUCT	START DATE	END DATE	TERMS (MONTH)	FIRST YEAR ACV	TOTAL PRICE
9	Additional Users	7/1/2020	6/30/2023	36	$0.00	$0.00
1	Website Subscription	7/1/2020	6/30/2023	36	$4,000.00	$12,000.00
1	Website Subscription	7/1/2020	6/30/2023	36	$2,500.00	$7,500.00
1	Website Subscription	7/1/2020	6/30/2023	36	$4,000.00	$12,000.00
1	Optimization Fee	7/1/2020	6/30/2023	36	$100.00	$300.00
1	Digitize	7/1/2020	6/30/2023	36	$7,175.20	$21,525.60
10	Platform User Licenses	7/1/2020	6/30/2023	36	$0.00	$0.00
999	Number of Forms	7/1/2020	6/30/2023	36	$0.00	$0.00

First Year Total: $17,775.20 **Contract Total:** $53,325.60

Custom Terms:

- N/A

Standard Terms of Agreement:

- This proposal expires on 6/30/2020
- By signing this proposal the client agrees to our Terms of Use available at https://www.seamlessdocs.com/terms-of-use.
- Each product and service purchased is serviced and maintained as specified in the table above.
- Service Hours and offerings expire 12 Months from the Subscription Start Date specified in the excecuted agreement and payable upfront.
- If included in the Services Agreement, related Travel and Expenses are to be billed as incurred.

Standard Payment Terms:

- Please email all Purchase Orders to billing@seamlessdocs.com for prompt processing.
- The client agrees to pay all fees specified in each Order.
- The invoice(s) will be sent to the Billing Contact via the delivery method as early as two weeks prior to the invoice date, which is the Subscription Start Date, specified in each Order.
- All fees are due upfront, and billed annually with the first annual payment due by the invoice due date (30 days from the Subscription Start Date) specified in each Order, unless specified otherwise.
- All fees are exclusive of applicable state, local, and federal taxes, which, if any, will be included in the invoice. It is the client's responsibility to provide applicable exemption certificate(s).
- 3 - 10% optimization fee may be added annually to the recurring products and services. SeamlessDocs reserves the right to modify optimization fee in accordance with the Terms of Use.
- If a Reseller is used, please ensure 'Coverage Terms' or 'Subscription Dates' are included in each Line Item's Material Description.

SeamlessDocs Contact Information:

- For additional questions or requests regarding your SeamlessDocs' Software or Services, please contact:
  - Email: support@seamlessdocs.com
  - Phone: (855) 777-3265

Contact and Billing Details

Primary Contact Name:	Joseph Gacioch	Org Name:	Ferndale, MI
Primary Contact Email:	jgacioch@ferndalemi.gov	Street Address:	300 E 9 Mile Rd
Billing Contact Name:	Kara Sokol	City, State, ZIP:	Ferndale, Michigan, 48220
Billing Contact Email:	ksokol@ferndalemi.gov	Invoice Delivery Method:	Email / Electronic
Billing Contact Phone:	2483364133	Payment Term:	Net 30

PARTNER		SEAMLESSDOCS	
Signature:	eSigned via SeamlessDocs.com Kara Wynn Sokol Key: 71c326f5b8a729a810f33cf6789f6dd4	**Signature:**	eSigned via SeamlessDocs.com Michael Brunwasser Key: 2f2dc89dc2e0a0f2b6ddaa96076defdd
Full Name:	Kara Wynn Sokol	**Full Name:**	Michael Brunwasser
Title:	Communications Director	**Title:**	Partner Success
Date:	06/29/2020	**Date:**	06/29/2020

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Joseph Gacioch

SUBJECT: Approval of the quote from Sound Planning Communications in the amount of $24,932 for Cable Broadcast Equipment Upgrades to support COVID-19 initiaives to be paid from the Cable fund account number 296-000-977-000, as submitted by City Manager

INTRODUCTION
The COVID-19 pandemic has caused the City to reevaluate the current configuration for managing audio and video needs for City Council broadcasts. The current governor's executive order allowing public meetings to be conducted digitally expires on July 31, 2020. The City's IT support has obtained a quote from Sound Planning Communications to provide and install a new camera that could accommodate upcoming hybrid city council meetings that will include a combination of in-person and Zoom attendance; three additional wireless microphones to accommodate physical distance requirements for the Planning Commission and other larger boards; an updated sound board that can accommodate the new audio input needs; and a backup video switcher to provide system redundancy.

SUMMARY & BACKGROUND
Through executive orders from Governor Whitmer adjusting the open meetings act, the City has used Zoom Meetings to broadcast official city meetings remotely to our cable channels. When the most recent executive order on remote meetings ends, City Council and City boards and commissions will be required to meet in person once again. With this update to our recording and broadcasting equipment, council meetings can continue to be accessed digitally by the general public who wish to participate but do not feel comfortable appearing in person.

The City's cable channel, WFRN broadcasts local public meetings for AT&T, WOW!, Comcast subscribers, as well as online streaming on the City's YouTube account. As of 2020, the City's IT contractor, D/A Central has provided technical and operational support for public meetings. D/A Central has initiated conversations with representatives of the broadcast companies mentioned above about ongoing technical issues and updates to local encoders. Most of these companies have reduced levels of customer support for government agencies.

Public, educational, and governmental (PEG) access channel fees are assessed by the City (cable franchising authority) unto cable providers. The City established the cable fund (296) to manage revenues and expenses related to PEG fees. PEG fees, by federal statute, may only be used for the capital costs incurred to accommodate the municipal public access channel/studio. General fund dollars are not used to support the municipal cable broadcast. The City does not fund a position dedicated for the cable department. This use of PEG funds, which are restricted, will serve to continue to improve access to those unable to join public meetings in person without using general fund dollars to do so.

BUDGETARY CONTEXT

Cable fund 296-000-977-000. Revenues from PEG fees charged to cable providers are used for capital expenses that support local cable broadcasts. No general fund dollars are used to support this capital need. PEG fees are restricted for municipal cable capital needs.

CIP#

ATTACHMENTS
D220053 - Ferndale Update.pdf

STRATEGIC PLANNING CONTEXT
Supported Infrastructure

RECOMMENDED ACTION
Approve the quote from Sound Planning Communications in the amount of $24,932 to be paid from the Cable fund account number 296-000-977-000, as submitted by City Manager

sound planning communications™
Complete Solutions for Communication Technologies

July 7th, 2020 D220053

Kohei Akio
City of Ferndale
300 E. Nine Mile Rd.
Ferndale, MI 48220

Kohei,

Thank you for reaching out to talk about expanding the City Hall Audio system and integrating it with a new camera into the Zoom platform for the future of Hybrid Meetings. We recommend the following upgrades to improve the quality of the zoom streams, improve the audio quality inside of the space, and provide a redundant system in the event the Tricaster or audio processor fails.

- 1x Symetrix Prism 16x16 DSP will replace your existing QSYS Core 110f processor to improve the audio quality of the system. An expansion module is included to provide enough inputs for the additional wireless microphones as well as leaving room for future improvements. **As a courtesy Sound Planning Communications will provide a $500 buy back credit for the QSYS Core 110f if desired. This discount is NOT factored into the cost below.**

- 3x Shure Handheld wireless microphones will be installed in the AV rack. These wireless microphones can be used in conjunction with your existing two wireless microphones and will easily be controlled through the Symetrix Crestron interface on your computer or optional iPad. Antenna distribution will be installed to improve reception quality and reduce dropouts.

- 1x Marshall compact camera will be mounted in the boardroom to provide a wide angle shot of the dias for the zoom video during board meetings.

- 1x Vaddio AV Bridge is included to merge the wide-angle camera, and the mixed audio out of the new signal processor to USB. A USB extender is included to allow the zoom conferencing computer to be placed at the Podium location.

- A full backup system is included with this proposal to ensure live streaming capabilities when a single point of failure is present in the system. A Roland V-1SDI video switcher, Shure SCM800 audio mixer, and other necessary components will be installed to bypass critical elements, where a critical failure would typically take down the entire system. This backup system can be taken online with the quick press of a button, ensuring that even If the TriCaster or the Audio system goes down in the middle of a meeting, backup microphones and cameras can be taken live to the air and help the community stay involved.

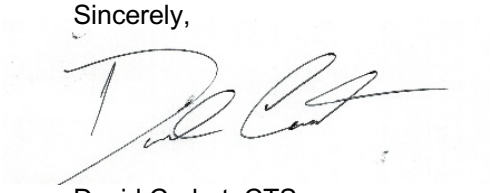
design
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service
acoustics
rentals

sound planning communications™
Complete Solutions for Communication Technologies

The total cost of the above video system upgrades including installation, programming, user-training, and our standard one-year, on-site warranty is **$24,932.00**

Please let me know if you require any further information or would like to proceed with a purchase; We look forward to working with you on this exciting project.

Sincerely,



David Corbat, CTS
Sales Engineer
Sound Planning Communications

A Certified Technology Specialist™ (CTS©) performs general technology solution tasks by creating, operating, and servicing AV solutions, while conducting AV management activities that provide for the best audiovisual resolutions of the client's needs, both on time and within budget.
An ANSI accredited certification meeting the ISO/IEC 17024:2012 standard



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service
acoustics
rentals

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Barb Miller

SUBJECT: Approval of the Bills and Payrolls as Submitted by the City Manager's Office and Subject to Review by the Council Finance Committee

INTRODUCTION
Approval of the bills and payrolls as submitted by the City Manager's office and subject to review by the Council Finance Committee.

SUMMARY & BACKGROUND
Approval of the bills and payrolls as submitted by the City Manager's office and subject to review by the Council Finance Committee.

BUDGETARY CONTEXT
N/A

CIP#
N/A

ATTACHMENTS

STRATEGIC PLANNING CONTEXT
Organizational and Financial Excellence

RECOMMENDED ACTION
Approve the bills and payrolls as submitted by the City Manager's Office and subject to review by the Council Finance Committee.

FERNDALE

July 13, 2020 Community & Economic Development

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Alexis Richards

SUBJECT: Consideration of the Contract with Fishbeck for On-Call Environmental Services

INTRODUCTION
Ferndale has demonstrated a commitment to becoming a more sustainable and resilient community. As we incorporate sustainability into our projects and goals, our need for environmental expertise continues to grow. In response to this need, City staff recommends contracting with an on-call environmental consultant.

The City received seventeen proposals from qualified firms interested in providing on-call environmental services. A selection committee comprised of City staff from CED, DPW, City Manager's Office, and a member of the Ferndale Environmental Sustainability Commission reviewed the proposals according to the criteria listed in the request for qualifications and narrowed the field to five firms for interview. Fishbeck was selected from the field of responses due to their qualifications to complete the scope of work, diverse services provided, holistic approach, community-focused engagement, and focus on quality.

SUMMARY & BACKGROUND
An environmental services firm is comprised of professionals from a multitude of fields (including biology, chemistry, and engineering) that lend their expertise to help municipalities like the City of Ferndale accomplish their community projects.

The benefits of on-call environmental experts are numerous, including the ability for the City to respond expediently to environmental issues, acting to mitigate prospective repercussions that could be exacerbated by time. A neutral third party can provide outside expertise and validate environmental data and reports that may be submitted to the City. Additionally, on-call experts could advise on future development projects, ensuring the best possible environmental outcomes. Just as important as the expertise to complete projects is the ability to distill scientific information into language that is digestible for members of the community, allowing for improved transparency, engagement, and understanding of environmental impacts.

Potential projects may include:
- Sampling (soil, air, and water)
- Evaluation of City buildings and properties
- Applications for state and federal grants
- Redevelopment planning
- Assistance with a Green House Gas (GHG) emissions baseline

The proposed contract would be for on-call environmental services for a period of three years with the option for two one-year extensions. The City would not incur fees or monthly maintenance costs; the agreement simply provides the City with on-call services by pre-vetted experts versus, saving critical time and resources spent having to source experts for each project and/or issue that arises. The Request for Qualifications,

Fishbeck's proposal, and the proposed contract with Fishbeck for on-call environmental services are attached below.

BUDGETARY CONTEXT
Services rendered by this service would be charged to account 101-371-818.000 for Contractual Services, Environmental Analysis, which has budgeted $8,000 for FY20 and $62,000 for FY21.

CIP#
N/A

ATTACHMENTS
On-Call_Environmental_Services_Presentation.pptx

RFQ - Environmental Consulting Firm.pdf

Proposed Contract

Fishbeck Proposal.pdf

STRATEGIC PLANNING CONTEXT
Healthy, Connected, and Invested Neighborhoods

RECOMMENDED ACTION
Approve the contract with Fishbeck for on-call environmental services in an amount not to exceed $8,000 for FY20 and $62,000 for FY21, charged to account 101-371-818.000 for Contractual Services, Environmental Analysis.



FERNDALE

ON-CALL ENVIRONMENTAL SERVICES

ALEXIS RICHARDS, CED PROJECT PLANNER

MONDAY, JULY 13, 2020 CITY COUNCIL

AGENDA

- Overview of project
- Selection process
- Recommendation
- Discussion & Questions



OVERVIEW

- Who are environmental experts?
  - Environmental experts have a variety of different backgrounds, and provide professional advice to clients on various community projects.
- Services provided may include:
  - Environmental assessments
  - Sampling (soil, water, air)
  - Remediation strategies for development projects



OVERVIEW

- Why does Ferndale need environmental experts?
  - Value of a neutral third-party
  - Ability to respond quickly to environmental concerns
  - Advise on future development projects
- Potential projects
  - Evaluation of City buildings and properties
  - Assistance with a Green House Gas (GHG) emissions baseline
  - Applications for state and federal grants and loans
  - Redevelopment planning



FERNDALE

OVERVIEW

Strategic Planning Context

- Organizational and Financial Excellence
- Healthy, Connected, and Invested Neighborhoods



SELECTION PROCESS

RFQ PROCESS

- Solicitation was posted on the Michigan Intergovernmental Trade Network (MITN)
- Timeline
  - Issue Date: February 27, 2020
  - Original Solicitation Deadline: March 27, 2020
  - Extended Solicitation Deadline: April 15, 2020
  - Interviews occurred: May, 2020
- Selection committee was comprised of City staff in CED, DPW, City Manager's Office, and a member of the Ferndale Environmental Sustainability Commission

SELECTION CRITERIA

- ❖ 17 proposals received, 5 selected to interview
- Professional Competence
- Project Understanding
- Experience with similar municipal environmental projects
- Timeliness of project deliverables
- Fee schedule

FERNDALE

SELECTION PROCESS

INTERVIEW PROCESS

- Interviews over Zoom
- Firms received 3 questions ahead of time
  - Experience with Green House Gas emission inventory and Climate Action Plan
  - Community outreach strategies
  - Redevelopment scenario



FIRMS SELECTED TO INTERVIEW

- Fishbeck
- MannikSmith
- ETC
- Envirologic Technologies
- DLZ

FERNDALE

RECOMMENDATION: FISHBECK

- Quality
- Community focused engagement
- Experience on similar projects
- Acknowledgement of Ferndale's unique needs
- Diverse services and a holistic approach

fishbeck

Engineers | Architects | Scientists | Constructors



FERNDALE

THANK YOU

ARICHARDS@FERNDALEMI.GOV

FERNDALEMI.GOV

City of Ferndale
300 East Nine Mile Road
Ferndale MI 48220
248.546.2525
www.ferndalemi.gov

Request for Qualifications for On-Call Environmental Consulting Services

Issue Date: February 27, 2020

Question Deadline: April 8, 2020 5pm

Solicitation Deadline: April 15, 2020 5pm

Contact: Alexis Richards, Project Planner
300 E 9 Mile Rd.
Ferndale, MI 48331
arichards@ferndalemi.gov

Purpose

The purpose of this request is to obtain statements of qualifications from firms to evaluate their qualifications through the review process and to select a firm(s) to provide on-call consultant services for potential upcoming City projects. The selected firm(s) would be required to enter into a standard consultant agreement, which would be valid for up to three (3) years from the date of execution, with possible extension of two consecutive one (1) year terms. Firms responding to this RFQ should be prepared and equipped to provide full service environmental consulting services to the City in an expeditious and timely matter to meet critical time deadlines and schedules.

This solicitation, along with all attachments, may be downloaded from the Michigan Intergovernmental Trade Network (MITN) website at https://www.bidnetdirect.com/mitn.

Note: any and all addenda issued by the City of Ferndale must be viewed or downloaded from the above listed website.

Submittals must be received electronically by the indicated due date and time. Late submittals will not be accepted. **NO HARD COPIES ACCEPTED.**

Send all responses to Alexis Richards, arichards@ferndalemi.gov , Jordan Twardy, jtwardy@ferndalemi.gov, and Justin Lyons jlyons@ferndalemi.gov

Instructions

Pre-Response Information and Questions

Each response that is received by the deadline will be evaluated on its merit and completeness of all requested information. In preparing responses, Consultants are advised to rely only upon the contents of this RFQ and accompanying documents and any written clarifications or addenda issued by the City of Ferndale City Manager's Office. If a Consultant finds a discrepancy, error, or omission in the RFQ package, or requires any written addendum thereto, the Consultant is requested to notify the contact noted on the cover of this RFQ, so that written clarification may be sent to all prospective Consultants. THE CITY IS NOT RESPONSIBLE FOR ANY ORAL INSTRUCTIONS. All questions must be submitted in writing to the Purchasing contact before the Question Deadline indicated on the front of this document. No contact regarding this document with other City employees is permitted. All answers will be issued in the form of an addendum.

a) All questions must be submitted in writing to the contact before the Question Deadline indicated on the front of this document.
b) No communication is permitted between Consultants and other City of Ferndale Departments or Divisions prior to the award of the bid unless sanctioned by the City Manager's Office.

RFQ Modifications/Addenda

Clarifications, modifications, or amendments may be made to this RFQ at the discretion of the City. Any and all Addenda issued by the City will be posted as noted on the Cover Page of this document. It is the responsibility of the Consultant to obtain the available Addenda and acknowledge Addenda on the Response Form of this RFQ. Failure to acknowledge Addenda shall result in your response being deemed non-responsive and rejected without any further evaluation. If any changes are made to this RFQ document by any party other than the City, the original RFQ document and associated Addenda in the City's files shall take precedence.

Qualifications Submission

The Consultant must include the following items, or the response may be deemed non-responsive:

- All forms contained in this RFQ, fully completed
- Evidence that the Minimum Qualifications listed in the Specifications/Scope of Work are met.
- Responses must be sent electronically to the contact listed on the cover page of this RFQ.
- Submission of a cover letter summarizing qualifications for services as described in this RFQ.
- For all types of services quoted in this RFQ, the Consultant shall provide estimated expectations for the length of time required to deliver a given service once requested by the City of Ferndale.
- Submission of a proposal establishes a conclusive presumption that the Consultant is thoroughly familiar with the RFQ and that the Consultant understands and agrees to abide by each, and all of the stipulations and requirements contained therein. Businesses that

have done work for the City of Ferndale are not exempt from submitting required documents or meeting other requirements listed in this RFQ.

- A firm profile and description of the project team, describing the firm's capabilities, experience and knowledge. The City of Ferndale expects that the firm will assign a dedicated project manager who will lead the consulting team, be the single point of accountability for project delivery, and provide the primary point of communications. Submittals should describe the proposed project manager and key team member experience on similar projects, experience on other City of Ferndale projects (if applicable), and skills and results supporting the ability to provide services described in this RFQ. The City expects that the proposed project manager will be available upon award of the contract and for the duration of the project.
- Comparable project experience. Firms are asked to provide a minimum of five project examples completed within the last five years.
- Provide a list of client references for whom your firm has provided related work. Include a brief (1-2 line) explanation of the type, scope, project period, and cost of each project completed for the client.
- Provide resumes for key personnel who would staff future projects for the City of Ferndale. Resumes should include project level experience, education background, degrees held, licenses, and professional registrations and shall not be more than two pages in length.
- Hourly Rates and Expense Schedule. Also provide laboratory testing rates (normal turn-around and expedited). Identify the name of the laboratory being used and associated qualifications.
- All costs incurred in the preparation and presentation of the response is the Consultant's sole responsibility; no pre-solicitation costs will be reimbursed to any Consultant. All documentation submitted with the proposal will become the property of the City of Ferndale.
- Responses must be held firm for a minimum of 90 days.

Withdrawal

Responses may only be withdrawn by written notice prior to the date and time set for the opening of responses. No Response may be withdrawn after the deadline for submission.

Rejection

The City reserves the right to reject any or all responses, or to accept or reject any response in part, and to waive any minor informality or irregularity in responses received if it is determined by the City of Ferndale that the best interest of the City will be served by doing so. If all Responses are rejected by the City, notice will be posted on the City's websites as noted on the Cover Page of this document. No Response will be considered from any person, firm or corporation in arrears or in default to the City on any contract, debt, or other obligation, or if the Consultant is debarred by the City from consideration for a contract award, or if Consultant has committed a violation of the City's Charter and/or Code of Ordinances which resulted in a termination of a contract or

other material sanction within the five (5) years immediately preceding the date of issuance of this document.

Procurement Policy
Procurement for the City will be handled in a manner providing fair opportunity to all businesses. This will be accomplished without abrogation or sacrifice of quality and as determined to be in the best interest of the City.

Response Signatures
Responses must be signed by an authorized official of the Consultant. Each signature represents binding commitment upon the Consultant to provide the goods and/or services offered to the City if the Consultant is determined to be the most responsive and responsible Consultant.

Evaluation Criteria
Qualified firms will be evaluated based on the following criteria:

- Professional competence
    - Firm's experience working with municipalities on a variety of environmental projects
    - Lead staff have held similar roles in other projects
    - A certification statement is submitted that it holds all licenses and registrations required by applicable federal, state, and local laws for businesses offering environmental services, and all licenses and registrations are currently in good standing
- Project understanding
    - Understanding environmental reporting needs of municipalities, specifically those similar in size and complexity
    - Identification of key project success factors
- Experience with environmental projects on behalf of municipalities on similar projects
    - Prior project descriptions clearly demonstrate successful completion of similar projects in the last five (5) years
- Ability to timely perform the required services
- Anticipated fee schedule

Each response submitted in response to this RFQ shall focus on these criteria. In addition, the evaluation team also may consider the past performance of the Consultant on other contracts with the City or other entities. The City reserves the right to make such additional investigations as it deems necessary and may require the submission of additional information.

Contract Award
The City reserves the right to award by item, group of items, or total response. The Consultant to whom the award is made will be notified at the earliest possible date. Tentative acceptance of the response, intent to recommend award of a contract and actual award of the contract will be

provided by written notice sent to the Consultant at the address designated in the response. All responses must be firm for at least 90 days from the due date of the response. After a final award of the RFQ by the City of Ferndale, the Consultant must execute and perform said items outlined in the RFQ. The date on which the Agreement is signed by the City of Ferndale marks the beginning of the Agreement.

FOIA Requirements
Responses are subject to public disclosure after the deadline for submission in accordance with state law.

Scope of Work

Objective
The objective of the Request for Qualifications (RFQ) is to help the City select an environmental consulting firm to conduct various environmental assessment activities, and to support a growing portfolio of future project activity.

Scope
The selected firms will be required to work closely with the City to meet project objectives, including but not limited to:

- Site and environmental assessment
- Soil and groundwater investigations
- Air quality studies, including health risk assessments
- Water quality studies
- Development of remediation strategies and clean-up programs
- Redevelopment planning and associated approvals
- Cost estimates and cost control
- Applications for state and federal grants and loans
- Community outreach
- Attend meetings and provide technical information as required to complete approved jobs expeditiously and within budget
- Attend pre-bid, pre-contract, construction management, and construction site meetings as required
- Professional advice on environmental concerns as they arise
- Submittal of any associated reports to the USEPA and/or Michigan Department of Environment, Great Lakes, and Energy (EGLE)

Responsibilities

- The Environmental Consulting Firm (“the Firm”) shall be responsible for the professional quality, technical accuracy, and coordination of all environmental related work under this RFQ.
- Neither the City of Ferndale’s review, approval or acceptance of, nor payment for, any of the Services required under this RFQ shall be construed to operate as a waiver of any rights under this RFQ or of any cause of action arising out of the performance of this RFQ,

and the Firm shall be and remain liable to the City of Ferndale in accordance with applicable law for all damages to the City of Ferndale caused by the Firm's negligent performance, and acts or omissions by The Firm of any of the Services furnished under this RFQ.

- The firm shall work in conjunction with other project members including but not limited to The City of Ferndale and its departments, sub-consultants, general Consultants, specialty Consultants, state and local governmental agencies, and any other related stakeholders on environmental related work on this RFQ.

Project Considerations/Requirements

- All projects must be completed within documented completion dates including punch list items. All projects must be completed within budget.
- All work must comply with local, state, and federal codes and laws.
- Firm(s) or individual(s) selected under this proposal will be required to meet with City staff in developing plans, scope of work, and specifications as they pertain to each project.
- Written notices, project documentation, invoicing, and all other correspondence related to the scope of work and associated projects shall be provided electronically as follows:

    - Erin Quetell, Environmental Sustainability Planner equetell@ferndalemi.gov with copy to Jordan Twardy, CED Director jtwardy@ferndalemi.gov and Alexis Richards, Project Planner arichards@ferndalemi.gov .

Examples of Potential Projects

- Investigative environmental sampling on City-owned property to include, but not limited to, soil sampling, soil gas sampling, groundwater sampling, and other associated or necessary sampling.
- Methane well monitoring on City-owned property. May include installation of new sampling wells.
- Environmental assessment of City-owned buildings for redevelopment and improvements.

Specific Contract Terms and Conditions

Contract Term

The resulting list will be maintained for a period of three years, with possible extension of two consecutive one (1) year terms.

Key Personnel and Subconsultants

It is essential that the Consultant provides adequate experienced personnel and subconsultants, capable of and devoted to the successful accomplishment of work to be performed under this contract. The Consultant must agree to assign specific individuals to the key positions.

- The Consultant agrees that, once assigned to work under this contract, key personnel and subconsultants shall not be removed or replaced without written notice to the City.

- If key personnel and subconsultants are not available for work under this contract for a continuous period exceeding thirty (30) calendar days, or are expected to devote substantially less effort to the work than initially anticipated, the Consultant shall immediately notify the City, and shall if needed, subject to the concurrence of the City, replace such personnel with personnel of substantially equal ability and qualifications.
- The use of any subconsultant is subject to pre-approval by the City of Ferndale's Legal Contract Administrator and Finance Department.

RFQ Terms and Conditions of Agreement

1. Assignment/Transfer: No assignment or transfer of this agreement without written consent of the City of Ferndale.

2. Excise and Sales Tax: The prices herein must not include any Federal excise taxes or sales taxes imposed by any State or Municipal Government. Such taxes, if included, must be deducted when submitting invoice for payment.

3. Invoices: Invoices for services must be submitted monthly for all services provided in the project. Payment will be delayed if the invoice fails to reference PO number, ordering department, unit prices, quantities, totals, and a full description of the order that matches the PO. Invoices are to be emailed to the City and will be dependent on the department issuing the work of the email address. The City's preferred method of payment is by Automated Clearing House (ACH).

4. Payment Terms: Payment will be 2%/10, Net 30 unless otherwise specified by the City of Ferndale.

5. IRS Form W-9: Seller must have on file with the City of Ferndale an IRS Form W-9 before Purchaser will issue any payment to Seller.

6. Compliance with Laws: Consultant represents and warrants that the performance of this order and the furnishing of services required shall be in accordance with the applicable standards, provisions and stipulations of all pertinent Federal, State or City of Ferndale laws, rules, regulations, resolutions, and ordinances including but not limited to the Fair Labor Standards Act, the Equal Employment Opportunity rules and regulations, the Transportation Safety Act and the Occupational Safety and Health Acts.

7. Iran Economic Sanctions Act: Further, Consultant certifies it is in compliance within the State of Michigan's Iran Economic Sanctions Act and is not an Iran linked business. By signing this document, I certify and agree on behalf of myself and the company submitting this bid/proposal the following:
   (1) that I am duly authorized to legally bind the company submitting this bid; and (2) that the company submitting this bid is not an "Iran-linked business," as that term is defined in Section 2(e) of the Iran Economic Sanctions Act, being
      1. Michigan Public Act No. 517 of 2012; and

(2) That I and the company submitting this bid will immediately comply with any further certifications or information submissions requested by the City in this regard.

8. Amendments: No amendment, modification or supplement to this contract shall be binding unless it is in writing and signed by authorized representatives of the parties.

9. Termination: When in the City of Ferndale's best interest, the City of Ferndale may unilaterally cancel this RFQ at any time, whether or not the Consultant is in default of any of its obligations hereunder. Cancellation will occur after a 30-day notice to the Consultant. Under any such cancellation, the Consultant agrees to waive any claim for damages, including loss of anticipated profit on account hereof. However, the City of Ferndale agrees that the Consultant shall be paid for items and/or services already accepted by City of Ferndale, but in no event shall the City of Ferndale be liable for any loss of profits on the order or portion thereof so terminated. Either party may terminate this RFQ at any time for the failure of the other to comply with any of its material terms and conditions and must provide a 30-day notice of termination.

10. Waiver of Breach: No waiver by either party of any breach of any of the covenants or conditions herein contained performed by the other party shall be construed as a waiver of any succeeding breach of this same or of any other covenant or condition.

11. Records and Right to Audit: Consultant's "records" shall upon reasonable notice be open to inspection and subject to audit and/or reproduction at during normal business working hours. The City's representative or an outside representative engaged by City may perform such audits. The City or its designee may conduct such audits or inspections throughout the term of this contract and for a period of three years after final payment or longer if required by law.

    (1) Consultant's "records" as referred to in this contract shall include any and all information, materials and data of every kind and character, including without limitation, records, books, papers, documents, subscriptions, recordings, agreements, purchase orders, leases, contracts, commitments, arrangements, notes, daily diaries, superintendent reports, drawings, receipts, vouchers and memoranda, and any and all other agreements, sources of information and matters that may in the City's judgment, have any bearing on or pertain to any matters, rights, duties or obligations under or covered by any Contract Document. Such records shall include (hard copy, as well as computer readable data if it can be made available), written policies and procedures; time sheets; payroll registers; cancelled checks; subcontract files (including proposals of successful and unsuccessful Consultants, proposal recaps, etc.); original estimates; estimating work sheets; correspondence; change order files (including documentation covering negotiated settlements); back charge logs and supporting documentation; general ledger entries detailing cash and trade discounts earned,

insurance rebates and dividends; and any other Consultant records which may have a bearing on matters of interest to the City in connection with rite Consultant's dealings with the City (all foregoing hereinafter referred to as "records") to the extent necessary to adequately permit evaluation and verification of: a) Consultant compliance with contract requirements, b) compliance with the City's Charter and policies, and c) compliance with provisions for pricing change orders, invoices or claims submitted by the Consultant or his payees.

(2) Consultant shall require all payees (examples of payees include subconsultants, insurance agents, material suppliers, etc.) to comply with the provisions of this article by incurring the requirements hereof in a written contract agreement between Consultant and payee. Such requirements to include flow-down right of audit provisions in contracts with payees will also apply to Subconsultants and Subconsultants, material suppliers, etc. Consultant will cooperate fully and will cancel Related Parties and all of Consultant's subconsultants (including those entering into lump sum subcontracts) to cooperate fully in furnishing or in making available to the City from time to time whenever requested in an expeditious manner any and all such information, materials and data.

(3) If an audit inspection or examination in accordance with this Article, discloses overpricing or overcharges (of any nature) by the Consultant to the City in excess of one-half of one percent (.5%) of the total contract billings the reasonable actual cost of the City's audit shall be reimbursed to the City by the Consultant. Any adjustments and/or payments which must be made as a result of any such audit or inspection of the Consultant's invoices and/or records shall be made within a reasonable amount of time (not to exceed 90 days) from presentation of the City's findings to Consultant.

12. Liability and Indemnity: Consultant agrees to protect, defend, reimburse, indemnify and hold the City of Ferndale, its officers, affiliates, employees and agents harmless at all times from and against any and all claims, liabilities, expenses, losses, demands, damages, fines and causes of action of every kind and character made, incurred, sustained or initiated by any party hereto, any party acquiring any interest hereunder, any agent or employee of any party hereto, any third or other party whomsoever, or any governmental agency, arising out of, incident to, or in connection with this contract, or in the performance, nonperformance or purported performance of the work or services or breach of the terms hereof, except when the City of Ferndale is solely at fault.

13. Records: The City of Ferndale reserves the right to inspect all vendor documents relating to this RFQ for up to three (3) years after expiration.

14. Insurance: The Consultant, at its own expense and in its own name must provide and keep in force during the term of the agreement between the Consultant and the City,

insurance coverage with limits not less than $5,000,000. Insurance must include General Liability naming the City, Auto Insurance, and Professional Liability Insurance.

15. Noncompliance: Failure to deliver in accordance with specifications will be cause for the City of Ferndale to cancel the contract or any part thereof and purchase on the open market, charging any additional cost to the Consultant.

16. Non-Discrimination Clause: The Consultant agrees not to discriminate against any employee or applicant for employment, to be employed in the performance of such contract, with respect to hire, tenure, terms, conditions or privileges, of employment, or any matter directly or indirectly related to employment, because of race, color, religion, national origin, age, sex, sexual orientation, gender expression, height, weight, or marital status. Breach of this covenant may be regarded as material breach of the contract as provided for in Act 220 and Act 453 of the Public Acts of 1976, as amended, entitled "Michigan Handicapper's Civil Rights Act" and the Michigan Elliott Larson Civil Rights Act." The Consultant further agrees to require similar provisions from any subconsultants, or suppliers. City of Ferndale has a zero-tolerance policy for discrimination.

17. Subcontracting: The use of a subconsultant is not permitted without written approval of the City of Ferndale.

18. Use of the City Seal: Consultants are prohibited from using the official Seal of the City of Ferndale in this Proposal or in any other manner.

19. Legal Proceedings: Any legal proceedings shall be resolved in Michigan courts.

Response Form

Failure to complete this form may result in your Response being deemed nonresponsive and rejected without any further evaluation.

To: City of Ferndale

The Undersigned hereby offers and agrees to furnish the goods and/or services in compliance with all terms, scope of work, conditions, specifications, and addenda in the Statement of Qualifications.

Addenda

The undersigned has read, understands and is fully cognizant of the Information to Consultants, Offer and Form of Agreement, all Exhibits thereto, together with any written addendum issued in connection with any of the above. The undersigned hereby acknowledges receipt of the following addendum(s): _____, _____, _____, _____ (write "none" if none). In addition, the undersigned has completely and appropriately filled out all required forms.

Obligation

The undersigned, by submission of this Offer, hereby agrees to be obligated, if selected as the Consultant, to provide the stated goods and/or services to the City, for the term as stated herein, and to enter into an Agreement with the City, in accordance with the Conditions, Scope and Terms, as well as the Form of Agreement, together with any written addendum as specified above.

Compliance

The undersigned hereby accepts all administrative requirements of the RFQ and will be in compliance with such requirements. By submitting this Response Form, the Consultant represents that: 1) the Consultant is in compliance with any applicable provisions of the City's Charter and Code of Ordinances, and 2) if awarded a contract to operate the concession or provide the goods or services required in the RFQ, the Consultant will comply with the City's Charter and Code of Ordinances. These documents can be found on the City of Ferndale's website on the City Clerk's page.

Non-Collusion

The undersigned, by submission of this Response Form, hereby declares that this Response is made without collusion with any other business making any other Response, or which otherwise would make a Response.

Performance Guarantee

The undersigned further agrees that if awarded the Agreement, it will submit to the City any required performance guarantee (i.e. irrevocable letter of credit or cash deposit).

Submittal Requirements
The undersigned certifies it has attached a complete response to each of the submittal requirements listed in the Evaluation Criteria and Submittal Requirements section of this RFQ.

No response may be accepted that has not been manually signed in ink in the appropriate space below.

I certify, under penalty of perjury, that I have the legal authorization to bind the firm hereunder:

Company Name	**For clarification of this offer, contact:**
Address	
City, State, Zip	
Phone	**Fax**
Email	
Signature	
Printed Name	**Title**
Federal Tax ID	

Business Information Questionnaire

Failure to complete this form may result in your Response being deemed nonresponsive and rejected without any further evaluation.

Name of Company	
Principal	
Office Address	
Phone Number	

Form of Ownership (Check One)
Corporation ( ) LLC ( ) Joint Venture ( )
State of Incorporation/Registration Date of Incorporation/Registration

Partnership ( ) If Partnership, select one of the following: Limited ( ) or General ( )

Individual ( )

List of Partners, Principals, Corporate Officers or Owners

Name	**Title**

Financial Disclosure/Conflicts of Interest

Identify any contract(s), including any contract involving an employment or consulting relationship, which the firm, or its partners, principals, corporate officers or owners currently has with the City of Ferndale, or with any of its Council members or officers.

Latest Credit Rating (Specify if other than Dun and Bradstreet)

I hereby certify that the foregoing business information is true, correct and complete to the best of (my/our) knowledge and belief:

Name of Company	
Signature	Date
Title	
Printed Name	

Subconsultant Form

Failure to complete this form may result in your Bid or Response being deemed nonresponsive and rejected without any further evaluation.

Are there any subconsultants to be utilized under this contract?

____ **YES** - You must complete both pages.

____ **NO -** You must complete only this page.

(If you have more than one Subconsultant, make additional copies as needed)

Prime Consultant
State relationship, if any, between Prime Consultant and each Subconsultant

NOTE: Both the Prime Consultant/Consultant and Subconsultant must sign this form appropriately.

Subconsultant	Fed Tax ID
Address	
City, State, Zip	
Phone	Fax
Email	

Owners/Partners/Corporate Directors/Principal Stockholders (>5% holdings):

Work to Perform:

Subcontract Amount $_____ Percent of Contract _____%

Subconsultant
I acknowledge that all the above information has been completely filled out and is true.

Signature	Printed Name
Title	Date

Prime Consultant
I acknowledge that all the above information has been completely filled out and is true.

Signature	Printed Name
Title	Date

Ethics in Contracting Vendor Form

Disclosure of Relationships with City of Ferndale contract managers by owners, officers, and key personnel of business.

Failure to complete this form may result in your Proposal being deemed nonresponsive and rejected without any further evaluation.

- This form must be completed by a person holding a key position in the business, such as an officer, director, trustee, partner, senior engineer or sales manager and have influence in making this proposal or response or in performing the contract if the City of Ferndale (City) awards it to your business.
- Please fill out this form to the best of your knowledge and belief.
- Detach and make additional copies of this form if needed.
- You are not required to question family members beyond what you already know of their affairs.
- Submit this form with your bid/quote/proposal. A copy will be kept on file by the City of Ferndale.
- If you fail to fully disclose the required information below, the City may terminate your contract if your business is awarded one.
- If you are awarded a contract and changes occur that would impact your responses below, it is your responsibility to update and resubmit this form.

1. Are you a City employee or an immediate family member of a City employee?
___ Yes ___ No

If Yes:

Name	**Relationship**
Title	**Department**

2. Without any further inquiry, are you aware if your business has employed a City employee or an immediate family member of a City employee within the previous twelve (12) months?
___ Yes ___ No

If Yes:

Name	**Relationship**
Title	**Department**

3. Without any further inquiry, are you aware if your business has discussed hiring a City contract manager or an immediate family member of a City contract manager within the previous twelve (12) months? ___ Yes ___ No

If Yes:

Name of Contract Manager	
Title	**Department**

4. Do you and a contract manager each have a financial interest in one or more of the same business ventures? ___ Yes ___ No

If Yes:

Name of Contract Manager	
Title	**Department**

Ethics Certification

I certify that I have disclosed all information within my knowledge, which is required by this disclosure form.

Name	
Signature	**Date**
Company Name	
Tax ID #	

Ethics Definitions

Contract Manager

An elected or appointed City of Ferndale official or a key employee identified as having significant discretion over City contracts.

Immediate Family

Your spouse, children, parents, brothers and sisters.

Financial Interest:

- Ownership of any interest or involvement in any relationship, which results in the receipt in $500 or more per year.

- Holding a key position in a business such as officer, director, trustee, partner, member, shareholder or sales manager. Exceptions: Officers who serve without compensation on the boards of charitable organizations.
- Receipt of any financial benefit, whether direct or indirect.

fishbeck
Engineers | Architects | Scientists | Constructors

1001 Woodward Avenue, Suite 860
Detroit, Michigan 48226

313.293.3550 | fishbeck.com

Professional Services Agreement

PROJECT NAME	On-call Consulting Services for Potential Upcoming City Projects
FISHBECK CONTACT	Leonard Harwell
CLIENT	City of Ferndale
CLIENT CONTACT	Alexis Richards, Project Planner, arichards@ferndalemi.gov
ADDRESS	300 E 9 Mile Road, Ferndale, MI 48331

Client hereby requests and authorizes Fishbeck to perform the following:

SCOPE OF SERVICES: On-call Consulting Services for Potential Upcoming City Projects

AGREEMENT. The Agreement consists of this page and the documents that are checked:

☒ Terms and Conditions for Professional Services, attached.
☐ Proposal dated
☒ Other: Amendment 1 to Fishbeck's Professional Services Agreement, attached.

METHOD OF COMPENSATION:

☐ Lump Sum for Defined Scope of Services
☒ Hourly Billing Rates plus Reimbursable Expenses
☐ Other:

Budget for Above Scope of Services: N.A.

ADDITIONAL PROVISIONS (IF ANY): N.A.

APPROVED FOR:		ACCEPTED FOR:	
City of Ferndale, Michigan		Fishbeck	
BY:		BY:	
TITLE:		TITLE:	Vice President
DATE:		DATE:	June 23, 2020

Terms and Conditions for Professional Services

1. **METHOD OF AUTHORIZATION.** Client may authorize Fishbeck to proceed with work either by signing a Professional Services Agreement or by issuance of an acknowledgment, confirmation, purchase order, or other communication. Regardless of the method used, these Terms and Conditions shall prevail as the basis of Client's authorization to Fishbeck. Any Client document or communication in addition to or in conflict with these Terms and Conditions is rejected.
2. **CLIENT RESPONSIBILITIES.** Client shall provide all criteria and full information as to requirements for the Project and designate in writing a person with authority to act on Client's behalf on all matters concerning the Project. If Fishbeck's services under this Agreement do not include full-time construction observation or review of Contractor's performance, Client shall assume responsibility for interpretation of contract documents and for construction observation, and shall waive all claims against Fishbeck that may be in any way connected thereto.
3. **HOURLY BILLING RATES.** Unless stipulated otherwise, Client shall compensate Fishbeck at hourly billing rates in effect when services are provided by Fishbeck employees of various classifications.
4. **REIMBURSABLE EXPENSES.** Those costs incurred on or directly for Client's Project. Reimbursement shall be at Fishbeck's current rate for mileage for service vehicles and automobiles, special equipment, and copying, printing, and binding. Reimbursement for commercial transportation, meals, lodging, special fees, licenses, permits, insurances, etc., and outside technical or professional services shall be on the basis of actual charges plus 10 percent.
5. **OPINIONS OF COST.** Any opinions of probable construction cost and/or total project cost provided by Fishbeck will be on a basis of experience and judgment, but since it has no control over market conditions or bidding procedures, Fishbeck cannot warrant that bids or ultimate construction or total project costs will not vary from such estimates.
6. **PROFESSIONAL STANDARDS; WARRANTY.** The standard of care for services performed or furnished by Fishbeck will be the care and skill ordinarily used by members of Fishbeck's profession practicing under similar circumstances at the same time and in the same locality. Fishbeck makes no warranties, express or implied, under this Agreement or otherwise, in connection with Fishbeck's services.
7. **TERMINATION.** Either Client or Fishbeck may terminate this Agreement by giving ten days' written notice to the other party. In such event, Client shall pay Fishbeck in full for all work previously authorized and performed prior to the effective date of termination, plus (at the discretion of Fishbeck) a termination charge to cover finalization work necessary to bring ongoing work to a logical conclusion. Such charge shall not exceed 30 percent of all charges previously incurred. Upon receipt of such payment, Fishbeck will return to Client all documents and information which are the property of Client.
8. **SUBCONTRACTORS.** Fishbeck may engage subcontractors on behalf of Client to perform any portion of the services to be provided by Fishbeck hereunder.
9. **PAYMENT TO FISHBECK.** Invoices will be issued every four weeks, payable upon receipt, unless otherwise agreed. Interest of 1 percent per four-week period will be payable on all amounts not paid within 28 days from date of invoice, payment thereafter to be applied first to accrued interest and then to the principal unpaid amount. Any attorney's fees or other costs incurred in collecting any delinquent amount shall be paid by Client.

   Client agrees to pay on a current basis, in addition to any proposal or contract fee understandings, all taxes including, but not limited to, sales taxes on services or related expenses which may be imposed on Fishbeck by any governmental entity.

   If Client directs Fishbeck to invoice another, Fishbeck will do so, but Client agrees to be ultimately responsible for Fishbeck's compensation until Client provides Fishbeck with that third party's written acceptance of all terms of this Agreement and until Fishbeck agrees to the substitution.

   In addition to any other remedies Fishbeck may have, Fishbeck shall have the absolute right to cease performing any basic or additional services in the event payment has not been made on a current basis.
10. **HAZARDOUS WASTE.** Fishbeck has neither created nor contributed to the creation or existence of any hazardous, radioactive, toxic, irritant, pollutant, or otherwise dangerous substance or condition at any site, and its compensation hereunder is in no way commensurate with the potential risk of injury or loss that may be caused by exposure to such substances or conditions. Fishbeck shall not be responsible for any alleged contamination, whether such contamination occurred in the past, is occurring presently, or will occur in the future, and the performance of services hereunder does not imply risk-sharing on the part of Fishbeck.
11. **LIMITATION OF LIABILITY.** To the fullest extent permitted by law, Fishbeck's total liability to Client for any cause or combination of causes, which arise out of claims based upon professional liability errors or omissions, whether based upon contract, warranty, negligence, strict liability, or otherwise is, in the aggregate, limited to the greater of $250,000 or the amount of the fee earned under this Agreement.

    To the fullest extent permitted by law, Fishbeck's total liability to Client for any cause or combination of causes, which arise out of claims for which Fishbeck is covered by insurance other than professional liability errors and omissions, whether based upon contract, warranty, negligence, strict liability, or otherwise is, in the aggregate, limited to the total insurance proceeds paid on behalf of or to Fishbeck by Fishbeck's insurers in settlement or satisfaction of Client's claims under the terms and conditions of Fishbeck's insurance policies applicable thereto.

    Higher limits of liability may be considered upon Client's written request, prior to commencement of services, and agreement to pay an additional fee.

12. **DELEGATED DESIGN.** Client recognizes and holds Fishbeck harmless for the performance of certain components of the Project which are traditionally specified to be designed by the Contractor.

13. **INSURANCE.** Client shall cause Fishbeck and Fishbeck's consultants, employees, and agents to be listed as additional insureds on all commercial general liability and property insurance policies carried by Client which are applicable to the Project. Client shall also provide workers' compensation insurance for Client's employees. Client agrees to have their insurers endorse these insurance policies to reflect that, in the event of payment of any loss or damages, subrogation rights under this Agreement are hereby waived by the insurer with respect to claims against Fishbeck.

    Upon request, Client and Fishbeck shall each deliver to the other certificates of insurance evidencing their coverages.

    Client shall require Contractor to purchase and maintain commercial general liability and other insurance as specified in the contract documents and to cause Fishbeck and Fishbeck's consultants, employees, and agents to be listed as additional insureds with respect to such liability and other insurance purchased and maintained by Contractor for the Project. Contractor must agree to have their insurers endorse these insurance policies to reflect that, in the event of payment of any loss or damages, subrogation rights under this Agreement are hereby waived by the insurer with respect to claims against Fishbeck.

14. **INDEMNIFICATION.** Fishbeck will defend, indemnify, and hold Client harmless from any claim, liability, or defense cost for injury or loss sustained by any party from exposures to the extent caused by Fishbeck's negligence or willful misconduct. Client agrees to defend, indemnify, and hold Fishbeck harmless from any claim, liability, or defense cost for injury or loss sustained by any party from exposures allegedly caused by Fishbeck's performance of services hereunder, except for injury or loss to the extent caused by the negligence or willful misconduct of Fishbeck. These indemnities are subject to specific limitations provided for in this Agreement.

15. **CONSEQUENTIAL DAMAGES.** Client and Fishbeck waive consequential damages for claims, disputes, or other matters in question relating to this Agreement including, but not limited to, loss of business.

16. **LEGAL EXPENSES.** If either Client or Fishbeck makes a claim against the other as to issues arising out of the performance of this Agreement, the prevailing party will be entitled to recover its reasonable expenses of litigation, including reasonable attorney's fees. If Fishbeck brings a lawsuit against Client to collect invoiced fees and expenses, Client agrees to pay Fishbeck's reasonable collection expenses including attorney fees.

17. **OWNERSHIP OF WORK PRODUCT.** Fishbeck shall remain the owner of all drawings, reports, and other material provided to Client, whether in hard copy or electronic media form. Client shall be authorized to use the copies provided by Fishbeck only in connection with the Project. Any other use or reuse by Client or others for any purpose whatsoever shall be at Client's risk and full legal responsibility, without liability to Fishbeck. Client shall defend, indemnify, and hold harmless Fishbeck from all claims, damages, losses, and expenses, including attorney's fees arising out of or resulting therefrom.

18. **ELECTRONIC MEDIA.** Data, reports, drawings, specifications, and other material and deliverables may be transmitted to Client in either hard copy, digital, or both formats. If transmitted electronically, and a discrepancy or conflict with the electronically transmitted version occurs, the hard copy in Fishbeck's files used to create the digital version shall govern. If a hard copy does not exist, the version of the material or document residing on Fishbeck's computer network shall govern. Fishbeck cannot guarantee the longevity of any material transmitted electronically nor can Fishbeck guarantee the ability of the Client to open and use the digital versions of the documents in the future.

19. **GENERAL CONSIDERATIONS.** Client and Fishbeck each are hereby bound and the partners, successors, executors, administrators, and legal representatives of Client and Fishbeck are hereby bound to the other party to this Agreement and to the partners, successors, executors, administrators, and legal representatives (and said assigns) of such other party, in respect of all covenants, agreements, and obligations of this Agreement.

    Neither Client nor Fishbeck shall assign this Agreement without the written consent of the other.

    Neither Client nor Fishbeck will have any liability for nonperformance caused in whole or in part by causes beyond Fishbeck's reasonable control. Such causes include, but are not limited to, Acts of God, civil unrest and war, labor unrest and strikes, acts of authorities, and events that could not be reasonably anticipated.

    This Agreement shall be governed by the law of the principal place of business of Fishbeck.

    This Agreement constitutes the entire agreement between Client and Fishbeck and supersedes all prior written or oral understandings. This Agreement may only be amended, supplemented, modified, or canceled by a duly executed written instrument.

End of Terms and Conditions for Professional Services

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Engineers | Architects | Scientists | Constructors

1001 Woodward Avenue, Suite 860
Detroit, Michigan 48226

313.293.3550 | fishbeck.com

Professional Services Agreement Amendment 1

Between Fishbeck and City of Ferndale, Michigan
Dated June 23, 2020
For On-Call Consultant Services for Potential Upcoming City Projects

The Terms and Conditions for this project are modified as follows:

- Delete Terms and Conditions for Professional Services Paragraphs 7, 9, 12, 13 and 14.
- Paragraph 8 Subcontractors. Add the following to the end of the paragraph: "with the prior written approval of Client."
- Paragraph 11 Limitation of Liability:
  - Delete first paragraph.
  - Second paragraph, delete "…other than professional liability errors and omissions…"
- Paragraph 16 Legal Expenses. Add the following to the end of the paragraph: "if it is the prevailing party."
- Add sections:
  - Key Personnel and Subconsultants
  - RFQ Terms and Conditions of Agreement
- In the event that any of the following Amendments conflict with the Terms and Conditions for Professional Services, this Amendment will govern.

Key Personnel and Subconsultants

It is essential that the Consultant provides adequate experienced personnel and subconsultants, capable of and devoted to the successful accomplishment of work to be performed under this contract. The Consultant must agree to assign specific individuals to the key positions.

- The Consultant agrees that, once assigned to work under this contract, key personnel and subconsultants shall not be removed or replaced without written notice to the City.
- If key personnel and subconsultants are not available for work under this contract for a continuous period exceeding thirty (30) calendar days, or are expected to devote substantially less effort to the work than initially anticipated, the Consultant shall immediately notify the City, and shall if needed, subject to the concurrence of the City, replace such personnel with personnel of substantially equal ability and qualifications.
- The use of any subconsultant is subject to pre-approval by the City of Ferndale's Legal Contract Administrator and Finance Department.

RFQ Terms and Conditions of Agreement

1. Assignment/Transfer: No assignment or transfer of this agreement without written consent of the City of Ferndale.
2. Excise and Sales Tax: The prices herein must not include any Federal excise taxes or sales taxes imposed by any State or Municipal Government. Such taxes, if included, must be deducted when submitting invoice for payment.

3. Invoices: Invoices for services must be submitted monthly for all services provided in the project. Payment will be delayed if the invoice fails to reference PO number, ordering department, unit prices, quantities, totals, and a full description of the order that matches the PO. Invoices are to be emailed to the City and will be dependent on the department issuing the work of the email address. The City's preferred method of payment is by Automated Clearing House (ACH).
4. Payment Terms: Payment will be 2%/10, Net 30 unless otherwise specified by the City of Ferndale.
5. IRS Form W-9: Seller must have on file with the City of Ferndale an IRS Form W-9 before Purchaser will issue any payment to Seller.
6. Compliance with Laws: Consultant represents and warrants that the performance of this order and the furnishing of services required shall be in accordance with the applicable standards, provisions and stipulations of all pertinent Federal, State or City of Ferndale laws, rules, regulations, resolutions, and ordinances including but not limited to the Fair Labor Standards Act, the Equal Employment Opportunity rules and regulations, the Transportation Safety Act and the Occupational Safety and Health Acts.
7. Iran Economic Sanctions Act: Further, Consultant certifies it is in compliance within the State of Michigan's Iran Economic Sanctions Act and is not an Iran linked business. By signing this document, I certify and agree on behalf of myself and the company submitting this bid/proposal the following:

   (1) that I am duly authorized to legally bind the company submitting this bid; and (2) that the company submitting this bid is not an "Iran-linked business," as that term is defined in Section 2(e) of the Iran Economic Sanctions Act, being

      1. Michigan Public Act No. 517 of 2012; and

   (2) that I and the company submitting this bid will immediately comply with any further certifications or information submissions requested by the City in this regard.
8. Amendments: No amendment, modification or supplement to this contract shall be binding unless it is in writing and signed by authorized representatives of the parties.
9. Termination: When in the City of Ferndale's best interest, the City of Ferndale may unilaterally cancel this RFQ at any time, whether or not the Consultant is in default of any of its obligations hereunder. Cancellation will occur after a 30-day notice to the Consultant. Under any such cancellation, the Consultant agrees to waive any claim for damages, including loss of anticipated profit on account hereof. However, the City of Ferndale agrees that the Consultant shall be paid for items and/or services already accepted by City of Ferndale, but in no event shall the City of Ferndale be liable for any loss of profits on the order or portion thereof so terminated. Either party may terminate this RFQ at any time for the failure of the other to comply with any of its material terms and conditions and must provide a 30-day notice of termination.
10. Waiver of Breach: No waiver by either party of any breach of any of the covenants or conditions herein contained performed by the other party shall be construed as a waiver of any succeeding breach of this same or of any other covenant or condition.
11. Records and Right to Audit: Consultant's "records" shall upon reasonable notice be open to inspection and subject to audit and/or reproduction during normal business working hours. The City's representative or an outside representative engaged by City may perform such audits. The City or its designee may conduct such audits or inspections throughout the term of this contract and for a period of three years after final payment or longer if required by law.

   (1) Consultant's "records" as referred to in this contract shall include any and all information, materials and data of every kind and character, including without limitation, records, books, papers, documents,

subscriptions, recordings, agreements, purchase orders, leases, contracts, commitments, arrangements, notes, daily diaries, superintendent reports, drawings, receipts, vouchers and memoranda, and any and all other agreements, sources of information and matters that may in the City's judgment, have any bearing on or pertain to any matters, rights, duties or obligations under or covered by any Contract Document. Such records shall include (hard copy, as well as computer readable data if it can be made available), written policies and procedures; time sheets; payroll registers; cancelled checks; subcontract files (including proposals of successful and unsuccessful Consultants, proposal recaps, etc.); original estimates; estimating work sheets; correspondence; change order files (including documentation covering negotiated settlements); back charge logs and supporting documentation; general ledger entries detailing cash and trade discounts earned, insurance rebates and dividends; and any other Consultant records which may have a bearing on matters of interest to the City in connection with rite Consultant's dealings with the City (all foregoing hereinafter referred to as "records") to the extent necessary to adequately permit evaluation and verification of: a) Consultant compliance with contract requirements, b) compliance with the City's Charter and policies, and c) compliance with provisions for pricing change orders, invoices or claims submitted by the Consultant or his payees.

(2) Consultant shall require all payees (examples of payees include subconsultants, insurance agents, material suppliers, etc.) to comply with the provisions of this article by incurring the requirements hereof in a written contract agreement between Consultant and payee. Such requirements to include flow-down right of audit provisions in contracts with payees will also apply to Subconsultants and Subconsultants' material suppliers, etc. Consultant will cooperate fully and will cancel Related Parties and all of Consultant's subconsultants (including those entering into lump sum subcontracts) to cooperate fully in furnishing or in making available to the City from time to time whenever requested in an expeditious manner any and all such information, materials and data.

(3) If an audit inspection or examination in accordance with this Article discloses overpricing or overcharges (of any nature) by the Consultant to the City in excess of one-half of one percent (.5%) of the total contract billings, the reasonable actual cost of the City's audit shall be reimbursed to the City by the Consultant. Any adjustments and/or payments which must be made as a result of any such audit or inspection of the Consultant's invoices and/or records shall be made within a reasonable amount of time (not to exceed 90 days) from presentation of the City's findings to Consultant.

12. Liability and Indemnity: Consultant agrees to protect, defend, reimburse, indemnify and hold the City of Ferndale, its officers, affiliates, employees and agents harmless at all times from and against any and all claims, liabilities, expenses, losses, demands, damages, fines and causes of action of every kind and character made, incurred, sustained or initiated by any party hereto, any party acquiring any interest hereunder, any agent or employee of any party hereto, any third or other party whomsoever, or any governmental agency, arising out of, incident to, or in connection with this contract, or in the performance, nonperformance or purported performance of the work or services or breach of the terms hereof, except when the City of Ferndale is solely at fault.

13. Records: The City of Ferndale reserves the right to inspect all vendor documents relating to this RFQ for up to three (3) years after expiration.

14. Insurance: The Consultant, at its own expense and in its own name must provide and keep in force during the term of the agreement between the Consultant and the City, insurance coverage with limits not less than $5,000,000. Insurance must include General Liability naming the City, Auto Insurance, and Professional Liability Insurance.

15. Noncompliance: Failure to deliver in accordance with specifications will be cause for the City of Ferndale to cancel the contract or any part thereof and purchase on the open market, charging any additional cost to the Consultant.
16. Non-Discrimination Clause: The Consultant agrees not to discriminate against any employee or applicant for employment, to be employed in the performance of such contract, with respect to hire, tenure, terms, conditions or privileges, of employment, or any matter directly or indirectly related to employment, because of race, color, religion, national origin, age, sex, sexual orientation, gender expression, height, weight, or marital status. Breach of this covenant may be regarded as material breach of the contract as provided for in Act 220 and Act 453 of the Public Acts of 1976, as amended, entitled "Michigan Handicapper's Civil Rights Act" and the "Michigan Elliott Larson Civil Rights Act." The Consultant further agrees to require similar provisions from any subconsultants or suppliers. City of Ferndale has a zero-tolerance policy for discrimination.
17. Subcontracting: The use of a subconsultant is not permitted without written approval of the City of Ferndale.
18. Use of the City Seal: Consultants are prohibited from using the official Seal of the City of Ferndale in this Proposal or in any other manner.
19. Legal Proceedings: Any legal proceedings shall be resolved in Michigan courts.

All other Terms and Conditions shall remain unchanged.

APPROVED FOR:		ACCEPTED FOR:	
City of Ferndale, Michigan		Fishbeck	
BY:		BY:	
TITLE:		TITLE:	Vice President
DATE:		DATE:	June 23, 2020



ON-CALL ENVIRONMENTAL CONSULTING SERVICES

CITY OF FERNDALE

STATEMENT OF QUALIFICATIONS
APRIL 15, 2020

fishbeck
Engineers | Architects | Scientists | Constructors

fishbeck
Engineers | Architects | Scientists | Constructors

39500 MacKenzie Drive, Suite 100
Novi, Michigan 48377

248.324.2090 | fishbeck.com

April 15, 2020

Erin Quetell
Environmental Sustainability Planner
City of Ferndale
300 East 9 Mile Road
Ferndale, MI 48331

Request for Qualifications (RFQ)
On-Call Environmental Consulting Services

Dear Erin:

Fishbeck is pleased and excited to provide this qualifications submittal to the City of Ferndale for On-Call Environmental Consulting Services. Fishbeck is well suited to provide the types of services enumerated in the RFQ and looks forward to partnering with Ferndale leadership to achieve the environmental and redevelopment goals you have established for your community.

As a premiere full-service consulting firm headquartered in Michigan, Fishbeck has the talent and capacity to provide Ferndale with exceptional service. As an employee owned company, we understand the importance of partnerships and operating as a team with the community stakeholders and regulators.

Fishbeck's Environmental Services Division routinely provides all the services listed in the RFQ. With a total of 56 professionals, Fishbeck's environmental professionals provide our clients with a diverse set of skills from geological, biological, and ecological sciences to environmental and chemical engineering and industrial hygiene. And our due diligences team is led by two senior level professionals with strong ties to the Michigan Department of Environment, Great Lakes and Energy (EGLE), having both worked for EGLE prior to joining Fishbeck. The depth of experience in our due diligence/brownfield services team has made this the fastest growing service at Fishbeck.

Our experience and team of experts, along with our commitment to helping the City achieve project success, are exactly the qualities you need in an environmental consultant – and we would love the chance to partner with you. Thank you for the opportunity to respond and we look forward to future conversations.

Sincerely,

Leonard Harwell
Vice President/Senior Project Manager

Stephen J. MacDonald, PE
Vice President/Senior Environmental Engineer

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01 — PROFESSIONAL COMPETENCE

PROFESSIONAL COMPETENCE

FIRM EXPERIENCE

Fishbeck provides innovative solutions and exceptional technical quality and service for municipal clients. We have an experienced, dedicated staff of scientists, engineers, and regulatory specialists who deliver excellence and value. Our team's municipal experience is both broad and deep, with decades of work in projects ranging from complex remediation engineering and implementation to brownfield redevelopment.

Our team helps communities comply with environmental regulations at the local, state, and federal level. Regulations have become complex, and it is difficult for one person to be knowledgeable in all areas. Fishbeck's team approach ensures our services comply with all applicable regulations and efficiently and effectively achieve our client's goals.

Fishbeck helps Michigan municipalities comply with EGLE soil, groundwater, vapor intrusion (VI), surface water, and air regulations. We maintain excellent working relationships with EGLE regulatory and brownfield incentive staff. Our team is trained and knowledgeable on current regulatory requirements, incentives, grants, and effective technical solutions to environmental compliance and risk management. The services we offer are summarized below.

EARTH SCIENCES, ENVIRONMENTAL MANAGEMENT, ECOLOGICAL, INDUSTRIAL HYGIENE, AND STORMWATER SERVICES

- Environmental investigations of groundwater, soil, VI, air, and water quality.
- Environmental permits and facility inspections.
- Environmental (regulatory) compliance evaluation, including municipal separate storm sewer system (MS4s).
- Indoor air and water quality studies, water management planning, stormwater pollution prevention initiatives (SWPPIs).
- Exposure assessments and auditing.
- Ecological and asbestos/lead assessments.
- Environmental health risks and conduct employee training.
- Reporting to EGLE and/or the US Environmental Protection Agency (USEPA).
- Project meeting coordination and technical information to complete approved jobs expeditiously and within budget.

Fishbeck provides environmental risk management services for the City of Farmington Hills from investigation and remediation of methane gas in soil, groundwater, and volatilization to indoor air pathway. Fishbeck is using innovative technology to accelerate the investigation process, providing defensible and quantitative subsurface information on which to base its remedial strategy, interacting regularly with EGLE and other interested parties, and reducing overall costs for the investigation and remedial action(s).

Fishbeck has prepared permit applications, negotiated permits, and obtained permits for a variety of projects including parks, bike paths, bridges, highways, buildings, landfills, and drain projects that impacted wetlands, floodplains, and/or inland lakes and streams. We have helped clients with permits under Michigan agencies including the Michigan Department of Transportation (MDOT), EGLE, Oakland County Water Resources Commission (OCWRC), Road Commission for Oakland County (RCOC), Detroit Water and Sewerage Department (DWSD), and many local municipalities.

REMEDIATION AND CONSTRUCTION SERVICES

- Remedial alternative design, remediation strategies, and clean-up plans.
- Cost control management with cost/benefit analysis.
- Pre-bid, pre-contract, construction management, and construction site meetings.
- Project closure activities, including punch list items.
- Operation and maintenance (O&M) plans, implementation, and effectiveness assessment.
- Green infrastructure and design.

Fishbeck's team is providing the City of Grand Rapids with professional and technical environmental and engineering services for the Grand Rapids Water Resource Recovery Facility. We are reviewing facility infrastructure, developing a conceptual site model (CSM), performing additional investigations to address due care issues related to vapor intrusion, evaluating remedial options, and assisting with site remedial actions and litigation support assistance. Fishbeck has successfully installed a vapor mitigation system for one occupied structure as a presumptive remedy. The CSM describes site features and subsurface conditions that influence the migration of contamination in soil, groundwater, and soil gas from potential source area(s) to site workers or visitors based on the identified (and/or inferred) hydrogeology and contaminant migration pathways such as groundwater, vapor intrusion, and subsurface utilities. The CSM will inform future

decisions and communication with EGLE and other concerned parties regarding potential exposure risks and the need for risk mitigation.

Fishbeck is a recognized industry expert in green infrastructure planning and design. Our construction team incorporates green infrastructure into community development plans and creates funding strategies to pay for it.

BROWNFIELD REDEVELOPMENT AND DUE DILIGENCE

- Redevelopment project coordination with incentive packaging.
- Phase I/II environmental site assessments (ESAs), baseline environmental assessments (BEAs), and lead, mold, and asbestos surveys.
- Hazardous materials inspections.
- Brownfield redevelopment authority support.

Fishbeck's brownfield redevelopment and due diligence team helps communities turn brownfields into new businesses, offices, recreation facilities, and homes. Some of Fishbeck's municipal brownfield redevelopment clients include the cities of Grand Haven, Cadillac, Manistee, East Jordan, and Ionia County, Lake County, Missaukee County, and the Traverse City Downtown Development Authority. We are working with our local government clients to win EGLE brownfield grants, create brownfield plans, redevelop a vacant school, build a new mixed-use space at the site of an old farm co-op, transform a burned-out, abandoned industrial site into a solar garden, and clean up and redevelop a former dry cleaner.

GRANTS, LOANS, PLACEMAKING, AND PUBLIC OUTREACH

- Applications for state and federal grants, loans, and tax incentives.
- Community outreach, community relations, and public meetings.
- Placemaking and community development.

Fishbeck has helped municipal clients win more than $15 million in grants and loans from federal and state agencies. Our grant awards help municipal clients pay for environmental cleanup, economic development, recreation, brownfield redevelopment, and water resource planning and implementation. The project team researches grant opportunities, manages grants, and reports to granting agencies for brownfield redevelopment and stormwater improvement projects. Our grant writers develop fundable applications and our in-house team of specialists contribute accurate budget estimates, so we help clients get the money they need for community development projects.

Some of our successful grant awards include:

- State Revolving Fund.
- Strategic Water Quality Initiative Fund.
- Drinking Water Revolving Fund.
- US Economic Development Administration Community Development Block Grants.
- EGLE and USEPA brownfield redevelopment grants and loans.
- Federal Emergency Management Agency (FEMA) Flood Hazard Mitigation Grants.
- Clean Water Act, Section 319 Planning, Implementation, and Project Priorities Grants.
- Michigan Department of Natural Resources Trust Fund.
- Department of Public Health, Water Act 307.
- MDOT Intermodal Surface Transportation Enhancement Grants.
- MDOT Transportation Economic Development Fund Grants (Category A).
- Stormwater, Asset Management, and Wastewater (SAW) Grants.

Our team members have experience in communications, public outreach, and placemaking. We can facilitate a public meeting, support Ferndale's downtown placemaking initiative, promote the City's successes, and help community members understand your environmental projects without technical jargon.

Fishbeck lead staff are well-rounded in all the major disciplines required to perform the services that would fall under this contract. The staff includes specialized expertise and competencies in the necessary areas of practice. Specifically, the project team includes engineers, geologists, hydrogeologists, and other scientists who specialize in the environmental services listed above. Fishbeck is especially experienced with *in situ* remediation technologies, natural attenuation evaluation, and cost-benefit analysis for assessing available options to address environmental problems.

LEAD STAFF SIMILAR PROJECT EXPERIENCE

Please see the organizational chart and resumes in this section.

CERTIFICATION STATEMENT

Fishbeck will ensure all licenses required by the State of Michigan and required insurances are maintained by our firm during the contract period, and that Fishbeck will comply with all applicable administrative procedures of the City of Ferndale.

ORGANIZATIONAL CHART

CITY OF FERNDALE

SOUTHEAST REGIONAL MUNICIPAL CLIENT MANAGER
Leonard Harwell

ENVIRONMENTAL SERVICES DIRECTOR
Steve MacDonald, PE

ENVIRONMENTAL PROGRAMS

ENVIRONMENTAL PROGRAMS MANAGER
Rick Dunkin, CPG, LPG

ENVIRONMENTAL ENGINEERING LEAD
Steve MacDonald, PE

ENVIRONMENTAL COMPLIANCE LEAD
Stephanie Jarrett, PE

AIR QUALITY/INDUSTRIAL HYGIENE LEAD
Jeff Fusee, CIH

BROWNFIELD PROGRAMS

BROWNFIELD PROGRAMS MANAGER
Roman Wilson

GRANTS/FINANCIAL INCENTIVES
Danielle Yoon, PE
Susan Wenzlick

DUE DILIGENCE/ESA
Tom Budge, CHMM
Todd Campbell, CPG



YEARS OF EXPERIENCE
30 years total

EDUCATION
Studied at Lawrence Technological University

REGISTRATIONS/ CERTIFICATIONS
Licensed Builder

LEONARD HARWELL

VICE PRESIDENT/SENIOR PROJECT MANAGER

Leonard has over 30 years of experience in the industry. He is well versed with a variety of engineering standards, concepts, practices, and procedures needed to meet today's client's expectations. Leonard has provided the design of various infrastructure improvements. His technical experience enables him to effectively prepare and oversee various projects. In addition to his design experience, Leonard has also provided project/construction management on many projects and is also a State of Michigan licensed builder. He has managed several projects for private developers and public entities such as the Detroit Housing Commission and the Detroit Economic Growth Corporation.

Leonard is very well rehearsed with Building Code Standards and has prepared construction documents for large projects within the Metro Detroit area, including several Detroit Public Schools projects.

EXPERIENCE

SOVEREIGN AEC OFFICE BUILDING | DETROIT, MICHIGAN
RENOVATIONS

Construction Manager/Designer – The project site was formally the design studio for Nathan Johnson Architects. The 10,000-sf building was vacant for many years and had decayed rapidly due to fire damage and subsequent exposure to elements. This was a complete demolition and renovation from literally the substructure to the roof lines, which entailed all new infrastructure. The end use was fashioned to be a collaborative workspace for small businesses in the professional consulting service industry.

LITTLE CAESARS GLOBAL RESOURCE CENTER | DETROIT, MICHIGAN
SECURITY SYSTEM INTEGRATION – NEW CONSTRUCTION

Project Manager – Consisted of complete installation and integration of the Avigilon Security Access Control and Camera system in the new 9-story global headquarters. There were over 126 Avigilon cameras, 12 Stentofon intercoms, and 213 HID card readers. Detailed coordination with ownership, the security consultant, and the general contractor for implementing the system backbone was paramount for the security.

STATE FAIR APARTMENTS | DETROIT, MICHIGAN
504 ADA UPGRADES

Construction Manager – Complete demolition and reconstruction of the 504 Interior Unit Upgrades at State Fair for ADA accessibility in the 9-story senior living apartment complex. Construction oversight included daily field monitoring and documentation, maintaining construction scheduling, and ensuring the scope and materials being used were in accordance with the contract documents. Also monitored Davis Bacon Wage verifications with employee interviews and punch list creation and enforcement.

WEST WARREN APARTMENTS | DETROIT, MICHIGAN
FIRE ALARM SYSTEM REPLACEMENT

Construction Manager – The project consisted of replacing the existing fire alarm system with a new addressable system. The construction included complete removal and replacement of the existing wiring and outdated modules in a nine-story high rise senior complex. Management duties consisted of construction oversight which included daily field monitoring and documentation, maintaining construction scheduling, and ensuring the scope and materials being used were in accordance with the contract documents. Also monitored Davis Bacon Wage verifications with employee interviews and punch list creation and enforcement.

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YEARS OF EXPERIENCE
20 years — Fishbeck
32 years — total

EDUCATION
BS in Environmental Engineering, Michigan Technological University

REGISTRATIONS/ CERTIFICATIONS
Professional Engineer – Michigan

HAZWOPER Site Worker

MEMBERSHIPS
American Society of Professional Engineers (West Michigan Chapter)

National Society of Professional Engineers

STEPHEN MACDONALD, PE

VICE PRESIDENT | SENIOR ENVIRONMENTAL ENGINEER

Steve's responsibilities include design and construction oversight for environmental remediation projects, operation and troubleshooting remediation systems, design review/quality assurance, cost estimating, feasibility studies, and management of soil and groundwater remediation projects. Steve is also the Director of Fishbeck's Earth Sciences Department. He has provided services to a variety of municipal, governmental, and industrial/commercial clients on many groundwater, surface water, process water, and soil cleanup projects. Steve also specializes in demolition and redevelopment projects. He has been directly involved in the design and specification of dozens of demolition projects from homes to large structures, and multibuilding facilities. In addition, Steve is an instrumental part of Fishbeck's PFAS services group and was responsible for the design and installation of the State's only treatment system for a non-community type 2 water supply system.

PROJECT MANAGEMENT EXPERIENCE

POOLS PRAIRIE SUPERFUND SITE REMOVAL ACTION | NEOSHO, MISSOURI

Cleanup of a former rocket engine testing and manufacturing plant contaminated with TC and other solvents. Technologies employed included SVE, soil excavation and onsite solar aeration treatment, and biosparging.

FORMER TELEDYNE SEMICONDUCTOR AND FORMER SPECTRA-PHYSICS LASERS, INC. SITES | MOUNTAIN VIEW, CALIFORNIA

Managing methane mitigation and SVE systems at former semiconductor manufacturing plant contaminated with TCE. The methane is a product of Enhanced Reductive Dechlorination employed by Fishbeck at this site.

ADDITIONAL EXPERIENCE

- Windward Pointe Redevelopment | Muskegon, Michigan
- Reynolds Consumer Products Landfill Management | Red Bluff, California
- Samuel Adams/Boston Beer Redevelopment | Cincinnati, Ohio
- Calamityville Tactical Laboratory | Fairborn, Ohio
- Western Michigan University | Kalamazoo, Michigan

MUNICIPAL/GOVERNMENT WORK EXPERIENCE

- AK Zinn/K&M Salvage | Battle Creek, Michigan
- Wesco Excavation | Fremont, Michigan
- Schoolcraft Plume A | Schoolcraft, Michigan
- Arenac County Landbank | Village of Turner, Michigan
- Platte River Hatchery | Beulah, Michigan
- Lakeside Refining | Kalamazoo, Michigan
- MDOT Maintenance Garage | Battle Creek, Michigan
- MDOT Maintenance Garage | Marshall, Michigan

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YEARS OF EXPERIENCE

1 year — Fishbeck
31 years — total

EDUCATION

MBA in Finance, Walsh College

MS in Geology,
University of Toledo

BA in Geology/Environmental Studies, Susquehanna University

REGISTRATIONS/ CERTIFICATIONS

Certified Professional Geologist, American Institute of Professional Geologists

Licensed Professional Geologist – Indiana

HAZWOPER Site Worker

HAZWOPER Supervisor

MEMBERSHIPS

American Institute of Professional Geologists

AIPG Michigan Section Workshop Planning Committee (Former Co-chair, 2014-2018)

National Groundwater Association

Michigan Association of Environmental Professionals

Huron River Watershed Council

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RICK DUNKIN, CPG, LPG

SENIOR GEOLOGIST

Rick has a wide range of environmental consulting and environmental risk management experience for EGLE, municipality, USEPA, NOAA and private sector clients. Areas of experience include project and technical management for Phase I/ II ESAs, site characterization and interim response actions, and soil and groundwater remediation. He is experienced in problem solving, data interpretation, report writing, navigating environmental regulations, and working collaboratively with multidisciplinary groups and clients. Rick is particularly specialized in water resources related to environmental legacy contamination, groundwater/surface water interaction (GSI) assessments, and the remediation of former industrial sites.

EXPERIENCE

CITY OF FARMINGTON HILLS, MICHIGAN

Conducting investigation and remediation of methane gas in soil, groundwater, and volatilization to indoor air pathways. Assessed onsite landfill closure, sampled landfill gas wells, installed and sampled monitoring wells and sub-slab vapor pins to assess potential for offsite migration of landfill gases. Working collaboratively with the client on strategy and use of innovative investigation methods to provide a more scientific approach, defensible data, and reduce overall project costs.

CITY OF GRAND RAPIDS, MICHIGAN

Developed a conceptual site model (CSM) for the Grand Rapids Water Resource Recovery Facility to describe site features and subsurface conditions that influence the migration of contamination as it relates to human receptors. Documented previous environmental investigations upgradient and onsite, evaluated due care issues, conducted vapor intrusion sampling, installed a vapor mitigation system for a new site structure, and in process of evaluating remedial options and providing litigation support assistance.

CITY OF DETROIT, MICHIGAN

Developed the CSM for the release of manufactured gas plant (MGP) waste by-products and their associated chemical derivatives to soil and sediments, from 1867 through 1954, on or adjacent to the former Detroit Gas Company MGP. Conducted several due care environmental investigations of public areas impacted by the former MGP from its operations, including a hydrogeological evaluation for a new skate park, dog park, and basketball courts on remediated parcels.

MDEQ | DETROIT, MICHIGAN

WELCOME CENTER (AMBASSADOR PROPERTIES) BROWNFIELD DEVELOPMENT

Characterized environmental conditions to assess impact on the intended brownfield redevelopment of nearly 200 residential and commercial lots. The remediated properties are now the sites of the International Welcome Center and small businesses complex in Mexicantown near the Ambassador Bridge off ramp.

MDEQ | STERLING HEIGHTS, MICHIGAN

Performed a methane gas investigation to delineate the extent of subsurface waste, prepared a biddable specifications package, evaluated bids, and provided oversight of the selected contractor to install a methane collection trench and passive gas ventilation system.



YEARS OF EXPERIENCE

2 year — Fishbeck
22 years — total

EDUCATION

BS in Environmental Biology, Taylor University

State of Michigan Leadership Academy

REGISTRATIONS/ CERTIFICATIONS

HAZWOPER Site Worker

MEMBERSHIPS

Air & Waste Management Association/West Michigan

ROMAN WILSON

BROWNFIELD PROGRAM MANAGER

Roman works with local government, developers, attorneys, realtors, lending institutions, and state and federal agencies to identify and secure incentives to facilitate redevelopment of properties compromised by brownfield conditions. With experience working in private consulting and for the MDEQ Brownfield Redevelopment Program, Roman offers a unique skillset to help clients maximize their brownfield opportunities. Areas of expertise include tax increment financing (TIF), EGLE brownfield redevelopment grants and loans, local brownfield revolving funds, Brownfield and Act 381 Work Plans, brownfield strategic planning, MEDC grants and loans, USEPA assessment grants, Phase I and II ESAs, BEAs, due care, and response activities.

EXPERIENCE

WINDWARD POINTE | MUSKEGON, MICHIGAN

Helped secure over $40 million in incentives for site investigation, remediation, demolition, site preparation, infrastructure, and redevelopment planning efforts at the project site. Incentives include TIF, a $1 million EGLE grant, and a $5 million Michigan Enhancement Grant. Windward Pointe is a proposed $200 million mixed-use redevelopment of a 120-acre former paper mill located along the south shore of Muskegon Lake.

EPICUREAN VILLAGE | SPRING LAKE, MICHIGAN

A $6 million mixed-use brownfield redevelopment of blighted property. Obtained TIF to offset environmental due diligence, asbestos abatement, and demolition costs associated with the project. Total TIF was approximately $375,000, including deposit into a Local Brownfield Revolving Fund. New tax revenue generated from the redevelopment is anticipated to be $2.5 million.

SOLAR GARDEN | CADILLAC, MICHIGAN

Secured $1.25 million in EGLE grant and loan funds for the City of Cadillac to facilitate environmental investigation and cleanup, asbestos abatement, and demolition at a City-owned former industrial property. Funding enabled Consumers Energy to commit to installing a solar garden that will provide green energy for local businesses and residents.

SENIOR LIVING CENTER | SARANAC, MICHIGAN

Obtained nearly $100,000 in TIF to support the repurposing of a vacant and functionally obsolete middle school building to a senior living facility. The 58,000-sf building was purchased by a developer after sitting idle for more than seven years. TIF resources were used to reimburse the developer for mold and asbestos surveys and abatement, Phase I and II ESAs, and select demolition activities. More than $4.5 million will be invested into the project, creating approximately $1.8 million in new tax revenue.

WENDY'S | HOLLAND, MICHIGAN

Over $230,000 in TIF was secured to help facilitate the redevelopment of a former auto repair shop and service station to a Wendy's restaurant. TIF was used to reimburse the developer for environmental site assessments, demolition, contaminated soil removal, and installation of a VI mitigation system. Private investment was approximately $2.5 million.

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KEY PERSONNEL

ENVIRONMENTAL COMPLIANCE LEAD



STEPHANIE JARRETT, PE
VICE PRESIDENT/SENIOR ENVIRONMENTAL ENGINEER

- 21 years of experience
- BS in Chemical Engineering, Michigan State University
- Professional Engineer – Michigan
- OSHA Hazardous Waste Operations and Emergency Response
- HAZWOPER Site Worker
- Member of Air and Waste Management Association; American Chemical Society
- ASTM Risk-Based Corrective Action (RBCA) Training
- Innov-X Systems Radiation Safety and Operator Training
- 2005 ESD/MWEA/SWANA Landfill Gas 201 Training

Stephanie's environmental experience includes coordination of a wide range of environmental compliance issues for a diverse clientele consisting of automotive suppliers, metal finishers, utilities, former and existing gasoline stations, and developers. Stephanie's area of expertise includes regulatory compliance assistance, air permitting, estimating and reporting emissions – including greenhouse gases (GHG), spill plans, and hazardous chemical inventories.

EXPERIENCE

- Wolverine Power Cooperative – Ongoing compliance and technical support at seven power plants, including submitting notifications and compliance reports and completing Title V ROP applications. Complete permit applications for as-needed modifications to permits. Provide annual emissions and GHG reporting.
- Dicastal North America – Technical lead for developing air permit applications for a new aluminum wheel manufacturing facility; also provide ongoing environmental compliance regulatory support.
- Saint Marys Cement – Project manager for developing an air permit for a $130 million upgrade to the cement plant. Continued regulatory compliance support for client following application and startup including permit required operations and maintenance plans; submittal of notifications and compliance reports.

AIR QUALITY/INDUSTRIAL HYGIENE LEAD



JEFF FUSEE, CIH, CSP
SENIOR INDUSTRIAL HYGIENIST | INDUSTRIAL HYGIENE DEPARTMENT HEAD

- 14 years of experience
- BS in Environmental Health and Safety Management, Ferris State University
- Certified Industrial Hygienist
- Certified Safety Professional
- HAZWOPER Site Worker
- Member of Board of Certified Safety Professionals; American Industrial Hygiene Association; American Board of Industrial Hygiene
- NIOSH 582 Equivalency Course Training

Jeff has a variety of industrial hygiene experience with commercial, manufacturing, institutional, municipal, and governmental clients. His experience includes IAQ assessments; asbestos, lead, mold, and abatement oversight; exposure assessments; and MIOSHA compliance audits and assessments. Jeff has also performed sampling and evaluation for other indoor air contaminants including fungi, bacteria, volatile and total organic carbons, lead, total suspended and respirable particulates, hydrocarbons, welding fumes, glycols, carbon monoxide, carbon dioxide, and oil mist.

EXPERIENCE

- Kent County, Michigan – Trainer for various MIOSHA compliance-related topics and consultant for IAQ-related matters.
- Grand Valley State University, Grand Rapids, Michigan – Hazardous materials inspections (asbestos, lead, and other hazardous materials), project specifications, and abatement/demolition oversight.
- Farmington Hills City Hall, Farmington Hills, Michigan – IAQ assessment and mold remediation protocol. Follow-up visual and clearance air sampling.

KEY PERSONNEL

GRANTS/FINANCIAL INCENTIVES



DANIELLE YOON, PE
CIVIL ENGINEER

- 6 years of experience
- BS in Civil Engineering, Michigan State University
- Professional Engineer – Michigan
- Member of Michigan Society of Professional Engineers

Danielle is a civil engineer working on a variety of projects including municipal funding applications, stormwater and wastewater asset management plans, storm and sanitary sewer; water main, and roadway design. She has worked closely with communities to develop and submit numerous grant and loan applications at the state and federal level; successful applications have secured more than $28 million grant and $4 million loan dollars to date.

Prior to her time at Fishbeck, Danielle spent four years at another consulting firm where she worked on municipal projects, developed models for community water systems, and developed numerous applications for various funding sources.

EXPERIENCE

- City of Reed City, Michigan Community Development Block Grant (CDBG) Infrastructure and Resiliency Application
- Materne North America Michigan Department of Agriculture and Rural Development (MDARD) Rural Development Fund Grant Application
- City of Flint, Michigan Economic Recovery Discretionary Grants

GRANTS/FINANCIAL INCENTIVES



SUSAN WENZLICK
SENIOR BROWNFIELD SPECIALIST

- 29 years of experience
- MA in Museum Studies, University of Leicester (United Kingdom)
- BA in Political Philosophy and Urban Studies, Michigan State University
- HAZWOPER 8-hour

Susan joined Fishbeck as a senior brownfield consultant after working 29 years in EGLE's Brownfield Redevelopment Unit. Susan has facilitated more brownfield redevelopment projects in Michigan than almost anyone. She was part of the original team that created EGLE's brownfield redevelopment and waterfront redevelopment programs. She has managed grants, loans, and Act 381 work plan approvals for hundreds of brownfield and waterfront redevelopment projects across Michigan.

In her last three years at EGLE, Susan managed communications and outreach for the brownfield program. She created the popular Brownfield Flip video series highlighting local brownfield success stories. Susan represented EGLE on the statewide Sense of Place Council and advised EGLE grantees on incorporating placemaking concepts into their projects. Susan is also an experienced and successful grant writer for environmental, arts, cultural, and recreational organizations in west Michigan.

EXPERIENCE

- Grand Traverse Commons, Traverse City, Michigan – Managed $3 million in brownfield grants for redevelopment of a historic former state hospital into retail, commercial, and residential space.
- Downtown Market, Grand Rapids, Michigan – Managed $1 million brownfield grant and approved EGLE TIF to transform abandoned industrial area into a specialty food market.
- Developed and produced EGLE Brownfield Flip video series.

KEY PERSONNEL

DUE DILIGENCE/ESA



TOM BUDGE, CHMM
SENIOR ENVIRONMENTAL SPECIALIST

- 22 years of experience
- BS in Business Administration, Central Michigan University
- BS in Biology, Grand Valley State University
- HAZWOPER Site Worker
- MDEQ Stormwater Management Operator – Industrial Site A-1
- Michigan Class A & B UST System Operator
- USDOT HAZMAT
- Member of Air and Waste Management Association/West Michigan Chapter; West Michigan Associates of Clean Water Professionals

Tom's environmental consulting experience includes environmental due diligence including Phase I and II ESAs, BEAs, due care plans, and response activity plans. Tom has also completed several Phase II ESA work plans including soil gas and indoor air sampling work plans to investigate VI.

His responsibilities include project management, providing technical support interpreting data, and due diligence report writing. Tom also specializes in environmental regulatory compliance including spill plans (PIPP, SPCC, SWPPP), annual reporting requirements, and hazardous waste regulations.

EXPERIENCE

- Old Orchard Brands, Sparta, Michigan – Phase II ESA, Sub-Slab Soil Gas Sampling, Assisted in VI Mitigation System Design
- Former Clark Station, Grand Haven, Michigan – Phase I and II ESA, Soil Gas Sampling, BEA, Due Care Plan
- Former Petroleum Storage Facility, Wyoming, Michigan – Phase I and II ESA, Soil Gas Sampling, BEA, Due Care Plan

DUE DILIGENCE/ESA



TODD CAMPBELL, CPG
SENIOR GEOLOGIST

- 25 years of experience
- BS in Geophysics, Western Michigan University
- Certified Professional Geologist
- Certified UST Professional
- HAZWOPER Site Worker
- HAZWOPER Supervisor
- Member of American Institute of Professional Geologists; National Groundwater Association

Todd's environmental consulting and management experience includes ESAs, aquifer pumping tests, slug tests, surveying, UST closures, direct push drilling, lagoon surface sampling, sludge sampling, private and municipal water supply development, and remedial system installation and start-up for air sparging, SVE, dual-phase extraction, and pump and treatment systems. He has conducted numerous Phase I and II ESAs, BEAs, and due care plans. Todd has also completed Act 381 work plans and TIF for projects.

His responsibilities include project management and providing technical support interpreting data and report writing for Phase I and II ESAs, BEAs, due care plans, UST closures, quarterly groundwater monitoring reports, RAPs, hydrogeological reports, no further action reports, Act 381 work plans, and proposal writing.

EXPERIENCE

- Gull Lake Distilling, Richland, Michigan – Phase I and II ESA, VI Sampling, BEA, Due Care Plan
- Stryker Research and Development Center, Portage, Michigan – Phase I and II ESA, BEA, Due Care Plan
- Dollar General, Jackson, Michigan – Phase I and II ESA, VI Sampling, BEA, Due Care Plan, TIF Table for Act 381 Work Plan

02 —— PROJECT UNDERSTANDING

PROJECT UNDERSTANDING

Fishbeck thoroughly understands the environmental reporting needs of municipalities, specifically those similar in size and complexity to those of the City of Ferndale. The following is a list of services specifically referenced in the City's RFQ.

- Site and environmental assessment.
- Soil and groundwater investigations.
- Air quality studies, including health risk assessments.
- Water quality studies.
- Development of remediation strategies and clean-up programs.
- Redevelopment planning and associated approvals.
- Cost estimates and cost control.
- Applications for state and federal grants and loans.
- Community outreach.
- Attend meetings and provide technical information as required to complete approved jobs expeditiously and within budget.
- Attend pre-bid, pre-contract, construction management, and construction site meetings, as required.
- Professional advice on environmental concerns as they arise.
- Submittal of any associated reports to the USEPA and/or EGLE.

Fishbeck will meet with City staff to develop/fine-tune plans and scopes of work for each new project. We are prepared to work in conjunction with the City and its departments, subconsultants, state and local governmental agencies, citizens, and other stakeholders on environmental-related work.

Also listed in the City's RFQ are examples of potential projects, which may include:

- Investigative environmental sampling on City-owned property to include, but not limited to, soil sampling, soil gas sampling, groundwater sampling, and other associated or necessary sampling.
- Methane well monitoring on City-owned property, which may include installation of new sampling wells.
- Environmental assessment of City-owned buildings for redevelopment and improvements.

Environmental compliance can come with a dizzying number of reports to regulatory agencies. Each EGLE program comes with its own forms and due dates. From tax capture to asbestos abatement, Fishbeck's staff of specialists know state programs and the public hearing and reporting requirements associated with them.

Ferndale's reporting needs appear to be modest and appropriate for a city of about 20,000 people. Ferndale has an active brownfield redevelopment authority, which reported 13 projects where tax increment financing (TIF) was collected in 2018. The TIF for each of these projects must be annually reported to the Michigan Department of Treasury.

When environmental response activities are undertaken, brownfield plans are amended, grants are awarded, or permits requested, Ferndale will be required to report pursuant to Natural Resources and Environmental Protection Act (NREPA) or other applicable laws. Fishbeck staff will inform the City when reporting is required, and complete reports as directed.

Fishbeck believes key project success factors include:

- Understanding our client's needs and goals.
- Providing skilled and talented staff for each project.
- Working collaboratively with our client partners.
- Working safely (maintaining neat, safe, and healthful working conditions).
- Using a proven quality management process.
- Commitment to delivery of a quality work product on time and with budget.
- Complying with local, state, and federal codes and laws.
- Effective communication.

Fishbeck structures our project teams to provide quality, responsive services. As the firm has grown, it has been necessary to develop more standards, procedures, and structure – yet we have attempted to avoid hierarchy and simplify decision making. It is far more than providing quality projects. It is a philosophy that covers everything we do, be it management, accounting, human resources, marketing, or projects.

Our project managers provide overall project direction and act as the primary contact for our clients. Our experience has shown mutual communication results in a collaborative client partnership and leads to successful projects. The project manager at Fishbeck has the primary responsibility to ensure project communications are effectively implemented. Depending on the nature and size of the project, communication could include daily reports (generally field

activities), weekly summary reports, and/or monthly progress reports. Fishbeck's communication platform is common across all our offices. This includes a secure, centralized electronic document storage system, which is accessible remotely by team members. All offices are equipped with videoconferencing systems and Microsoft Teams to improve team communication and eliminate unnecessary travel. Our email and telephone systems are integrated to allow secure access to all messages. Fishbeck team members are readily available via landline, cell phone, or email and will be responsive to all communications.

03 —— SIMILAR ENVIRONMENTAL PROJECT EXPERIENCE

SIMILAR ENVIRONMENTAL PROJECT EXPERIENCE

SUMMARY OF REQUESTED SERVICES

Following is a list of services specifically referenced in the RFQ. We have grouped and expanded some of the descriptions based on our experience on how many of these tasks are grouped and/or managed:

- Site and ESA.
  - Phase I and II ESAs.
  - Soil investigations.
  - Surface water and groundwater quality studies.
- Air quality studies, including health risk assessments.
  - Indoor air quality sampling and assessment (mold, VOCs, asbestos, methane, etc.).
  - VI sampling.
- Remediation and redevelopment.
  - Development of remediation strategies and clean-up programs.
  - Redevelopment planning and associated approvals.
  - Identification of funding sources (brownfield, refined petroleum fund, economic development grants, historical preservation tax credits, etc.).
  - Applications for state and federal grants and low-interest loans.
  - TIF.
  - Cost estimates and cost control.
  - Attend pre-bid, pre-contract, construction management, and construction site meetings as required.
- Overall program management and client support.
  - Community outreach.
  - Attend meetings and provide technical information as required to complete approved jobs expeditiously and within budget.
  - Professional advice on environmental concerns as they arise.
  - Submittal of any associated reports to the USEPA and/or EGLE.

EXPERIENCE WITH STATE AND LOCAL UNITS OF GOVERNMENT

Fishbeck has a wealth of experience in state, county, and municipal projects in traditional and specialized environmental services. Our Environmental Division includes three departments: Earth Sciences, Industrial Hygiene, and Environmental Compliance. While the majority of the services sought by the City are provided by the Earth Sciences Department, professionals will be used throughout the company based on who provides the best service to the City. Fishbeck has the expertise to provide all desired tasks in-house, which will provide you single-source services with minimal coordination.

Fishbeck has over 30 years of servicing the State of Michigan on environmental projects under various contracting mechanisms. Currently, Fishbeck holds an Environmental Indefinite-Scope Indefinite-Delivery (ISID) Contract that allows us to provide EGLE with environmental services on an expedited basis. Fishbeck is also one of only five consultants in Michigan who hold a Brownfield Site Assessment Program Contract allowing us to provide ESA services to EGLE.

Fishbeck provides services to over 200 cities, townships, villages, and county agencies; currently provides general consulting engineering services to 17 communities; and is actively working with more than 10 brownfield redevelopment authorities in Michigan in varying capacities. Following are some examples of communities where Fishbeck is providing services directly to the community or municipality, or with private developers working with their community partners for a common goal.

CITY OF FARMINGTON HILLS (2018 TO PRESENT)

Providing environmental services relating to a closed landfill including landfill gas mapping, methane mitigation planning, and VI monitoring.

GRAND HAVEN AREA PUBLIC SCHOOLS (2019 TO PRESENT)

General PFAS-related services including securing grant funds for PFAS in drinking water, treatment of PFAS-contaminated drinking water, and installation of a new public drinking water supply well.

MISSAUKEE COUNTY (2019 TO PRESENT)

County's official brownfield redevelopment consultant. Assist with strategic planning, the preparation and review of brownfield plans and Act 381 work plans, and securing brownfield grant funding.

CITY OF MANISTEE (2018 TO PRESENT)

City's official brownfield redevelopment consultant. Assist with strategic planning, the preparation and review of brownfield plans and Act 381 work plans, and securing brownfield grant funding.

CITY OF CADILLAC (2018 TO PRESENT)

Fishbeck obtained $1.25 million in EGLE grant and loan funds for a green energy brownfield project. The City has hired Fishbeck to be the third-party oversight consultant for the project.

WESTERN MICHIGAN UNIVERSITY (2004 TO PRESENT)

Fishbeck is a preferred professional services provider for asbestos/lead, hazardous materials management, and demolition services. Fishbeck has prepared design documents for the abatement, demolition, and/or renovation of over 30 structures over the past 10 years. Fishbeck has also provided abatement and demolition cost estimating, and field oversight.

CITY OF GRAND RAPIDS (1987 TO PRESENT)

Fishbeck is providing engineering and environmental services at the Grand Rapids Water Resource Recovery Facility. Fishbeck's role as the lead environmental consultant during the expansion of the plant includes design and oversight of vapor mitigation systems for new structures, and the assessment, management, and documentation of contamination from a neighboring facility. Specifically, Fishbeck is managing site due care responsibilities during construction and providing assistance to the City for potential cost recovery from the adjacent property owner.

CITY OF LANSING (1983 TO PRESENT)

Fishbeck is providing services for Phase V, Segment 3 of the City's Integrated Wet Weather Control Program. The $420 million program provides a comprehensive, system-wide hybrid plan of sewer separation, wet weather source control, green infrastructure, storage for equalization, transport improvements, emergency bypasses, high rate treatment, and pump station improvements and replacements.

GRAND RAPIDS TOWNSHIP (2019)

Fishbeck provided an overall assessment of an obsolete fire station being considered for demolition or repurposing. This assessment included conducting a hazardous materials assessment survey, a structural assessment, and cost benefit analysis for renovation/ demolition.

CITY OF CEDAR SPRINGS (2000 TO PRESENT)

Fishbeck has a long-standing relationship with the City of Cedar Springs, providing them various services. Fishbeck has worked with the City on numerous water supply and wastewater projects. Most notably, we are working with the City on identifying the sources of and planning on mitigation of sources of PFAS in the drinking water aquifer.

KENT COUNTY (2016 TO 2018)

Fishbeck provided services on two landfills for the county. We provided methane assessment services for the Kentwood Landfill and groundwater assessment services at the Sparta Landfill Superfund Site. The issue at both landfills was fugitive methane both through the unsaturated soil and in the groundwater and the Sparta site had concerns with ammonia. The Kentwood Landfill work also included aiding the County in their community relations phase and sampling of individual homes for methane intrusion.

EXPERIENCE HIGHLIGHTS

Fishbeck professionals have extensive experience completing environmental projects from inception to closure. Our approach to developing effective teams with a high degree of technical capabilities has given us the opportunity to be involved in large-scale environmental projects throughout the country. As a result, several of our projects have been highlighted at local and national conferences. Following are descriptions of several projects that highlight Fishbeck's experience, ingenuity, and depth of services.

ADA VILLAGE BROWNFIELD REDEVELOPMENT, ADA, MICHIGAN

Fishbeck was retained by a private developer to conduct environmental due diligence services for a former gasoline station/bank branch location, to be redeveloped into a fresh foods market. A Phase I ESA identified the site as a leaking underground storage tank (LUST) site. A Phase II ESA investigation confirmed the presence of soil contamination and groundwater impacts exceeding EGLE cleanup criteria, potentially including free product. A BEA was filed with the MDEQ to document existing conditions.

To prepare for redevelopment, Fishbeck conducted an additional due care investigation to delineate the extent of impacted soil, developed due care recommendations for safely redeveloping the site, and prepared cost estimates for implementing the due care measures. The developer elected to remove the bulk of the contaminated soil that would have been located directly under the proposed food market and installed a vapor mitigation system to protect against VI from any remaining contamination.

Fishbeck implemented the site cleanup, including hiring the remediation, contractor, monitoring and directing remediation activities, and documenting the results with post-cleanup sampling. Fishbeck also designed and supervised construction of the subsurface vapor mitigation system, including a polyethylene membrane below the new floor and a sub-slab vapor collection and venting system below the membrane. The vapor mitigation system was cost effectively installed during the initial stages of building foundation construction.

PURE MUSKEGON/WINDWARD POINTE, MUSKEGON, MICHIGAN

Fishbeck was hired to be a part of a collaborative team that included local business and government leaders in the Muskegon area to help navigate the site's complex environmental issues, maximize the potential for tax incentives and grants, maintain synergy between all the project stakeholders, and advance redevelopment efforts. The stakeholders included an investment group known as Pure Muskegon, the City of Muskegon, and Muskegon County. Fishbeck's first environmental tasks included assessment of the property and cost evaluation of potential remedial needs. Though a previous consultant on the site determined the environmental liability was minimal on this 120-acre former papermill site, Fishbeck found that the site's groundwater geochemistry was problematic. The presence of soluble sulfate and high levels of dissolved organic carbon in an oxygen deficient saturated environment had the potential to generate toxic and explosive gases. Follow-up studies performed by Fishbeck found that high concentrations of methane, hydrogen sulfide, and ammonia were being produced onsite. In addition, Fishbeck found high levels of PFOS and PFOA in the groundwater.

Fishbeck performed a targeted feasibility study that included a cost-benefit analysis of innovative groundwater treatment technologies including the use of site derived materials (lime and coal) to reduce PFAS and sulfate concentrations, cutting edge *in situ* treatment methods, and traditional groundwater recovery techniques. This study was presented to EGLE to get their buy-in on the project and gain their support for securing remediation funding. Ultimately, a $5 million grant was obtained from the State. The grant was provided to Muskegon County who in turn assigned management responsibilities to the City of Muskegon. Fishbeck was asked to utilize the grant funds to clean the groundwater to the extent practical with the available funds and within a two-year window. Based on these constraints, Fishbeck determined the most cost-effective remediation method was to extract the groundwater from the areas with the greatest contaminant load, treat it for PFAS, and discharge the water to the Muskegon County Wastewater Management Facility. Fishbeck successfully negotiated with the County for reduced wastewater discharge rates to ensure the grant funds would be sufficient for the intended purpose.

GRAND HAVEN BROWNFIELD REDEVELOPMENT AUTHORITY, GRAND HAVEN, MICHIGAN

Fishbeck was retained by the Grand Haven Brownfield Redevelopment Authority to conduct environmental due diligence services through a brownfield grant on a vacant 0.14-acre parcel. The site was formerly a gasoline station that utilized two unregistered gasoline underground storage tanks (USTs). At the time of the Phase I ESA, there was no documentation indicating the USTs had been removed from the ground. A Phase II ESA investigation consisting of a ground penetrating radar (GPR) survey and soil and groundwater sampling was conducted to determine the absence/presence of USTs and contamination. The GPR survey revealed no USTs. Soil and groundwater samples confirmed the presence of soil and groundwater contamination. A BEA was filed with EGLE to document existing conditions and provide liability protection for a new property owner. To ensure the property's reuse as an ice cream shop would not result in unacceptable exposures to contamination or create exacerbation concerns, a Due Care Plan was prepared.

MAHLE INDUSTRIES HARVEY STREET FACILITY REMEDIATION, MUSKEGON, MICHIGAN

This project included hexavalent chromium and trichloroethylene (TCE) remediation in source area soils and groundwater. Site manufacturing included piston rings. Hexavalent chromium was released to the soil (14-foot-thick vadose zone) and groundwater (60-foot-thick aquifer) under a plating bath area that included 14 plating lines. The TCE was released in the same general area from multiple degreasing operations. As an industry leader in the design and application of *in situ* remedial technologies, Fishbeck quickly identified applicable cost-saving approaches to traditional remedial techniques.

Fishbeck performed all investigative studies, feasibility study, remediation design, construction, and performance monitoring of the remedial activities, including development of all associated work plans and reporting. The hexavalent chromium remediation was accomplished using *in situ* injection of calcium polysulfide to reduce the chromium to an immobile form. The prescribed amount and locations of injectant were accomplished based on field investigation, and pilot and bench scale testing. There were no detectable levels of hexavalent chromium remaining in the source area one year after completing the injection work. Chromium concentrations in the downgradient plume area have declined to the extent that offsite migration of concentrations above drinking water criteria are not anticipated.

TCE remediation was accomplished using an aggressive air sparging and soil vapor extraction (SVE) system. Most of the TCE was remediated during this time frame. Soil and groundwater sampling verification was performed, and all results indicated closure criteria were met. A closure report was submitted to the MDEQ for final closure, and a no further action status for TCE was granted.

WESTERN MICHIGAN UNIVERSITY (WMU), KALAMAZOO, MICHIGAN

Fishbeck has worked with WMU for over 10 years on multiple property acquisition, and abatement and demolition projects. For new properties, Fishbeck has completed several Phase I and Phase II ESAs to support property acquisition. For existing

WMU properties and structures, Fishbeck's demolition services typically include a NESHAP survey, hazardous materials inventory, development of abatement and demolition specifications, utility rerouting and/or abandonment, abatement and demolition oversight/inspection, and air sampling during abatement and demolition. Special attention is paid to electrical transformers and other electrical devices to ensure they do not contain PCBs or mercury.

Since WMU places a high priority on resource conservation and recycling, they participate in the Leadership in Energy and Environmental Design (LEED) program for all new development projects. LEED credits start with the development of proper demolition specifications. Fishbeck works with WMU to identify and prescribe the handling of materials and components (i.e., equipment, appliances, furniture, and items of historical significance) for preservation, recycling, or repurposing. In many instances, these items need to be tested for lead, asbestos, and potentially other hazardous substances prior to recycling/repurposing.

Over the past 10 years, Fishbeck has provided demolition services, including asbestos/lead services, and hazardous material management for WMU on the following projects:

- Draper/Siedschlag Halls HMI/Abatement/Demolition
- East Campus Abatement/Demolition and Redevelopment
- Hoekje/Bigelow HMI/Abatement/Demolition
- Elmwood Apartment A through P Demolition/South Neighborhood Development
- Knauss Hall HMI
- Knollwood Building 039 Abatement
- Moore Hall Asbestos and Mold Abatement
- New and Old McCracken Halls HMI and Abatement/Demolition Bid Specifications
- School of Medicine
- Stadium Drive Apartments HMI and Demolition
- Sangren Hall Renovation
- Seibert Administration Building Demolition
- Vandercook HMI and Demolition Specifications

REFERENCES

PROJECT NAME: WESTERN MICHIGAN UNIVERSITY DEMOLITION PROJECTS

Project Address: 1903 Western Michigan Avenue
Project City/State/Zip: Kalamazoo, Michigan 49008
Contact Name and Telephone #: Shannon Sauer-Becker, 269.207.9203

PROJECT NAME: MAHLE INDUSTRIES HARVEY STREET FACILITY REMEDIATION

Project Address: 2051 South Harvey Street
Project City/State/Zip: Muskegon, Michigan 49444
Contact Name and Telephone #: Michael Zack, 248.596.8905

PROJECT NAME: GHBRA/SAG 1453 WASHINGTON – EGLE BROWNFIELD SITE ASSESSMENT GRANT

Project Scope: Phase I and II ESAs, BEA, and Due Care Plan
Project Cost: $30,000
Project Address: 1453 Washington Avenue
Project City/State/Zip: Grand Haven, Michigan, 49456
Contact Name and Telephone #: Patrick McGinnis, 616.847.4888

04 —— ABILITY TO TIMELY PERFORM THE REQUIRED SERVICES

ABILITY TO TIMELY PERFORM THE REQUIRED SERVICES

Fishbeck personnel selected for Ferndale's project are highly qualified, with many years of experience in their fields. Many of the project team members have overlapping skills. This allows us to quickly and seamlessly adjust roles for tasks or projects while maintaining consistency in the overall project team.

Fishbeck has over 400 staff in Michigan, 56 of whom are part of our Environmental Services Division. This provides us with the depth of personnel to manage many projects simultaneously and pull resources from elsewhere in the company when needed.

While we do not intend to use alternate personnel, we understand we are obligated to inform the City when key personnel will be unavailable for a period of 30 calendar days or longer. We often partner with qualified subconsultants when needed to improve the quality or timeliness of project deliverables.

Prior to beginning an assignment, Fishbeck will meet with the City to discuss the project requirements and review the critical success factors, including schedule. We will review the types of professionals needed and the project duration to ensure proper allocation of resources. The duration of many routine tasks is predictable. Fishbeck makes every effort to meet project time frames, especially for time-critical tasks. For reference, following is a list of due diligence tasks and our standard timelines.

SUGGESTED TIMELINES

Fishbeck has developed procedures, systems, and templates over the years to reduce project turnaround times and minimize costs for clients. We set aggressive goals for preparation of deliverables to meet typical project demands. However, as with most projects, schedule adjustments often become necessary to account for delays in the delivery of information, laboratory data, and other factors outside our control. We do our best to understand our clients' needs to establish and meet reasonable project deadlines. Following is a summary of typical deliverable time frames relative to the services noted in this RFQ and based on our experience.

DELIVERABLE	TYPICAL DAYS TO COMPLETE (CALENDAR DAYS)	NOTES
Phase I ESA	10-15 days	Assumes FOIA documents delivered in less than 7 days
Phase II ESA	7-14 days following field work	Assumes 7- to 10-day laboratory analysis turnaround
Baseline Environmental Assessment (BEA)	5-10 days	Assumes Phase II data is available
Due Care Plan	5-10 days from completion of BEA	Typically, can be completed concurrent with BEA
Soil and Groundwater Investigation	30-90 days	Typical generic soil and groundwater investigation
Air Quality Studies	25-50 days	Typical generic air quality study
Water Quality Studies	14-120 days	Based on type of water quality study
Development of Remediation Strategies and Clean-Up Programs	10-90 days	General time frame for basic site
Redevelopment Planning and Associated Approvals	30-180 days	Depends on nature of project
Cost Estimates and Cost Control	Varies	Depends on nature of project
Professional Advice on Environmental Concerns as They Arise	1-7 days	Depends on type of project
Submittal of any Associated Reports to the USEPA and/or EGLE	30-90 days	Depends on type of project

LABORATORY SUBCONSULTANT

Fishbeck is not affiliated with any specific laboratory, but utilizes multiple laboratories based on their capabilities with sample media/matrices and analyses, certifications, capacity, and the best cost, quality, and ability to meet turnaround times (schedules). One of these environmental laboratories, Eurofins TestAmerica (Eurofins) and its affiliates, has the capabilities needed to analyze all sample types likely to be collected by Fishbeck based on the RFQ requirements. Fishbeck has provided the hourly rates and expense schedule, and sample testing rates for normal and expedited turnaround time in Section 5 of this proposal. Eurofins qualifications, including certifications, for all of the proposed services provided by this firm are attached in Section 7.

When necessary or desired, Fishbeck will contact several laboratories to obtain competitive quotes to ensure best value for our clients. Fishbeck will provide qualifications and certifications for any proposed laboratory prior to engaging their services on any project. If the City has a preferred laboratory for a particular analysis, Fishbeck will include them as appropriate.

05 —— ANTICIPATED FEE SCHEDULE

ANTICIPATED FEE SCHEDULE

Fees for lump sum projects, including Phase I and II ESAs, BEAs, and due care plans are provided below. An hourly rate breakdown for key personnel and support staff utilized for non-lump sum fee services and standard expense schedule follow in this section.

LUMP SUM PROJECTS

DELIVERABLE	FEE RANGE	NOTES
Phase I ESA	$1,500 - $3,000	Phase I ESAs typically average $2,000/site
Phase II ESA	$3,500 - $15,000	Depends on number of concerns identified in the Phase I ESA
BEA	$1,500 - $2,750	Depends on nature of contamination
Due Care Plan	$2,250 - $3,500	Depends on nature of contamination and future site use

ANNUALIZED INDIVIDUAL HOURLY RATES

ROLE	2020 RATES	2021 RATES	2022 RATES	2023 RATES	2024 RATES
Project Management					
Client/Program Manager	$196	$200	$205	$210	$215
Project Manager	$196	$200	$205	$210	$215
Environmental Engineer					
Senior Engineer	$155	$159	$163	$168	$173
Engineer	$120	$124	$128	$133	$138
Staff Engineer	$96	$99	$102	$106	$110
Scientist					
Senior Geologist/Scientist	$170	$174	$178	$183	$188
Senior Ecologist	$155	$159	$163	$168	$173
Geologist/Scientist/Ecologist	$110	$113	$116	$110	$114
Staff Geologist/Scientist	$84	$88	$92	$96	$100
Due Diligence/Brownfield					
Senior Environmental Specialist	$125	$128	$131	$135	$139
Environmental Specialist	$101	$104	$107	$111	$115
Staff Environmental Specialist	$90	$93	$96	$100	$104
ESA Technician	$75	$77	$80	$83	$86
Field Services					
Senior Technician	$115	$118	$212	$126	$130
Technician	$100	$103	$106	$110	$114
Staff Technician	$80	$82	$84	$87	$90
GIS/Mapping/CADD					
Senior Technician	$118	$121	$124	$128	$132
Technician	$98	$100	$103	$106	$110
Staff Technician	$80	$82	$85	$88	$101
Administrative					
Clerical/Production Support	$75	$77	$80	$83	$86
Specialist					
Senior Engineering Specialist	$148	$152	$156	$161	$166
Senior Estimator	$170	$174	$178	$183	$188

NOTES

Travel labor will be billed as though all staff originate out of Fishbeck's Novi, Michigan office.

2020 Rates – from time of contract execution through June 30, 2021.

2021 Rates – from July 1, 2021, through June 30, 2022.

2022 Rates – from July 1, 2022, through June 30, 2023.

2023 Rates – from July 1, 2023, through June 30, 2024.

2024 Rates – from July 1, 2024, through June 30, 2025.

Invoices are rendered every four weeks and payment is due upon receipt.

DIRECT EXPENSES

Category	
Photocopies	$0.10/copy
Mileage/Passenger Vehicles	$0.70/mile
Field and Service Vehicles	$0.95/mile ($37/day minimum)
Global Positioning Unit	$50/hour
Survey Robot	$35/hour
Flow Monitor	$650/month
Expenses and Outside Services	Cost plus 10%

NOTE

Travel expenses will be billed as though all staff originate out of Fishbeck's Novi, Michigan office.

Eurofins TestAmerica, Grand Rapids
4595 Broadmoor Ave SE Suite 195
Grand Rapids, MI 49512

Tel: (616) 871-2026

April 14, 2020

Rick Dunkin
Fishbeck Thompson Carr & Huber Inc
39500 MacKenzie Drive, Suite 100
Novi, MI 48377
rdunkin@ftch.com

Subject: Analytical Services Proposal - City of Ferndale
Eurofins TestAmerica Quotation Number 24024793

Dear Rick Dunkin:

We appreciate the opportunity to provide your company with a quotation for your City of Ferndale project. Eurofins TestAmerica has a unique combination of full service capabilities, technical expertise, local service options, and online resources necessary to ensure successful project outcomes.

At Eurofins TestAmerica, quality is the hallmark of our business. To ensure your project's data quality objectives are met, we offer experienced personnel who are trained and committed to completing your analytical project on time, a fully documented QA/QC program, and state-of-the-art laboratory equipment and facilities. In addition to being a full service laboratory, we are part of the nation's largest environmental laboratory network. This provides access to an unparalleled spectrum of capabilities and turnaround time options, all through a single point of contact. Kris Brooks has been assigned as your Project Manager for this work and can be reached by phone at 330 966-9790 or via email at kris.brooks@testamericainc.com.

- **Total Access**: a web portal offering you customizable, real time access to data. With 24 hour access you can perform data trending, compare data to industry or project limits, track CoCs, invoices, reports and much more.
- **Level IV Deliverables/Customizable EDDs**: high resolution, text searchable reports, available in virtually any format.
- **Extensive Experience**: Project Managers with in-depth knowledge of regulatory protocols and procedures.
- **Nationwide Logistical Support**: bringing you an extensive courier network, service centers and shipping options throughout the U.S. and abroad.
- **PFAS, Dioxins/Furans, Air, Radiochemistry, IH** and other specialty analyses are offered alongside routine soil and water methods with seamless reports and consolidated EDDs.

The following quotation includes a detailed price breakdown, as well as any notes and clarifications pertaining to your project, and is subject to Eurofins TestAmerica's Standard Terms and Conditions, unless otherwise agreed upon in writing.

We thank you for choosing Eurofins TestAmerica, and we look forward to working with you on this project.

Sincerely,

Deborah Dunn
Client Relations Manager
deborah.dunn@testamericainc.com

cc: Gail Carr; Kris Brooks

Eurofins TestAmerica, Grand Rapids
4595 Broadmoor Ave SE Suite 195
Grand Rapids, MI 49512

Prepared for:
Rick Dunkin
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Novi, MI 48377
rdunkin@ftch.com

Prepared by	Dunn, Deborah
Date	4/14/2020
Expiration Date	7/13/2020
Est. Start Date	

Project: City of Ferndale *Quote Number: 24024793 - 0*

Groundwater **TAT: 10_Days (Business Days)** **(to be analyzed by Eurofins TestAmerica, Canton)**

Matrix	Method	Test Description	Quantity	Unit Price	Extended Price
Water	8260B	8260B, Michigan TCL VOCs	1	$ 55.00	$ 55.00
Water	8270C	8270C, Michigan PNAs	1	$ 75.00	$ 75.00
Water	8270C	8270C, Michigan TCL SVOCs	1	$ 124.00	$ 124.00
Water	8082A	8082A, PCBs - 7 Aroclors	1	$ 50.00	$ 50.00
Water	8081A	8081A, Michigan TCL Pesticides	1	$ 85.00	$ 85.00
Water	RSK-175	Methane	1	$ 55.00	$ 55.00
		Total Groundwater			**$ 444.00**

Soil **TAT: 10_Days (Business Days)** **(to be analyzed by Eurofins TestAmerica, Canton)**

Matrix	Method	Test Description	Quantity	Unit Price	Extended Price
Solid	8260B MI	8260B Michigan TCL VOCs (MeOH preserved)	1	$ 55.00	$ 55.00
Solid	5035	Prep - Field Methanol Preservation Kit	1	$ 10.00	$ 10.00
Solid	8270C	8270C, Michigan PNAs, Soxhlet	1	$ 75.00	$ 75.00
Solid	8270C	8270C, Michigan TCL SVOCs, Soxhlet	1	$ 124.00	$ 124.00
Solid	8082A	8082A, PCBs - 7 Aroclors	1	$ 50.00	$ 50.00
Solid	8081A	8081A, Michigan TCL Pesticides	1	$ 85.00	$ 85.00
Solid	Moisture	Percent Moisture	1	$ 2.50	$ 2.50
		Total Soil			**$ 401.50**

Additional Testing - water **TAT: 10_Days (Business Days)** **(to be analyzed by Eurofins TestAmerica, Sacramento)**

Matrix	Method	Test Description	Quantity	Unit Price	Extended Price
Water	537 (modified)	PFAS, Standard List (28 Analytes)	1	$ 295.00	$ 295.00
		Total Additional Testing - water			**$ 295.00**

Additional Testing - Soil **TAT: 10_Days (Business Days)** **(to be analyzed by Eurofins TestAmerica, Sacramento)**

Matrix	Method	Test Description	Quantity	Unit Price	Extended Price
Solid	537 (modified)	PFAS, Standard List (28 Analytes)	1	$ 295.00	$ 295.00
Solid	D 2216	Percent Moisture	1	$ 2.50	$ 2.50
		Total Additional Testing - Soil			**$ 297.50**

Eurofins TestAmerica, Grand Rapids
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Est. Start Date	

Project: City of Ferndale *Quote Number: 24024793 - 0*

Air **TAT: 10_Days (Business Days)** **(to be analyzed by Eurofins TestAmerica, Knoxville)**

Matrix	Method	Test Description	Quantity	Unit Price	Extended Price
Air	D1946	Methane	1	$ 100.00	$ 100.00
		Total Air			**$ 100.00**

Lead in Paint **TAT: 10_Days (Business Days)** **(to be analyzed by Eurofins TestAmerica, Phoenix)**

Matrix	Method	Test Description	Quantity	Unit Price	Extended Price
Solid	6010B ELLAP	Lead in paint	1	$ 22.00	$ 22.00
		Total Lead in Paint			**$ 22.00**

Quote Other Charges

Description	Quantity	Unit Price	Extended Price
Services - Courier Service <40 miles	1	$ 0.00	$ 0.00
Deliverables - Level II Report	1	$ 0.00	$ 0.00
Deliverables - Standard EDD	1	$ 0.00	$ 0.00
Total Access - data tools and access to data 24/7	1	$ 0.00	$ 0.00
Safe and Environmentally Responsible Waste Management (per sample)	1	$ 2.50	$ 2.50
Minimum Total Invoice per analytical receipt (for details see T&Cs)	0	$ 150.00	$ 0.00
Summa Canister batch cert.	1	$ 45.00	$ 45.00
Flow controller	1	$ 20.00	$ 20.00
Total Other Charge			**$67.50**

Total Other Charges	**$ 67.50**
Total Analysis Charges	**$ 1,560.00**
Grand Total for Quote 24024793	**$ 1,627.50**

***Quoted charges do not include sales tax. Applicable sales tax will be added to invoices where required by law.*

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PROJECT DETAILS

Certifications

If listed, work will be provided according to the following certifications. None required

Additional Quote Notes

Expedited Turnaround Time: Expedited turnaround times may be available and must be pre-approved by the laboratory. Expedited turnaround delivery is contingent upon meeting the agreed upon delivery date/time and number of samples. Samples received after 11 AM will be considered received the next business day. Results will be provided via e-mail or TotalAccess by close of business in the lab's time zone unless another time has been agreed to in advance.

Expedited turnaround time surcharges for standard analyses are:
- 5 Business Days TAT = 30%
- 4 Business Days TAT = 45%
- 3 Business Days TAT = 60%
- 2 Business Days TAT = 75%
- 1 Business Day TAT = 100%

Michigan TDLs

Some of the Michigan Memo 2 target detection limits (TDLs) are at lower levels than standard method reporting limits. Depending on what the data is being used for (GSI criteria, cleanup, closure, etc), it may not be necessary to meet all of these limits. If meeting all the MI EGLE TDL's is required, please contact the laboratory regarding additional methods needed.

Eurofins TestAmerica Business T&Cs

Confidentiality -
This quote has been prepared by TestAmerica Laboratories, Inc. dba Eurofins TestAmerica (Eurofins TestAmerica), solely for the use of the customer to whom it is addressed in evaluating Eurofins TestAmerica's qualifications and capabilities in connection with a particular project. The user of this document agrees by its acceptance to return it to Eurofins TestAmerica upon request and not to reproduce, copy, lend, or otherwise disclose its contents, directly or indirectly, and not to use it for any purpose other than that for which it was specifically provided. The user also agrees that where consultants or other outside parties are involved in the evaluation process, access to this document shall not be given to said parties unless those parties also specifically agree to these conditions. In the absence of signed acceptance, submittal of samples will indicate acceptance of this quotation.

Terms and Conditions -
This quotation is based solely upon Eurofins TestAmerica's standard product (routine QA/QC, detection limits, deliverables and standard turnaround times) and noted exceptions herein. The discounts incorporated into the pricing are based upon the sample quantity, test method, and schedule quoted. Any deviations may impact pricing and/or the acceptance of work. Final acceptance of this work is contingent upon a mutually agreed Sample Delivery Schedule. All sales are subject to Eurofins TestAmerica's Terms and Conditions **unless alternative terms have been agreed to in writing**. Submittal of samples will indicate acceptance of this quotation.

Quote Expiration -
Pricing listed in the proposal will expire **90 days** from the quote date unless the project is awarded/confirmed within that time period. Unless otherwise set forth in this quotation, Eurofins TestAmerica reserves the right to re-evaluate pricing for extended length projects on an annual basis.

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SERWM -
A fee, notated as Safe and Environmentally Responsible Waste Management (SERWM), will be applied to all invoices for each sample processed by the laboratory.

PROJECT SETUP
Field Sampling Products -
Eurofins TestAmerica can provide field sampling products upon request and these products are billable to the client at the time of shipment.

Field sampling products may include, but are not limited to:
- VOA sampling devices, preservation kits, ISM supplies, tubing and filters
- Industrial Hygiene media, surface sampling wipes, source sampling traps

The cost of the soil sampling devices is not included in the quoted rates for volatile analysis.
Core Samplers
- 5 gram Core N' One and EnCore samplers are available at $10 each (three required per sample).
- Disposable Core N' One T-Handles are available at $15 each.
- Eurofins TestAmerica does not supply EnCore T-Handles.

Field Preservation
- TerraCore Kits (varied) - quoted based on client required configurations
- Disposable Lock N' Load Handles are available at $12 each.

If any sampling supplies for soil VOCs are requested, they will be included in the quote under Other Charges.

Coolers and Sampling Supplies -
- Sampling Supplies: Eurofins TestAmerica will provide sample containers and coolers to support the sampling of water and soil samples. Extra bottles may be provided (up to 10%) in case of breakage. Eurofins TestAmerica expects that samples and supplies will be returned to the lab, including empty coolers and a reasonable percentage of the projected sample load - 70% or higher of the expected/quoted sample number. Coolers not received back by the projected deadline or as agreed with the PM may be charged at $30 per cooler. Similarly, if the sample containers received as samples are less than 90% of the containers provided, the sample containers not received as samples will be charged at a flat rate of $1 per container.

- Sample Container Shipping: The containers and preservatives required by the project shall be delivered via ground transportation. A minimum of **5 business days** advance notice is required in order to achieve shipment by ground transportation. Supply shipments requiring priority delivery due to insufficient lead time for ground transportation shall be charged to the client at Eurofins TestAmerica's cost. Alternatively, Eurofins TestAmerica can ship the supplies via carrier of choice by the client using the client's shipping account.

  Eurofins TestAmerica does not supply wet ice or blue ice for shipments. If shipping containers are not returned within 60 days, a charge for the containers will be billed at the current market rate. Please contact your PM for the current charges.

Courier Services and Sample Pick-Up -
Courier Services are offered by some Eurofins TestAmerica facilities. Where offered, the cost of the services will vary based on the distance traveled, the scope of the project being supported, and whether sufficient notice (typically 48 hours) is provided to facilitate efficient scheduling. If no details are described in this quotation and you are interested in learning more

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Prepared by	Dunn, Deborah
Date	4/14/2020
Expiration Date	7/13/2020
Est. Start Date	

Project: City of Ferndale *Quote Number: 24024793 - 0*

about courier options, please contact your Client Relations Manager or Project Manager to inquire about availability and cost.

Minimum Log-In Charges -
Eurofins TestAmerica's minimum charge is **$150** for a group of samples received together for analysis. Our minimum invoice value is $150.

QC Limit Disclaimer -
The laboratory's reporting limits, detection limits, and control limits are subject to change as these values are updated periodically to reflect analytical sensitivity and capability.

Turnaround Time -

- Quoted Turnaround Time - Data will be delivered at the proposed turnaround time in Business Days from Sample Receipt unless otherwise agreed upon. TAT begins the day the laboratory performing analyses receives the samples (day of lab receipt = day zero).

  Samples received after 11 AM will be considered received the next business day.

- Expedited Turnaround Time: Expedited turnaround times may be available and must be pre-approved by the laboratory. Expedited turnaround delivery is contingent upon meeting the agreed upon delivery date/time and number of samples. Samples received after 11 AM will be considered received the next business day. Results will be provided via e-mail or TotalAccess by close of business in the lab's time zone unless another time has been agreed to in advance.

  Expedited turnaround time surcharges for standard analyses are:
  - 5 Business Days TAT = 30%
  - 4 Business Days TAT = 45%
  - 3 Business Days TAT = 60%
  - 2 Business Days TAT = 75%
  - 1 Business Day TAT = 100%

  Different surcharges may apply for specialty analyses. These will be provided in your quotation. Weekend TAT can be arranged on a project-specific basis at an additional cost. Please contact your PM to inquire about availability and cost.

PROJECT DELIVERABLES
Eurofins TestAmerica will provide two analytical report formats, a final report in PDF format and a standard Eurofins TestAmerica EDD. Both electronic report formats will be delivered via email or web portal. If additional formats or retroactive deliverables are requested, costs of report generation will be billable. Charges will be based on labor and materials cost of report generation and data retrieval. Please contact your PM to inquire about availability and the price of additional deliverables.

- Report Format: Unless a level III or IV deliverable is specifically listed on the pricing page, this quotation includes delivery of a Level I or II report. Level III or IV reports are available at an additional charge.

- Electronic Data Deliverable Format: Eurofins TestAmerica has many EDD formats available to our clients including the most widely used commercial formats. Eurofins TestAmerica offers data using a standard EDD. Other EDD formats are available for a minimal cost of $25 per format (if not included as part of the report options listed in the quotation). The development of EDD formats that are not already available, including modification to existing formats to fit client specific needs, can be provided for a fee starting at $100. Additional fees will be estimated by the lab and approved by the client. Additional

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programming fees are billed at $50/hour.

PROJECT SPECIFICATIONS

Cancellation Fee -

A fee will be charged for cancellation of samples/analyses after a project is received in the laboratory. The fee will be based on the status of analysis at the time of cancellation in accordance with the following categories:

- Received - 35%
- Prepped - 50%
- Analyzed - 95%

Changes in Scope and Work Revisions -

Project requirements must be agreed upon prior to sample receipt. Samples will be logged according to the chain of custody received with the samples. Changes after initiation of the project will be subject to additional charges, including labor time required to reset project, communicate changes to laboratory staff, and rework data. Turnaround time will be reset or rush surcharges will be assessed where applicable. Analyses added with less than 1/2 of the analytical hold time remaining will incur rush turnaround charges. Your project manager will evaluate project specific charges at the time a change order is received.

Held Samples -

- Held samples not analyzed: Samples submitted on hold will be billed at 35% of the analysis fee (minimum $10/sample). If samples are later analyzed, the handling fee will be waived and only the analysis price will be charged. Samples taken off hold with less than 1/2 of the analytical hold time remaining may incur rush turnaround charges. Samples will be disposed of 30 days after the report for analyzed samples in the same job is issued, unless alternate archival arrangements are made in advance.

- Extracted/Prepped and Held samples: Samples submitted for prep and hold will be billed at 60% of the analysis fee for each prepped sample (minimum $30/sample). Samples taken off hold with less than 1/2 of the analytical hold time remaining may incur rush turnaround charges. Samples will be disposed of 30 days after the report for analyzed samples in the same job is issued, unless alternate archival arrangements are made in advance.

- Extended archival of samples: Extended archival of samples (including held samples) may be available for a fee starting at $2 per container per month (minimum $10/sample). This fee will be billed in advance on a quarterly basis for every quarter after the standard sample retention time of 30 days after the report is issued. Fees for larger volumes, non-standard matrices or cold storage will be negotiated on a case-by-case basis. Please contact your PM to inquire about availability and pricing for samples that are sent to the lab and archived.

Matrix Spike/Spike Duplication (MS/MSD) Samples -

When MS/MSDs are not specifically requested, Eurofins TestAmerica will strive to perform the required QC using whatever sample is available but will not report the QC results unless the client requests it. The reporting of client requested MS/MSD results will be charged at applicable unit rates. If MS/MSDs are specifically required or requested, the client must provide additional sample volume.

Multiple Dilutions Analyzed -

Eurofins TestAmerica strives to analyze samples without dilution or with the minimum dilution required. Samples are diluted to bring the primary analyte within the calibration range of the instrument, to compensate for matrix co-extractives, or to prevent instrument contamination.

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Eurofins TestAmerica will report the analytical run containing the highest concentration component/analyte in the sample within the calibrated (quantifiable) range of the method. Analytical screening runs are not reported. If project specific data quality objectives require additional runs, analyses will be billable unless otherwise noted in this quote. Please contact your PM to inquire about the availability of this service for your project.

Sample Disposal -
Eurofins TestAmerica will dispose of non-hazardous samples, sample extracts and digestates 30 days after the final report is issued. Charges for disposal of non-routine or uniquely hazardous samples will be billed to the client. Alternatively, samples can be returned to the client for disposal. Cost of return shipping will be billable to the client.

Special Sample Handling Fees -
Unit prices assume that samples are a single-phase matrix and that analyses can be performed in accordance with the laboratory's standard analytical procedures. If additional handling is required, additional fees may apply. Examples of special handling include (but are not limited to):

- Matrices requiring additional dilutions or special clean up steps
- Multiphasic samples requiring separate preparations and/or analyses
- Particle size reduction or special sub-sampling procedures
- Extra disposal costs for unique waste streams

Trip Blanks -
Eurofins TestAmerica typically provides trip blanks with our sample kits containing volatile analysis. When samples are received at the laboratory with trip blanks, the lab will analyze, report and charge the unit rate for the analysis. Please add this sample to your chain of custody. If you do not want the trip blank analyzed, please note this on the COC.

ADDITIONAL BUSINESS TERMS AND CONDITIONS
Environmental Management Fee
If this fee is included in the Other Charges section of the pricing page, a fee equal to the listed percentage of the total invoice amount will be applied to all work done under this quotation. The Fee will appear as a separate line item on each invoice. In the absence of any other firm pricing agreements, your sending work to us under this quotation will signify your acceptance of responsibility for payment of the Fee.

Field Parameters -
pH, Temperature, and Dissolved Oxygen analyses, along with Residual Chlorine screening, are properly performed and treated in the field at the time of sample collection. Laboratory analysis may result in a holding time exceedance qualifier.

Network or Subcontract Labs -

- Networking: Eurofins TestAmerica reserves the right to perform the services at any laboratory in the Eurofins TestAmerica network, unless the Client has required a particular location for the work.

- Subcontracting: Eurofins TestAmerica reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in Eurofins TestAmerica's sole judgment, it is reasonably necessary, appropriate or advisable to do so. Eurofins TestAmerica will make every effort to notify the client prior to delivering samples to an out-of-network laboratory. Eurofins TestAmerica will in no way be liable for any subcontracted services (outside the Eurofins TestAmerica network) except for work performed at laboratories which have been audited and approved by Eurofins TestAmerica.

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Price Surcharge Due To Sample Volume -
Unless dictated by contract, this quotation is based on the scope of work defined in the quote request. If the volume of samples submitted is less than 70% of the projected volume, a surcharge of 10% of the total project cost may be assessed.

Professional and Administrative Services -
A variety of professional and administrative services are available. Prices for services not specifically detailed in this quotation will be billed in accordance with Eurofins TestAmerica's Professional Rate Schedule.

Taxes -
Where reports are issued in or delivered to a state which assesses sales tax on Eurofins TestAmerica's services, applicable sales taxes will be added to the invoice as required by law, unless an appropriate sales tax exemption form is on file with Eurofins TestAmerica.

Rev: 04/04/2019

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Groundwater

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Water	8260B	8260B, Michigan TCL VOCs	Acetone	10.0	5.41	ug/L
			Benzene	1.00	0.130	ug/L
			Bromodichloromethane	1.00	0.170	ug/L
			Bromoform	1.00	0.760	ug/L
			Bromomethane	1.00	0.420	ug/L
			2-Butanone (MEK)	10.0	1.16	ug/L
			Carbon disulfide	5	0.280	ug/L
			Carbon tetrachloride	1.00	0.260	ug/L
			Chlorobenzene	1.00	0.140	ug/L
			Chloroethane	1.00	0.830	ug/L
			Chloroform	1.00	0.130	ug/L
			Chloromethane	1.00	0.200	ug/L
			1,1-Dichloroethane	1.00	0.170	ug/L
			1,2-Dichloroethane	1.00	0.210	ug/L
			1,1-Dichloroethene	1.00	0.190	ug/L
			1,2-Dichloropropane	1.00	0.150	ug/L
			cis-1,3-Dichloropropene	1.00	0.610	ug/L
			trans-1,3-Dichloropropene	1.00	0.670	ug/L
			Ethylbenzene	1.00	0.110	ug/L
			2-Hexanone	10.0	0.540	ug/L
			Methylene Chloride	5	2.62	ug/L
			4-Methyl-2-pentanone (MIBK)	10.0	0.420	ug/L
			Styrene	1.00	0.100	ug/L
			1,1,2,2-Tetrachloroethane	1.00	0.130	ug/L
			Tetrachloroethene	1.00	0.150	ug/L
			Toluene	1.00	0.140	ug/L
			Trichloroethene	1.00	0.100	ug/L
			Vinyl chloride	1.00	0.200	ug/L
			Xylenes, Total	2.00	0.150	ug/L
			1,1,1-Trichloroethane	1.00	0.240	ug/L
			1,1,2-Trichloroethane	1.00	0.0900	ug/L
			Cyclohexane	1.00	0.240	ug/L
			1,2-Dibromo-3-Chloropropane	1	0.910	ug/L
			1,2-Dibromoethane	1.00	0.120	ug/L
			Dichlorodifluoromethane	1.00	0.350	ug/L
			cis-1,2-Dichloroethene	1.00	0.160	ug/L
			trans-1,2-Dichloroethene	1.00	0.190	ug/L
			Isopropylbenzene	1.00	0.0900	ug/L
			Methyl acetate	10.0	1.72	ug/L
			Methyl tert-butyl ether	1.00	0.0700	ug/L
			1,1,2-Trichloro-1,2,2-trifluoroethane	1.00	0.410	ug/L
			1,2,4-Trichlorobenzene	1.00	0.260	ug/L
			1,2-Dichlorobenzene	1.00	0.150	ug/L
			1,3-Dichlorobenzene	1.00	0.150	ug/L
			1,4-Dichlorobenzene	1.00	0.160	ug/L

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Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Trichlorofluoromethane	1.00	0.450	ug/L
			Dibromochloromethane	1.00	0.390	ug/L
			Methylcyclohexane	1.00	0.330	ug/L
		Surrogate Cpnd				
			1,2-Dichloroethane-d4 (Surr)	1.00		
			4-Bromofluorobenzene (Surr)	1.00		
			Toluene-d8 (Surr)	1.00		
			Dibromofluoromethane (Surr)	1.00		
				RL	MDL	Units
Water	8270C	8270C, Michigan PNAs	Benzo[a]anthracene	1	0.171	ug/L
			Benzo[a]pyrene	1	0.173	ug/L
			Benzo[b]fluoranthene	1	0.154	ug/L
			Benzo[g,h,i]perylene	1	0.178	ug/L
			Benzo[k]fluoranthene	1	0.140	ug/L
			Anthracene	5	0.135	ug/L
			Chrysene	1	0.186	ug/L
			Dibenz(a,h)anthracene	2	0.151	ug/L
			Fluoranthene	1	0.160	ug/L
			Fluorene	5	0.169	ug/L
			Indeno[1,2,3-cd]pyrene	2	0.135	ug/L
			Phenanthrene	2	0.167	ug/L
			Pyrene	5	0.175	ug/L
			Acenaphthene	5	0.172	ug/L
			Acenaphthylene	5	0.125	ug/L
			Naphthalene	5	0.109	ug/L
			2-Methylnaphthalene	5	0.111	ug/L
		Surrogate Cpnd				
			2-Fluorobiphenyl (Surr)			
			2-Fluorophenol (Surr)			
			2,4,6-Tribromophenol (Surr)			
			Nitrobenzene-d5 (Surr)			
			Phenol-d5 (Surr)			
			Terphenyl-d14 (Surr)			
				RL	MDL	Units
Water	8270C	8270C, Michigan TCL SVOCs	1,1'-Biphenyl	5	0.492	ug/L
			2,2'-oxybis[1-chloropropane]	5	0.551	ug/L
			2,4,5-Trichlorophenol	5	1.99	ug/L
			2,4,6-Trichlorophenol	4	1.80	ug/L
			2,4-Dichlorophenol	10	0.262	ug/L
			2,4-Dimethylphenol	5	0.518	ug/L
			2,4-Dinitrophenol	20	6.21	ug/L
			2,4-Dinitrotoluene	5	2.07	ug/L

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Groundwater

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			2,6-Dinitrotoluene	5	2.13	ug/L
			2-Chloronaphthalene	5	0.483	ug/L
			2-Chlorophenol	5	0.273	ug/L
			2-Methylnaphthalene	5	0.111	ug/L
			2-Methylphenol	5	0.209	ug/L
			2-Nitroaniline	20	0.510	ug/L
			2-Nitrophenol	5	0.564	ug/L
			3,3'-Dichlorobenzidine	5.00	1.15	ug/L
			3-Nitroaniline	20	0.566	ug/L
			4,6-Dinitro-2-methylphenol	20	2.82	ug/L
			4-Bromophenyl phenyl ether	5	0.499	ug/L
			4-Chloro-3-methylphenol	5	0.296	ug/L
			4-Chloroaniline	10	0.316	ug/L
			4-Chlorophenyl phenyl ether	5	0.551	ug/L
			4-Nitroaniline	20	0.917	ug/L
			4-Nitrophenol	20	2.17	ug/L
			Acenaphthene	5	0.172	ug/L
			Acenaphthylene	5	0.125	ug/L
			Acetophenone	5	0.366	ug/L
			Anthracene	5	0.135	ug/L
			Atrazine	3	0.952	ug/L
			Benzaldehyde	5	0.759	ug/L
			Benzo[a]anthracene	1	0.171	ug/L
			Benzo[a]pyrene	1	0.173	ug/L
			Benzo[b]fluoranthene	1	0.154	ug/L
			Benzo[g,h,i]perylene	1	0.178	ug/L
			Benzo[k]fluoranthene	1	0.140	ug/L
			Bis(2-chloroethoxy)methane	5	0.455	ug/L
			Bis(2-chloroethyl)ether	1	0.402	ug/L
			Bis(2-ethylhexyl) phthalate	5	2.22	ug/L
			Butyl benzyl phthalate	5	0.666	ug/L
			Caprolactam	10	0.934	ug/L
			Carbazole	10	0.490	ug/L
			Chrysene	1	0.186	ug/L
			Dibenz(a,h)anthracene	2	0.151	ug/L
			Dibenzofuran	4	0.561	ug/L
			Diethyl phthalate	5	3.82	ug/L
			Dimethyl phthalate	5	0.515	ug/L
			Di-n-butyl phthalate	5	1.80	ug/L
			Di-n-octyl phthalate	5	0.821	ug/L
			Fluoranthene	1	0.160	ug/L
			Fluorene	5	0.169	ug/L
			Hexachlorobenzene	0.2	0.161	ug/L
			Hexachlorobutadiene	1	0.543	ug/L
			Hexachlorocyclopentadiene	5	1.76	ug/L
			Hexachloroethane	5	0.395	ug/L
			Indeno[1,2,3-cd]pyrene	2	0.135	ug/L

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Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Isophorone	5	0.324	ug/L
			Naphthalene	5	0.109	ug/L
			Nitrobenzene	3	0.514	ug/L
			N-Nitrosodi-n-propylamine	5	0.253	ug/L
			N-Nitrosodiphenylamine	5	0.440	ug/L
			Pentachlorophenol	5	3.10	ug/L
			Phenol	5	0.128	ug/L
			Phenanthrene	2	0.167	ug/L
			Pyrene	5	0.175	ug/L
			3 & 4 Methylphenol	5	0.191	ug/L
		Surrogate Cpnd				
			2-Fluorobiphenyl (Surr)			
			2-Fluorophenol (Surr)			
			2,4,6-Tribromophenol (Surr)			
			Nitrobenzene-d5 (Surr)			
			Phenol-d5 (Surr)			
			Terphenyl-d14 (Surr)			
				RL	MDL	Units
Water	8082A	8082A, PCBs - 7 Aroclors	Aroclor-1016	.2	0.0560	ug/L
			Aroclor-1221	.2	0.0570	ug/L
			Aroclor-1232	.2	0.0740	ug/L
			Aroclor-1242	.2	0.0760	ug/L
			Aroclor-1248	.2	0.0500	ug/L
			Aroclor-1254	.2	0.0400	ug/L
			Aroclor-1260	.2	0.0460	ug/L
		Surrogate Cpnd				
			Tetrachloro-m-xylene			
			DCB Decachlorobiphenyl			
				RL	MDL	Units
Water	8081A	8081A, Michigan TCL Pesticides	4,4'-DDD	0.1	0.00530	ug/L
			4,4'-DDE	0.1	0.00430	ug/L
			4,4'-DDT	0.02	0.00480	ug/L
			Aldrin	0.01	0.00240	ug/L
			alpha-BHC	0.0500	0.00200	ug/L
			cis-Chlordane	0.0500	0.00320	ug/L
			beta-BHC	0.02	0.00460	ug/L
			delta-BHC	0.0500	0.00430	ug/L
			Dieldrin	0.02	0.00230	ug/L
			Endosulfan I	0.03	0.00370	ug/L
			Endosulfan II	0.03	0.00230	ug/L
			Endosulfan sulfate	0.0500	0.00370	ug/L
			Endrin	0.02	0.00250	ug/L

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Groundwater

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Endrin aldehyde	0.02	0.00460	ug/L
			Endrin ketone	0.02	0.00400	ug/L
			gamma-BHC (Lindane)	0.03	0.00250	ug/L
			trans-Chlordane	0.0500	0.00500	ug/L
			Heptachlor	0.01	0.00330	ug/L
			Heptachlor epoxide	0.01	0.00260	ug/L
			Methoxychlor	0.5	0.00470	ug/L
			Toxaphene	1.0	0.0581	ug/L
		Surrogate Cpnd				
			DCB Decachlorobiphenyl	0.250		
			Tetrachloro-m-xylene	0.250		

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Water	RSK-175	Methane	Methane	1.00	0.174	ug/L
		Surrogate Cpnd				
			1,1,1-Trifluoroethane			

Soil

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Solid	8260B MI	8260B Michigan TCL VOCs (MeOH preserved)	1,1,1-Trichloroethane	40.0	15.0	ug/Kg
			1,1,2,2-Tetrachloroethane	40.0	12.0	ug/Kg
			1,1,2-Trichloro-1,2,2-trifluoroethane	200	60.0	ug/Kg
			1,1,2-Trichloroethane	40.0	12.0	ug/Kg
			1,1-Dichloroethane	40.0	8.00	ug/Kg
			1,1-Dichloroethene	40.0	16.0	ug/Kg
			1,2,4-Trichlorobenzene	200	56.0	ug/Kg
			1,2-Dibromo-3-Chloropropane	200	80.0	ug/Kg
			1,2-Dichlorobenzene	80.0	25.0	ug/Kg
			1,2-Dichloroethane	40.0	15.0	ug/Kg
			1,2-Dichloropropane	40.0	11.0	ug/Kg
			1,3-Dichlorobenzene	80.0	23.0	ug/Kg
			1,4-Dichlorobenzene	80.0	18.0	ug/Kg
			2-Hexanone	2000	333	ug/Kg
			Acetone	600	229	ug/Kg
			Benzene	40.0	9.00	ug/Kg
			Bromoform	80.0	31.0	ug/Kg
			Bromomethane	250	204	ug/Kg
			Carbon disulfide	200	110	ug/Kg
			Carbon tetrachloride	40.0	16.0	ug/Kg
			Chlorobenzene	40.0	9.00	ug/Kg
			Chloroethane	200	164	ug/Kg

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Soil

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Chloroform	40.0	11.0	ug/Kg
			Chloromethane	200	84.0	ug/Kg
			cis-1,2-Dichloroethene	40.0	9.00	ug/Kg
			cis-1,3-Dichloropropene	40.0	21.0	ug/Kg
			Cyclohexane	960	181	ug/Kg
			Bromodichloromethane	80.0	19.0	ug/Kg
			Dichlorodifluoromethane	80.0	36.0	ug/Kg
			Ethylbenzene	40.0	12.0	ug/Kg
			1,2-Dibromoethane	200	38.0	ug/Kg
			Isopropylbenzene	200	36.0	ug/Kg
			Methyl acetate	960	787	ug/Kg
			2-Butanone (MEK)	600	141	ug/Kg
			4-Methyl-2-pentanone (MIBK)	2000	340	ug/Kg
			Methyl tert-butyl ether	200	50.0	ug/Kg
			Methylene Chloride	500	178	ug/Kg
			Styrene	40.0	14.0	ug/Kg
			Tetrachloroethene	40.0	18.0	ug/Kg
			Toluene	80.0	24.0	ug/Kg
			trans-1,2-Dichloroethene	40.0	10.0	ug/Kg
			trans-1,3-Dichloropropene	40.0	22.0	ug/Kg
			Trichloroethene	40.0	11.0	ug/Kg
			Trichlorofluoromethane	80.0	40.0	ug/Kg
			Vinyl chloride	32.0	12.0	ug/Kg
			Xylenes, Total	120	27.0	ug/Kg
			Methylcyclohexane	960	62.0	ug/Kg
			Dibromochloromethane	40.0	36.0	ug/Kg
		Surrogate Cpnd				
			1,2-Dichloroethane-d4 (Surr)			
			4-Bromofluorobenzene (Surr)			
			Toluene-d8 (Surr)			
			Dibromofluoromethane (Surr)			

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Solid	8270C	8270C, Michigan PNAs, Soxhlet	Benzo[a]anthracene	264	3.41	ug/Kg
			Benzo[a]pyrene	264	9.34	ug/Kg
			Benzo[b]fluoranthene	264	6.50	ug/Kg
			Benzo[g,h,i]perylene	264	7.10	ug/Kg
			Benzo[k]fluoranthene	264	6.93	ug/Kg
			Anthracene	264	2.41	ug/Kg
			Chrysene	264	1.49	ug/Kg
			Dibenz(a,h)anthracene	264	6.92	ug/Kg
			Fluoranthene	264	4.45	ug/Kg
			Fluorene	264	2.74	ug/Kg
			Indeno[1,2,3-cd]pyrene	264	7.36	ug/Kg
			Phenanthrene	264	2.23	ug/Kg
			Pyrene	264	2.14	ug/Kg

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Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Acenaphthene	264	2.86	ug/Kg
			Acenaphthylene	264	4.01	ug/Kg
			Naphthalene	264	2.41	ug/Kg
			2-Methylnaphthalene	264	1.96	ug/Kg
		Surrogate Cpnd				
			2-Fluorobiphenyl (Surr)			
			2-Fluorophenol (Surr)			
			2,4,6-Tribromophenol (Surr)			
			Nitrobenzene-d5 (Surr)			
			Phenol-d5 (Surr)			
			Terphenyl-d14 (Surr)			
				RL	MDL	Units
Solid	8270C	8270C, Michigan TCL SVOCs, Soxhlet	1,1'-Biphenyl	264	17.0	ug/Kg
			2,2'-oxybis[1-chloropropane]	264	10.0	ug/Kg
			2,4,5-Trichlorophenol	264	69.0	ug/Kg
			2,4,6-Trichlorophenol	264	64.0	ug/Kg
			2,4-Dichlorophenol	264	44.0	ug/Kg
			2,4-Dimethylphenol	264	40.0	ug/Kg
			2,4-Dinitrophenol	150	142	ug/Kg
			2,4-Dinitrotoluene	264	62.0	ug/Kg
			2,6-Dinitrotoluene	264	56.0	ug/Kg
			2-Chloronaphthalene	264	14.0	ug/Kg
			2-Chlorophenol	264	10.0	ug/Kg
			2-Methylnaphthalene	264	1.96	ug/Kg
			2-Methylphenol	264	31.0	ug/Kg
			2-Nitroaniline	200	40.0	ug/Kg
			2-Nitrophenol	264	13.0	ug/Kg
			3,3'-Dichlorobenzidine	1600	43.0	ug/Kg
			3-Nitroaniline	200	49.0	ug/Kg
			4,6-Dinitro-2-methylphenol	150	80.0	ug/Kg
			4-Bromophenyl phenyl ether	264	14.0	ug/Kg
			4-Chloro-3-methylphenol	264	45.0	ug/Kg
			4-Chloroaniline	200	30.0	ug/Kg
			4-Chlorophenyl phenyl ether	264	14.0	ug/Kg
			4-Nitroaniline	200	60.0	ug/Kg
			4-Nitrophenol	330	94.0	ug/Kg
			Acenaphthene	264	2.86	ug/Kg
			Acenaphthylene	264	4.01	ug/Kg
			Acetophenone	264	11.0	ug/Kg
			Anthracene	264	2.41	ug/Kg
			Atrazine	40	36.0	ug/Kg
			Benzaldehyde	264	23.0	ug/Kg
			Benzo[a]anthracene	264	3.41	ug/Kg
			Benzo[a]pyrene	264	9.34	ug/Kg
			Benzo[b]fluoranthene	264	6.50	ug/Kg

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Continued						
			Benzo[g,h,i]perylene	264	7.10	ug/Kg
			Benzo[k]fluoranthene	264	6.93	ug/Kg
			Bis(2-chloroethoxy)methane	264	12.0	ug/Kg
			Bis(2-chloroethyl)ether	80	12.0	ug/Kg
			Bis(2-ethylhexyl) phthalate	264	51.0	ug/Kg
			Butyl benzyl phthalate	264	22.0	ug/Kg
			Caprolactam	264	75.0	ug/Kg
			Carbazole	264	19.0	ug/Kg
			Chrysene	264	1.49	ug/Kg
			Dibenz(a,h)anthracene	264	6.92	ug/Kg
			Dibenzofuran	264	13.0	ug/Kg
			Diethyl phthalate	264	31.0	ug/Kg
			Dimethyl phthalate	264	14.0	ug/Kg
			Di-n-butyl phthalate	264	22.0	ug/Kg
			Di-n-octyl phthalate	264	28.0	ug/Kg
			Fluoranthene	264	4.45	ug/Kg
			Fluorene	264	2.74	ug/Kg
			Hexachlorobenzene	264	2.85	ug/Kg
			Hexachlorobutadiene	40	12.0	ug/Kg
			Hexachlorocyclopentadiene	264	62.0	ug/Kg
			Hexachloroethane	264	9.00	ug/Kg
			Indeno[1,2,3-cd]pyrene	264	7.36	ug/Kg
			Isophorone	264	12.0	ug/Kg
			Naphthalene	264	2.41	ug/Kg
			Nitrobenzene	264	13.0	ug/Kg
			N-Nitrosodi-n-propylamine	264	11.0	ug/Kg
			N-Nitrosodiphenylamine	264	12.0	ug/Kg
			Pentachlorophenol	150	58.0	ug/Kg
			Phenol	264	8.00	ug/Kg
			Phenanthrene	264	2.23	ug/Kg
			Pyrene	264	2.14	ug/Kg
			3 & 4 Methylphenol	264	29.0	ug/Kg
		Surrogate Cpnd				
			2-Fluorobiphenyl (Surr)			
			2-Fluorophenol (Surr)			
			2,4,6-Tribromophenol (Surr)			
			Nitrobenzene-d5 (Surr)			
			Phenol-d5 (Surr)			
			Terphenyl-d14 (Surr)			

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Solid	8082A	8082A, PCBs - 7 Aroclors	Aroclor-1016	264	22.0	ug/Kg
			Aroclor-1221	264	24.0	ug/Kg
			Aroclor-1232	264	23.0	ug/Kg
			Aroclor-1242	264	19.0	ug/Kg
			Aroclor-1248	264	24.0	ug/Kg

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Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Aroclor-1254	264	23.0	ug/Kg
			Aroclor-1260	264	22.0	ug/Kg
		Surrogate Cpnd				
			Tetrachloro-m-xylene			
			DCB Decachlorobiphenyl			
				RL	MDL	Units
Solid	8081A	8081A, Michigan TCL Pesticides	Aldrin	5.00	0.770	ug/Kg
			Endrin	5.00	1.90	ug/Kg
			gamma-BHC (Lindane)	5.00	1.79	ug/Kg
			trans-Chlordane	5.00	1.23	ug/Kg
			Heptachlor	5.00	1.58	ug/Kg
			Heptachlor epoxide	5.00	1.44	ug/Kg
			Methoxychlor	10.0	6.56	ug/Kg
			Toxaphene	100	25.0	ug/Kg
		Surrogate Cpnd				
			DCB Decachlorobiphenyl			
			Tetrachloro-m-xylene			
				RL	RL	Units
Solid	Moisture	Percent Moisture	Percent Solids	0.100	0.100	%

Additional Testing - water

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Water	537 (modified)	PFAS, Standard List (28 Analytes)	Perfluorobutanoic acid (PFBA)	2.00	0.350	ng/L
			Perfluoropentanoic acid (PFPeA)	2.00	0.490	ng/L
			Perfluorohexanoic acid (PFHxA)	2.00	0.580	ng/L
			Perfluoroheptanoic acid (PFHpA)	2.00	0.250	ng/L
			Perfluorooctanoic acid (PFOA)	2.00	0.850	ng/L
			Perfluorononanoic acid (PFNA)	2.00	0.270	ng/L
			Perfluorodecanoic acid (PFDA)	2.00	0.310	ng/L
			Perfluoroundecanoic acid (PFUnA)	2.00	1.10	ng/L
			Perfluorododecanoic acid (PFDoA)	2.00	0.550	ng/L
			Perfluorotridecanoic acid (PFTriA)	2.00	1.30	ng/L
			Perfluorotetradecanoic acid (PFTeA)	2.00	0.290	ng/L
			Perfluorobutanesulfonic acid (PFBS)	2.00	0.200	ng/L

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Additional Testing - water

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Continued						
			Perfluoropentanesulfonic acid (PFPeS)	2.00	0.300	ng/L
			Perfluorohexanesulfonic acid (PFHxS)	2.00	0.170	ng/L
			Perfluoroheptanesulfonic Acid (PFHpS)	2.00	0.190	ng/L
			Perfluorooctanesulfonic acid (PFOS)	2.00	0.540	ng/L
			Perfluorononanesulfonic acid (PFNS)	2.00	0.160	ng/L
			Perfluorodecanesulfonic acid (PFDS)	2.00	0.320	ng/L
			Perfluorooctanesulfonamide (FOSA)	2.00	0.350	ng/L
			N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	20.0	3.10	ng/L
			N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	20.0	1.90	ng/L
			4:2 FTS	20.0	5.20	ng/L
			6:2 FTS	20.0	2.00	ng/L
			8:2 FTS	20.0	2.00	ng/L
			4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	2.00	0.180	ng/L
			HFPO-DA (GenX)	4.00	1.50	ng/L
			F-53B Major	2.00	0.240	ng/L
			F-53B Minor	2.00	0.320	ng/L
		Isotope Dilution				
			13C4 PFBA			
			13C5 PFPeA			
			13C2 PFHxA			
			13C4 PFHpA			
			13C4 PFOA			
			13C5 PFNA			
			13C2 PFDA			
			13C2 PFUnA			
			13C2 PFDoA			
			13C2 PFTeDA			
			13C3 PFBS			
			18O2 PFHxS			
			13C4 PFOS			
			13C8 FOSA			
			d3-NMeFOSAA			
			d5-NEtFOSAA			
			M2-6:2 FTS			
			M2-8:2 FTS			
			M2-4:2 FTS			
			13C3 HFPO-DA			

Additional Testing - Soil

Matrix	Method	Test Description	Analyte

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Additional Testing - Soil

Matrix	Method	Test Description	Analyte	RL	MDL	Units
Solid	537 (modified)	PFAS, Standard List (28 Analytes)	Perfluorobutanoic acid (PFBA)	0.200	0.0280	ug/Kg
			Perfluoropentanoic acid (PFPeA)	0.200	0.0770	ug/Kg
			Perfluorohexanoic acid (PFHxA)	0.200	0.0420	ug/Kg
			Perfluoroheptanoic acid (PFHpA)	0.200	0.0290	ug/Kg
			Perfluorooctanoic acid (PFOA)	0.200	0.0860	ug/Kg
			Perfluorononanoic acid (PFNA)	0.200	0.0360	ug/Kg
			Perfluorodecanoic acid (PFDA)	0.200	0.0220	ug/Kg
			Perfluoroundecanoic acid (PFUnA)	0.200	0.0360	ug/Kg
			Perfluorododecanoic acid (PFDoA)	0.200	0.0670	ug/Kg
			Perfluorotridecanoic acid (PFTriA)	0.200	0.0510	ug/Kg
			Perfluorotetradecanoic acid (PFTeA)	0.200	0.0540	ug/Kg
			Perfluorobutanesulfonic acid (PFBS)	0.200	0.0250	ug/Kg
			Perfluoropentanesulfonic acid (PFPeS)	0.200	0.0200	ug/Kg
			Perfluorohexanesulfonic acid (PFHxS)	0.200	0.0310	ug/Kg
			Perfluoroheptanesulfonic Acid (PFHpS)	0.200	0.0350	ug/Kg
			Perfluorooctanesulfonic acid (PFOS)	0.500	0.200	ug/Kg
			Perfluorononanesulfonic acid (PFNS)	0.200	0.0200	ug/Kg
			Perfluorodecanesulfonic acid (PFDS)	0.200	0.0390	ug/Kg
			Perfluorooctanesulfonamide (FOSA)	0.200	0.0820	ug/Kg
			N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2.00	0.390	ug/Kg
			N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2.00	0.370	ug/Kg
			4:2 FTS	2.00	0.370	ug/Kg
			6:2 FTS	2.00	0.150	ug/Kg
			8:2 FTS	2.00	0.250	ug/Kg
			4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	0.200	0.0180	ug/Kg
			HFPO-DA (GenX)	0.250	0.110	ug/Kg
			F-53B Major	0.200	0.0270	ug/Kg
			F-53B Minor	0.200	0.0220	ug/Kg
		Isotope Dilution				
			13C4 PFBA			
			13C5 PFPeA			
			13C2 PFHxA			
			13C4 PFHpA			

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Additional Testing - Soil

Matrix	Method	Test Description	Analyte			
Continued		**Isotope Dilution**				
			13C4 PFOA			
			13C5 PFNA			
			13C2 PFDA			
			13C2 PFUnA			
			13C2 PFDoA			
			13C2 PFTeDA			
			13C3 PFBS			
			18O2 PFHxS			
			13C4 PFOS			
			13C8 FOSA			
			d3-NMeFOSAA			
			d5-NEtFOSAA			
			M2-6:2 FTS			
			M2-8:2 FTS			
			M2-4:2 FTS			
			13C3 HFPO-DA			
				RL	RL	Units
Solid	D 2216	Percent Moisture	Percent Solids	0.100	0.100	%

Air

Matrix	Method	Test Description	Analyte			
				RL	RL	Units
Air	D1946	Methane	Methane	0.100	0.100	% v/v

Lead in Paint

Matrix	Method	Test Description	Analyte			
				RL	MDL	Units
Solid	6010B ELLAP	Lead in paint	Lead	5.00	0.118	mg/Kg

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EUROFINS TESTAMERICA TERMS AND CONDITIONS OF SALE (Short Form)

When a purchaser (Client) places an order for laboratory, consulting or sampling services from TestAmerica Laboratories, Inc., a Delaware corporation (Eurofins TestAmerica), Eurofins TestAmerica shall provide the ordered services pursuant to these Terms and Conditions and the related Quotation or Price Schedule, or as agreed in a negotiated contract. In the absence of a written agreement to the contrary, a client order constitutes an acceptance by the Client of Eurofins TestAmerica's offer to do business under these Terms and Conditions, and an agreement to be bound by these Terms and Conditions. Receipt of a Client's samples at a Eurofins TestAmerica laboratory constitutes acceptance of these Terms and Conditions (in the absence of any other negotiated contract). No contrary or additional terms and conditions expressed in a Client's document shall be deemed to become a part of the contract created upon acceptance of these Terms and Conditions, unless accepted by Eurofins TestAmerica in writing.

1. ORDERS AND RECEIPT OF SAMPLES

1.1 A Client may place an order (i.e., specify a Scope of Work) either by submitting a purchase order to Eurofins TestAmerica in writing or by telephone subsequently confirmed in writing, or by negotiated contract. Whichever option the Client selects for placing an order, the order shall not be valid unless it contains sufficient specification to enable Eurofins TestAmerica to carry out the Client's requirements. In particular, samples must be accompanied by: a) adequate instruction on type of analysis requested, and b) complete written disclosure of the known or suspected presence of any hazardous substances, as defined by applicable federal or state law. If a Client fails to provide these required disclosures accompanying the submission of samples, and such failure results in an interruption in the lab's ability to process work due to contamination of instruments or work areas, the Client will be responsible for the costs of clean-up and recovery.

1.2 The Client shall provide one week's advance notice of the sample delivery schedule, or any changes to the schedule, whenever possible. Upon timely delivery of samples, Eurofins TestAmerica will use its best efforts to meet mutually agreed turnaround times. All turnaround times will be calculated from the point in time when Eurofins TestAmerica has determined that it can proceed with defined work following receipt, inspection of samples, and resolution of any discrepancies in Chain-of-Custody forms and project guidance regarding work to be done (Sample Delivery Acceptance). Rush turnaround times not requested in advance of the delivery of samples and specifically agreed to by the lab are not guaranteed. If the Client changes the sample delivery schedule prior to Sample Delivery Acceptance, Eurofins TestAmerica reserves its rights to modify its turnaround time commitment, change the date upon which Eurofins TestAmerica will accept samples, or refuse Sample Delivery Acceptance for the affected samples.

1.3 Eurofins TestAmerica reserves the right, exercisable at any time, to refuse or revoke Sample Delivery Acceptance for any sample which in the sole judgment of Eurofins TestAmerica: a) is of unsuitable volume; b) may pose a risk or become unsuitable for handling, transport, or processing for any health, safety, environmental or other reason, whether or not due to the presence of any hazardous substance in the sample and whether or not such presence has been disclosed to Eurofins TestAmerica by the Client; or c) holding times cannot be met, due to passage of more than 48 hours from the time of sampling or 1/2 the holding time for the requested test, whichever is less.

1.4 Prior to Sample Delivery Acceptance, the entire risk of loss or damage to samples remains with the Client, except where Eurofins TestAmerica provides courier services. In no event will Eurofins TestAmerica have any responsibility or liability for the action or inaction of any carrier shipping or delivering any sample to or from Eurofins TestAmerica's premises. Client is responsible for assuring that any sample that contains or may contain any hazardous substance to be delivered to Eurofins TestAmerica's premises is properly packaged, labeled, transported and delivered, all in accordance with applicable laws.

1.5 Eurofins TestAmerica reserves the right to begin processing samples upon receipt, unless the Client specifically notifies Eurofins TestAmerica in writing prior to sample receipt that the samples are to be held without preparation or other processing or pending receipt of a purchase order. Eurofins TestAmerica shall under no circumstances be responsible for missed holding times or turnaround times or for re-sampling costs if samples are released from hold with less than 48 hours or 1/2 the holding time for the requested test remaining, whichever is less.

2. PAYMENT TERMS

2.1 Services performed by Eurofins TestAmerica will be in accordance with prices quoted and later confirmed in writing or as stated in the Price Schedule. Quoted prices do not include sales tax. Applicable sales tax will be added to invoices where required by law.

2.2 Invoices may be submitted to Client upon completion of any sample delivery group. Billing corrections must be requested within 30 days of invoice date. Payment in advance is required for all clients except those whose credit has been established with Eurofins TestAmerica. For clients with approved credit, payment terms are net 30 days from the date of invoice by Eurofins TestAmerica, unless alternative terms have been agreed in a separate written agreement. Payment shall be made without retainage, and shall not be contingent upon the receipt of funds from third parties. All overdue payments are subject to an additional interest and service charge of one and one half percent (1.5%) (or the maximum rate permissible by law, whichever is less) per month or portion thereof from the due date until the date of payment. All fees are charged or billed directly to the Client. The billing of a third party will not be accepted without a statement, signed by the third party, acknowledging and accepting payment responsibility in accordance with these payment terms.

2.3 If Client fails to make timely payment of its invoices, Eurofins TestAmerica reserves the right to pursue all appropriate remedies, including withdrawing certifications, suspending work and withholding delivery of data under this order without recourse. Client shall be responsible for all reasonable fees, expenses, and costs of collection including but not limited to arbitrator's and attorney's fees. Eurofins TestAmerica reserves the right to refuse to proceed with work at any time based upon an unfavorable Client credit report.

3. CHANGE ORDERS, TERMINATION

3.1 Changes to the Scope of Work, price, or result delivery date may be initiated by Eurofins TestAmerica after Sample Delivery Acceptance due to any condition which conflicts with analytical, QA or other protocols warranted in these Terms and Conditions. Eurofins TestAmerica will not proceed with such changes until an agreement with the Client is reached on the amount of any cost, schedule change or technical change to the Scope of Work, and such agreement is documented in writing.

3.2 Changes to the Scope of Work, including but not limited to increasing or decreasing the work, changing test and analysis specification, or acceleration in the performance of the work may be initiated by the Client after Sample Delivery Acceptance. Such change must be documented in writing and may result in a change in cost and turnaround time commitment. Eurofins TestAmerica's acceptance of such changes is contingent upon technical feasibility and operational capacity.

3.3 Suspension or termination of all or any part of the work may be initiated by the Client. Eurofins TestAmerica will be compensated consistent with Section 2 of these Terms and Conditions. Eurofins TestAmerica will complete all work in progress and be paid in full for all work completed.

4. WARRANTIES AND LIABILITY

4.1 Where applicable, Eurofins TestAmerica will use appropriate and approved analytical test methods. Eurofins TestAmerica has referenced these methods in its Laboratory Quality Manuals and has documented them in Standard Operating Procedures. Eurofins TestAmerica reserves the right based on its reasonable judgment to deviate from these methodologies as necessary or appropriate to the extent required by the nature or composition of the sample, which deviations, if any, will be made on a basis consistent with recognized standards of the industry and/or Eurofins TestAmerica's Laboratory Quality Manuals. Client may request that Eurofins TestAmerica perform according to a mutually agreed Quality Assurance Project Plan (QAPP). If samples arrive prior to agreement on a QAPP, Eurofins TestAmerica will proceed with analyses under its standard Quality Manuals then in effect. Eurofins TestAmerica will not be responsible for any resampling or other charges if work must be repeated to comply with a subsequently finalized QAPP.

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4.2 Eurofins TestAmerica shall start preparation and/or analysis within holding times provided that Sample Delivery Acceptance occurs within 48 hours of sampling or 1/2 of the holding time for the test, whichever is less, unless the Client has specifically requested that Eurofins TestAmerica hold the samples without preparation or other processing or pending receipt of a purchase order. Where resolution of inconsistencies leading to Sample Delivery Acceptance does not occur within this period, Eurofins TestAmerica will use its best efforts to meet holding times and will proceed with the work provided that, in Eurofins TestAmerica's judgment, the chain-of-custody or definition of the Scope of Work provide sufficient guidance. Reanalysis of samples to comply with Eurofins TestAmerica's Quality Manuals will be deemed to have met holding times provided the initial analysis was performed within the applicable holding time. Where reanalysis demonstrates that sample matrix interference is the cause of failure to meet any Quality Manual requirements, the warranty will be deemed to have been met.

4.3 Eurofins TestAmerica warrants that it possesses and maintains all licenses and certifications that are required to perform services under these Terms and Conditions provided that such requirements are specified in writing to Eurofins TestAmerica prior to Sample Delivery Acceptance. Eurofins TestAmerica will notify the Client in writing of any decertification or revocation of any license, or notice of either, that affects work in progress.

4.4 The warranty obligations set forth in Sections 4.1, 4.2 and 4.3 are the sole and exclusive warranties given by Eurofins TestAmerica in connection with any services performed by Eurofins TestAmerica or any results generated from such services, and Eurofins TestAmerica gives and makes NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. No representative of Eurofins TestAmerica is authorized to give or make any other representation or warranty or modify this warranty in any way.

4.5 Client's sole and exclusive remedy for breach of warranty in connection with any services performed by Eurofins TestAmerica will be limited to repeating any services performed, contingent on the Client's providing, at the request of Eurofins TestAmerica and at the Client's expense, additional sample(s) if necessary. Any reanalysis requested by the Client generating results consistent with the original results will be at the Client's expense. If resampling is necessary, Eurofins TestAmerica's liability for resampling costs will be limited to actual cost or one hundred and fifty dollars ($150) per sample, whichever is less.

4.6 Eurofins TestAmerica's liability for any and all causes of action arising hereunder, whether based in contract, tort, warranty, negligence or otherwise, shall be limited to the lesser amount of compensation for the services performed or $100,000. All claims, including those for negligence, shall be deemed waived unless suit thereon is filed within one year after Eurofins TestAmerica's completion of the services. Under no circumstances, whether arising in contract, tort (including negligence), or otherwise, shall Eurofins TestAmerica be responsible for loss of use, loss of profits, or for any special, indirect, incidental or consequential damages occasioned by the services performed or by application or use of the reports prepared.

4.7 In no event shall Eurofins TestAmerica have any responsibility or liability to the Client for any failure or delay in performance by Eurofins TestAmerica that results, directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of Eurofins TestAmerica. Such causes and circumstances include, but are not limited to, acts of God, acts of Client, acts or orders of any governmental authority, strikes or other labor disputes, natural disasters, accidents, wars, civil disturbances, equipment breakdown, matrix interference or unknown highly contaminated samples that impact instrument operation, unavailability of supplies from usual suppliers, difficulties or delays in transportation, mail or delivery services, or any other cause beyond Eurofins TestAmerica's reasonable control.

5. RESULTS, WORK PRODUCT

5.1 Data or information provided to Eurofins TestAmerica or generated by services performed under this agreement shall only become the property of the Client upon receipt in full by Eurofins TestAmerica of payment for the entire order. Ownership of any analytical method, QA/QC protocols, software programs or equipment developed by Eurofins TestAmerica for performance of work will be retained by Eurofins TestAmerica. Client shall not disclose such information to any third party without Eurofins TestAmerica's express prior consent.

5.2 Data and sample materials provided by Client or at Client's request, and the result obtained by Eurofins TestAmerica shall be held in confidence (unless such information is generally available to the public or is in the public domain or Client has failed to pay Eurofins TestAmerica for all services rendered or is otherwise in breach of these Terms and Conditions), subject to any disclosure required by law or legal process.

5.3 Should the results delivered by Eurofins TestAmerica be used by the Client or Client's client, even though subsequently determined not to meet the warranties described in these Terms and Conditions, then the compensation will be adjusted based upon mutual agreement. In no case shall the Client unreasonably withhold Eurofins TestAmerica's right to independently defend its data.

5.4 Eurofins TestAmerica reserves the right to perform the services at any laboratory in the Eurofins TestAmerica network. If a Client has requested a particular location for the work, Eurofins TestAmerica will inform the Client when operational constraints require the work to be performed at another Eurofins TestAmerica location. In addition, Eurofins TestAmerica reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in Eurofins TestAmerica's sole judgment, it is reasonably necessary, appropriate or advisable to do so. Eurofins TestAmerica will in no way be liable for any subcontracted services (outside the Eurofins TestAmerica network) except for work performed at laboratories which have been audited and approved by Eurofins TestAmerica.

5.5 Eurofins TestAmerica will dispose of non-hazardous samples, sample extracts and digestates 30 days after the final analytical report is issued, unless instructed to store them for an alternate period of time or to return such samples to the Client, in a manner consistent with U.S. Environmental Protection Agency regulations or other applicable federal, state or local requirements. Charges for disposal will be billed to the client. Alternatively, samples can be returned to the client for disposal. Cost of return shipping will be billable to the client. Air samples in Summa canisters and tedlar bags are used and the containers cleaned immediately after testing, such that those samples are not retained. Longer storage periods may be requested and may be accommodated if space allows, and for an additional charge. Any samples for projects that are canceled or not accepted, or for which return was requested, will be returned to the Client at its own expense. Eurofins TestAmerica reserves the right to return to the Client any sample or unused portion of a sample that is not within Eurofins TestAmerica's permitted capability or the capabilities of Eurofins TestAmerica's designated waste disposal vendor(s). ALL DIOXIN, MIXED WASTE, AND RADIOACTIVE SAMPLES WILL BE RETURNED TO THE CLIENT, unless prior arrangements for disposal are made.

5.6 Unless a different time period is agreed to in an order under these Terms and Conditions, Eurofins TestAmerica agrees to retain all records for five (5) years.

5.7 If Eurofins TestAmerica is required to respond to legal process related to services for Client, Client agrees to reimburse Eurofins TestAmerica for hourly charges for personnel involved in the response and attorney's fees reasonably incurred in obtaining advice concerning the response, preparation to testify, and appearances related to the legal process, travel and all reasonable expenses associated with the litigation. Additional consulting beyond that normally associated with lab reports will be billed at Eurofins TestAmerica's current published rates.

6. INSURANCE

6.1 During the performance of services under these Terms and Conditions, Eurofins TestAmerica shall maintain in force Workers' Compensation and Employer's Liability Insurance in accordance with the laws of the states having jurisdiction over Eurofins TestAmerica's employees who are engaged in the performance of the work. Eurofins TestAmerica shall also maintain during such period Comprehensive General and Contractual Liability (limit of $1,000,000 per occurrence/ $2,000,000 aggregate), Comprehensive Automobile Liability, owned and hired, ($1,000,000 combined single limit), Professional Liability Insurance (limit of $5,000,000 per claim/ aggregate and Pollution Liability insurance (limit of $5,000,000 per claim/aggregate).

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7. MISCELLANEOUS PROVISIONS

7.1 These Terms and Conditions, together with any additions or revisions which may be agreed to in writing by Eurofins TestAmerica, embody the whole agreement of the parties and provide the only remedies available. There are no promises, terms, conditions, understandings, obligations or agreements other than those contained herein, and these Terms and Conditions shall supersede all previous communications, representations, or agreements, either verbal or written, between the Client and Eurofins TestAmerica. These Terms and Conditions, and any transactions or agreements to which they apply, shall be governed both as to interpretation and performance by the laws of the state where Eurofins TestAmerica's services are performed.

7.2 The invalidity or unenforceability, in whole or in part, of any provision, term or condition hereof shall not affect in any way the validity or enforceability of the remainder of these Terms and Conditions, the intent of the parties being that the provisions be severable. The section headings of these Terms and Conditions are intended solely for convenient reference and shall not define, limit or affect in any way these Terms and Conditions or their interpretations. No waiver by either party of any provision, term or condition hereof or of any obligation of the other party hereunder shall constitute a waiver of any subsequent breach or other obligation.

7.3 The obligations, liabilities, and remedies of the parties, as provided herein, are exclusive and in lieu of any others available at law or in equity. Indemnifications, releases from liability and limitations of liability shall apply, notwithstanding the fault, negligence or strict liability of the party to be indemnified, released, or whose liability is limited, except to the extent of sole negligence or willful misconduct.

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Service Price List for Fishbeck, Thompson, Carr & Huber, Inc. 13243

Service	Standard	Next day	Same day	Holiday weekend
FUNGAL AIR				
Culturable air fungi (Incl. Asp spp.)	$36.83	--	--	--
Culturable air fungi full (Pen&Clad genus)	$36.83	--	--	--
Culturable air fungi full speciation	$97.19	--	--	--
Metals/Metalloids in Air OSHA ID-121 (sub-contracted)	$29.16	$43.74	--	--
Spore trap analysis	$32.57	$32.57	$48.33	$81.50
Spore trap analysis (Clad & Pen/Asp differentiation)	$69.73	$104.59	$139.46	$209.19
Spore trap analysis other particles-Supplement	$22.07	$33.11	$44.14	$66.21
Yeast identification	$47.23	--	--	--
FUNGAL SURFACE				
1-Media fungi surface culture (Incl. Asp spp.)	$36.83	--	--	--
1-Media fungi surface culture full (Pen&Clad genus)	$36.83	--	--	--
1-Media fungi surface culture full speciation	$97.19	--	--	--
2-Media fungi surface culture (Incl. Asp spp.)	$59.61	--	--	--
2-Media fungi surface culture full (Pen&Clad genus)	$76.49	--	--	--
2-Media fungi surface culture full speciation	$87.20	--	--	--
3-Media fungi surface culture (Incl. Asp. spp.)	$70.86	--	--	--
3-Media fungi surface culture full (Pen&Clad genus)	$106.86	--	--	--
3-Media fungi surface culture full speciation	$141.72	--	--	--
Direct microscopic exam (Qualitative)	$27.62	$27.62	$55.24	$82.86
Dust characterization	$60.95	$91.43	$121.90	$182.85
Quantitative spore count direct exam	$41.61	$41.61	$83.22	$124.83
Wood decay analysis	$96.60	--	--	--
ASBESTOS				
Asbestos PCM Air ISO 8672/ASTM D7201 (sub-contracted)	$30.18	$45.27	--	--
Asbestos PLM*	$7.25	$10.36	$15.54	$21.75
Asbestos PLM NY State ELAP 198.1 (sub-contracted)	$38.50	--	--	--
Asbestos PLM NY State ELAP 198.6 (sub-contracted)	$49.48	--	--	--
Asbestos PLM NY State ELAP 198.8 Vermiculite - Chrysotile and Amphibole (sub-contracted)	$259.33	--	--	--
Asbestos PLM NY State ELAP 198.8 Vermiculite - Chrysotile Only (sub-contracted)	$167.57	--	--	--
Asbestos TEM AHERA (sub-contracted)	$131.94	$197.91	--	--
Asbestos TEM Air ISO 13794 (sub-contracted)	$475.70	--	--	--
Asbestos TEM ASTM 6281-15 (sub-contracted)	$135.65	$203.48	--	--
Asbestos TEM ASTM D5755 (sub-contracted)	$164.92	$247.38	--	--
Asbestos TEM ASTM D6480 (sub-contracted)	$192.42	$288.63	--	--
Asbestos TEM ASTM D7521-16 (sub-contracted)	$199.49	--	--	--
Asbestos TEM Bulk - Qualitative ISO 22262-2 (sub-contracted)	$204.60	$306.90	--	--
Asbestos TEM Chatfield (sub-contracted)	$65.97	$98.95	--	--
Asbestos TEM Cincinnati Method Vermiculite (sub-contracted)	$119.69	--	--	--
Asbestos TEM EPA 100.2 - All Fibers (>=0.5 um only) - (sub-contracted)	$245.52	--	--	--
Asbestos TEM EPA 100.2 - Long Fibers (> 10 um only) - (sub-contracted)	$176.47	--	--	--

This service price list document may not reflect current pricing and turnaround time for your account. Prices are subject to change without notice. Contact customer service with questions regarding pricing and turnaround time. *Price is per sample up to 3 layers. Each layer >3 is charged at the following TAT rates: Standard = $5.00, Next-day = $7.15, Same-day = $10.71, Holiday/Weekend = $15.00

This price list was generated on 04/14/2020

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Service Price List for Fishbeck, Thompson, Carr & Huber, Inc. 13243

Service	Standard	Next day	Same day	Holiday weekend
Asbestos TEM EPA Level II (sub-contracted)	$76.96	$115.44	--	--
Asbestos TEM ISO 10312 (sub-contracted)	$302.38	--	--	--
Asbestos TEM NIOSH 7402 (sub-contracted)	$104.46	$156.69	--	--
Asbestos TEM NY State ELAP 198.4 (sub-contracted)	$65.97	--	--	--
Asbestos TEM Vermiculite - Qualitative (sub-contracted)	$89.00	--	--	--
Asbestos XRD Bulk - ISO 22262-3 (sub-contracted)	$245.52	--	--	--
Asbestos-airborne fiber count (NIOSH 7400)	$11.00	$16.50	$22.00	$33.00
Asbestos-CARB 435 (1000 pt ct)	$219.14/layer	--	--	--
Asbestos-CARB 435 (400 pt ct)	$164.92/layer	--	--	--
Asbestos-EPA 1000 point count	$108.45/layer	$162.68/layer	$216.90/layer	$325.35/layer
Asbestos-EPA 200 point count	$27.12/layer	$40.68/layer	$54.24/layer	$81.36/layer
Asbestos-EPA 400 point count	$36.28/layer	$54.42/layer	$72.56/layer	$108.84/layer
Asbestos-Gravimetric 1000 Point Count	$137.41/layer	$206.12/layer	--	--
Asbestos-Gravimetric 400 Point Count	$84.40/layer	$126.60/layer	--	--
Asbestos-gravimetric point count (sub-contracted)	$137.44	--	--	--
Asbestos-OSHA with TWA	$11.00	$16.50	$22.00	$33.00
Asbestos-TEM Qualitative P/A (sub-contracted)	$104.46	$156.69	--	--
PLM Asbestos	$27.12/unit	$40.68/unit	$54.24/unit	$81.36/unit
BACTERIAL AIR				
Culturable air bact 3-Genus ID	$94.48	--	--	--
Culturable air bact 3-Species ID	$152.97	--	--	--
Culturable air bact 5-Genus ID	$126.07	--	--	--
Culturable air bact 5-Species ID	$236.20	--	--	--
Culturable air bact gram stain and counts	$41.61	--	--	--
Culturable air bact thermophilic actinomycetes	$39.76	--	--	--
Culturable air bact total count	$41.61	--	--	--
BACTERIAL SURFACE				
Acid Producing Bacteria	$172.50	--	--	--
Bacteria surface culture 3-Genus ID	$88.25	--	--	--
Bacteria surface culture 3-Species ID	$152.97	--	--	--
Bacteria surface culture 5-Genus ID	$126.07	--	--	--
Bacteria surface culture 5-Species ID	$236.20	--	--	--
Bacteria surface culture gram stain and counts	$38.87	--	--	--
Bacteria surface culture thermophilic actinomycetes	$58.24	--	--	--
Bacterial Identification-Genus	$59.61	--	--	--
Bacterial Identification-Species	$118.12	--	--	--
Endotoxin analysis	$120.74	--	--	--
Fecal Coliform,Total Coliform, E. coli-P/A	$54.06	$81.09	--	$162.18
Heterotrophic plate count	$47.23	--	--	$141.69
Hydrocarbon Degrading Bacteria	$172.50	--	--	--
Iron Related Bacteria P/A (BART)	$86.25	--	--	--

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Service Price List for Fishbeck, Thompson, Carr & Huber, Inc. 13243

Service	Standard	Next day	Same day	Holiday weekend
Legionella-CDC method	$105.06	--	--	--
Legionella-ISO method	$112.48	--	--	--
Legionella-NY ELAP method	$112.48	--	--	--
Membrane filtration standard	$36.80/organism	--	--	$110.40/organism
MF-Sewage screen	$85.10	--	--	$255.30
MPN-Salmonella	$90.85	--	--	$272.55
MPN-Standard Bacteria	$54.06/organism	$81.09/organism	--	$162.18/organism
MPN-Sulfate reducing bacteria	$90.85	--	--	--
QuantiTray-Enterococcus	$52.87	$79.30	--	--
QuantiTray-Pseudomonas aeruginosa	$52.87	$79.30	--	--
QuantiTray-sewage screen	$77.75	$116.62	--	$233.25
QuantiTray-Total Coliform, E. coli	$52.87	$79.30	--	$158.61
Slime Forming Bacteria P/A (BART)	$86.25	--	--	--
Sulfate Reducing Bacteria P/A (BART)	$86.25	--	--	--
Total Coliform, E. coli-P/A	$27.31	$40.96	--	$81.93
ALLERGEN				
Allergen: Cat, Fel d1 (sub-contracted)	$90.90	--	--	--
Allergen: Cockroach, Bla g2 (sub-contracted)	$90.90	--	--	--
Allergen: Dog, Can f1 (sub-contracted)	$90.90	--	--	--
Allergen: Dust mite, Der f1 (sub-contracted)	$90.90	--	--	--
Allergen: Dust mite, Der p1 (sub-contracted)	$90.90	--	--	--
Allergen: Mouse, Mus m1 (sub-contracted)	$90.90	--	--	--
Allergen: Rat, Rat n1 (sub-contracted)	$90.90	--	--	--
Allergen-MARIA screen (sub-contracted)	$227.80	--	--	--
PCR				
PCR panel-Aspergillus Nosocomial	$147.35	$221.02	$294.70	--
PCR screen: Avian Pathogen	$181.70	$272.55	--	--
PCR-15 important indoor molds	$236.20	$354.30	$472.40	--
PCR-23 important indoor molds	$295.82	$443.73	$591.64	--
PCR-BioRad iQ-Check Legionella	$147.26	$220.89	$294.52	--
PCR-Chlamydophila psittaci	$115.01	$172.52	--	--
PCR-Cryptococcus neoformans	$115.01	$172.52	--	--
PCR-Custom Panel	$90.85/unit	$136.27/unit	$181.70/unit	--
PCR-ERMI panel	$287.50	$431.25	$575.00	$862.50
PCR-Histoplasma capsulatum	$115.01	$172.52	--	--
PCR-Meruliporia incrassata	$362.24	$543.36	$724.48	--
USP				
USP 797 Count & ID 26-30C	$44.90	--	--	--
USP 797 Count & ID 30-35C	$44.90	--	--	--
USP 797-Bacteria Gloved Finger Sampling	$23.63	--	--	--
USP 797-Media Fill Test	$23.63	--	--	--

This service price list document may not reflect current pricing and turnaround time for your account. Prices are subject to change without notice. Contact customer service with questions regarding pricing and turnaround time.

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Service Price List for Fishbeck, Thompson, Carr & Huber, Inc. 13243

Service	Standard	Next day	Same day	Holiday weekend
USP 800 (sub-contracted) - Eleven Group 1 Drugs	$670.07	--	--	--
USP 800 (sub-contracted) - Four Group 1 Drugs	$255.75	--	--	--
USP 800 (sub-contracted) - Four Group 3 Drugs	$255.75	--	--	--
USP 800 (sub-contracted) - Gemcitabine Hydrochloride	$117.65	--	--	--
USP 800 (sub-contracted) - Individual Group 1 Drug	$117.65	--	--	--
USP 800 (sub-contracted) - Individual Group 3 Drug	$117.65	--	--	--
USP 800 (sub-contracted) - Platinum Analogues	$117.65	--	--	--
USP 800 (sub-contracted) - Seven Group 1 Drugs	$465.47	--	--	--
OTHER				
Algae enumeration	$59.61	--	--	--
Asphalt Fume NIOSH 5042 (sub-contracted)	$52.17	$78.25	--	--
Carbon Black NIOSH 5000 (sub-contracted)	$33.76	$50.64	--	--
Combustion By-Products ASTM D6602-13 (sub-contracted)	$111.71	$167.56	--	--
Combustion By-Products w/ TEM Confirmation ASTM D6602-13 (sub-contracted)	$223.42	$335.13	--	--
Hold	$0.00	--	--	--
Lead - Flame AA	$27.00	$40.50	$54.00	$81.00
Lead Analysis (sub-contracted)	$27.00	$40.50	--	--
Particle Identification via PLM (sub-contracted)	$116.62	$174.93	--	--
Radon in Air	$23.63	$35.45	$47.26	$70.89
Respirable Dust NIOSH 0600 (sub-contracted)	$33.76	$50.64	--	--
Sub-contracted Dust Characterization via PLM	$116.62	--	--	--
TCLP Lead EPA 1311/7000B (sub-contracted)	$98.21	--	--	--
Total/Nuisance Dust NIOSH 0500 (sub-contracted)	$33.76	$50.64	--	--
XRD Crystalline Silica NIOSH 7500/OSHA ID-142 mod (sub-contracted)	$148.34	$222.51	--	--

This service price list document may not reflect current pricing and turnaround time for your account. Prices are subject to change without notice. Contact customer service with questions regarding pricing and turnaround time.

06 — REQUIRED FORMS

Response Form

Failure to complete this form may result in your Response being deemed nonresponsive and rejected without any further evaluation.

To: City of Ferndale

The Undersigned hereby offers and agrees to furnish the goods and/or services in compliance with all terms, scope of work, conditions, specifications, and addenda in the Statement of Qualifications.

Addenda

The undersigned has read, understands and is fully cognizant of the Information to Consultants, Offer and Form of Agreement, all Exhibits thereto, together with any written addendum issued in connection with any of the above. The undersigned hereby acknowledges receipt of the following addendum(s): _1_, _2_, _3_, _____ (write "none" if none). In addition, the undersigned has completely and appropriately filled out all required forms.

Obligation

The undersigned, by submission of this Offer, hereby agrees to be obligated, if selected as the Consultant, to provide the stated goods and/or services to the City, for the term as stated herein, and to enter into an Agreement with the City, in accordance with the Conditions, Scope and Terms, as well as the Form of Agreement, together with any written addendum as specified above.

Compliance

The undersigned hereby accepts all administrative requirements of the RFQ and will be in compliance with such requirements. By submitting this Response Form, the Consultant represents that: 1) the Consultant is in compliance with any applicable provisions of the City's Charter and Code of Ordinances, and 2) if awarded a contract to operate the concession or provide the goods or services required in the RFQ, the Consultant will comply with the City's Charter and Code of Ordinances. These documents can be found on the City of Ferndale's website on the City Clerk's page.

Non-Collusion

The undersigned, by submission of this Response Form, hereby declares that this Response is made without collusion with any other business making any other Response, or which otherwise would make a Response.

Performance Guarantee

The undersigned further agrees that if awarded the Agreement, it will submit to the City any required performance guarantee (i.e. irrevocable letter of credit or cash deposit).

Submittal Requirements
The undersigned certifies it has attached a complete response to each of the submittal requirements listed in the Evaluation Criteria and Submittal Requirements section of this RFQ.

No response may be accepted that has not been manually signed in ink in the appropriate space below.

I certify, under penalty of perjury, that I have the legal authorization to bind the firm hereunder:

Company Name Fishbeck	**For clarification of this offer, contact:** Steve MacDonald, PE - Vice President
Address 39500 Mackenzie Drive, Suite 100	
City, State, Zip Novi, Michigan 48377	
Phone 248.324.2090	**Fax** N/A
Email sjmacdonald@fishbeck.com	
Signature 	
Printed Name Steve MacDonald, PE	**Title** Vice President/Senior Environmental Engineer
Federal Tax ID 38-1841857	

Business Information Questionnaire

Failure to complete this form may result in your Response being deemed nonresponsive and rejected without any further evaluation.

Name of Company	Fishbeck
Principal	Fishbeck has 18 principals - a full list can be provided upon request.
Office Address	39500 Mackenzie Drive, Suite 100, Novi, MI 48377
Phone Number	248.324.2090

Form of Ownership (Check One)
Corporation (X) LLC ( ) Joint Venture ( )
State of Incorporation/Registration Michigan Date of Incorporation/Registration 1967

Partnership ( ) If Partnership, select one of the following: Limited ( ) or General ( )

Individual ( )

List of Partners, Principals, Corporate Officers or Owners

Name	Title
Fishbeck has 18 principals, 28 senior associates, and 58 associates who are part of the more than 225 shareholders in the firm. A full list of these individuals can be provided upon request.	

Financial Disclosure/Conflicts of Interest

Identify any contract(s), including any contract involving an employment or consulting relationship, which the firm, or its partners, principals, corporate officers or owners currently has with the City of Ferndale, or with any of its Council members or officers.

Fishbeck has no contracts with conflicts of interest.

Latest Credit Rating (Specify if other than Dun and Bradstreet) 4A2

I hereby certify that the foregoing business information is true, correct and complete to the best of (my/our) knowledge and belief:

Name of Company Fishbeck	
Signature 	Date 4/15/20
Title Vice President/Senior Environmental Engineer	
Printed Name Stephen J. MacDonald, PE	

Subconsultant Form

Failure to complete this form may result in your Bid or Response being deemed nonresponsive and rejected without any further evaluation.

Are there any subconsultants to be utilized under this contract?

____ **YES** - You must complete both pages.

__X__ **NO** - You must complete only this page.

(If you have more than one Subconsultant, make additional copies as needed)

Prime Consultant
State relationship, if any, between Prime Consultant and each Subconsultant

NOTE: Both the Prime Consultant/Consultant and Subconsultant must sign this form appropriately.

Subconsultant	Fed Tax ID
Address	
City, State, Zip	
Phone	Fax
Email	

Owners/Partners/Corporate Directors/Principal Stockholders (>5% holdings):

Work to Perform:

Subcontract Amount $_____ Percent of Contract _____%

Subconsultant
I acknowledge that all the above information has been completely filled out and is true.

Signature	Printed Name
Title	Date

Prime Consultant
I acknowledge that all the above information has been completely filled out and is true.

Signature	Printed Name
Title	Date

Ethics in Contracting Vendor Form

Disclosure of Relationships with City of Ferndale contract managers by owners, officers, and key personnel of business.

Failure to complete this form may result in your Proposal being deemed nonresponsive and rejected without any further evaluation.

- This form must be completed by a person holding a key position in the business, such as an officer, director, trustee, partner, senior engineer or sales manager and have influence in making this proposal or response or in performing the contract if the City of Ferndale (City) awards it to your business.
- Please fill out this form to the best of your knowledge and belief.
- Detach and make additional copies of this form if needed.
- You are not required to question family members beyond what you already know of their affairs.
- Submit this form with your bid/quote/proposal. A copy will be kept on file by the City of Ferndale.
- If you fail to fully disclose the required information below, the City may terminate your contract if your business is awarded one.
- If you are awarded a contract and changes occur that would impact your responses below, it is your responsibility to update and resubmit this form.

1. Are you a City employee or an immediate family member of a City employee?
___ Yes _X_ No

If Yes:

Name	**Relationship**
Title	**Department**

2. Without any further inquiry, are you aware if your business has employed a City employee or an immediate family member of a City employee within the previous twelve (12) months?
___ Yes _X_ No

If Yes:

Name	**Relationship**
Title	**Department**

3. Without any further inquiry, are you aware if your business has discussed hiring a City contract manager or an immediate family member of a City contract manager within the previous twelve (12) months? ___ Yes _X_ No

If Yes:

Name of Contract Manager	
Title	**Department**

4. Do you and a contract manager each have a financial interest in one or more of the same business ventures? ___ Yes _X_ No

If Yes:

Name of Contract Manager	
Title	**Department**

Ethics Certification

I certify that I have disclosed all information within my knowledge, which is required by this disclosure form.

Name Stephen J. MacDonald, PE	
Signature Stephen J. MacDonald	**Date** 4/15/20
Company Name Fishbeck	
Tax ID # 38-1841857	

Ethics Definitions

Contract Manager

An elected or appointed City of Ferndale official or a key employee identified as having significant discretion over City contracts.

Immediate Family

Your spouse, children, parents, brothers and sisters.

Financial Interest:

- Ownership of any interest or involvement in any relationship, which results in the receipt in $500 or more per year.

- Holding a key position in a business such as officer, director, trustee, partner, member, shareholder or sales manager. Exceptions: Officers who serve without compensation on the boards of charitable organizations.
- Receipt of any financial benefit, whether direct or indirect.

07 —— LABORATORY SUBCONSULTANT QUALIFICATIONS

TestAmerica Laboratories, Inc.
dba Eurofins TestAmerica



Statement of Qualifications

January 2020

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Section 1 Mission Statement and Values

Eurofins Vision Statement

To be the Global Leader in Testing for Life.

Mission Statement

To contribute to a safer and healthier world by providing our customers with innovative and high quality laboratory, research and advisory services while creating opportunities for our employees and generating sustainable shareholder value.

Our Values

Customer Focus

- Delivering customer satisfaction by listening to and exceeding customer expectations
- Adding value for our customers through our services
- Seeking innovative solutions to help our customers achieve their goals

Quality

- Delivering quality in all our work; providing accurate results on time
- Using the best appropriate technology and methods
- Seeking to improve or change our processes for the better

Competence and Team Spirit

- Employing a team of talented and competent staff
- Investing in training and creating good career opportunities
- Recognizing and encouraging outstanding performance

Integrity

- Behaving ethically in all our business and financial activities
- Demonstrating respect towards our customers and our staff
- Operating responsible environmental policies

Section 2 Company Overview

Eurofins Environment Testing

Eurofins TestAmerica is a division of Eurofins Scientific; the world leader in environmental, food, pharmaceutical products testing and agroscience services. Eurofins collectively offers more than 200,000 testing methods, offered by over 45,000 staff in more than 800 laboratories across 47 countries.

The combined Eurofins Environment Testing footprint of U.S. locations, which is comprised of Eurofins TestAmerica and a number of affiliates, includes 35 laboratories and over 40 service centers delivering innovative technical expertise and comprehensive analytical testing services.

Eurofins TestAmerica

Eurofins and TestAmerica are well positioned to support clients in both the public and private sector. Whether it is the Department of Defense, Department of Energy, Industry or the consulting and engineering firms that support them, Eurofins and TestAmerica have unique and innovative solutions to address the most challenging opportunities.

Specialty services include emerging contaminants (PFAS, 1,4-Dioxane and others); dioxins; explosives; specialty organics; air (source/ambient/indoor) and water quality (drinking/surface/groundwater) monitoring; emergency response, decommissioning, sediment and tissue program support; industrial hygiene; aquatic toxicity; desalination; radiochemistry and mixed waste testing; state-specific UST methods; treatability studies and many others.

Eurofins TestAmerica maintains leadership positions with a variety of environmental trade associations, regulatory review boards, and laboratory industry steering committees. Eurofins TestAmerica's leadership helps to shape how analytical solutions are brought to market, sets the standard for quality and ethics, and challenges conventional wisdom to drive an industry culture of continuous improvement. Eurofins TestAmerica holds active leadership positions in each of the following organizations:

- NELAC - National Environmental Laboratory Accreditation Conference
- ACIL - American Council of Independent Laboratories
- SAME - Society of American Military Engineers
- A&WMA - Air & Waste Management Association
- ASTM International
- ITRC - Interstate Technology & Regulatory Council
- U.S. EPA – Organic & Inorganic Method Work Groups

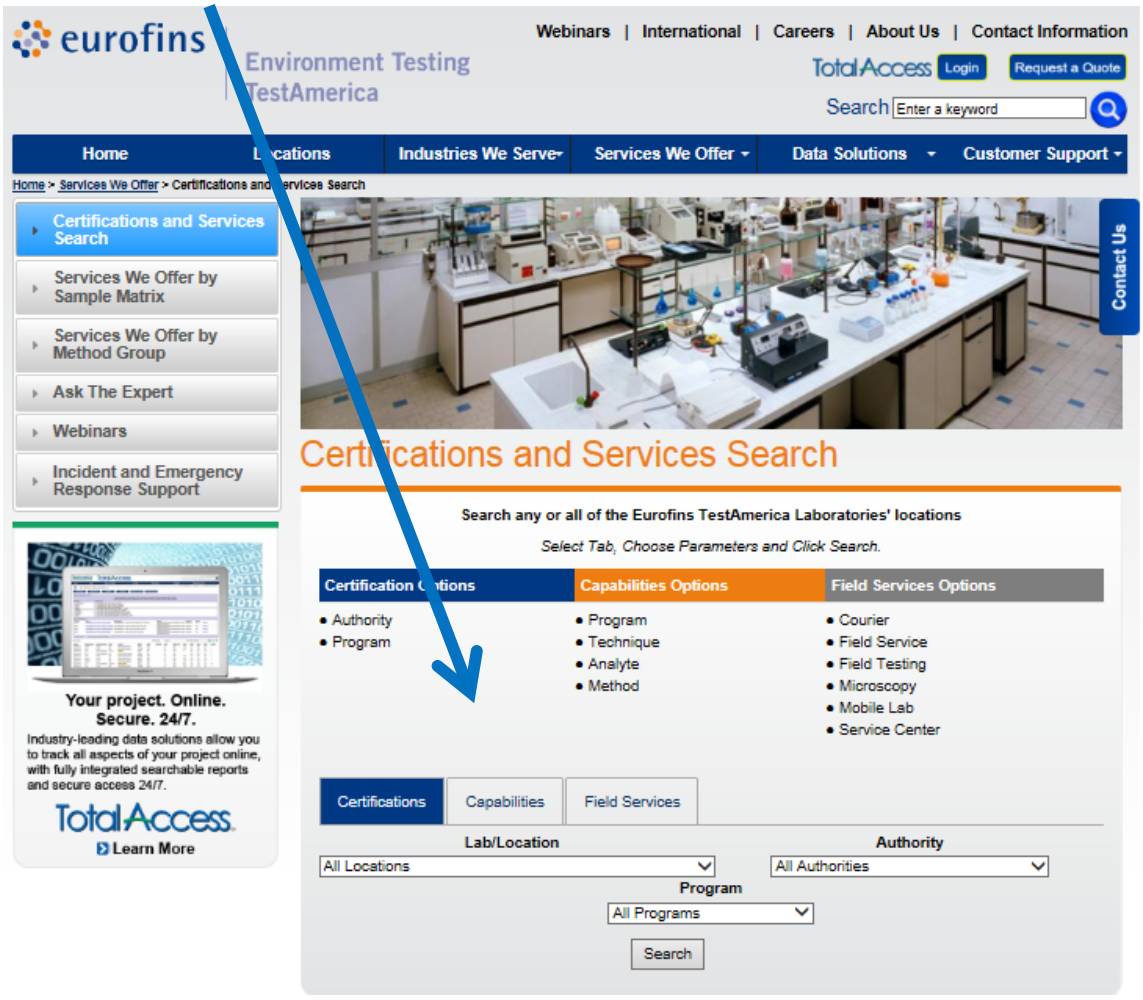
Eurofins TestAmerica is committed to a common business principle: leading through expertise, beyond providing the basic services or products. We believe that we deliver the greatest value when our experts can support our clients with insights on the test methods and products that can best help their project to be successful. Eurofins TestAmerica has backed this commitment by investing in the skilled people, systems and equipment that truly define leadership.

Capabilities

Eurofins TestAmerica brings a unique blend of expertise, quality and convenience to its clients. Our ability to deliver the widest variety of environmental testing services is a function of our unmatched expertise and capacity.

The list of methods supported by Eurofins TestAmerica's network is extensive. At www.testamericainc.com , you can search for individual methods by laboratory or across labs, or view all methods available from all labs simply by changing your search criteria.

http://www.testamericainc.com/services-we-offer/analytical-services-search/?searchType=1&



Because our laboratories support different regulatory programs, labs' constituent lists and limits may vary for the same method. When requesting specific analyses, constituent lists or detection limits, call your primary laboratory contact for support. Our integrated Laboratory Information Management System (LIMS) allows them to evaluate the best fit across the Eurofins TestAmerica network from their own desktop.

Specialty Capabilities

Eurofins TestAmerica's comprehensive approach to analytical service support, backed by industry leading technical expertise, makes Eurofins TestAmerica the valued choice of customers who depend on their laboratory to provide solutions to their most complex testing needs. Our specialty offerings are constantly changing based on regulatory and client demand. As noted above, capabilities can be searched in real-time on our website.

Detailed information on many of these services can be found on our website.

Regulatory Support

Eurofins TestAmerica offers expertise and services designed to address the specific requirements of a broad spectrum of regulatory programs. The ability to understand and support regulatory platforms, the decision criteria they drive and their prescription for quality analytical testing is critical for the development and delivery of test results that meet the needs of their intended use.

Eurofins TestAmerica has long led the environmental industry in the development and refinement of analytical methodologies for a host of regulatory programs. Eurofins TestAmerica staff serves as members of steering committees who have shaped the standard of quality and practice for the environmental testing industry.

Among the regulatory programs Eurofins TestAmerica routinely supports are:

RCRA:	Resource Conservation & Recovery Act	**NPDES**:	National Pollution Discharge Elimination System
CWA:	Clean Water Act TMDL: Total Max Daily Load	**MPRSA**:	Marine Protection, Research & Sanctuaries Act
CAA:	Clean Air Act (CAA)	**MACT**:	Maximum Achievable Control Technology
SDWA:	Safe Drinking Water Act	**NESHAP**:	National Emission Standards for Hazardous Air Pollutants
CERCLA:	Comprehensive Environmental Response, Compensation & Liability Act (Superfund)	**Brownfield Programs**	
SARA:	Superfund Amendments & Reauthorization Act	**Sediment**:	Inland, Upland & Ocean Testing Manuals
TSCA:	Toxic Substances Control Act	**REMP**:	Radioactive Environmental Monitoring Program
FIFRA:	Federal Insecticide, Fungicide & Rodenticide Act	**UST**:	State Underground Storage Tank Programs
NEPA:	National Environmental Policy Act	**DoD**:	QSM, Version 5.0

Section 3 Value Added Services

An overriding benefit that Eurofins TestAmerica clients receive as a function of our scale and coverage is the inherent convenience in the way we deliver our services. Each client's needs are unique, and as a result, each has their own definition of convenience. Eurofins TestAmerica adds the elements of flexibility, adaptability, and convenience to our analytical service offering in the following ways:

TotalAccess® – The Complete Online Data Delivery Solution

TotalAccess® is Eurofins TestAmerica's online data delivery solution, available to all clients at no added cost. Allowing clients to track all aspects of their environmental data program, TotalAccess® provides an additional means for clients to interact with their laboratory. Accessible from any web browser, TotalAccess® provides the following benefits to our clients:

- Rapid access to data for real time decision making
- Customizable EDD creation
- Data trending capabilities by sample and analyte
- Budgeting tool for analytical projects
- Project status updates for results, electronic deliverables and other documents generated for your project
- Downloadable project documentation; invoices, reports, EDDs, and COCs
- Customizable displays capturing data in a single grid and single click downloads to Excel
- Multi-project report generation capabilities allowing for the consolidation of multiple sample events into one EDD report
- Preloaded regulatory limits enabling the comparison of client results to existing regulatory standards
- Ability to create personalized limits capable of comparison to client results

Following guidance from the National Institute of Standards and Technology (NIST SP 800-171), Eurofins TestAmerica has upgraded processes to improve data securing. Delivery of data to clients via TotalAccess® offers clients improved security over traditional, non-encrypted email messages.

The TotalAccess system is available free of charge to all Eurofins TestAmerica customers.



Technical Support

Questions



Eurofins TestAmerica is recognized as the industry's technical leader, focused on global concerns related to environmental testing. Featuring many of our well-known industry leading technical experts, Eurofins TestAmerica's web-based "Ask the Expert" program allows any individual with a question relative to environmental testing to access the thoughts and opinions of recognized experts in their field through a free, easy to use online platform.

"Of all the services requested by our customers, none is more sought after than our knowledge. All environmental decisions are, in part, based upon the data collected. Our customers prefer and in some cases demand the application specific expertise we provide as it adds assurance that data provided appropriately matches their decision objectives," offered Jim Miller, Senior Vice President.

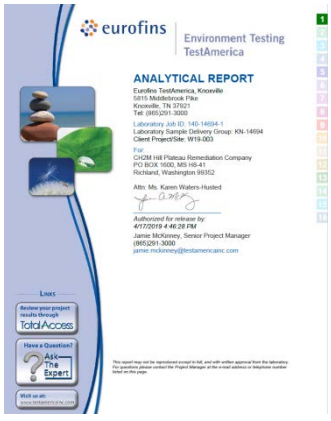
Webinars

Eurofins TestAmerica's "Ask the Expert" webinars are designed to provide an in-depth learning experience. Each month, the webinar series presents technical based webinars relating to the environmental laboratory analysis process supporting our clients' projects. Each webinar consists of approximately 45 minutes of material presentation followed by a question and answer session with the presenting expert. Our experts remain on the webinar to field questions relating to the topic.



Reports & Deliverables

National and multinational clients who centrally manage environmental data benefit from Eurofins TestAmerica's unified LIMS. Reports and electronic deliverables from any location, or deliverables that include data from multiple Eurofins TestAmerica locations, will be consistent and seamless. Our staff of dedicated IT professionals focuses exclusively on the delivery of data via electronic means to accommodate hundreds of client custom data management systems.



Reports That Are Easy to Navigate

Eurofins TestAmerica's reports are easy to review, are consistent across the company and are fully bookmarked for easy electronic navigation.

The searchable PDF file allows users to quickly find and review data, reducing data management and validation costs.

Electronic Data

Eurofins TestAmerica provides electronic data deliverables (EDDs) to numerous government and commercial clients. EDDs can be provided in Eurofins TestAmerica standard formats, or can be customized to meet client requirements. We currently provide EDDs in various ASCII, Access, DBF and Excel spreadsheet file formats. While offering many standard formats, most EDDs are customized to meet our clients' individual requirements, some of which are very complex. Eurofins TestAmerica employs a technical staff that is dedicated to EDD development and client consultation, ensuring that electronic data provided to our clients are accurate and formatted to meet the clients' exacting requirements.

National Program Coordination

Clients interested in developing a uniform approach to contracting laboratory services on a national level benefit from Eurofins TestAmerica's unique approach to national account support. Eurofins TestAmerica is the only environmental laboratory services provider to offer truly national coverage through our network of business locations in the continental United States, Alaska and Hawaii. That coverage allows Eurofins TestAmerica to provide our national customers with a breadth and depth of service offerings that is unmatched in the industry. Each of our national service programs is customized to meet the unique needs of each customer and is managed through a single point of contact, a National Program Manager, capable of orchestrating the delivery of services from the entire Eurofins TestAmerica network.

Among the many benefits clients enjoy when contracting with Eurofins TestAmerica on a national basis:

Consistency

The Eurofins TestAmerica approach to national program support drives consistency in the manner in which analytical data are developed, prepared and delivered to our clients. Our approach provides clients assurance that data they obtain to support a variety of programs under a variety of regulatory requirements is prepared with a standard of care and analytical practice that is consistent across laboratory facilities. Consolidation

With over 80 business locations in the United States, Alaska, and Hawaii, Eurofins TestAmerica couriers provide more geographic coverage than any other laboratory company in the country, and support projects in all 50 states. Our laboratories and service centers provide logistical support for sample transport to and from the labs and many locations offer sampling support to assist clients with their compliance monitoring needs. Eurofins TestAmerica's broad-based coverage provides clients the opportunity to centralize their program, leveraging their purchasing dollars without compromise to the service demands of their monitoring programs.

Custom Planning

Complex projects often require project specific quality assurance plans customized to suit the needs of the regulating body. Eurofins TestAmerica routinely assists our clients with evaluating project specific data quality objectives and employs appropriate analytical techniques to ensure that those objectives are consistently met.

Eurofins TestAmerica SOPs are widely utilized in project plans governed by federal and state regulators and are widely recognized for their high quality standards.

When commonly prescribed test methods don't meet project specific needs, Eurofins TestAmerica works cooperatively with our clients to develop sound scientific applications that deliver confidence and data suitable for its intended use. As the industry leader, Eurofins TestAmerica routinely serves on industry steering committees that evaluate, refine and promote new analytical practices to address the evolving testing needs presented by emerging analytical challenges.

Economies of Scale

Driven by individual buyer philosophy and goals, Eurofins TestAmerica develops custom service packages that create financial incentive and scale economy benefits for our clients. Supporting a variety of industry preferred e-procurement systems; Eurofins TestAmerica facilitates further client savings and sustainability objectives through the use of electronic commerce technology.

E-Procurement

The procurement of environmental services is being revolutionized by the introduction of new on-line business software solutions that help clients efficiently manage their expenditures for environmental services. Eurofins TestAmerica leads the industry by providing a dedicated team of finance professionals to assist clients with the implementation and management of their e-solutions for procuring laboratory services, saving each client significant time and money. Eurofins TestAmerica supports dozens of commercial and client proprietary e-procurement systems:

• Ariba	• Enfos	• Oracle	• Web-Commerce
• Bottomline Business	• Exostar	• Oil-Dex	• WebEDI
• CAS	• OB10	• Online Filing Cabinet	• Xing
• Catalyst			

Incident Response Support

Eurofins TestAmerica has been at the forefront in partnering with clients to provide a single environmental testing source for incident responses ranging from small, local releases to incidents of national significance.

Our Incident Response Program offers clients an engaged partnership with benefits that include:

- ***Scalable*** testing support, ***flexibility*** in service offerings, and ***adaptability*** to evolving requirements.
- 24/7/365 access to Eurofins TestAmerica's Response Team.
- Strategically located facilities nationwide to provide logistical support.
- A dedicated Eurofins TestAmerica single point of contact for detailed coordination, planning and data delivery
- Environmental testing services for water, soil, sediment and air with unmatched capacity for rush turnaround support
- Real-time online data access and EDD delivery via TotalAccess® to assist in the decision making process
- Certifications/accreditations in all available states for a wide variety of programs.

- Comprehensive service offerings for tiered responses
  - Fixed based laboratory services
  - Sample management office
  - On-site/mobile laboratories
  - Dedicated Project Manager for detailed coordination and planning
  - Support staff and technical experts
  - Online reports, data access and EDD delivery via TotalAccess®
- Extensive experience in providing incident response support

Options for Mobile Laboratories, On-Site Support and Same Day Testing Services



Environmental projects with compressed timelines, public or regulatory scrutiny and expensive on-site equipment may require on-site sample management services and/or the expedited delivery of data, often on the same day that samples are received. Eurofins TestAmerica offers a suite of services that assist clients with the management of field samples and the "same day" delivery of data. These services help clients achieve their goals of cost reduction, process improvement and system optimization.

On-Site Sample Management Office Support

Eurofins TestAmerica's on-site SMO service helps clients minimize chain of custody and documentation errors, improve on-site processes associated with sample management and handling, and support overall logistics. SMO personnel reduce complexity associated with supplies inventory and management, courier management, communication and logistics and reduce overall cost of management and risk. The key functions of the SMO are to:

- Be the primary communication contact and on-site lead with the project team
- Support incident responses
- Manage sample logistics from the site to Eurofins TestAmerica
- Provide on-site customer support
- Lead Eurofins TestAmerica team internal calls on project status and needs
- Participate in the client's daily update meeting on project status, as needed

Local Fixed Facility Support with Same Day Service

Many projects that require the same day delivery of data are in close proximity to Eurofins TestAmerica's fixed site laboratories. In these cases, Eurofins TestAmerica provides support services from our closest fixed based location. To meet the need for same day delivery, we operate 24/7 in the departments that provide the required test methods. Data is reviewed and then reported via TotalAccess®, our 24/7, online data portal.

On-Site Laboratory Services Using Existing Facility Space

In some cases, project sites have vacant building space available for the set up and operation of a sample management office and/or laboratory services. In these cases, Eurofins TestAmerica will lease or move laboratory equipment and personnel to the site to provide real time on-site support.

Mobile Laboratories

Eurofins TestAmerica has mobile laboratories available to support projects in the Pacific Northwest and Alaska. We will also lease portable laboratory space and configure and deploy it for long term projects. Mobile lab analytical results are available for review in the field immediately upon completion. Results are provided after each analysis with final hard copy report provided upon completion of the sample delivery group. Data is also made available via the TotalAccess® system for remote project support personnel.

Generally, these projects must be of a long duration, 2-4 months or longer, and we generally need 2-3 months' notice or longer to formalize project plans, select employees, mobilize the lab and equipment, set-up and become certified, if required.

Section 4 Dedication, Security and Sustainability

Relationships between the client and laboratory are a critical component of a successful analytical program. Partner relationships result in more effective planning, successful communication and desired project results. Eurofins TestAmerica looks forward to working as a partner to help ensure the success of your analytical programs.

Personnel & Management

Eurofins TestAmerica attributes its success to the professionalism and technical expertise of its people. Not only our technical experts, but also the dedicated staff of experienced professional chemists and technicians in each individual laboratory, are key to our position as a leader in the environmental laboratory industry. The majority of our technical staff have a Bachelors' Degree or higher in Chemistry, Biology, Environmental Science or another related field.

We value and reward high performance, hard work, honesty, and teamwork. Eurofins TestAmerica employees hold themselves accountable to the highest standards of ethics, trust, and quality. These high professional standards, coupled with unparalleled technical leadership, decidedly set Eurofins TestAmerica apart from the competition. Organizational charts and key personnel summaries for our corporate management and support teams, and each of the fixed base laboratories are available upon request.

Resources

As the world's leading environmental testing company, Eurofins TestAmerica offers an unparalleled collection of physical resources designed and managed to support the wide and varied needs of our clientele. Strategically positioned expertise and a carefully orchestrated system of planned redundancy provides a platform for the delivery of analytical services that meet the exacting needs of hundreds of regulatory and client programs while providing the capacity to address peak demand without compromise to client schedules and budget.

Facility maps, Instrument lists and Capacity Summaries for each of our fixed base laboratories can be provided upon request.

Health and Safety

Eurofins TestAmerica is committed to providing a work environment that is free of recognized environmental safety and health hazards. It is Eurofins TestAmerica's policy that all work will be conducted in a manner that is safe to the employee, the community and the environment. We believe that every employee can work without injury or unreasonable exposure to hazardous work conditions. We further believe that all work can be done in a manner that protects the environment.

Our Vice President of Quality and Environmental Health and Safety (EHS) leads an organization committed to ensuring that a safe and environmentally sound business is not compromised. Under the supervision of Regional EHS Managers, each business unit has a designated Environmental Health & Safety Coordinator (EHSC), who is responsible for ensuring that health and safety operating policies and practices are adhered to at all levels of the operating unit they oversee.

The Corporate Safety Manual is the primary tool for managing our EHS policy and practice. For regulatory purposes, this document serves as the Chemical Hygiene Plan for laboratory

activities and the Hazard Communication Program for non-laboratory activities. It incorporates responsibilities, procedures and protective equipment, as well as facility requirements for our operations.

Data Security

Eurofins TestAmerica is dedicated to the protection of our systems and our data from the growing threat of cyber-attacks. In order to ensure we are as secure as possible, we have implemented multiple levels of security at all levels of IT infrastructure. Our hardware protection measures include:

- Redundant firewalls with Intrusion Detection/Protection Sensor (IDS/IPS) technology
- Network appliance log monitoring device which is monitored 24/7 by a third party service
- Cisco Iron Port proxy server for URL filtering
- Barracuda email scanning appliance to filter spam and suspicious emails

Eurofins TestAmerica also utilizes two separate virus detection and protection software systems installed on all PCs and laptops as well as detection and monitoring software for our core networking devices. In addition, we employ a third-party networking service that monitors and safeguards our network infrastructure. All user access from outside the network is accomplished through Citrix connections or secure VPN, and all company websites are hosted in a DMZ.

The IT department has a security team that continuously monitors our security position and makes recommendations for further improving our security posture. Vulnerability logs are reviewed quarterly and issues are acted upon accordingly. We have a System Intrusion Response Plan to ensure that IT personnel and company management have the information and knowledge of the tools necessary to react to any attempted breaches quickly and efficiently.

Following guidance from the National Institute of Standards and Technology (NIST), Eurofins TestAmerica has implemented procedures to protect Controlled Unclassified Information (CUI) generated by our analytical facilities. The guidance, Special Publication (SP) 800-171, outlines recommended security requirements to be implemented by nonfederal contractors to protect the confidentiality of CUI.

In support of NIST SP 800-171, Eurofins TestAmerica has upgraded many features and processes to improve data security, including:

- Delivery of data to clients, including those working with the Department of Defense, via a secured data portal, TotalAccess®. TotalAccess offers clients improved security over traditional, non-encrypted email messages, as well as functionality for customizable EDD creation, data trending and result comparison to state and federal regulatory limits.
- Multi-factor authentication to protect network assets and verify users.
- Increased mobile device security management to prevent unauthorized access to internal servers and data.

Implementation of these, and various other internal initiatives, will continue to ensure that Eurofins TestAmerica remains the nation's leading provider of legally defensible, high quality and secure data. For additional information on NIST SP 800-171 requirements, please visit the NIST Computer Security Resource Center.

Disaster Recovery

Data

All of Eurofins TestAmerica's data and information is stored in such a manner as to provide protection against disasters and to allow efficient data and file recovery. In addition, Eurofins TestAmerica maintains a company-wide Disaster Recovery Plan. The Plan is reviewed annually and modified, as needed. Business confidential IT Contingency Plans detail the logistics of the Disaster Recovery Plan.

Data and Information Storage

- Hard copy information - Most of the hard copy records are scanned and stored electronically. The few actual hard copy records are stored either on-site in protected areas or at an approved third-party off-site storage facility.
- All electronic systems - All electronic systems are backed up regularly using CommVault. In addition, data sets are continuously replicated to our disaster recovery site through CDR software and log shipping.

Backup Facilities for data recovery

Eurofins TestAmerica maintains co-location data center facilities. All data is replicated daily from the production locations to central servers in Denver and to the Eurofins TestAmerica disaster recovery site in Dallas.

Disaster Recovery Tests

Eurofins TestAmerica periodically performs a disaster recovery test on limited subsections of our operations to verify that recovery systems are working as designed.

Physical Plant

In case of a major natural catastrophe, portions or the entire sample load may be diverted to other approved/accredited Eurofins TestAmerica laboratory facilities in order to provide project continuity and to meet sample holding time or critical project schedule requirements. In the event of instrument failure, portions of the sample load may be diverted to duplicate instrumentation within the facility. In some instances, an alternate approved technique such as manual colorimetric determination in lieu of an automated determination can be accommodated. Detailed procedures for emergency circumstances and a description of emergency systems are described in the Eurofins TestAmerica's Corporate Safety Manual.

Corporate Social Responsibility and Sustainability

Eurofins TestAmerica is proud to be the leader in environmental testing and data deliverables, providing services that enable clients to make decisions that positively impact the environment. Our laboratories and all our support functional groups are guided by the core values of quality, service, integrity, and environmental leadership; and operating as a socially accountable business is firmly embedded in everything that we do. Our approach to the environment, the workplace, and the communities, in which we operate, contribute to and shape our business strategies. In that spirit of environmental stewardship, our Corporate Social Responsibility (CSR) and Sustainability processes take into account the social, ethical, and environmental impacts that our activities have on our employees, local communities, and the global community we serve.

Eurofins TestAmerica's Contribution

The foundational blocks of our CSR and Sustainability Framework are not novel or new. We have been consciously working on sustainability initiatives for many years, and will continue to build upon our progress and implementation of initiatives that are both socially responsible and sustainable solutions. Examples of our sustainability initiatives include:

- **Supply Chain Management**: Working with suppliers to improve their social and environmental performance, and cooperatively seeking opportunities to reduce our collective carbon footprint relative to the delivery of services to the Eurofins TestAmerica network, and our clients.
- **Charitable & Community Support:** Encouraging the support of local and national charitable organizations, as well as other initiatives that assist local communities connected to our business and employees. Our employees frequently participate in environmental sustainability community programs to promote green living and environmental awareness in their communities.
- **Public Policy:** Working with government agencies, regulators and policymakers, we seek to aid in the improved quality of analytical methods, ensuring consistent delivery of legally defensible data.

Process Optimization and Waste Minimization

Eurofins TestAmerica monitors our use and handling of a variety of chemicals and solvents used in our daily operational activities. Best practices have been defined across our business sectors to minimize solvent usage, and reduce waste and air emissions based on the potential impacts to the environment. These solutions have included the following:

- Recycling and reduction of solvent and chemical waste streams, whenever possible.
- Minimizing solvent usage by reducing volumes required during sample preparation and analysis.
- Use of efficient high-tech instrumentation such as microwave, solid phase and soxtherm extractions, which provide for up to a 75% reduction in solvent use versus traditional technologies.
- Through continued method enhancements, the sample volumes required for many analyses have been drastically reduced, thus minimizing the number and weight of containers required for each sampling event. This Lower Volume Initiative also allows for reduced shipping volume, thereby reducing carbon dioxide emissions, as well as a reduction in laboratory waste.

Travel Efficiency

- Eurofins TestAmerica measures vehicle mileage each month on a lab-by-lab basis across our entire business. As part of this review, best practices have been defined across the business to reduce air emissions and the potential impacts to the environment. These solutions include:
- The addition of service center locations to extend Eurofins TestAmerica's footprint in various geographies, maximizing logistical efficiencies, and reducing our road and air transportation impacts.
- Utilization of modern, fuel efficient courier vehicles, to reduce our carbon emissions.

- Focus on the logistical routing and management of courier routes to minimize travel time.
- Increased utilization of Web-based meetings to support both internal and external conference calls and presentations, mitigating air and car travel.

Facility Design and Operation

- Our laboratories and service centers have been designed and modified to provide on-going sustainability initiatives, including electrical, lighting and HVAC efficiency, as well as a focus on our facility footprints, sample storage and employee comfort and satisfaction in their working environment.

Reduction in the Use of Paper

- The environmental testing business has traditionally been a very high user of paper both in the analytical process, as well as final hard copy data reports. Eurofins TestAmerica has, and continues to, focus on internal systems and external deliverables, with the mission of achieving a paperless environment.
- Since 2005, Eurofins TestAmerica has reduced its paper usage by over 95%. Our online secure data service, TotalAccess®, makes data reports, status information, and invoices available to clients electronically. High quality, automated, and searchable .pdf analytical reports are primarily delivered electronically through email, web portal or TotalAccess®, thus reducing paper usage, as well as packing material and mailing.

Section 5 Quality

Eurofins TestAmerica is committed to providing the highest quality data and the best overall service available in the environmental testing industry. To ensure that data produced and reported meet the requirements of our clients and comply with the letter and spirit of municipal, state and federal regulations, Eurofins TestAmerica maintains a quality system that is clear, effective, well communicated and supported at all levels of the organization. Under the leadership of the Vice President of Quality and Environmental Health and Safety, Eurofins TestAmerica has instituted a culture of quality that is a product of its organizational design, comprehensive training programs and industry leading systems of checks and balances.

Eurofins TestAmerica quality programs are governed by a corporate quality management plan (CQMP) and laboratory specific quality manuals (QAMs) that define our business policies and management practices, and articulate our systems for quality control, quality assessment and quality improvement.

Ethics and Data Integrity Policy

Eurofins TestAmerica is dedicated to maintaining the highest ethical standards, in all aspects of the laboratory and business operations.

Training

Ethics is a major component of Eurofins TestAmerica's Quality and Data Integrity Systems. The CQMP contains requirements and general guidelines under which all Eurofins TestAmerica laboratories shall conduct their operations.

Two senior corporate staff fulfill the role of Ethics and Compliance officers. They are assigned to ensure that the organization distributes the ethics and integrity policies to all employees, ensure annual training and orientation of new hires to the Ethics Program and policies, and establish and maintain a mechanism to foster employee reporting of incidents of illegal, unethical or improper practices in a safe and confidential environment. Ongoing data integrity refresher training is required for all staff, and data integrity is always an integral part of that training. Employees are trained as to the legal and environmental repercussions that result from data misrepresentation.

All employees must sign an Ethics Statement on an annual basis, committing to ensure the highest standards of quality and integrity of the data and services provided to our clients. Ethical and/or Data Integrity violations are not tolerated, and employees who violate policies are subject to disciplinary actions up to and including termination. A data integrity hotline is maintained by Eurofins TestAmerica and administered by the Corporate Quality Department.

Monitoring

Where possible, Eurofins TestAmerica instruments are equipped with computerized data management programs and instrument control systems. Data is electronically transferred directly into the Laboratory Information Management System (LIMS), reducing or eliminating transcription errors. The server provides safeguards against multiple entries of the same data, unauthorized entries, or any manual changes to the data without proper authorization.

Internal audits, annual quality audits and QA technical audits further protect the company from data integrity issues.

Client Confidentiality

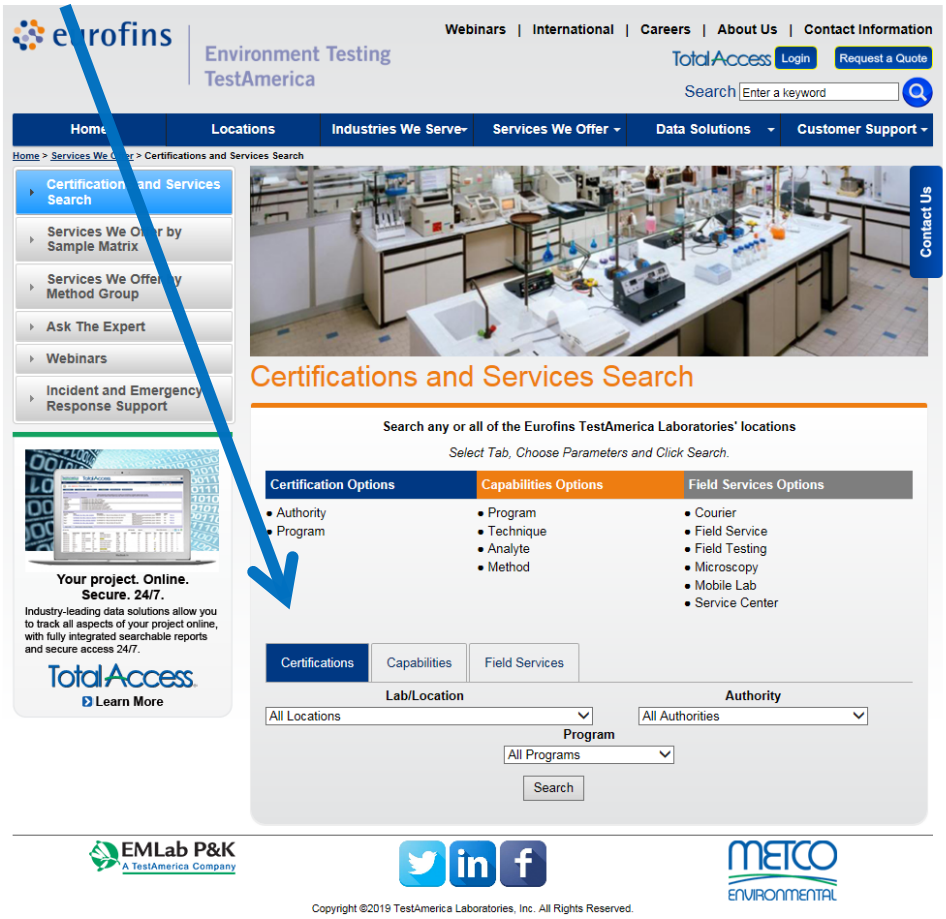
Data and sample materials provided by the client or at the client's request, and the results obtained by Eurofins TestAmerica, are held in confidence subject to any disclosure required by law or legal process. Eurofins TestAmerica's reports, and the data and information provided therein, are for the exclusive use and benefit of the client, and are not released to a third party without written consent from the client.

Continuous Improvement

It is Eurofins TestAmerica's policy to continually improve systems and provide support to quality improvement efforts. The company recognizes that the implementation of a quality assurance program requires management's commitment and support as well as the involvement of the entire staff. Every staff member plays an integral part in quality assurance and is held responsible and accountable for the quality of their work.

Accreditations

Current copies of Eurofins TestAmerica's lab accreditations can be downloaded from our website at http://www.testamericainc.com/services-we-offer/certifications-and-services-search/.



State and NELAP Accreditations

The Eurofins TestAmerica network of laboratories collectively maintains State and NELAP laboratory certifications, accreditations to provide overlap of laboratory services and capabilities to our clients. These numerous certifications and accreditations enable work sharing on national, regional and local levels. This includes maintaining redundant method capabilities and technologies to manage large program sample volumes.

The NELAC Institute (TNI) defines consensus standards for the generation of data of known and documented quality through the National Environmental Laboratory Accreditation Program (NELAP). Eurofins TestAmerica is active on various TNI committees.

Federal Accreditations

Eurofins TestAmerica had the first laboratory to be audited and approved under the new DoD Environmental Laboratory Approval Program (ELAP) and now has 8 facilities accredited under the program. Eurofins TestAmerica has been closely involved with the DoD's development of the new accreditation program, and has made many contributions that are included in the new DoD Quality Systems Manual (QSM) Version 5.1. Eurofins TestAmerica is also active in Department of Energy (DOE) programs with multiple facilities having successfully passed DOECAP audits. Additionally, Eurofins TestAmerica is a participant in the USEPA Contract Laboratory Program and has 18 facilities with membership in the USEPA Environmental Response Laboratory Network (ERLN) and Water Laboratory Alliance (WLA).

Proficiency Testing

Eurofins TestAmerica analyzes Proficiency Test (PT) samples as required for accreditation and as outlined in the National Environmental Laboratory Accreditation Conference (NELAC) Standard. Each facility participates in the PT program semiannually for each area of testing and matrices (e.g. organics, inorganics, microscopy, radiological, microbiological, aqueous and drinking water) for which it is certified.

Proficiency Testing scores are a key performance measure of company performance capability. Laboratory scores are monitored to ensure continuous improvement and sustained high achievement. Eurofins TestAmerica consistently ranks above industry-wide proficiency testing norms.

Audits

Eurofins TestAmerica facilities are routinely audited by clients, regulatory authorities and accrediting agencies. It is Eurofins TestAmerica's policy to cooperate fully with all regulatory authorities and other auditing entities. Eurofins TestAmerica makes every effort to provide auditors with access to facilities, personnel, and documentation.

In addition, Eurofins TestAmerica Quality Assurance group conducts an annual internal audit of each laboratory's quality system. All areas of the laboratory are reviewed to ensure that policies and procedures outlined in the Quality Assurance Manual are being implemented. Root cause analyses and corrective actions, if any, are documented just as they would be with an external audit.

Data Management

Eurofins TestAmerica's integrated Laboratory Information Management System (LIMS) links our network of laboratories and creates one single fully searchable, color coded and tabbed PDF report and a client specific electronic data deliverable (EDD), regardless of analysis location, saving review and compilation time, reducing validation costs and preventing transcription errors.

With a portfolio of more than 150 different report formats ranging from level 1 to level 4 reports, and over 1000 EDD formats, Eurofins TestAmerica has a solution for all clients. We employ a technical staff that is dedicated to deliverable development and client consultation, ensuring that electronic data provided to our clients are accurate and formatted to meet the clients' exacting requirements. Two of the critical systems are profiled below.

The data management system enhances coordination among all laboratories' activities by providing automated communication and data transfer.

- Network-wide integrated LIMS supports fully automatic data processing, direct instrument interfacing and fully automated report generation for level 1-4 reports.
- We have created a full suite of direct instrument uploads to eliminate manual data entry. With few exceptions, the majority of Eurofins TestAmerica instrument data is directly ported into the LIMS.
- The LIMS automatically processes all data upon delivery from the instrumentation, reducing and/or eliminating the need for manual interpretation and calculation.
- All of the instrument raw data is ported to and housed in the LIMS for assembly into full data packages, dramatically reducing Level 4/Full Raw Data Package production and assembly time and reducing potential errors.

Our customized LIMS sample tracking ensures samples are processed and reported within project deadlines and EPA holding time requirements.

- Sample logs are customized for optimal use within a department or laboratory group to track holding times and project deadlines.
- Status data is displayed in real time, updating as samples progress from one process to the next, moving the most urgent or critical deadlines to the top of the display.
- Automated QC review tools ensure analytical results are accurate and complete and meet all QC requirements at the time of report or data generation.
- The TALS QC Checker provides a basic electronic QC review of data searching for common QC and data integrity problems encountered in processing final data.
- TotalAccess web portal provides real-time online access to results, documents and job status for clients 365/24/7.

Record Retention & Archival

Eurofins TestAmerica has developed a formal record retention policy in its Corporate Quality Management Plan that outlines the period of time various record types must be archived. Archives are indexed such that records are accessible on either a project or temporal basis. Archives are protected against fire, theft, loss, deterioration and vermin. Electronic records are protected from deterioration caused by magnetic fields and/or electronic deterioration. Access to archives is controlled and documented.

Section 6 Experience

As the industry leading provider of environmental analytical services, comprised of 80 locations nationwide, combining hundreds of years of experience, Eurofins TestAmerica has developed broad based experience in support of a multitude of environmental projects for private and public sector clients alike.

We support thousands upon thousands of commercial and government projects each year, with regulatory oversight by Federal EPA, state environmental agencies and many local government entities. We can provide experience summaries for projects in every category. A few select examples are provided below.

International

Eurofins TestAmerica partners with clients to provide international analytical testing support on six continents. Our international experience includes work on site assessments, property transfers, groundwater monitoring programs, industrial hygiene and drinking water programs for many industries and governmental agencies. Eurofins TestAmerica has provided laboratory support in more than 50 countries worldwide.

Effectively managing international shipments of field supplies and samples, to and from foreign countries and often extremely remote locations, can be a critical factor to the success of an international sampling event. Eurofins TestAmerica provides our clients with all the paperwork necessary to quickly and safely ship samples back to the United States. Our established relationships with multiple international shipping vendors allow us to efficiently facilitate the timely shipment of samples to our laboratory locations.

We also offer Spanish language analytical reports that meet the requirements of regulatory entities throughout the Americas and the Caribbean.

- Eurofins TestAmerica provides analytical services and field support for international consulting firms conducting Phase II site investigations and underground storage tank projects in several Asian countries. Data are produced to meet USEPA, international and country-specific technical and defensibility criteria. Eurofins TestAmerica assists by providing project management, coordinating international sample shipments and provides technical support covering multiple countries, including very remote project locations.
- Eurofins TestAmerica provided lab support to the investigation and remediation of a large closed exploration and production tract in South America for an international oil and gas corporation. An in-country lab was established to facilitate quick turnaround time requirements and assist with sample logistics for samples being returned to the United States. Lab support included full range organics with metals analyses along with level IV deliverables.
- Eurofins TestAmerica provides support to an international environmental consulting company, analyzing samples from various site assessments, investigations and monitoring programs conducted at retail gas stations, terminals and refineries located throughout Latin America, South America and the Caribbean. Analyses of sediment, soil and groundwater typically include Petroleum Hydrocarbons, PAHs, BTEX/MTBE/Ethanol, metals and various Inorganic analyses. Eurofins TestAmerica coordinates international shipment of samples

and sampling supplies to and from the field addressing a variety of country specific requirements and restrictions.

Oil & Gas - Upstream, Midstream, Downstream and Retail

Eurofins TestAmerica provides fast and reliable laboratory testing data to the Oil and Gas industry in all vertical operations including upstream, midstream, downstream and retail. We also offer a broad range of specialty testing programs for source emissions, fenceline monitoring, industrial hygiene monitoring, TENORM, fracking and incident response.

We have provided critical and timely environmental testing services for over 2 million analyses associated with hydraulic fracturing, oil and gas exploration and production. Eurofins TestAmerica is uniquely qualified and committed to providing turnkey support to the Oil and Gas industry.

- Comprehensive environmental testing support
- Easy to use data reports and electronic deliverables
- Courier and logistics services
- Secure access to real-time information via TotalAccess®, Eurofins TestAmerica's 24/7 on line data portal
- Emergency testing programs for small and large incidents.

Upstream

Eurofins TestAmerica's Support for Exploration & Production: Eurofins TestAmerica provides extensive support to the oil and gas exploration sector throughout the United States and abroad. The delivery of quality, reliable data for our clients requires a keen understanding of the impact the exploration and production process has on environmental testing. Potential environmental issues can stem from naturally occurring constituents of concern, chemicals introduced through the drilling process, as well as the high level of dissolved salts and turbidity from formation waters. If not addressed appropriately, these issues can negatively affect data quality.

Eurofins TestAmerica has testing programs for oil and gas exploration and production programs and vast experience with onshore, offshore and fracking operations. We also provide a full suite of TENORM radiochemistry testing services, and emergency testing programs for small and large incidents.

Midstream

Distribution Testing Services at Eurofins TestAmerica: Eurofins TestAmerica provides a full suite of environmental testing capabilities in support of the distribution of crude oil, refined petroleum and other related products. Services are provided for all phases of distribution including the installation of new pipelines, routine monitoring and incident response. Eurofins TestAmerica currently has national contracts in place with many of the largest distribution companies in the United States including those in the following sectors:

- Pipeline transport
- Transloading
- Terminal developers and operators

Eurofins TestAmerica has testing programs for real estate transfers, waste characterization, remediation and air emissions, with support for various states' unique hydrocarbon methods.

Downstream

Eurofins TestAmerica's Comprehensive Support for Refinery Operations: Refinery operators face many environmental compliance challenges. These expansive industrial complexes have compliance programs to monitor the surrounding water, soil, sediment, waste and air.

Eurofins TestAmerica provides testing and logistical support to the nation's largest refineries and to each of the Top 10 Oil and Gas companies in America and abroad. Our comprehensive suite of environmental testing services to the Downstream sector includes discharge monitoring, groundwater monitoring, storm water monitoring, source emissions testing, benzene fenceline monitoring, industrial hygiene testing, ambient air, waste characterization, site investigations and remedial action support. Eurofins TestAmerica provides local logistical support, including sample pickup and testing services, from laboratories and service centers located throughout the United States, and in close proximity to the largest refining states, including Texas, Louisiana, California, Washington, Illinois, Indiana, Pennsylvania and New Jersey.

Program services include easy to read and use reports, electronic deliverables, 24/7 availability of data through TotalAccess®, our on-line web based portal, Spanish language reports and national program management that is coordinated through experienced project management professionals.

Retail

Retail and Distribution and Underground Storage Tank Program Support: Eurofins TestAmerica's suite of environmental testing services include logistics support for sampling kits and sample pickup, a broad array of state hydrocarbon methods, air testing for petroleum vapor intrusion, waste characterization, site investigations and remedial action support.

Power Utilities

Eurofins TestAmerica is uniquely positioned to meet the changing needs of the utility sector and its highly regulated and multifaceted environmental challenges. We provide a full suite of testing services to assist in the management of environmental programs ranging from Subtitle D groundwater support to the restoration of manufactured gas plant (MGP) sites. We also offer specialty services, such as the analysis of flue gas desulfurization (FGD) discharge waters, arsenic speciation, selenium speciation, and Leaching Environmental Assessment Framework (LEAF) methods for the beneficial use of coal combustion residuals (CCR).

Eurofins TestAmerica's capabilities include laboratory support for CCR monitoring, decommissioning, soil and sediment investigations, source emissions monitoring, incident response and ambient air programs. Our national footprint and comprehensive selection of state and federal certifications ensures that Eurofins TestAmerica can provide the service you need for projects both big and small.

Waste Management

Eurofins TestAmerica has more than 25 years of experience supporting the Waste Management Sector and offers a comprehensive suite of analytical options including groundwater and leachate monitoring, landfill gas monitoring, ambient air monitoring and waste characterization.

Our programmatic approach to groundwater and leachate monitoring at waste management facilities allows for cost savings and risk reduction, whilst also reducing the logistical burden on samplers. Our labs are respected for their contributions to landfill gas and ambient air testing through participation in state and federal regulatory work groups and independent organizations. We also support RCRA characteristic testing for ignitability, corrosivity, reactivity and toxicity. Multiple waste characterization methods are available to determine toxicity, including TCLP, SPLP and CA WET methods.

Eurofins TestAmerica offers customers in the Waste Management Sector a single source solution for analytical testing needs.

Chemical

Eurofins TestAmerica offers clients in the chemical industry a comprehensive laboratory program to support all aspects of environmental and personnel monitoring. We have more than 20 years of experience supporting companies that produce and/or use base chemicals, polymers, resins, films, acids, fibers, lubricating oils, adhesives, paints, coatings, flame retardants, explosive compounds, fuels, pesticides, fertilizers and gases.

With certifications in all states offering certification programs, as well as with numerous Federal and private entities, Eurofins TestAmerica offers a single source solution to clients across the nation. Eurofins TestAmerica is committed to providing exceptional client service, high quality data and an unmatched service offering to support your environmental needs.

Services are specifically tailored towards Brownfields, discharge and groundwater monitoring, incident response, industrial hygiene, ambient air and source emissions monitoring.

Manufacturing

Eurofins TestAmerica supports a wide range of companies in the Manufacturing sector with comprehensive laboratory services to support all aspects of environmental and personnel monitoring. We have more than 20 years of experience supporting companies that produce electronics, automobiles and automobile parts, heavy equipment, machinery, glass, steel, aluminum and other metals, ordnance, wood and paper products, cement, gypsum, consumer goods, food and beverages, fragrances, lighting and appliances, manufactured housing, and others.

Eurofins TestAmerica holds certifications in all states offering certification programs as well as with numerous Federal and private entities. We offer a single source solution to clients across the nation. Eurofins TestAmerica is committed to providing exceptional client service, high quality data and an unmatched service offering to support your environmental needs with offerings specifically tailored towards Brownfields, discharge and groundwater monitoring, decommissioning, industrial hygiene, ambient air and source emissions monitoring.

Transportation

Eurofins TestAmerica has supported more than 850 Department of Transportation (DOT) projects in more than 25 states. Services include waste characterization for sample disposal, water quality testing for NPDES, storm water and TMDL programs, soil testing and sediment testing in support of the US Army Corps of Engineers (USACE) and other river, port and harbor programs.

The Fixing America's Surface Transportation Act (FAST), authorized $305 billion over five years for highway, transit and rail programs. It is the first law enacted in over ten years that provides long-term funding certainty for surface transportation. Upon passage of the FAST Act, the DOT quickly awarded funding to States and other grantees. About $40 billion in funds were apportioned to States in January, 2016.

The law also reduced the bureaucratic red tape that can stall and delay transportation projects from moving forward. The FAST Act adopted a number of Administration proposals to speed permitting processes while still protecting the environment.

Eurofins TestAmerica's network of laboratories is certified in every available state in the nation and is positioned to support infrastructure projects throughout the country. Service centers provide sampling kits and convenient sample drop off locations and couriers are available to pick up samples.

Government

Eurofins TestAmerica supports government projects for the Department of Defense, Department of Energy, Environmental Protection Agency, US Geological Survey, Fish and Wildlife, Department of the Interior, Department of Transportation and others on the federal level. We also support projects managed for or by various state, local agencies and municipalities.

Our focus on delivering a consistent, quality product, while also adding value to our customer's operations has made us an ideal partner for clients working in the government sector.

General Service Administration (GSA) Contract

Eurofins TestAmerica Supports Projects at the Federal Level with our GSA Contract: Eurofins TestAmerica supports our Federal Government clients in executing their mission with our GSA Contract GS-07F-5687P for Chemical Testing (SIN 837-2) and Geotechnical Testing (SIN 873-4). This includes projects for the Department of Defense, Department of Energy, Environmental Protection Agency, U.S. Geological Survey, U.S. Fish and Wildlife Services and others.

Department of Defense

Eurofins TestAmerica's Expertise with the Department of Defense: In October, 2009 the Department of Defense (DoD) established the Environmental Laboratory Accreditation Program (ELAP) as the basis for laboratories to demonstrate conformance to various standards as described in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM). To participate in the program, laboratories must seek accreditation and certification with DoD ELAP. Eurofins TestAmerica Savannah was the first laboratory in the nation to be audited and subsequently accredited under the DoD ELAP program.

Currently, Eurofins TestAmerica has 7 labs in its network with DoD ELAP accreditation.



As the nation's premier laboratory network supporting DoD laboratory work, Eurofins TestAmerica has developed a program to meet the needs of nearly every laboratory customer. With strategically located laboratories across the nation, Eurofins TestAmerica's network provides analytical support for all routine DoD laboratory methods and many specialty analytical offerings including ambient air, low-level organics, radiochemistry, dioxins, chemical warfare degradates, PFASs and PCB Congeners. Eurofins TestAmerica's Quality Assurance group continues to conduct in-house DoD compliance assessments in addition to those performed by our DoD Accreditation Bodies (ABs) to ensure the highest level of quality and service available in the industry.

Eurofins TestAmerica actively supported the DOD Environmental Data Quality Workgroup (EDQW) and the Department of Energy (DOE) joint initiative to develop a single quality document referred to as the Department of Defense/ Department of Energy Consolidated Quality Systems Manual (DOD/DOE QSM). Eurofins TestAmerica is directly involved in reviewing and suggesting improvements to all seven modules of the document on an ongoing basis, including the recently released DOD/DOE QSM Version 5.3. Eurofins TestAmerica is accredited to QSM Version 5.1.1, and continues to support historical versions QSM versions 5.0 and 4.2, Eurofins TestAmerica quality systems are in compliance with QSM Version 5.3, and all Eurofins TestAmerica DOD/DOE facilities are scheduled to be audited and accredited to this version by 12/31/19, one year prior to the deadline established by EDQW.

How is Eurofins TestAmerica Helping DoD Customers? Eurofins TestAmerica has provided analytical support to multiple environmental engineering firms managing projects in the Midwest located at a DoD Army Ammunition Arsenal for the past 12 years. Work was performed following the Army Shell document and subsequently graduating to Corp District specific guidelines. Eurofins TestAmerica worked closely with USACE to support the development of this unique program, including providing R&D work to develop soil grinding techniques used in multi-incremental sample processing. Analytical support to date has involved full TCL/TAL Organic and Inorganic parameters, various general chemistry analyses and TCLP analyses as well as explosive and energetic compounds. Report deliverables include Level IV data package and client specific electronic data files.

- **Hill Air** Force **Base**: Since 2011, Eurofins TestAmerica has provided analytical services in support of Hill AFB Base-Wide monitoring for groundwater and remediation systems including the following analytical parameters and methods: VOCs (8260B & TO-15), SVOCs, dissolved gases, pesticides, polychlorinated biphenyls, total petroleum hydrocarbons GRO/DRO, metals, and miscellaneous wet chemistry parameters. Eurofins TestAmerica Denver is following QSM Version 4.2 compliance, as well as the Hill AFB Basewide Project-Specific Work Plan In Support of Basewide Monitoring and Operations and Maintenance, 27 APR 2011, and any updates as they become available for this Dynamic document. The deliverables are provided in a fully validated Level 4 report, as well as three EDDs (ERPIMS 6.1 [ErpToolX], EQuIS, and ADR [ADR.net checker). These deliverables are provided via CD ROM and TotalAccess.

  One of the nuances of the project is the multiple volatile and metals lists required for different areas of the site. Attention to detail is critical when logging samples to ensure that the appropriate list is reported in each case. Eurofins TestAmerica's experience and successful implementation are key to our long term support on this site.
- **Pueblo Chemical Depot**: Eurofins TestAmerica provides analytical services to support long term monitoring efforts at the Pueblo Chemical Depot. DoD QSM protocols are followed. The samples are analyzed for explosives using Method 8321A by LC/MS. All deliverables are provided as full raw data packages in both hard copy and CD ROM formats with CLP-like forms. EDD are submitted in AFCEC's ERPIMS format.

Department of Energy

Twenty Years of Department of Energy Support by Eurofins TestAmerica: Eurofins TestAmerica has been supporting the Department of Energy (DOE) with laboratory support services for nearly two decades. As the nation's largest environmental laboratory network, Eurofins TestAmerica offers the DOE and its contractors an unmatched portfolio of services including chemical, physical and radiochemical analyses on a variety of different matrices including soil, sediment, sludge, groundwater, surface water, waste matrices and building materials such as wood, concrete, metals, and painted materials.

Each of the laboratories listed below participate in the DOE's Consolidated Audit Program (DOECAP). The DOECAP program was developed to improve the quality of environmental data produced at commercial laboratories supporting DOE sites, while also offering DOE Program Managers the confidence they need to ensure that data is both high-quality and legally defensible. Of the laboratories listed below, Eurofins TestAmerica St. Louis provides radiochemistry services and holds comprehensive radioactive materials licenses.

Laboratory
Eurofins TestAmerica St. Louis
Eurofins TestAmerica Denver
Eurofins TestAmerica Knoxville
Eurofins TestAmerica Sacramento

As noted above, Eurofins TestAmerica actively supported the DOD Environmental Data Quality Workgroup (EDQW) and the Department of Energy (DOE) joint initiative to develop a single quality document referred to as the Department of Defense/ Department of Energy Consolidated Quality Systems Manual (DOD/DOE QSM). Eurofins TestAmerica is accredited to QSM Version 5.1.1, and continues to support historical versions QSM versions 5.0 and 4.2. Eurofins

TestAmerica quality systems are in compliance with QSM Version 5.3, and all Eurofins TestAmerica DOD/DOE facilities are scheduled to be audited and accredited to this version by 12/31/19, one year prior to the deadline established by EDQW.

Eurofins TestAmerica DOE Project Experience: Eurofins TestAmerica participates in many studies conducted in and around Department of Energy plants located in Oak Ridge, TN and Kansas City, MO. Concerns over PCB levels contained in native fish tissues resulted in the establishment of several biomonitoring studies. Eurofins TestAmerica began supporting the projects during the 2006 monitoring event analyzing more than 300 fish and clams over the last three years for PCB aroclors by SW 8082 and for PCB congeners by 1668A. Dragonflies were also analyzed for PCB congeners by 1668A.

Environmental Protection Agency

Eurofins TestAmerica's Support for EPA Projects: Eurofins TestAmerica and its legacy companies have supported the EPA for more than three decades, providing laboratory support for various programs, projects and emergency situations. Pairing an industry leading portfolio of analyses with our nationally recognized quality assurance program, Eurofins TestAmerica is the premier commercial laboratory network to support EPA work.

Eurofins TestAmerica currently supports organic and inorganic methods using the current USEPA Contract Laboratory Program (CLP) Statements of Work. Eurofins TestAmerica's laboratories offer fully compliant deliverables, including reports and EDDs to meet the specifics in the Statements of Work.

EPA's Brownfields Program was designed to empower stakeholders to come together and work towards the common goal of redeveloping and reusing parcels of land that were once used for industrial or commercial purposes. Eurofins TestAmerica has over 20 years' experience providing analytical testing services for soil, water, air, waste, building debris and sediment samples in support of Brownfields redevelopment and cleanups. Our approach to Brownfields support blends high quality analytical techniques with personalized project management support to create unique and cost effective solutions for your environmental testing needs.

Eurofins TestAmerica's EPA Experience: Eurofins TestAmerica provides services at a former chrome plating shop located in California, working cooperatively with a global environmental engineering firm under an EPA Brownfields grant. Hundreds of soil and groundwater samples have been analyzed to date for VOCs, metals, and hexavalent chromium, often requiring final results within 24 hours of sample receipt at the lab.

Eurofins TestAmerica provides analytical services and field support for international consulting firms conducting Phase II site investigations and underground storage tank projects in several Asian countries. Data are produced to meet EPA, international and country-specific technical and defensibility criteria. Eurofins TestAmerica assists by providing project management, coordinating international sample shipments and provides technical support covering multiple countries, including very remote project locations.

Specialty Analyses

- **PFCs:** Eurofins TestAmerica has been supporting the analysis of PFAS compounds since 2000. The method capability was originally developed based on a client's request that we utilize our LC/MS/MS technology to analyze for PFOA and PFOS. Eurofins TestAmerica's role was to provide that client and others with a commercial supplier of high quality analytical services outside of universities and internal laboratories. In the years since, we have added to our list of PFAS compounds and increasingly worked to lower detection limits as federal and state regulatory programs continue to evolve. Users of analytical results for PFAS recognize that a high level of technical expertise and experience is necessary due to the complexity of LC/MS/MS instrumentation, the challenging nature of many sample matrices, and the potential for laboratory and sampling artifacts generated by the ubiquitous presence of PFAS in the field and laboratory environment.

  Eurofins TestAmerica has developed the necessary expertise over these many years of application, and now supports PFAS analyses in drinking water, groundwater, soil, tissue, and product matrices. Thirty-six PFAS compounds are routinely supported, and the list continues to expand as regulatory requirements continue to evolve. While there are some differences in lists and limits based on regional requirements, Eurofins TestAmerica is supporting PFAS analyses in three labs (Sacramento, Denver and Burlington) located in three different time zones, ensuring that capacity and technical support are available for clients from coast to coast. Our integrated LIMS systems and organization facilitate constant collaboration within the labs supporting the practice.

  Method research is ongoing in this complex area. Eurofins TestAmerica has partnered with the New York State DEC and DOH to develop automated in-line SPE techniques for method 537, in order to improve the performance of the conventional off-line SPE technique. Eurofins TestAmerica has also developed the Total Oxidizable Precursor (TOP) Assay, a technique that will allow our clients to more accurately measure their PFAS risk from precursors. Under NYSDEC contract, Eurofins TestAmerica supports analysis of Perfluorinated Compounds (PFCs) that were suspected of being present in the drinking water supplies of residents in the Hoosick Falls, NY area. Logistic support provided by Eurofins TestAmerica's Albany, NY Service Center includes daily pick-up of samples and drop off of coolers and containers at the command center. Over 3500 samples were analyzed for the 6 PFCs listed under UCMR3.

- **Sediments**: Eurofins TestAmerica has provided analytical support for many dredge material management projects for the Baltimore, Norfolk, Mobile and Savannah Corps of Engineers Districts for the past 13 years. The projects require analyses via SW846 methods of sediment, site water, elutriate as defined by the USEPA/USACE Dredged Material Guidance documents as well as Regional Implementation Manuals following project specific QAPjPs.

  Many of the projects required elutriate generation, including modified, effluent and standard, depending on the potential placement of the dredged material. Our support also included the analysis of both clam and worm tissue in support of the sediment bioaccumulation testing, which was required for some of the testing programs.

  The various testing scopes have involved extensive suites of analyses including low level semi-volatiles, low level organo-chlorine pesticides, PCB congeners, dioxins, TOC (Lloyd Kahn), organo-phosphorus pesticides, cyanide, sulfide, ammonia, metals, mercury, total nitrogen (Kjeldahl), total phosphorus and organotins.

Several projects required specialized tests as defined in the USACE Upland Testing Manual which included Simplified Laboratory Runoff Procedure [SLRP] and the Sequential Batch Leachate Test [SBLT].

Eurofins TestAmerica contributes to the ongoing success of these projects by providing high quality analytical results plus extensive technical support and weekly conference calls during project active times to assure that project goals are met in a timely manner.

Managed out of Eurofins TestAmerica's Pittsburgh laboratory, four Eurofins TestAmerica labs are involved in supporting the program. Our integrated LIMS supports a single Level 4 data package containing all labs' data, along with a custom EDD.

Incident and Emergency Response

As the nation's leading environmental laboratory network, Eurofins TestAmerica has been at the forefront in providing routine and specialized environmental testing in support of incident responses.

Timely and accurate environmental chemistry data is critical in assessing the potential impact of unintended releases of chemicals into the environment. We partner with our clients to provide a single environmental testing source for responses ranging from small, local releases to incidents of national significance. To download our brochure on Eurofins TestAmerica's Emergency/Incident Response Program, please click here.

History of our Emergency Response Support

Over the past two decades, Eurofins TestAmerica built systems, structures and capacity based on lessons learned from some of the most urgent incident responses including:

- 9/11 Ground Zero response
- Space Shuttle accident response
- UPS anthrax scare response
- MC 252 response at the Houma Command Center
- Marshall Michigan pipeline oil release
- Animas River Mine Release
- Flint Michigan lead in pipes investigation
- 16+years of train derailment responses, nationwide and from coast to coast

How Can Eurofins TestAmerica Help You?

Eurofins TestAmerica's Incident Response Program offers clients an engaged partnership with the benefits of scalable, flexible, and adaptable environmental testing support that includes:

- Scalable testing support, flexibility in service offerings, and adaptability to evolving requirements.
- 24/7/365 access to TestAmerica's Response Team.
- 80 strategically located facilities nationwide to provide logistical support.

- A dedicated TestAmerica single point of contact for detailed coordination, planning and data delivery
- Comprehensive environmental testing services for water, soil, sediment and air with unmatched capacity for rush turnaround support
- Real-time online data access and EDD delivery via TotalAccess® to assist in the decision making process
- Certifications/accreditations in all available states for a wide variety of programs.
- Comprehensive service offerings for tiered responses.

    - Fixed based laboratory services
    - Sample management office
    - On-site/mobile laboratories
    - Dedicated Project Manager for detailed coordination and planning
    - Support staff and technical experts
    - Online reports, data access and EDD delivery via TotalAccess®.

Railroad Incident Response Case Study

Situation Overview

A derailment caused rail cars to go off the tracks in a remote location. The rail cars caught fire and slid into a river with a chemical reportedly leaking from some of the cars. The railroad company set up a response team to monitor the river for the presence of the chemical of concern and started a restoration and remediation plan to minimize the environmental impact. Throughout the incident, the client needed environmental testing data immediately. Eurofins TestAmerica's experienced incident response team worked with field contractors to minimize the potential impact to human health and the environment.

Eurofins TestAmerica's Solution

Eurofins TestAmerica received an incident response call at 2:00 PM the day after the derailment and immediately mobilized to pick up samples that evening from a rural location. In just 10 hours, Eurofins TestAmerica validated a modification to an EPA method for the compound of concern because it was not a part of the established EPA Method. Lab personnel worked around the clock, 24/7, for ten consecutive days reporting time-critical data. On many days, the lab received as many as 100 samples and reported data on a same day basis.

Situation Result

A railroad's mission is to conduct operations safely, ensure environmental responsibility and leave a positive legacy. When an incident occurs, timely and accurate environmental chemistry data is critical in helping to assess the potential impact of an unintended release of chemicals in to the environment. Eurofins TestAmerica's partnership with the railroad company provided a single environmental testing source for the incident response. Having a single source for all environmental testing data provided the client and their incident response team with the timely information they needed to make critical decisions to protect the environment.

Affiliated Business

Eurofins EMLab P&K



Eurofins EMLab P&K is the leading indoor air quality (IAQ) testing laboratory in North America, specializing in lab analysis of air and surface samples for mold, fungi, bacteria, asbestos and allergens with more accredited locations and analysts than any other lab in the nation. Eurofins EMLab P&K is committed to providing outstanding service, quality and support to industrial hygienists, laboratories, state and local public health departments, hospitals and IAQ professionals.

OREGON

Environmental Laboratory Accreditation Program

TestAmerica Canton

4062

4101 Shuffel Street NW

North Canton, OH 44720

NELAP Recognized

IS GRANTED APPROVAL BY ORELAP UNDER THE 2009 TNI STANDARDS, TO PERFORM ANALYSES ON ENVIRONMENTAL SAMPLES IN MATRICES AS LISTED BELOW :

Air	*Drinking Water*	*Non Potable Water*	*Solids and Chem. Waste*	*Tissue*
		Chemistry	Chemistry	

AND AS RECORDED IN THE LIST OF APPROVED ANALYTES, METHODS, ANALYTICAL TECHNIQUES, AND FIELDS OF TESTING ISSUED CONCURRENTLY WITH THIS CERTIFICATE AND REVISED AS NECESSARY.

ACCREDITED STATUS DEPENDS ON SUCCESSFUL ONGOING PARTICIPATION IN THE PROGRAM AND CONTINUED COMPLIANCE WITH THE STANDARDS.

CUSTOMERS ARE URGED TO VERIFY THE LABORATORY'S CURRENT ACCREDITATION STATUS IN OREGON.

Alia D. Servin, Ph.D.
Oregon State Public Health Laboratory
ORELAP Program Manager
7202 NE Evergreen Parkway, Suite 100
Hillsboro, OR 97124

EFFECTIVE DATE : 02/24/2019

EXPIRATION DATE : 02/23/2020

Certificate No : 4062 - 008

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

TestAmerica Canton
4101 Shuffel Street NW
North Canton, OH 44720

EPA CODE: OH00048
Certificate: 4062 - 008

Issue Date: 2/24/2019 Expiration Date: 2/23/2020

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MATRIX	Reference	Code	Analyte	Code	Description
Non-Potable Water					
	ASTM D3987-06			30030708	Shake Extraction of Solid Waste with Water
		8031	Extraction/Preparation		
	EPA 120.1			10006209	Conductance - Specific @ 25 C
		1610	Conductivity		
	EPA 1311			10118806	Toxicity Characteristic Leaching Procedure
		8031	Extraction/Preparation		
	EPA 1312			10119003	Synthetic Precipitation Leaching Procedure
		8031	Extraction/Preparation		
	EPA 1630			10122608	Methyl Mercury by Purge & Trap Cold Vapor Atomic Fluorescence Spectrometry
		1205	Methyl Mercury		
	EPA 1631E			10237204	Mercury in Water by Oxidation, Purge & Trap, and Cold Vapor Atomic Fluorescence
		1095	Mercury		
	EPA 1664A (HEM)			10127807	N-Hexane Extractable Material (Oil and Grease) by Extraction and Gravimetry
		1803	n-Hexane Extractable Material (O&G)		
	EPA 1664A (SGT-HEM)			10261606	Silica Gen Treated N-Hexane Extractable Material (Oil and Grease)
		2050	Total Petroleum Hydrocarbons (TPH)		
	EPA 1664B			10261617	N-Hexane Extractable Material (Oil and Grease) by Extraction and Gravimetry
		6143	Hexane Extractable Material (HEM)		
	EPA 1664B (SGT-HEM)			10260628	Silica Gel Treated n-Hexane Extractable Material (Oil & Grease)
		2050	Total Petroleum Hydrocarbons (TPH)		
	EPA 180.1			10011402	Turbidity - Nephelometric
		2055	Turbidity		
	EPA 200.7 4.4			10013806	ICP - metals
		1000	Aluminum		
		1005	Antimony		
		1010	Arsenic		
		1015	Barium		
		1020	Beryllium		
		1025	Boron		
		1030	Cadmium		
		1035	Calcium		

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Non-Potable Water	EPA 200.7 4.4	1040	Chromium	
		1050	Cobalt	
		1055	Copper	
		1070	Iron	
		1075	Lead	
		1080	Lithium	
		1085	Magnesium	
		1090	Manganese	
		1100	Molybdenum	
		1105	Nickel	
		1125	Potassium	
		1140	Selenium	
		1990	Silica as SiO2	
		1145	Silicon	
		1150	Silver	
		1155	Sodium	
		1160	Strontium	
		1165	Thallium	
		1175	Tin	
		1180	Titanium	
		1185	Vanadium	
		1190	Zinc	
	EPA 200.8			10014401 ICP/MS - metals
		1000	Aluminum	
		1005	Antimony	
		1010	Arsenic	
		1015	Barium	
		1020	Beryllium	
		1025	Boron	
		1030	Cadmium	
		1035	Calcium	
		1040	Chromium	
		1050	Cobalt	
		1055	Copper	
		1070	Iron	
		1075	Lead	
		1080	Lithium	
		1085	Magnesium	
		1090	Manganese	
		1100	Molybdenum	
		1105	Nickel	
		1125	Potassium	
		1140	Selenium	

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Non-Potable Water

EPA 200.8	1150	Silver		
	1155	Sodium		
	1160	Strontium		
	1165	Thallium		
	1175	Tin		
	1180	Titanium		
	1185	Vanadium		
	1190	Zinc		
EPA 245.1			10036201	Mercury by Cold Vapor Atomic Absorption
	1095	Mercury		
EPA 300.0			10053006	Ion chromatography - anions.
	1540	Bromide		
	1575	Chloride		
	1730	Fluoride		
	1810	Nitrate as N		
	1840	Nitrite as N		
	2000	Sulfate		
EPA 3005A			10133207	Acid Digestion of waters for Total Recoverable or Dissolved Metals
	8031	Extraction/Preparation		
EPA 3010A			10133605	Acid Digestion of Aqueous samples and Extracts for Total Metals
	8031	Extraction/Preparation		
EPA 335.4			10061208	Methods for the Determination of Inorganic Substances in Environmental Samples
	1645	Total cyanide		
EPA 3510C			10138202	Separatory Funnel Liquid-liquid extraction
	8031	Extraction/Preparation		
EPA 3520C			10139001	Continuous Liquid-liquid extraction
	8031	Extraction/Preparation		
EPA 353.2			10067206	Nitrate/Nitrite Nitrogen - Automated, Cadmium
	1820	Nitrate-nitrite		
EPA 3620B			10145809	Florisil Cleanup
	8031	Extraction/Preparation		
EPA 3630C			10146802	Silica gel cleanup
	8031	Extraction/Preparation		
EPA 365.3			10070607	Phosphorous - Colorimetric, two reagent.
	1870	Orthophosphate as P		
	1908	Total Phosphate		

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EPA 3650B			10147805	Acid base partition cleanup
	8031	Extraction/Preparation		
EPA 3660B			10148400	Sulfur cleanup
	8031	Extraction/Preparation		
EPA 3665A			10148808	Sulfuric Acid / permanganate Cleanup
	8031	Extraction/Preparation		
EPA 410.4			10077006	Chemical Oxygen Demand - Colorimetric, Automated.
	1565	Chemical oxygen demand		
EPA 420.1			10079206	Phenolics - Spectrophotometric, manual.
	1905	Total phenolics		
EPA 5030B			10153409	Purge and trap for aqueous samples
	8031	Extraction/Preparation		
EPA 5030C			10284603	Purge-and-Trap for Aqueous Samples
	8031	Extraction/Preparation		
EPA 6010B			10155609	ICP - AES
	1000	Aluminum		
	1005	Antimony		
	1010	Arsenic		
	1015	Barium		
	1020	Beryllium		
	1025	Boron		
	1030	Cadmium		
	1035	Calcium		
	1040	Chromium		
	1050	Cobalt		
	1055	Copper		
	1070	Iron		
	1075	Lead		
	1080	Lithium		
	1085	Magnesium		
	1090	Manganese		
	1100	Molybdenum		
	1105	Nickel		
	1125	Potassium		
	1140	Selenium		
	1990	Silica as SiO2		
	1145	Silicon		
	1150	Silver		
	1155	Sodium		
	1160	Strontium		

Non-Potable Water

EPA 6010B	1165	Thallium		
	1175	Tin		
	1180	Titanium		
	1185	Vanadium		
	1190	Zinc		
EPA 6010C 3			10155905	Inductively Coupled Plasma - Atomic Emission Spectrometry
	1000	Aluminum		
	1005	Antimony		
	1010	Arsenic		
	1015	Barium		
	1020	Beryllium		
	1025	Boron		
	1030	Cadmium		
	1035	Calcium		
	1040	Chromium		
	1050	Cobalt		
	1055	Copper		
	1070	Iron		
	1075	Lead		
	1080	Lithium		
	1085	Magnesium		
	1090	Manganese		
	1100	Molybdenum		
	1105	Nickel		
	1125	Potassium		
	1140	Selenium		
	1990	Silica as SiO2		
	1145	Silicon		
	1150	Silver		
	1155	Sodium		
	1160	Strontium		
	1165	Thallium		
	1175	Tin		
	1180	Titanium		
	1185	Vanadium		
	1190	Zinc		
EPA 6010D 4			10155916	Metals by ICP - AES
	1000	Aluminum		
	1005	Antimony		
	1010	Arsenic		
	1015	Barium		
	1020	Beryllium		

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EPA 6010D 4			
	1025	Boron	
	1030	Cadmium	
	1035	Calcium	
	1040	Chromium	
	1050	Cobalt	
	1055	Copper	
	1070	Iron	
	1075	Lead	
	1080	Lithium	
	1085	Magnesium	
	1090	Manganese	
	1100	Molybdenum	
	1105	Nickel	
	1125	Potassium	
	1140	Selenium	
	1990	Silica as SiO2	
	1145	Silicon	
	1150	Silver	
	1155	Sodium	
	1160	Strontium	
	1165	Thallium	
	1175	Tin	
	1180	Titanium	
	1185	Vanadium	
	1190	Zinc	
EPA 6020		10156000	Inductively Coupled Plasma-Mass Spectrometry
	1000	Aluminum	
	1005	Antimony	
	1010	Arsenic	
	1015	Barium	
	1020	Beryllium	
	1025	Boron	
	1030	Cadmium	
	1035	Calcium	
	1040	Chromium	
	1050	Cobalt	
	1055	Copper	
	1070	Iron	
	1075	Lead	
	1080	Lithium	
	1085	Magnesium	
	1090	Manganese	
	1100	Molybdenum	

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Non-Potable Water

EPA 6020	1105	Nickel		
	1125	Potassium		
	1140	Selenium		
	1150	Silver		
	1155	Sodium		
	1160	Strontium		
	1165	Thallium		
	1175	Tin		
	1180	Titanium		
	1185	Vanadium		
	1190	Zinc		
EPA 6020A 1			10156419	Inductively Coupled Plasma -Mass Spectrometry
	1000	Aluminum		
	1005	Antimony		
	1010	Arsenic		
	1015	Barium		
	1020	Beryllium		
	1025	Boron		
	1030	Cadmium		
	1035	Calcium		
	1040	Chromium		
	1050	Cobalt		
	1055	Copper		
	1070	Iron		
	1075	Lead		
	1080	Lithium		
	1085	Magnesium		
	1090	Manganese		
	1100	Molybdenum		
	1105	Nickel		
	1125	Potassium		
	1140	Selenium		
	1150	Silver		
	1155	Sodium		
	1160	Strontium		
	1165	Thallium		
	1175	Tin		
	1180	Titanium		
	1185	Vanadium		
	1190	Zinc		
EPA 6020B 2			10156420	Inductively Coupled Plasma-Mass Spectrometry
	1000	Aluminum		

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EPA 6020B 2	1005	Antimony	
	1010	Arsenic	
	1015	Barium	
	1020	Beryllium	
	1025	Boron	
	1030	Cadmium	
	1035	Calcium	
	1040	Chromium	
	1050	Cobalt	
	1055	Copper	
	1070	Iron	
	1075	Lead	
	1080	Lithium	
	1085	Magnesium	
	1090	Manganese	
	1100	Molybdenum	
	1105	Nickel	
	1125	Potassium	
	1140	Selenium	
	1150	Silver	
	1155	Sodium	
	1160	Strontium	
	1165	Thallium	
	1175	Tin	
	1180	Titanium	
	1185	Vanadium	
	1190	Zinc	
EPA 608			10103603 Organochlorine Pesticides & PCBs by GC/ECD
	7355	4,4'-DDD	
	7360	4,4'-DDE	
	7365	4,4'-DDT	
	7025	Aldrin	
	7110	alpha-BHC (alpha-Hexachlorocyclohexane)	
	8880	Aroclor-1016 (PCB-1016)	
	8885	Aroclor-1221 (PCB-1221)	
	8890	Aroclor-1232 (PCB-1232)	
	8895	Aroclor-1242 (PCB-1242)	
	8900	Aroclor-1248 (PCB-1248)	
	8905	Aroclor-1254 (PCB-1254)	
	8910	Aroclor-1260 (PCB-1260)	
	8912	Aroclor-1262 (PCB-1262)	
	8913	Aroclor-1268 (PCB-1268)	

Non-Potable Water	EPA 608			
		7115	beta-BHC (beta-Hexachlorocyclohexane)	
		7250	Chlordane (tech.)	
		7240	cis-chlordane (alpha-Chlordane)	
		7105	delta-BHC	
		7470	Dieldrin	
		7510	Endosulfan I	
		7515	Endosulfan II	
		7520	Endosulfan sulfate	
		7540	Endrin	
		7530	Endrin aldehyde	
		7535	Endrin ketone	
		7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)	
		7685	Heptachlor	
		7690	Heptachlor epoxide	
		6275	Hexachlorobenzene	
		7725	Isodrin	
		7740	Kepone	
		7810	Methoxychlor	
		7870	Mirex	
		8250	Toxaphene (Chlorinated camphene)	
		7245	trans-chlordane (gamma-Chlordane)	
	EPA 608.3 GC-ECD			10296614 Organochlorine Pesticides and PCBs by GC/ECD
		7355	4,4'-DDD	
		7360	4,4'-DDE	
		7365	4,4'-DDT	
		7025	Aldrin	
		7110	alpha-BHC (alpha-Hexachlorocyclohexane)	
		8880	Aroclor-1016 (PCB-1016)	
		8885	Aroclor-1221 (PCB-1221)	
		8890	Aroclor-1232 (PCB-1232)	
		8895	Aroclor-1242 (PCB-1242)	
		8900	Aroclor-1248 (PCB-1248)	
		8905	Aroclor-1254 (PCB-1254)	
		8910	Aroclor-1260 (PCB-1260)	
		8912	Aroclor-1262 (PCB-1262)	
		8913	Aroclor-1268 (PCB-1268)	
		7115	beta-BHC (beta-Hexachlorocyclohexane)	
		7250	Chlordane (tech.)	
		7240	cis-chlordane (alpha-Chlordane)	
		7105	delta-BHC	

Non-Potable Water	EPA 608.3 GC-ECD	7405	Diallate	
		7470	Dieldrin	
		7510	Endosulfan I	
		7515	Endosulfan II	
		7520	Endosulfan sulfate	
		7540	Endrin	
		7530	Endrin aldehyde	
		7535	Endrin ketone	
		7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)	
		7685	Heptachlor	
		7690	Heptachlor epoxide	
		6275	Hexachlorobenzene	
		7725	Isodrin	
		7740	Kepone	
		7810	Methoxychlor	
		7870	Mirex	
		8250	Toxaphene (Chlorinated camphene)	
		7245	trans-chlordane (gamma-Chlordane)	
	EPA 624			10107207 Volatile Organic Compounds by purge and trap GC/MS
		5105	1,1,1,2-Tetrachloroethane	
		5160	1,1,1-Trichloroethane	
		5110	1,1,2,2-Tetrachloroethane	
		5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	
		5165	1,1,2-Trichloroethane	
		4630	1,1-Dichloroethane	
		4640	1,1-Dichloroethylene	
		4670	1,1-Dichloropropene	
		5150	1,2,3-Trichlorobenzene	
		5180	1,2,3-Trichloropropane	
		5155	1,2,4-Trichlorobenzene	
		5210	1,2,4-Trimethylbenzene	
		4570	1,2-Dibromo-3-chloropropane (DBCP)	
		4585	1,2-Dibromoethane (EDB, Ethylene dibromide)	
		4610	1,2-Dichlorobenzene	
		4635	1,2-Dichloroethane (Ethylene dichloride)	
		4655	1,2-Dichloropropane	
		5215	1,3,5-Trimethylbenzene	
		4615	1,3-Dichlorobenzene	
		4660	1,3-Dichloropropane	
		4675	1,3-Dichloropropene	
		4620	1,4-Dichlorobenzene	

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

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Non-Potable Water

EPA 624

4665	2,2-Dichloropropane
4410	2-Butanone (Methyl ethyl ketone, MEK)
4500	2-Chloroethyl vinyl ether
4535	2-Chlorotoluene
4860	2-Hexanone (MBK)
4540	4-Chlorotoluene
4910	4-Isopropyltoluene (p-Cymene)
4995	4-Methyl-2-pentanone (MIBK)
4315	Acetone
4325	Acrolein (Propenal)
4340	Acrylonitrile
4355	Allyl chloride (3-Chloropropene)
4375	Benzene
4385	Bromobenzene
4390	Bromochloromethane
4395	Bromodichloromethane
4400	Bromoform
4450	Carbon disulfide
4455	Carbon tetrachloride
4475	Chlorobenzene
4575	Chlorodibromomethane
4485	Chloroethane (Ethyl chloride)
4505	Chloroform
4705	cis & trans-1,2-Dichloroethene
4645	cis-1,2-Dichloroethylene
4680	cis-1,3-Dichloropropene
4555	Cyclohexane
4595	Dibromomethane (Methylene bromide)
4625	Dichlorodifluoromethane (Freon-12)
4627	Dichlorofluoromethane (Freon 21)
4725	Diethyl ether
4755	Ethyl acetate
4810	Ethyl methacrylate
4765	Ethylbenzene
4835	Hexachlorobutadiene
4870	Iodomethane (Methyl iodide)
4875	Isobutyl alcohol (2-Methyl-1-propanol)
4900	Isopropylbenzene (Cumene)
5240	m+p-xylene
4940	Methyl acetate
4950	Methyl bromide (Bromomethane)
4960	Methyl chloride (Chloromethane)
4990	Methyl methacrylate

Non-Potable Water

EPA 624	5000	Methyl tert-butyl ether (MTBE)	
	4965	Methylcyclohexane	
	4975	Methylene chloride (Dichloromethane)	
	5245	m-Xylene	
	5005	Naphthalene	
	4435	n-Butylbenzene	
	4855	n-Hexane	
	5090	n-Propylbenzene	
	5250	o-Xylene	
	5080	Propionitrile (Ethyl cyanide)	
	5255	p-Xylene	
	4440	sec-Butylbenzene	
	5100	Styrene	
	4420	tert-Butyl alcohol	
	4445	tert-Butylbenzene	
	5115	Tetrachloroethylene (Perchloroethylene)	
	5120	Tetrahydrofuran (THF)	
	5140	Toluene	
	4700	trans-1,2-Dichloroethylene	
	4685	trans-1,3-Dichloropropylene	
	4605	trans-1,4-Dichloro-2-butene	
	5170	Trichloroethene (Trichloroethylene)	
	5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)	
	5225	Vinyl acetate	
	5235	Vinyl chloride	
	5260	Xylene (total)	
EPA 624.1			10298121 Purgeables by GC/MS
	5105	1,1,1,2-Tetrachloroethane	
	5160	1,1,1-Trichloroethane	
	5110	1,1,2,2-Tetrachloroethane	
	5185	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	
	5165	1,1,2-Trichloroethane	
	4630	1,1-Dichloroethane	
	4640	1,1-Dichloroethylene	
	4670	1,1-Dichloropropene	
	5150	1,2,3-Trichlorobenzene	
	5180	1,2,3-Trichloropropane	
	5182	1,2,3-Trimethylbenzene	
	5155	1,2,4-Trichlorobenzene	
	5210	1,2,4-Trimethylbenzene	
	4570	1,2-Dibromo-3-chloropropane (DBCP)	

Non-Potable Water	EPA 624.1	4585	1,2-Dibromoethane (EDB, Ethylene dibromide)
		4610	1,2-Dichlorobenzene
		4635	1,2-Dichloroethane (Ethylene dichloride)
		4655	1,2-Dichloropropane
		5215	1,3,5-Trimethylbenzene
		9318	1,3-Butadiene
		4615	1,3-Dichlorobenzene
		4660	1,3-Dichloropropane
		4675	1,3-Dichloropropene
		4620	1,4-Dichlorobenzene
		4665	2,2-Dichloropropane
		4410	2-Butanone (Methyl ethyl ketone, MEK)
		4500	2-Chloroethyl vinyl ether
		4535	2-Chlorotoluene
		4860	2-Hexanone (MBK)
		5020	2-Nitropropane
		4540	4-Chlorotoluene
		4910	4-Isopropyltoluene (p-Cymene)
		4995	4-Methyl-2-pentanone (MIBK)
		4315	Acetone
		4320	Acetonitrile
		4325	Acrolein (Propenal)
		4340	Acrylonitrile
		4355	Allyl chloride (3-Chloropropene)
		4375	Benzene
		5635	Benzyl chloride
		4385	Bromobenzene
		4390	Bromochloromethane
		4395	Bromodichloromethane
		4400	Bromoform
		4450	Carbon disulfide
		4455	Carbon tetrachloride
		4475	Chlorobenzene
		4575	Chlorodibromomethane
		4485	Chloroethane (Ethyl chloride)
		4505	Chloroform
		4525	Chloroprene (2-Chloro-1,3-butadiene)
		4705	cis & trans-1,2-Dichloroethene
		4645	cis-1,2-Dichloroethylene
		4680	cis-1,3-Dichloropropene
		4555	Cyclohexane
		4560	Cyclohexanone
		4595	Dibromomethane (Methylene bromide)

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

TestAmerica Canton

EPA CODE: OH00048

4101 Shuffel Street NW

Certificate: 4062 - 008

North Canton, OH 44720 Issue Date: 2/24/2019 Expiration Date: 2/23/2020

As of 2/24/2019 this list supersedes all previous lists for this certificate number.

Non-Potable Water	EPA 624.1	4625	Dichlorodifluoromethane (Freon-12)
		4627	Dichlorofluoromethane (Freon 21)
		4725	Diethyl ether
		9375	Di-isopropylether (DIPE)
		4755	Ethyl acetate
		4810	Ethyl methacrylate
		4765	Ethylbenzene
		4770	Ethyl-t-butylether (ETBE) (2-Ethoxy-2-methylpropane)
		4835	Hexachlorobutadiene
		4870	Iodomethane (Methyl iodide)
		4875	Isobutyl alcohol (2-Methyl-1-propanol)
		4900	Isopropylbenzene (Cumene)
		5240	m+p-xylene
		4925	Methacrylonitrile
		4940	Methyl acetate
		4950	Methyl bromide (Bromomethane)
		4960	Methyl chloride (Chloromethane)
		4990	Methyl methacrylate
		5000	Methyl tert-butyl ether (MTBE)
		4965	Methylcyclohexane
		4975	Methylene chloride (Dichloromethane)
		5245	m-Xylene
		5005	Naphthalene
		4425	n-Butyl alcohol (1-Butanol, n-Butanol)
		4435	n-Butylbenzene
		4855	n-Hexane
		5090	n-Propylbenzene
		5250	o-Xylene
		5080	Propionitrile (Ethyl cyanide)
		5255	p-Xylene
		4440	sec-Butylbenzene
		5100	Styrene
		4370	T-amylmethylether (TAME)
		4420	tert-Butyl alcohol
		4445	tert-Butylbenzene
		5115	Tetrachloroethylene (Perchloroethylene)
		5120	Tetrahydrofuran (THF)
		5140	Toluene
		4700	trans-1,2-Dichloroethylene
		4685	trans-1,3-Dichloropropylene
		4605	trans-1,4-Dichloro-2-butene
		5170	Trichloroethene (Trichloroethylene)

Non-Potable Water

EPA 624.1	5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)	
	5225	Vinyl acetate	
	5235	Vinyl chloride	
	5260	Xylene (total)	
EPA 625			10300002 Base/Neutrals and Acids by GC/MS
	6703	1,1'-Biphenyl (BZ-0)	
	6705	1,2,3,4-Tetrachlorobenzene	
	5150	1,2,3-Trichlorobenzene	
	6715	1,2,4,5-Tetrachlorobenzene	
	5155	1,2,4-Trichlorobenzene	
	4610	1,2-Dichlorobenzene	
	6221	1,2-Diphenylhydrazine	
	4615	1,3-Dichlorobenzene	
	4620	1,4-Dichlorobenzene	
	4735	1,4-Dioxane (1,4- Diethyleneoxide)	
	5790	1-Chloronaphthalene	
	4	1-Methyl-2-pyrrlidinone	
	4659	2,2-Oxybis(1-chloropropane)	
	6835	2,4,5-Trichlorophenol	
	6840	2,4,6-Trichlorophenol	
	6000	2,4-Dichlorophenol	
	6130	2,4-Dimethylphenol	
	6175	2,4-Dinitrophenol	
	6185	2,4-Dinitrotoluene (2,4-DNT)	
	6005	2,6-Dichlorophenol	
	6190	2,6-Dinitrotoluene (2,6-DNT)	
	5795	2-Chloronaphthalene	
	5800	2-Chlorophenol	
	6360	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2-methylphenol)	
	5145	2-Methylaniline (o-Toluidine)	
	6385	2-Methylnaphthalene	
	6400	2-Methylphenol (o-Cresol)	
	6460	2-Nitroaniline	
	6490	2-Nitrophenol	
	6412	3 & 4 Methylphenol	
	5945	3,3'-Dichlorobenzidine	
	6465	3-Nitroaniline	
	5660	4-Bromophenyl phenyl ether (BDE-3)	
	5700	4-Chloro-3-methylphenol	
	5745	4-Chloroaniline	
	5825	4-Chlorophenyl phenylether	
	6470	4-Nitroaniline	

Non-Potable Water

EPA 625

6500	4-Nitrophenol
5500	Acenaphthene
5505	Acenaphthylene
5510	Acetophenone
5545	Aniline
5555	Anthracene
7065	Atrazine
5562	Azobenzene
5570	Benzaldehyde
5595	Benzidine
5575	Benzo(a)anthracene
5580	Benzo(a)pyrene
5590	Benzo(g,h,i)perylene
5600	Benzo(k)fluoranthene
5585	Benzo[b]fluoranthene
5610	Benzoic acid
5630	Benzyl alcohol
5760	bis(2-Chloroethoxy)methane
5765	bis(2-Chloroethyl) ether
5670	Butyl benzyl phthalate
7180	Caprolactam
5680	Carbazole
5855	Chrysene
5862	Cresols, Total
6065	Di(2-ethylhexyl) phthalate (bis(2-Ethylhexyl)phthalate, DEHP)
5895	Dibenz(a,h) anthracene
5905	Dibenzofuran
6070	Diethyl phthalate
6135	Dimethyl phthalate
5925	Di-n-butyl phthalate
6200	Di-n-octyl phthalate
6265	Fluoranthene
6270	Fluorene
6275	Hexachlorobenzene
4835	Hexachlorobutadiene
6285	Hexachlorocyclopentadiene
4840	Hexachloroethane
6315	Indeno(1,2,3-cd) pyrene
6320	Isophorone
5005	Naphthalene
5875	n-Decane
5015	Nitrobenzene
6525	n-Nitrosodiethylamine

Non-Potable Water

EPA 625	6530	n-Nitrosodimethylamine	
	5025	n-Nitroso-di-n-butylamine	
	6545	n-Nitrosodi-n-propylamine	
	6535	n-Nitrosodiphenylamine	
	6565	n-Nitrosopyrrolidine	
	6580	n-Octadecane	
	6590	Pentachlorobenzene	
	6600	Pentachloronitrobenzene	
	6605	Pentachlorophenol	
	6615	Phenanthrene	
	6625	Phenol	
	6665	Pyrene	
	5095	Pyridine	
EPA 625.1			10300024 Base/Neutrals and Acids by GC/MS
	6703	1,1'-Biphenyl (BZ-0)	
	6705	1,2,3,4-Tetrachlorobenzene	
	5150	1,2,3-Trichlorobenzene	
	6715	1,2,4,5-Tetrachlorobenzene	
	5155	1,2,4-Trichlorobenzene	
	4610	1,2-Dichlorobenzene	
	6221	1,2-Diphenylhydrazine	
	4615	1,3-Dichlorobenzene	
	4620	1,4-Dichlorobenzene	
	4735	1,4-Dioxane (1,4- Diethyleneoxide)	
	6630	1,4-Phenylenediamine	
	5790	1-Chloronaphthalene	
	4	1-Methyl-2-pyrrlidinone	
	6425	1-Naphthylamine	
	4659	2,2-Oxybis(1-chloropropane)	
	6735	2,3,4,6-Tetrachlorophenol	
	6835	2,4,5-Trichlorophenol	
	6840	2,4,6-Trichlorophenol	
	6000	2,4-Dichlorophenol	
	6130	2,4-Dimethylphenol	
	6175	2,4-Dinitrophenol	
	6185	2,4-Dinitrotoluene (2,4-DNT)	
	6005	2,6-Dichlorophenol	
	6190	2,6-Dinitrotoluene (2,6-DNT)	
	5515	2-Acetylaminofluorene	
	5795	2-Chloronaphthalene	
	5800	2-Chlorophenol	
	6360	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2 -methylphenol)	

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

TestAmerica Canton

EPA CODE: OH00048

4101 Shuffel Street NW

Certificate: 4062 - 008

North Canton, OH 44720

Issue Date: 2/24/2019 Expiration Date: 2/23/2020

As of 2/24/2019 this list supersedes all previous lists for this certificate number.

Non-Potable Water	EPA 625.1	5145	2-Methylaniline (o-Toluidine)
		6385	2-Methylnaphthalene
		6400	2-Methylphenol (o-Cresol)
		6430	2-Naphthylamine
		6460	2-Nitroaniline
		6490	2-Nitrophenol
		6412	3 & 4 Methylphenol
		5945	3,3'-Dichlorobenzidine
		6120	3,3'-Dimethylbenzidine
		6355	3-Methylcholanthrene
		6405	3-Methylphenol (m-Cresol)
		6465	3-Nitroaniline
		6365	4,4-Methylenebis(2-chloroaniline)
		5540	4-Aminobiphenyl
		5660	4-Bromophenyl phenyl ether (BDE-3)
		5700	4-Chloro-3-methylphenol
		5745	4-Chloroaniline
		5825	4-Chlorophenyl phenylether
		6105	4-Dimethyl aminoazobenzene
		6410	4-Methylphenol (p-Cresol)
		6470	4-Nitroaniline
		6500	4-Nitrophenol
		6510	4-Nitroquinoline 1-oxide
		6570	5-Nitro-o-toluidine
		6115	7,12-Dimethylbenz(a) anthracene
		6125	a-a-Dimethylphenethylamine
		5500	Acenaphthene
		5505	Acenaphthylene
		5510	Acetophenone
		5545	Aniline
		5555	Anthracene
		5560	Aramite
		7065	Atrazine
		5562	Azobenzene
		5570	Benzaldehyde
		5567	Benzenethiol (Phenylmercaptan)
		5595	Benzidine
		5575	Benzo(a)anthracene
		5580	Benzo(a)pyrene
		5590	Benzo(g,h,i)perylene
		5600	Benzo(k)fluoranthene
		5585	Benzo[b]fluoranthene
		5610	Benzoic acid

Non-Potable Water

EPA 625.1

5630	Benzyl alcohol
5760	bis(2-Chloroethoxy)methane
5765	bis(2-Chloroethyl) ether
5780	bis(2-Chloroisopropyl) ether
5670	Butyl benzyl phthalate
7180	Caprolactam
5680	Carbazole
7260	Chlorobenzilate
5855	Chrysene
8906	Coelution - 3-Chlorophenol + 4-Chlorophenol
5862	Cresols, Total
6065	Di(2-ethylhexyl) phthalate (bis(2-Ethylhexyl)phthalate, DEHP)
7405	Diallate
5900	Dibenz(a, j) acridine
5895	Dibenz(a,h) anthracene
5905	Dibenzofuran
6070	Diethyl phthalate
7475	Dimethoate
6135	Dimethyl phthalate
5925	Di-n-butyl phthalate
6200	Di-n-octyl phthalate
8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)
6205	Diphenylamine
8625	Disulfoton
6260	Ethyl methanesulfonate
6265	Fluoranthene
6270	Fluorene
6275	Hexachlorobenzene
4835	Hexachlorobutadiene
6285	Hexachlorocyclopentadiene
4840	Hexachloroethane
6295	Hexachloropropene
6315	Indeno(1,2,3-cd) pyrene
7725	Isodrin
6320	Isophorone
6325	Isosafrole
6345	Methapyrilene
6375	Methyl methanesulfonate
7825	Methyl parathion (Parathion, methyl)
5005	Naphthalene
5875	n-Decane

Non-Potable Water

EPA 625.1	5015	Nitrobenzene		
	6525	n-Nitrosodiethylamine		
	6530	n-Nitrosodimethylamine		
	5025	n-Nitroso-di-n-butylamine		
	6545	n-Nitrosodi-n-propylamine		
	6535	n-Nitrosodiphenylamine		
	6550	n-Nitrosomethylethylamine		
	6555	n-Nitrosomorpholine		
	6560	n-Nitrosopiperidine		
	6565	n-Nitrosopyrrolidine		
	6580	n-Octadecane		
	8290	o,o,o-Triethyl phosphorothioate		
	7955	Parathion, ethyl		
	6590	Pentachlorobenzene		
	6600	Pentachloronitrobenzene		
	6605	Pentachlorophenol		
	6610	Phenacetin		
	6615	Phenanthrene		
	6625	Phenol		
	7985	Phorate		
	6650	Pronamide (Kerb)		
	6665	Pyrene		
	5095	Pyridine		
	6685	Safrole		
	8235	Thionazin (Zinophos)		
EPA 7196A			10162400	Chromium Hexavalent colorimetric
	1045	Chromium VI		
EPA 7470A			10165807	Mercury in Liquid Waste by Cold Vapor Atomic Absorption
	1095	Mercury		
EPA 8011			10173009	1,2-Dibromoethane and 1,2-Dibromo-3-chloropropane by Microextraction and GC/ECD
	4570	1,2-Dibromo-3-chloropropane (DBCP)		
	4585	1,2-Dibromoethane (EDB, Ethylene dibromide)		
EPA 8015B			10173601	Non-halogenated organics using GC/FID
	9369	Diesel range organics (DRO)		
	9408	Gasoline range organics (GRO)		
EPA 8015C			10173805	Non-halogenated organics using GC/FID
	9369	Diesel range organics (DRO)		
	9408	Gasoline range organics (GRO)		

Non-Potable Water

EPA 8015D			10305609	Nonhalogenated Organics Using GC/FID
	9369	Diesel range organics (DRO)		
	9408	Gasoline range organics (GRO)		
EPA 8081A			10178606	Organochlorine Pesticides by GC/ECD
	7355	4,4'-DDD		
	7360	4,4'-DDE		
	7365	4,4'-DDT		
	7025	Aldrin		
	7110	alpha-BHC (alpha-Hexachlorocyclohexane)		
	7115	beta-BHC (beta-Hexachlorocyclohexane)		
	7250	Chlordane (tech.)		
	7260	Chlorobenzilate		
	7240	cis-chlordane (alpha-Chlordane)		
	7105	delta-BHC		
	7405	Diallate		
	7470	Dieldrin		
	7510	Endosulfan I		
	7515	Endosulfan II		
	7520	Endosulfan sulfate		
	7540	Endrin		
	7530	Endrin aldehyde		
	7535	Endrin ketone		
	7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)		
	7685	Heptachlor		
	7690	Heptachlor epoxide		
	6275	Hexachlorobenzene		
	7725	Isodrin		
	7740	Kepone		
	7810	Methoxychlor		
	7870	Mirex		
	8250	Toxaphene (Chlorinated camphene)		
	7245	trans-chlordane (gamma-Chlordane)		
EPA 8081B			10178800	Organochlorine Pesticides by GC/ECD
	7355	4,4'-DDD		
	7360	4,4'-DDE		
	7365	4,4'-DDT		
	7025	Aldrin		
	7110	alpha-BHC (alpha-Hexachlorocyclohexane)		

Non-Potable Water

EPA 8081B	7115	beta-BHC (beta-Hexachlorocyclohexane)		
	7250	Chlordane (tech.)		
	7260	Chlorobenzilate		
	7240	cis-chlordane (alpha-Chlordane)		
	7105	delta-BHC		
	7405	Diallate		
	7470	Dieldrin		
	7510	Endosulfan I		
	7515	Endosulfan II		
	7520	Endosulfan sulfate		
	7540	Endrin		
	7530	Endrin aldehyde		
	7535	Endrin ketone		
	7120	gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)		
	7685	Heptachlor		
	7690	Heptachlor epoxide		
	6275	Hexachlorobenzene		
	7725	Isodrin		
	7740	Kepone		
	7810	Methoxychlor		
	7870	Mirex		
	8250	Toxaphene (Chlorinated camphene)		
	7245	trans-chlordane (gamma-Chlordane)		
EPA 8082			10179007	Polychlorinated Biphenyls (PCBs) by GC/ECD
	8880	Aroclor-1016 (PCB-1016)		
	8885	Aroclor-1221 (PCB-1221)		
	8890	Aroclor-1232 (PCB-1232)		
	8895	Aroclor-1242 (PCB-1242)		
	8900	Aroclor-1248 (PCB-1248)		
	8905	Aroclor-1254 (PCB-1254)		
	8910	Aroclor-1260 (PCB-1260)		
	8912	Aroclor-1262 (PCB-1262)		
	8913	Aroclor-1268 (PCB-1268)		
EPA 8082A			10179201	Polychlorinated Biphenyls (PCBs) by GC/ECD
	8880	Aroclor-1016 (PCB-1016)		
	8885	Aroclor-1221 (PCB-1221)		
	8890	Aroclor-1232 (PCB-1232)		
	8895	Aroclor-1242 (PCB-1242)		
	8900	Aroclor-1248 (PCB-1248)		
	8905	Aroclor-1254 (PCB-1254)		
	8910	Aroclor-1260 (PCB-1260)		

Non-Potable Water

EPA 8082A	8912	Aroclor-1262 (PCB-1262)		
	8913	Aroclor-1268 (PCB-1268)		
EPA 8151A			10183207	Chlorinated Herbicides by GC/ECD
	8655	2,4,5-T		
	8545	2,4-D		
	8560	2,4-DB		
	8555	Dalapon		
	8595	Dicamba		
	8605	Dichloroprop (Dichlorprop)		
	8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)		
	7775	MCPA		
	7780	MCPP		
	6605	Pentachlorophenol		
	8650	Silvex (2,4,5-TP)		
EPA 8260B			10184802	Volatile Organic Compounds by purge and trap GC/MS
	5105	1,1,1,2-Tetrachloroethane		
	5160	1,1,1-Trichloroethane		
	5110	1,1,2,2-Tetrachloroethane		
	5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)		
	5165	1,1,2-Trichloroethane		
	4630	1,1-Dichloroethane		
	4640	1,1-Dichloroethylene		
	4670	1,1-Dichloropropene		
	5150	1,2,3-Trichlorobenzene		
	5180	1,2,3-Trichloropropane		
	5182	1,2,3-Trimethylbenzene		
	5155	1,2,4-Trichlorobenzene		
	5210	1,2,4-Trimethylbenzene		
	4570	1,2-Dibromo-3-chloropropane (DBCP)		
	4585	1,2-Dibromoethane (EDB, Ethylene dibromide)		
	4610	1,2-Dichlorobenzene		
	4635	1,2-Dichloroethane (Ethylene dichloride)		
	4655	1,2-Dichloropropane		
	6800	1,3,5-Trichlorobenzene		
	5215	1,3,5-Trimethylbenzene		
	9318	1,3-Butadiene		
	4615	1,3-Dichlorobenzene		
	4660	1,3-Dichloropropane		
	4675	1,3-Dichloropropene		
	4620	1,4-Dichlorobenzene		

Non-Potable Water

EPA 8260B

4735	1,4-Dioxane (1,4- Diethyleneoxide)
4510	1-Chlorohexane
4665	2,2-Dichloropropane
4410	2-Butanone (Methyl ethyl ketone, MEK)
4500	2-Chloroethyl vinyl ether
4535	2-Chlorotoluene
4538	2-Ethyltoluene
4860	2-Hexanone (MBK)
6385	2-Methylnaphthalene
5020	2-Nitropropane
4531	3-Ethyltoluene (1-Methyl-3-ethylbenzene)
4540	4-Chlorotoluene
4910	4-Isopropyltoluene (p-Cymene)
4995	4-Methyl-2-pentanone (MIBK)
4315	Acetone
4320	Acetonitrile
4325	Acrolein (Propenal)
4340	Acrylonitrile
4355	Allyl chloride (3-Chloropropene)
4375	Benzene
5635	Benzyl chloride
4385	Bromobenzene
4390	Bromochloromethane
4395	Bromodichloromethane
4400	Bromoform
4403	Butyl acetate
4450	Carbon disulfide
4455	Carbon tetrachloride
4475	Chlorobenzene
4575	Chlorodibromomethane
4485	Chloroethane (Ethyl chloride)
4505	Chloroform
4525	Chloroprene (2-Chloro-1,3-butadiene)
4705	cis & trans-1,2-Dichloroethene
4645	cis-1,2-Dichloroethylene
4680	cis-1,3-Dichloropropene
4555	Cyclohexane
4560	Cyclohexanone
4595	Dibromomethane (Methylene bromide)
4625	Dichlorodifluoromethane (Freon-12)
4627	Dichlorofluoromethane (Freon 21)
4725	Diethyl ether
9375	Di-isopropylether (DIPE)

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Non-Potable Water	EPA 8260B	4745	Epichlorohydrin (1-Chloro-2,3-epoxypropane)
		4755	Ethyl acetate
		4760	Ethyl acrylate
		4810	Ethyl methacrylate
		4765	Ethylbenzene
		4795	Ethylene oxide
		4770	Ethyl-t-butylether (ETBE) (2-Ethoxy-2-methylpropane)
		4835	Hexachlorobutadiene
		4870	Iodomethane (Methyl iodide)
		4875	Isobutyl alcohol (2-Methyl-1-propanol)
		4900	Isopropylbenzene (Cumene)
		5240	m+p-xylene
		4925	Methacrylonitrile
		4940	Methyl acetate
		4950	Methyl bromide (Bromomethane)
		4960	Methyl chloride (Chloromethane)
		4990	Methyl methacrylate
		5000	Methyl tert-butyl ether (MTBE)
		4965	Methylcyclohexane
		4975	Methylene chloride (Dichloromethane)
		5245	m-Xylene
		5005	Naphthalene
		4425	n-Butyl alcohol (1-Butanol, n-Butanol)
		4435	n-Butylbenzene
		4825	n-Heptane
		4855	n-Hexane
		5090	n-Propylbenzene
		5250	o-Xylene
		5035	Pentachloroethane
		5080	Propionitrile (Ethyl cyanide)
		9579	Propylene oxide
		5255	p-Xylene
		4440	sec-Butylbenzene
		5100	Styrene
		4370	T-amylmethylether (TAME)
		4420	tert-Butyl alcohol
		4445	tert-Butylbenzene
		5115	Tetrachloroethylene (Perchloroethylene)
		5120	Tetrahydrofuran (THF)
		9574	Tetrahydrothiophene
		5140	Toluene
		5205	Total trihalomethanes

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EPA 8260B		10184904	Volatile Organic Compounds by purge and trap GC/MS-SIM
	4700	trans-1,2-Dichloroethylene	
	4685	trans-1,3-Dichloropropylene	
	4605	trans-1,4-Dichloro-2-butene	
	5170	Trichloroethene (Trichloroethylene)	
	5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)	
	5225	Vinyl acetate	
	5235	Vinyl chloride	
	5260	Xylene (total)	
EPA 8260B SIM		10184904	Volatile Organic Compounds by purge and trap GC/MS-SIM
	4735	1,4-Dioxane (1,4- Diethyleneoxide)	
EPA 8260C		10307003	Volatile Organics: GC/MS (capillary column)
	5105	1,1,1,2-Tetrachloroethane	
	5160	1,1,1-Trichloroethane	
	5110	1,1,2,2-Tetrachloroethane	
	5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	
	5165	1,1,2-Trichloroethane	
	4630	1,1-Dichloroethane	
	4640	1,1-Dichloroethylene	
	4670	1,1-Dichloropropene	
	5150	1,2,3-Trichlorobenzene	
	5180	1,2,3-Trichloropropane	
	5182	1,2,3-Trimethylbenzene	
	5155	1,2,4-Trichlorobenzene	
	5210	1,2,4-Trimethylbenzene	
	4570	1,2-Dibromo-3-chloropropane (DBCP)	
	4585	1,2-Dibromoethane (EDB, Ethylene dibromide)	
	4610	1,2-Dichlorobenzene	
	4635	1,2-Dichloroethane (Ethylene dichloride)	
	4655	1,2-Dichloropropane	
	6800	1,3,5-Trichlorobenzene	
	5215	1,3,5-Trimethylbenzene	
	9318	1,3-Butadiene	
	4615	1,3-Dichlorobenzene	
	4660	1,3-Dichloropropane	
	4675	1,3-Dichloropropene	
	4620	1,4-Dichlorobenzene	
	4735	1,4-Dioxane (1,4- Diethyleneoxide)	
	4510	1-Chlorohexane	
	4665	2,2-Dichloropropane	
	4410	2-Butanone (Methyl ethyl ketone, MEK)	

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Non-Potable Water

EPA 8260C

4500	2-Chloroethyl vinyl ether
4535	2-Chlorotoluene
4538	2-Ethyltoluene
4860	2-Hexanone (MBK)
6385	2-Methylnaphthalene
5020	2-Nitropropane
4531	3-Ethyltoluene (1-Methyl-3-ethylbenzene)
4540	4-Chlorotoluene
4910	4-Isopropyltoluene (p-Cymene)
4995	4-Methyl-2-pentanone (MIBK)
4315	Acetone
4320	Acetonitrile
4325	Acrolein (Propenal)
4340	Acrylonitrile
4355	Allyl chloride (3-Chloropropene)
4375	Benzene
5635	Benzyl chloride
4385	Bromobenzene
4390	Bromochloromethane
4395	Bromodichloromethane
4400	Bromoform
4403	Butyl acetate
4450	Carbon disulfide
4455	Carbon tetrachloride
4475	Chlorobenzene
4575	Chlorodibromomethane
4485	Chloroethane (Ethyl chloride)
4505	Chloroform
4525	Chloroprene (2-Chloro-1,3-butadiene)
4705	cis & trans-1,2-Dichloroethene
4645	cis-1,2-Dichloroethylene
4680	cis-1,3-Dichloropropene
4555	Cyclohexane
4560	Cyclohexanone
4595	Dibromomethane (Methylene bromide)
4625	Dichlorodifluoromethane (Freon-12)
4627	Dichlorofluoromethane (Freon 21)
4725	Diethyl ether
9375	Di-isopropylether (DIPE)
4745	Epichlorohydrin (1-Chloro-2,3-epoxypropane)
4755	Ethyl acetate
4760	Ethyl acrylate

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Non-Potable Water	EPA 8260C	4810	Ethyl methacrylate
		4765	Ethylbenzene
		4795	Ethylene oxide
		4770	Ethyl-t-butylether (ETBE) (2-Ethoxy-2-methylpropane)
		4835	Hexachlorobutadiene
		4870	Iodomethane (Methyl iodide)
		4875	Isobutyl alcohol (2-Methyl-1-propanol)
		4900	Isopropylbenzene (Cumene)
		5240	m+p-xylene
		4925	Methacrylonitrile
		4940	Methyl acetate
		4950	Methyl bromide (Bromomethane)
		4960	Methyl chloride (Chloromethane)
		4990	Methyl methacrylate
		5000	Methyl tert-butyl ether (MTBE)
		4965	Methylcyclohexane
		4975	Methylene chloride (Dichloromethane)
		5245	m-Xylene
		5005	Naphthalene
		4425	n-Butyl alcohol (1-Butanol, n-Butanol)
		4435	n-Butylbenzene
		4825	n-Heptane
		4855	n-Hexane
		5090	n-Propylbenzene
		5250	o-Xylene
		5035	Pentachloroethane
		5080	Propionitrile (Ethyl cyanide)
		9579	Propylene oxide
		5255	p-Xylene
		4440	sec-Butylbenzene
		5100	Styrene
		4370	T-amylmethylether (TAME)
		4420	tert-Butyl alcohol
		4445	tert-Butylbenzene
		5115	Tetrachloroethylene (Perchloroethylene)
		5120	Tetrahydrofuran (THF)
		9574	Tetrahydrothiophene
		5140	Toluene
		5205	Total trihalomethanes
		4700	trans-1,2-Dichloroethylene
		4685	trans-1,3-Dichloropropylene
		4605	trans-1,4-Dichloro-2-butene
		5170	Trichloroethene (Trichloroethylene)

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EPA 8260C	5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)		
	5225	Vinyl acetate		
	5235	Vinyl chloride		
	5260	Xylene (total)		
EPA 8270C			10185805	Semivolatile Organic compounds by GC/MS
	6703	1,1'-Biphenyl (BZ-0)		
	6705	1,2,3,4-Tetrachlorobenzene		
	6710	1,2,3,5-Tetrachlorobenzene		
	5150	1,2,3-Trichlorobenzene		
	6715	1,2,4,5-Tetrachlorobenzene		
	5155	1,2,4-Trichlorobenzene		
	4610	1,2-Dichlorobenzene		
	6221	1,2-Diphenylhydrazine		
	6800	1,3,5-Trichlorobenzene		
	6885	1,3,5-Trinitrobenzene (1,3,5-TNB)		
	4615	1,3-Dichlorobenzene		
	6160	1,3-Dinitrobenzene (1,3-DNB)		
	4620	1,4-Dichlorobenzene		
	6165	1,4-Dinitrobenzene		
	4735	1,4-Dioxane (1,4- Diethyleneoxide)		
	6420	1,4-Naphthoquinone		
	6630	1,4-Phenylenediamine		
	5790	1-Chloronaphthalene		
	6380	1-Methylnaphthalene		
	6425	1-Naphthylamine		
	5754	1-Phenoxy-2-propanol		
	4659	2,2-Oxybis(1-chloropropane)		
	6735	2,3,4,6-Tetrachlorophenol		
	6740	2,3,5,6-Tetrachlorophenol		
	6835	2,4,5-Trichlorophenol		
	6840	2,4,6-Trichlorophenol		
	6000	2,4-Dichlorophenol		
	6130	2,4-Dimethylphenol		
	6175	2,4-Dinitrophenol		
	6185	2,4-Dinitrotoluene (2,4-DNT)		
	6005	2,6-Dichlorophenol		
	6190	2,6-Dinitrotoluene (2,6-DNT)		
	5515	2-Acetylaminofluorene		
	5735	2-Chloroaniline		
	5795	2-Chloronaphthalene		
	5800	2-Chlorophenol		

Non-Potable Water	EPA 8270C	6360	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2 -methylphenol)
		5145	2-Methylaniline (o-Toluidine)
		6385	2-Methylnaphthalene
		6400	2-Methylphenol (o-Cresol)
		6430	2-Naphthylamine
		6460	2-Nitroaniline
		6490	2-Nitrophenol
		5050	2-Picoline (2-Methylpyridine)
		6412	3 & 4 Methylphenol
		5945	3,3'-Dichlorobenzidine
		6120	3,3'-Dimethylbenzidine
		5995	3,4-Dichloronitrobenzene
		6355	3-Methylcholanthrene
		6405	3-Methylphenol (m-Cresol)
		6465	3-Nitroaniline
		6365	4,4-Methylenebis(2-chloroaniline)
		5540	4-Aminobiphenyl
		5660	4-Bromophenyl phenyl ether (BDE-3)
		5700	4-Chloro-3-methylphenol
		5745	4-Chloroaniline
		5825	4-Chlorophenyl phenylether
		6105	4-Dimethyl aminoazobenzene
		6410	4-Methylphenol (p-Cresol)
		6470	4-Nitroaniline
		6500	4-Nitrophenol
		6510	4-Nitroquinoline 1-oxide
		6516	4-tert-Butylphenol
		6570	5-Nitro-o-toluidine
		6112	6-Methylchrysene
		6115	7,12-Dimethylbenz(a) anthracene
		6125	a-a-Dimethylphenethylamine
		5500	Acenaphthene
		5505	Acenaphthylene
		5510	Acetophenone
		4330	Acrylamide
		5545	Aniline
		5555	Anthracene
		5560	Aramite
		7065	Atrazine
		5562	Azobenzene
		5570	Benzaldehyde
		5567	Benzenethiol (Phenylmercaptan)
		5595	Benzidine

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Non-Potable Water

EPA 8270C

5575	Benzo(a)anthracene
5580	Benzo(a)pyrene
5590	Benzo(g,h,i)perylene
5600	Benzo(k)fluoranthene
5585	Benzo[b]fluoranthene
5610	Benzoic acid
5630	Benzyl alcohol
5760	bis(2-Chloroethoxy)methane
5765	bis(2-Chloroethyl) ether
5780	bis(2-Chloroisopropyl) ether
5670	Butyl benzyl phthalate
7180	Caprolactam
5680	Carbazole
7260	Chlorobenzilate
7300	Chlorpyrifos
5855	Chrysene
5862	Cresols, Total
6065	Di(2-ethylhexyl) phthalate (bis(2-Ethylhexyl)phthalate, DEHP)
7405	Diallate
9354	Dibenz(a, h) acridine
5900	Dibenz(a, j) acridine
5895	Dibenz(a,h) anthracene
5890	Dibenzo(a,e) pyrene
5905	Dibenzofuran
6070	Diethyl phthalate
7475	Dimethoate
6135	Dimethyl phthalate
5925	Di-n-butyl phthalate
6200	Di-n-octyl phthalate
8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)
6210	Diphenyl ether (Diphenyl Oxide)
6205	Diphenylamine
8625	Disulfoton
4810	Ethyl methacrylate
6260	Ethyl methanesulfonate
7580	Famphur
6265	Fluoranthene
6270	Fluorene
6275	Hexachlorobenzene
4835	Hexachlorobutadiene
6285	Hexachlorocyclopentadiene
4840	Hexachloroethane

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Non-Potable Water	EPA 8270C	6295	Hexachloropropene
		6312	Indene
		6315	Indeno(1,2,3-cd) pyrene
		7725	Isodrin
		6320	Isophorone
		6325	Isosafrole
		7740	Kepone
		6345	Methapyrilene
		6375	Methyl methanesulfonate
		7825	Methyl parathion (Parathion, methyl)
		6443	n, n-Dimethylacetamide
		5005	Naphthalene
		5875	n-Decane
		6300	n-Hexadecane
		5015	Nitrobenzene
		6525	n-Nitrosodiethylamine
		6530	n-Nitrosodimethylamine
		5025	n-Nitroso-di-n-butylamine
		6545	n-Nitrosodi-n-propylamine
		6535	n-Nitrosodiphenylamine
		6550	n-Nitrosomethylethylamine
		6555	n-Nitrosomorpholine
		6560	n-Nitrosopiperidine
		6565	n-Nitrosopyrrolidine
		6580	n-Octadecane
		8290	o,o,o-Triethyl phosphorothioate
		3960	o-Phenylphenol
		7955	Parathion, ethyl
		6590	Pentachlorobenzene
		5035	Pentachloroethane
		6600	Pentachloronitrobenzene
		6605	Pentachlorophenol
		6610	Phenacetin
		6615	Phenanthrene
		6625	Phenol
		7985	Phorate
		6650	Pronamide (Kerb)
		6665	Pyrene
		5095	Pyridine
		6670	Quinoline
		6685	Safrole
		8155	Sulfotepp
		8235	Thionazin (Zinophos)

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Non-Potable Water	EPA 8270C	6750	Thiophenol (Benzenethiol)		
		8262	Tributyl phosphate		
	EPA 8270D			10186002	Semivolatile Organic compounds by GC/MS
		6703	1,1'-Biphenyl (BZ-0)		
		6705	1,2,3,4-Tetrachlorobenzene		
		6710	1,2,3,5-Tetrachlorobenzene		
		5150	1,2,3-Trichlorobenzene		
		6715	1,2,4,5-Tetrachlorobenzene		
		5155	1,2,4-Trichlorobenzene		
		4610	1,2-Dichlorobenzene		
		6221	1,2-Diphenylhydrazine		
		6800	1,3,5-Trichlorobenzene		
		6885	1,3,5-Trinitrobenzene (1,3,5-TNB)		
		4615	1,3-Dichlorobenzene		
		6160	1,3-Dinitrobenzene (1,3-DNB)		
		4620	1,4-Dichlorobenzene		
		6165	1,4-Dinitrobenzene		
		4735	1,4-Dioxane (1,4- Diethyleneoxide)		
		6420	1,4-Naphthoquinone		
		6630	1,4-Phenylenediamine		
		5790	1-Chloronaphthalene		
		6380	1-Methylnaphthalene		
		6425	1-Naphthylamine		
		5754	1-Phenoxy-2-propanol		
		6735	2,3,4,6-Tetrachlorophenol		
		6740	2,3,5,6-Tetrachlorophenol		
		6835	2,4,5-Trichlorophenol		
		6840	2,4,6-Trichlorophenol		
		6000	2,4-Dichlorophenol		
		6130	2,4-Dimethylphenol		
		6175	2,4-Dinitrophenol		
		6185	2,4-Dinitrotoluene (2,4-DNT)		
		6005	2,6-Dichlorophenol		
		6190	2,6-Dinitrotoluene (2,6-DNT)		
		5515	2-Acetylaminofluorene		
		5735	2-Chloroaniline		
		5795	2-Chloronaphthalene		
		5800	2-Chlorophenol		
		6360	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2-methylphenol)		
		5145	2-Methylaniline (o-Toluidine)		
		6385	2-Methylnaphthalene		
		6400	2-Methylphenol (o-Cresol)		

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Non-Potable Water	EPA 8270D	6430	2-Naphthylamine
		6460	2-Nitroaniline
		6490	2-Nitrophenol
		5050	2-Picoline (2-Methylpyridine)
		6412	3 & 4 Methylphenol
		5945	3,3'-Dichlorobenzidine
		6120	3,3'-Dimethylbenzidine
		5995	3,4-Dichloronitrobenzene
		6355	3-Methylcholanthrene
		6405	3-Methylphenol (m-Cresol)
		6465	3-Nitroaniline
		6365	4,4-Methylenebis(2-chloroaniline)
		5540	4-Aminobiphenyl
		5660	4-Bromophenyl phenyl ether (BDE-3)
		5700	4-Chloro-3-methylphenol
		5745	4-Chloroaniline
		5825	4-Chlorophenyl phenylether
		6105	4-Dimethyl aminoazobenzene
		6410	4-Methylphenol (p-Cresol)
		6470	4-Nitroaniline
		6500	4-Nitrophenol
		6510	4-Nitroquinoline 1-oxide
		6516	4-tert-Butylphenol
		6570	5-Nitro-o-toluidine
		6112	6-Methylchrysene
		6115	7,12-Dimethylbenz(a) anthracene
		6125	a-a-Dimethylphenethylamine
		5500	Acenaphthene
		5505	Acenaphthylene
		5510	Acetophenone
		4330	Acrylamide
		5545	Aniline
		5555	Anthracene
		5560	Aramite
		7065	Atrazine
		5562	Azobenzene
		5570	Benzaldehyde
		5567	Benzenethiol (Phenylmercaptan)
		5595	Benzidine
		5575	Benzo(a)anthracene
		5580	Benzo(a)pyrene
		5590	Benzo(g,h,i)perylene
		5600	Benzo(k)fluoranthene

Non-Potable Water

EPA 8270D

5585	Benzo[b]fluoranthene
5610	Benzoic acid
5630	Benzyl alcohol
5760	bis(2-Chloroethoxy)methane
5765	bis(2-Chloroethyl) ether
5780	bis(2-Chloroisopropyl) ether
5670	Butyl benzyl phthalate
7180	Caprolactam
5680	Carbazole
7260	Chlorobenzilate
7300	Chlorpyrifos
5855	Chrysene
5862	Cresols, Total
6065	Di(2-ethylhexyl) phthalate (bis(2-Ethylhexyl)phthalate, DEHP)
7405	Diallate
9354	Dibenz(a, h) acridine
5900	Dibenz(a, j) acridine
5895	Dibenz(a,h) anthracene
5890	Dibenzo(a,e) pyrene
5905	Dibenzofuran
6070	Diethyl phthalate
7475	Dimethoate
6135	Dimethyl phthalate
5925	Di-n-butyl phthalate
6200	Di-n-octyl phthalate
8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)
6210	Diphenyl ether (Diphenyl Oxide)
6205	Diphenylamine
8625	Disulfoton
4810	Ethyl methacrylate
6260	Ethyl methanesulfonate
7580	Famphur
6265	Fluoranthene
6270	Fluorene
6275	Hexachlorobenzene
4835	Hexachlorobutadiene
6285	Hexachlorocyclopentadiene
4840	Hexachloroethane
6295	Hexachloropropene
6312	Indene
6315	Indeno(1,2,3-cd) pyrene
7725	Isodrin

Non-Potable Water	EPA 8270D	6320	Isophorone		
		6325	Isosafrole		
		7740	Kepone		
		6345	Methapyrilene		
		6375	Methyl methanesulfonate		
		7825	Methyl parathion (Parathion, methyl)		
		6443	n, n-Dimethylacetamide		
		5005	Naphthalene		
		5875	n-Decane		
		6300	n-Hexadecane		
		5015	Nitrobenzene		
		6525	n-Nitrosodiethylamine		
		6530	n-Nitrosodimethylamine		
		5025	n-Nitroso-di-n-butylamine		
		6545	n-Nitrosodi-n-propylamine		
		6535	n-Nitrosodiphenylamine		
		6550	n-Nitrosomethylethylamine		
		6555	n-Nitrosomorpholine		
		6560	n-Nitrosopiperidine		
		6565	n-Nitrosopyrrolidine		
		6580	n-Octadecane		
		8290	o,o,o-Triethyl phosphorothioate		
		3960	o-Phenylphenol		
		7955	Parathion, ethyl		
		6590	Pentachlorobenzene		
		5035	Pentachloroethane		
		6600	Pentachloronitrobenzene		
		6605	Pentachlorophenol		
		6610	Phenacetin		
		6615	Phenanthrene		
		6625	Phenol		
		7985	Phorate		
		9663	p-Phenylenediamine		
		6650	Pronamide (Kerb)		
		6665	Pyrene		
		5095	Pyridine		
		6670	Quinoline		
		6685	Safrole		
		8155	Sulfotepp		
		8235	Thionazin (Zinophos)		
		8262	Tributyl phosphate		
	EPA 8315A			10188008	Determination of Carbonyl Compounds by HPLC/UV-VIS
		4815	Formaldehyde		

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Non-Potable Water

EPA 9012A			10193405	Total and Amenable Cyanide (automated colorimetric with off-line distillation)
	1510	Amenable cyanide		
	1645	Total cyanide		
EPA 9012B			10243206	Total and Amenable Cyanide (automated colorimetric with off-line distillation)
	1510	Amenable cyanide		
	1645	Total cyanide		
EPA 9030B			10195605	Acid-Soluble and Acid-Insoluble sulfides: Distillation
	2005	Sulfide		
EPA 9034			10196006	Titrimetric Procedure for Acid-Soluble and Acid-Insoluble Sulfides
	2005	Sulfide		
EPA 9040B			10197203	pH Electrometric Measurement
	1900	pH		
EPA 9040C			10244403	pH Electrometric Measurement
	1900	pH		
EPA 9050A			10198808	Specific Conductance
	1610	Conductivity		
EPA 9056A			10199607	Determination of Inorganic Anions by Ion Chromatography
	1540	Bromide		
	1575	Chloride		
	1730	Fluoride		
	1810	Nitrate as N		
	1840	Nitrite as N		
	2000	Sulfate		
EPA 9060			10200201	Total Organic Carbon
	1710	Dissolved organic carbon (DOC)		
	2040	Total organic carbon		
EPA 9060A			10244801	Total Organic Carbon
	1710	Dissolved organic carbon (DOC)		
	2040	Total organic carbon		
EPA 9065			10200405	Phenolics (Spectrophotometric, Manual 4-AAP with Distillation)
	1905	Total phenolics		
EPA 9095A			10204203	Paint Filter Liquids Test
	8031	Extraction/Preparation		
EPA 9095B			10245600	Paint Filter Liquids Test
	8031	Extraction/Preparation		

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EPA RSK-175 (GC-FID)			10212905	Methane, Ethane, and Ethene in water by Headspace GC/FID
	4323	Acetylene		
	4747	Ethane		
	4752	Ethene		
	4926	Methane		
	5029	n-Propane		
NJ DEP Modified 8270 Isotope Dilution			90014269	NJ DEP 8270 Using Full Scan GC/MS with Isotope Dilution
	4735	1,4-Dioxane (1,4- Diethyleneoxide)		
SM 2320 B-2011 online			20045618	Alkalinity as CaCO3
	1505	Alkalinity as CaCO3		
SM 2320 B-97 SM 2320 B-97			20045607	Alkalinity by Titration Method
	1505	Alkalinity as CaCO3		
SM 2340 B-2011 online			20046611	Hardness
	1750	Hardness		
SM 2340 B-97 SM 2340 B-97			20046600	Hardness by calculation
	1755	Total hardness as CaCO3		
SM 2340 C-2011 22nd Ed			20047614	Hardness by EDTA Titration
	1755	Total hardness as CaCO3		
SM 2340 C-97 online			20047603	Hardness by EDTA Titration Method
	1755	Total hardness as CaCO3		
SM 2510 B-2011			20048617	Conductivity by Probe
	1610	Conductivity		
SM 2510 B-97 SM 2510 B-97			20048606	Conductivity by Probe
	1610	Conductivity		
SM 2540 B-2011 2011			20049416	Total Solids Dried at 103 - 105C
	1950	Residue-total		
SM 2540 B-97 SM 2540 B-97			20049405	Total Solids Dried at 103 - 105C
	1950	Residue-total		
SM 2540 C-2011 online			20050413	Residue-filterable (TDS)
	1955	Residue-filterable (TDS)		
SM 2540 C-97 SM 2540 C-97			20050402	Total Dissolved Solids Dried at 180C
	1955	Residue-filterable (TDS)		
SM 2540 D-2011			20051212	Total Suspended Solids Dried at 103 - 105 C
	1960	Residue-nonfilterable (TSS)		
SM 2540 D-97 SM 2540 D-97			20051201	Total Suspended Solids Dried at 103 - 105C
	1960	Residue-nonfilterable (TSS)		

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SM 2540 F-2011			20052215	Settleable Solids
	1965	Residue-settleable		
SM 2540 F-97 online			20052204	Settleable Solids
	1965	Residue-settleable		
SM 3500-Cr B-2009 online			20066255	Chromium by Colorimetric Method
	1045	Chromium VI		
SM 3500-Cr B-2011			20066266	Chromium by Colorimetric Method
	1045	Chromium VI		
SM 3500-Fe B-2011			20069016	Iron by Phenanthroline Method
	1070	Iron		
SM 3500-Fe B-97 online			20069005	Iron by Phenanthroline Method
	1070	Iron		
SM 4500-Cl G-2000 online			20081612	Chlorine (Residual) by DPD Colorimetric Determination
	1940	Total residual chlorine		
SM 4500-Cl G-2011 22nd ED			20081623	Chlorine (Residual) by DPD Colorimetric Method
	1580	Chlorine		
	1945	Residual free chlorine		
	1940	Total residual chlorine		
SM 4500-CN C-1999			20095652	Cyanide (Total) after Distillation
	1635	Cyanide		
SM 4500-CN E-1999			20096417	Cyanide by Colorimetric Method
	1645	Total cyanide		
SM 4500-CN E-2011 2011			20096428	Cyanide by Colormetric Method
	1635	Cyanide		
SM 4500-CN G-1999 online			20097216	Cyanide Amenable to Chlorination after Distillation
	1510	Amenable cyanide		
SM 4500-CN I 20th ED			20093601	Weak Acid Dissociable Cyanide
	1635	Cyanide		
SM 4500-CN⁻ C-2011			20065663	Cyanide (Total) After Distillation
	1645	Total cyanide		
SM 4500-CN⁻ G-2011			20097227	Cyanides Amenable to Chlorination after Distillation
	1510	Amenable cyanide		
SM 4500-H+ B-2000 online			20105219	pH Value by Electrometric Method .
	1900	pH		
SM 4500-H+ B-2011			20105220	pH - Electrometric Measurement
	1900	pH		

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SM 4500-NH3 B-2011 22nd ED			20106018	Ammonia Nitrogen Distillation
	1515	Ammonia as N		
	1795	Kjeldahl nitrogen - total		
SM 4500-NH3 B-97 online			20106007	Ammonia by Preliminary Distillation Step
	1515	Ammonia as N		
	1795	Kjeldahl nitrogen - total		
SM 4500-NH3 C-2011 22nd ED			20108412	Ammonia Nitrogen by Titration
	1515	Ammonia as N		
	1795	Kjeldahl nitrogen - total		
SM 4500-NH3 C-97 online			20108401	Ammonia by Titrimetric Method
	1515	Ammonia as N		
	1795	Kjeldahl nitrogen - total		
SM 4500-NH3 D-2011 online			20109415	Ammonia Nitrogen by Selective Ion Probe
	3751	Ammonia		
SM 4500-NH3 D-97 online			20109404	Ammonia by Ammonia-Selective Electrode Method .
	1515	Ammonia as N		
SM 4500-Norg C-2011 22nd ED			20120018	Organic Nitrogen by Macro Kjeldahl Method
	1795	Kjeldahl nitrogen - total		
SM 4500-Norg C-97 online			20120007	Nitrogen (Organic) by Semi-Micro-Kjeldahl Method
	1795	Kjeldahl nitrogen - total		
SM 4500-O G-2001 online			20121657	Dissolved Oxygen by Membrane Electrode Method
	1880	Oxygen, dissolved		
SM 4500-O G-2011 22nd ED			20121668	Dissolved Oxygen by Membrane Electrode
	1880	Oxygen, dissolved		
SM 4500-P B5-2011			20123368	Phosphorus by Persulfate Digestion Method
	1910	Phosphorus, total		
SM 4500-P E-2011			20124225	Phosphorus by Ascorbic Acid Method
	1870	Orthophosphate as P		
	1910	Phosphorus, total		
SM 4500-P E-97 online			20124203	Phosphorus by Ascorbic Acid Method
	1870	Orthophosphate as P		
	1910	Phosphorus, total		
SM 4500-S2 F-2011			20126663	Sulfide by Iodometric Method
	2005	Sulfide		

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Non-Potable Water

SM 4500-S2¯ F-2000 online			20126652	Sulfide by Iodometric Method
	2005	Sulfide		
SM 5210 B-2001 online			20135255	Biochemical Oxygen Demand (BOD), 5-Day
	1530	Biochemical oxygen demand		
	1555	Carbonaceous BOD, CBOD		
SM 5210 B-2011 online			20135266	Biochemical Oxygen Demand (5 days @ 20 C).
	1530	Biochemical oxygen demand		
	1555	Carbonaceous BOD, CBOD		
SM 5220 D-2011 2011			20136816	Chemical Oxygen Demand by Closed Reflux and Colorimetric Determination
	1565	Chemical oxygen demand		
SM 5220 D-97 online			20136805	COD by Closed Reflux, Colorimetric Method
	1565	Chemical oxygen demand		
SM 5310 C-2000 online			20138812	Total Organic Carbon by Persulfate-Ultraviolet Oxidation Method
	2040	Total organic carbon		
SM 5310 C-2011 online			20138823	TOC by Persulfate-Ultraviolet or Heated-Persulfate Oxidation Method
	2040	Total organic carbon		
SM 5540 C-2011			20145066	Surfactants as MBAS
	2025	Surfactants - MBAS		
SM 5540 C-93 online			20145000	Surfactants by Anionic Surfactants as MBAS
	2025	Surfactants - MBAS		
WI(95) DRO			90019457	Wisconsin DNR - Modified Method for Determination of Diesel Range Organics by GC-FID
	9369	Diesel range organics (DRO)		
WI(95) GRO			90019468	Wisconsin DNR - Modified Method for Determining Gasoline Range Organics GC-FID
	9408	Gasoline range organics (GRO)		

Solids

ASTM D3987-06			30030708	Shake Extraction of Solid Waste with Water
	8031	Extraction/Preparation		
EPA 1311			10118806	Toxicity Characteristic Leaching Procedure
	8031	Extraction/Preparation		
EPA 1312			10119003	Synthetic Precipitation Leaching Procedure
	8031	Extraction/Preparation		

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Solids

EPA 1630			10122608	Methyl Mercury by Purge & Trap Cold Vapor Atomic Fluorescence Spectrometry
	1205	Methyl Mercury		
EPA 1631E			10237204	Mercury in Water by Oxidation, Purge & Trap, and Cold Vapor Atomic Fluorescence
	1095	Mercury		
EPA 3050B			10135601	Acid Digestion of Sediments, Sludges, and soils
	8031	Extraction/Preparation		
EPA 3060A			10136604	Alkaline Digestion for Hexavalent Chromium
	8031	Extraction/Preparation		
EPA 3540C			10140202	Soxhlet Extraction
	8031	Extraction/Preparation		
EPA 3546			10141205	Microwave Extraction
	8031	Extraction/Preparation		
EPA 3550B			10141807	Ultrasonic Extraction
	8031	Extraction/Preparation		
EPA 3550C			10142004	Ultrasonic Extraction
	8031	Extraction/Preparation		
EPA 3580A			10143007	Waste Dilution
	8031	Extraction/Preparation		
EPA 3620B			10145809	Florisil Cleanup
	8031	Extraction/Preparation		
EPA 3630C			10146802	Silica gel cleanup
	8031	Extraction/Preparation		
EPA 3650B			10147805	Acid base partition cleanup
	8031	Extraction/Preparation		
EPA 3660B			10148400	Sulfur cleanup
	8031	Extraction/Preparation		
EPA 3665A			10148808	Sulfuric Acid / permanganate Cleanup
	8031	Extraction/Preparation		
EPA 5030B			10153409	Purge and trap for aqueous samples
	8031	Extraction/Preparation		
EPA 5030C			10284603	Purge-and-Trap for Aqueous Samples
	8031	Extraction/Preparation		

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Solids

EPA 5035			10154004	Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples
	8031	Extraction/Preparation		
EPA 5035A			10284807	Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples
	8031	Extraction/Preparation		
EPA 6010B			10155609	ICP - AES
	1000	Aluminum		
	1005	Antimony		
	1010	Arsenic		
	1015	Barium		
	1020	Beryllium		
	1025	Boron		
	1030	Cadmium		
	1035	Calcium		
	1040	Chromium		
	1050	Cobalt		
	1055	Copper		
	1070	Iron		
	1075	Lead		
	1080	Lithium		
	1085	Magnesium		
	1090	Manganese		
	1100	Molybdenum		
	1105	Nickel		
	1125	Potassium		
	1140	Selenium		
	1990	Silica as SiO2		
	1145	Silicon		
	1150	Silver		
	1155	Sodium		
	1160	Strontium		
	1165	Thallium		
	1175	Tin		
	1180	Titanium		
	1185	Vanadium		
	1190	Zinc		
EPA 6010C 3			10155905	Inductively Coupled Plasma - Atomic Emission Spectrometry
	1000	Aluminum		
	1005	Antimony		
	1010	Arsenic		
	1015	Barium		

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Solids	EPA 6010C 3	1020	Beryllium	
		1025	Boron	
		1030	Cadmium	
		1035	Calcium	
		1040	Chromium	
		1050	Cobalt	
		1055	Copper	
		1070	Iron	
		1075	Lead	
		1080	Lithium	
		1085	Magnesium	
		1090	Manganese	
		1100	Molybdenum	
		1105	Nickel	
		1125	Potassium	
		1140	Selenium	
		1990	Silica as SiO2	
		1145	Silicon	
		1150	Silver	
		1155	Sodium	
		1160	Strontium	
		1165	Thallium	
		1175	Tin	
		1180	Titanium	
		1185	Vanadium	
		1190	Zinc	
	EPA 6010D 4		10155916	Metals by ICP - AES
		1000	Aluminum	
		1005	Antimony	
		1010	Arsenic	
		1015	Barium	
		1020	Beryllium	
		1025	Boron	
		1030	Cadmium	
		1035	Calcium	
		1040	Chromium	
		1050	Cobalt	
		1055	Copper	
		1070	Iron	
		1075	Lead	
		1080	Lithium	
		1085	Magnesium	
		1090	Manganese	

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Solids	EPA 6010D 4	1100	Molybdenum	
		1105	Nickel	
		1125	Potassium	
		1140	Selenium	
		1990	Silica as SiO2	
		1145	Silicon	
		1150	Silver	
		1155	Sodium	
		1160	Strontium	
		1165	Thallium	
		1175	Tin	
		1180	Titanium	
		1185	Vanadium	
		1190	Zinc	
	EPA 6020			10156000 Inductively Coupled Plasma-Mass Spectrometry
		1000	Aluminum	
		1005	Antimony	
		1010	Arsenic	
		1015	Barium	
		1020	Beryllium	
		1025	Boron	
		1030	Cadmium	
		1035	Calcium	
		1040	Chromium	
		1050	Cobalt	
		1055	Copper	
		1070	Iron	
		1075	Lead	
		1080	Lithium	
		1085	Magnesium	
		1090	Manganese	
		1100	Molybdenum	
		1105	Nickel	
		1125	Potassium	
		1140	Selenium	
		1150	Silver	
		1155	Sodium	
		1160	Strontium	
		1165	Thallium	
		1175	Tin	
		1180	Titanium	
		1185	Vanadium	
		1190	Zinc	

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Solids

EPA 6020A 1		10156419	Inductively Coupled Plasma -Mass Spectrometry
1000	Aluminum		
1005	Antimony		
1010	Arsenic		
1015	Barium		
1020	Beryllium		
1025	Boron		
1030	Cadmium		
1035	Calcium		
1040	Chromium		
1050	Cobalt		
1055	Copper		
1070	Iron		
1075	Lead		
1080	Lithium		
1085	Magnesium		
1090	Manganese		
1100	Molybdenum		
1105	Nickel		
1125	Potassium		
1140	Selenium		
1150	Silver		
1155	Sodium		
1160	Strontium		
1165	Thallium		
1175	Tin		
1180	Titanium		
1185	Vanadium		
1190	Zinc		
EPA 6020B 2		10156420	Inductively Coupled Plasma-Mass Spectrometry
1000	Aluminum		
1005	Antimony		
1010	Arsenic		
1015	Barium		
1020	Beryllium		
1025	Boron		
1030	Cadmium		
1035	Calcium		
1040	Chromium		
1050	Cobalt		
1055	Copper		
1070	Iron		

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	EPA 6020B 2	1075	Lead	
		1080	Lithium	
		1085	Magnesium	
		1090	Manganese	
		1100	Molybdenum	
		1105	Nickel	
		1125	Potassium	
		1140	Selenium	
		1150	Silver	
		1155	Sodium	
		1160	Strontium	
		1165	Thallium	
		1175	Tin	
		1180	Titanium	
		1185	Vanadium	
		1190	Zinc	
	EPA 7196A			10162400 Chromium Hexavalent colorimetric
		1045	Chromium VI	
	EPA 7470A			10165807 Mercury in Liquid Waste by Cold Vapor Atomic Absorption
		1095	Mercury	
	EPA 7471A			10166208 Mercury in Solid Waste by Cold Vapor Atomic Absorption
		1095	Mercury	
	EPA 7471B			10166402 Mercury by Cold Vapor Atomic Absorption
		1095	Mercury	
	EPA 8015B			10173601 Non-halogenated organics using GC/FID
		9369	Diesel range organics (DRO)	
		9408	Gasoline range organics (GRO)	
	EPA 8015C			10173805 Non-halogenated organics using GC/FID
		9369	Diesel range organics (DRO)	
		9408	Gasoline range organics (GRO)	
	EPA 8015D			10305609 Nonhalogenated Organics Using GC/FID
		9369	Diesel range organics (DRO)	
		9408	Gasoline range organics (GRO)	
	EPA 8081A			10178606 Organochlorine Pesticides by GC/ECD
		7355	4,4'-DDD	
		7360	4,4'-DDE	
		7365	4,4'-DDT	
		7025	Aldrin	

Solids

EPA 8081A	7110	alpha-BHC (alpha-Hexachlorocyclohexane)	
	7115	beta-BHC (beta-Hexachlorocyclohexane)	
	7250	Chlordane (tech.)	
	7260	Chlorobenzilate	
	7240	cis-chlordane (alpha-Chlordane)	
	7105	delta-BHC	
	7405	Diallate	
	7470	Dieldrin	
	7510	Endosulfan I	
	7515	Endosulfan II	
	7520	Endosulfan sulfate	
	7540	Endrin	
	7530	Endrin aldehyde	
	7535	Endrin ketone	
	7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)	
	7685	Heptachlor	
	7690	Heptachlor epoxide	
	6275	Hexachlorobenzene	
	7725	Isodrin	
	7740	Kepone	
	7810	Methoxychlor	
	7870	Mirex	
	8250	Toxaphene (Chlorinated camphene)	
	7245	trans-chlordane (gamma-Chlordane)	
EPA 8081B			10178800 Organochlorine Pesticides by GC/ECD
	7355	4,4'-DDD	
	7360	4,4'-DDE	
	7365	4,4'-DDT	
	7025	Aldrin	
	7110	alpha-BHC (alpha-Hexachlorocyclohexane)	
	7115	beta-BHC (beta-Hexachlorocyclohexane)	
	7250	Chlordane (tech.)	
	7260	Chlorobenzilate	
	7240	cis-chlordane (alpha-Chlordane)	
	7105	delta-BHC	
	7405	Diallate	
	7470	Dieldrin	
	7510	Endosulfan I	
	7515	Endosulfan II	
	7520	Endosulfan sulfate	

Solids

	EPA 8081B	7540	Endrin	
		7530	Endrin aldehyde	
		7535	Endrin ketone	
		7120	gamma-BHC (Lindane, gamma-HexachlorocyclohexanE)	
		7685	Heptachlor	
		7690	Heptachlor epoxide	
		6275	Hexachlorobenzene	
		7725	Isodrin	
		7740	Kepone	
		7810	Methoxychlor	
		7870	Mirex	
		8250	Toxaphene (Chlorinated camphene)	
		7245	trans-chlordane (gamma-Chlordane)	
	EPA 8082			10179007 Polychlorinated Biphenyls (PCBs) by GC/ECD
		8880	Aroclor-1016 (PCB-1016)	
		8885	Aroclor-1221 (PCB-1221)	
		8890	Aroclor-1232 (PCB-1232)	
		8895	Aroclor-1242 (PCB-1242)	
		8900	Aroclor-1248 (PCB-1248)	
		8905	Aroclor-1254 (PCB-1254)	
		8910	Aroclor-1260 (PCB-1260)	
		8912	Aroclor-1262 (PCB-1262)	
		8913	Aroclor-1268 (PCB-1268)	
	EPA 8082A			10179201 Polychlorinated Biphenyls (PCBs) by GC/ECD
		8880	Aroclor-1016 (PCB-1016)	
		8885	Aroclor-1221 (PCB-1221)	
		8890	Aroclor-1232 (PCB-1232)	
		8895	Aroclor-1242 (PCB-1242)	
		8900	Aroclor-1248 (PCB-1248)	
		8905	Aroclor-1254 (PCB-1254)	
		8910	Aroclor-1260 (PCB-1260)	
		8912	Aroclor-1262 (PCB-1262)	
		8913	Aroclor-1268 (PCB-1268)	
	EPA 8151A			10183207 Chlorinated Herbicides by GC/ECD
		8655	2,4,5-T	
		8545	2,4-D	
		8560	2,4-DB	
		8555	Dalapon	
		8595	Dicamba	
		8605	Dichloroprop (Dichlorprop)	

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Solids

EPA 8151A	8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)	
	7775	MCPA	
	7780	MCPP	
	6605	Pentachlorophenol	
	8650	Silvex (2,4,5-TP)	
EPA 8260B			10184802 Volatile Organic Compounds by purge and trap GC/MS
	5105	1,1,1,2-Tetrachloroethane	
	5160	1,1,1-Trichloroethane	
	5110	1,1,2,2-Tetrachloroethane	
	5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	
	5165	1,1,2-Trichloroethane	
	4630	1,1-Dichloroethane	
	4640	1,1-Dichloroethylene	
	4670	1,1-Dichloropropene	
	5150	1,2,3-Trichlorobenzene	
	5180	1,2,3-Trichloropropane	
	5182	1,2,3-Trimethylbenzene	
	5155	1,2,4-Trichlorobenzene	
	5210	1,2,4-Trimethylbenzene	
	4570	1,2-Dibromo-3-chloropropane (DBCP)	
	4585	1,2-Dibromoethane (EDB, Ethylene dibromide)	
	4610	1,2-Dichlorobenzene	
	4635	1,2-Dichloroethane (Ethylene dichloride)	
	4655	1,2-Dichloropropane	
	6800	1,3,5-Trichlorobenzene	
	5215	1,3,5-Trimethylbenzene	
	9318	1,3-Butadiene	
	4615	1,3-Dichlorobenzene	
	4660	1,3-Dichloropropane	
	4675	1,3-Dichloropropene	
	4620	1,4-Dichlorobenzene	
	4735	1,4-Dioxane (1,4- Diethyleneoxide)	
	4510	1-Chlorohexane	
	4665	2,2-Dichloropropane	
	4410	2-Butanone (Methyl ethyl ketone, MEK)	
	4500	2-Chloroethyl vinyl ether	
	4535	2-Chlorotoluene	
	4538	2-Ethyltoluene	
	4860	2-Hexanone (MBK)	
	6385	2-Methylnaphthalene	
	5020	2-Nitropropane	

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Solids	EPA 8260B	4531	3-Ethyltoluene (1-Methyl-3-ethylbenzene)
		4540	4-Chlorotoluene
		4910	4-Isopropyltoluene (p-Cymene)
		4995	4-Methyl-2-pentanone (MIBK)
		4315	Acetone
		4320	Acetonitrile
		4325	Acrolein (Propenal)
		4340	Acrylonitrile
		4355	Allyl chloride (3-Chloropropene)
		4375	Benzene
		5635	Benzyl chloride
		4385	Bromobenzene
		4390	Bromochloromethane
		4395	Bromodichloromethane
		4400	Bromoform
		4403	Butyl acetate
		4450	Carbon disulfide
		4455	Carbon tetrachloride
		4475	Chlorobenzene
		4575	Chlorodibromomethane
		4485	Chloroethane (Ethyl chloride)
		4505	Chloroform
		4525	Chloroprene (2-Chloro-1,3-butadiene)
		4705	cis & trans-1,2-Dichloroethene
		4645	cis-1,2-Dichloroethylene
		4680	cis-1,3-Dichloropropene
		4555	Cyclohexane
		4560	Cyclohexanone
		4595	Dibromomethane (Methylene bromide)
		4625	Dichlorodifluoromethane (Freon-12)
		4627	Dichlorofluoromethane (Freon 21)
		4725	Diethyl ether
		9375	Di-isopropylether (DIPE)
		4745	Epichlorohydrin (1-Chloro-2,3-epoxypropane)
		4755	Ethyl acetate
		4760	Ethyl acrylate
		4810	Ethyl methacrylate
		4765	Ethylbenzene
		4795	Ethylene oxide
		4770	Ethyl-t-butylether (ETBE) (2-Ethoxy-2-methylpropane)
		4835	Hexachlorobutadiene

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Solids	EPA 8260B	4870	Iodomethane (Methyl iodide)
		4875	Isobutyl alcohol (2-Methyl-1-propanol)
		4900	Isopropylbenzene (Cumene)
		5240	m+p-xylene
		4925	Methacrylonitrile
		4940	Methyl acetate
		4950	Methyl bromide (Bromomethane)
		4960	Methyl chloride (Chloromethane)
		4990	Methyl methacrylate
		5000	Methyl tert-butyl ether (MTBE)
		4965	Methylcyclohexane
		4975	Methylene chloride (Dichloromethane)
		5245	m-Xylene
		5005	Naphthalene
		4425	n-Butyl alcohol (1-Butanol, n-Butanol)
		4435	n-Butylbenzene
		4825	n-Heptane
		4855	n-Hexane
		5090	n-Propylbenzene
		5250	o-Xylene
		5035	Pentachloroethane
		5080	Propionitrile (Ethyl cyanide)
		9579	Propylene oxide
		5255	p-Xylene
		4440	sec-Butylbenzene
		5100	Styrene
		4370	T-amylmethylether (TAME)
		4420	tert-Butyl alcohol
		4445	tert-Butylbenzene
		5115	Tetrachloroethylene (Perchloroethylene)
		5120	Tetrahydrofuran (THF)
		9574	Tetrahydrothiophene
		5140	Toluene
		5205	Total trihalomethanes
		4700	trans-1,2-Dichloroethylene
		4685	trans-1,3-Dichloropropylene
		4605	trans-1,4-Dichloro-2-butene
		5170	Trichloroethene (Trichloroethylene)
		5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)
		5225	Vinyl acetate
		5235	Vinyl chloride
		5260	Xylene (total)

Solids	EPA 8260C		10307003	Volatile Organics: GC/MS (capillary column)

5105	1,1,1,2-Tetrachloroethane
5160	1,1,1-Trichloroethane
5110	1,1,2,2-Tetrachloroethane
5195	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
5165	1,1,2-Trichloroethane
4630	1,1-Dichloroethane
4640	1,1-Dichloroethylene
4670	1,1-Dichloropropene
5150	1,2,3-Trichlorobenzene
5180	1,2,3-Trichloropropane
5182	1,2,3-Trimethylbenzene
5155	1,2,4-Trichlorobenzene
5210	1,2,4-Trimethylbenzene
4570	1,2-Dibromo-3-chloropropane (DBCP)
4585	1,2-Dibromoethane (EDB, Ethylene dibromide)
4610	1,2-Dichlorobenzene
4635	1,2-Dichloroethane (Ethylene dichloride)
4655	1,2-Dichloropropane
6800	1,3,5-Trichlorobenzene
5215	1,3,5-Trimethylbenzene
9318	1,3-Butadiene
4615	1,3-Dichlorobenzene
4660	1,3-Dichloropropane
4675	1,3-Dichloropropene
4620	1,4-Dichlorobenzene
4735	1,4-Dioxane (1,4- Diethyleneoxide)
4510	1-Chlorohexane
4665	2,2-Dichloropropane
4410	2-Butanone (Methyl ethyl ketone, MEK)
4500	2-Chloroethyl vinyl ether
4535	2-Chlorotoluene
4538	2-Ethyltoluene
4860	2-Hexanone (MBK)
6385	2-Methylnaphthalene
5020	2-Nitropropane
4531	3-Ethyltoluene (1-Methyl-3-ethylbenzene)
4540	4-Chlorotoluene
4910	4-Isopropyltoluene (p-Cymene)
4995	4-Methyl-2-pentanone (MIBK)
4315	Acetone

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Solids EPA 8260C

4320	Acetonitrile
4325	Acrolein (Propenal)
4340	Acrylonitrile
4355	Allyl chloride (3-Chloropropene)
4375	Benzene
5635	Benzyl chloride
4385	Bromobenzene
4390	Bromochloromethane
4395	Bromodichloromethane
4400	Bromoform
4403	Butyl acetate
4450	Carbon disulfide
4455	Carbon tetrachloride
4475	Chlorobenzene
4575	Chlorodibromomethane
4485	Chloroethane (Ethyl chloride)
4505	Chloroform
4525	Chloroprene (2-Chloro-1,3-butadiene)
4705	cis & trans-1,2-Dichloroethene
4645	cis-1,2-Dichloroethylene
4680	cis-1,3-Dichloropropene
4555	Cyclohexane
4560	Cyclohexanone
4595	Dibromomethane (Methylene bromide)
4625	Dichlorodifluoromethane (Freon-12)
4627	Dichlorofluoromethane (Freon 21)
4725	Diethyl ether
9375	Di-isopropylether (DIPE)
4745	Epichlorohydrin (1-Chloro-2,3-epoxypropane)
4755	Ethyl acetate
4760	Ethyl acrylate
4810	Ethyl methacrylate
4765	Ethylbenzene
4795	Ethylene oxide
4770	Ethyl-t-butylether (ETBE) (2-Ethoxy-2-methylpropane)
4835	Hexachlorobutadiene
4870	Iodomethane (Methyl iodide)
4875	Isobutyl alcohol (2-Methyl-1-propanol)
4900	Isopropylbenzene (Cumene)
5240	m+p-xylene
4925	Methacrylonitrile
4940	Methyl acetate

Solids	EPA 8260C	4950	Methyl bromide (Bromomethane)	
		4960	Methyl chloride (Chloromethane)	
		4990	Methyl methacrylate	
		5000	Methyl tert-butyl ether (MTBE)	
		4965	Methylcyclohexane	
		4975	Methylene chloride (Dichloromethane)	
		5245	m-Xylene	
		5005	Naphthalene	
		4425	n-Butyl alcohol (1-Butanol, n-Butanol)	
		4435	n-Butylbenzene	
		4825	n-Heptane	
		4855	n-Hexane	
		5090	n-Propylbenzene	
		5250	o-Xylene	
		5035	Pentachloroethane	
		5080	Propionitrile (Ethyl cyanide)	
		9579	Propylene oxide	
		5255	p-Xylene	
		4440	sec-Butylbenzene	
		5100	Styrene	
		4370	T-amylmethylether (TAME)	
		4420	tert-Butyl alcohol	
		4445	tert-Butylbenzene	
		5115	Tetrachloroethylene (Perchloroethylene)	
		5120	Tetrahydrofuran (THF)	
		9574	Tetrahydrothiophene	
		5140	Toluene	
		5205	Total trihalomethanes	
		4700	trans-1,2-Dichloroethylene	
		4685	trans-1,3-Dichloropropylene	
		4605	trans-1,4-Dichloro-2-butene	
		5170	Trichloroethene (Trichloroethylene)	
		5175	Trichlorofluoromethane (Fluorotrichloromethane, Freon 11)	
		5225	Vinyl acetate	
		5235	Vinyl chloride	
		5260	Xylene (total)	
	EPA 8270C			10185805 Semivolatile Organic compounds by GC/MS
		6703	1,1'-Biphenyl (BZ-0)	
		6705	1,2,3,4-Tetrachlorobenzene	
		6710	1,2,3,5-Tetrachlorobenzene	
		5150	1,2,3-Trichlorobenzene	
		6715	1,2,4,5-Tetrachlorobenzene	

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Solids	EPA 8270C	5155	1,2,4-Trichlorobenzene
		4610	1,2-Dichlorobenzene
		6221	1,2-Diphenylhydrazine
		6800	1,3,5-Trichlorobenzene
		6885	1,3,5-Trinitrobenzene (1,3,5-TNB)
		4615	1,3-Dichlorobenzene
		6160	1,3-Dinitrobenzene (1,3-DNB)
		4620	1,4-Dichlorobenzene
		6165	1,4-Dinitrobenzene
		4735	1,4-Dioxane (1,4- Diethyleneoxide)
		6420	1,4-Naphthoquinone
		6630	1,4-Phenylenediamine
		5790	1-Chloronaphthalene
		6380	1-Methylnaphthalene
		6425	1-Naphthylamine
		5754	1-Phenoxy-2-propanol
		4659	2,2-Oxybis(1-chloropropane)
		6735	2,3,4,6-Tetrachlorophenol
		6740	2,3,5,6-Tetrachlorophenol
		6835	2,4,5-Trichlorophenol
		6840	2,4,6-Trichlorophenol
		6000	2,4-Dichlorophenol
		6130	2,4-Dimethylphenol
		6175	2,4-Dinitrophenol
		6185	2,4-Dinitrotoluene (2,4-DNT)
		6005	2,6-Dichlorophenol
		6190	2,6-Dinitrotoluene (2,6-DNT)
		5515	2-Acetylaminofluorene
		5735	2-Chloroaniline
		5795	2-Chloronaphthalene
		5800	2-Chlorophenol
		6360	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2-methylphenol)
		5145	2-Methylaniline (o-Toluidine)
		6385	2-Methylnaphthalene
		6400	2-Methylphenol (o-Cresol)
		6430	2-Naphthylamine
		6460	2-Nitroaniline
		6490	2-Nitrophenol
		5050	2-Picoline (2-Methylpyridine)
		6412	3 & 4 Methylphenol
		5945	3,3'-Dichlorobenzidine
		6120	3,3'-Dimethylbenzidine
		5995	3,4-Dichloronitrobenzene

Solids	EPA 8270C	6355	3-Methylcholanthrene
		6405	3-Methylphenol (m-Cresol)
		6465	3-Nitroaniline
		6365	4,4-Methylenebis(2-chloroaniline)
		5540	4-Aminobiphenyl
		5660	4-Bromophenyl phenyl ether (BDE-3)
		5700	4-Chloro-3-methylphenol
		5745	4-Chloroaniline
		5825	4-Chlorophenyl phenylether
		6105	4-Dimethyl aminoazobenzene
		6410	4-Methylphenol (p-Cresol)
		6470	4-Nitroaniline
		6500	4-Nitrophenol
		6510	4-Nitroquinoline 1-oxide
		6516	4-tert-Butylphenol
		6570	5-Nitro-o-toluidine
		6112	6-Methylchrysene
		6115	7,12-Dimethylbenz(a) anthracene
		6125	a-a-Dimethylphenethylamine
		5500	Acenaphthene
		5505	Acenaphthylene
		5510	Acetophenone
		4330	Acrylamide
		5545	Aniline
		5555	Anthracene
		5560	Aramite
		7065	Atrazine
		5562	Azobenzene
		5570	Benzaldehyde
		5567	Benzenethiol (Phenylmercaptan)
		5595	Benzidine
		5575	Benzo(a)anthracene
		5580	Benzo(a)pyrene
		5590	Benzo(g,h,i)perylene
		5600	Benzo(k)fluoranthene
		5585	Benzo[b]fluoranthene
		5610	Benzoic acid
		5630	Benzyl alcohol
		5760	bis(2-Chloroethoxy)methane
		5765	bis(2-Chloroethyl) ether
		5780	bis(2-Chloroisopropyl) ether
		5670	Butyl benzyl phthalate
		7180	Caprolactam

Solids	EPA 8270C	5680	Carbazole
		7260	Chlorobenzilate
		7300	Chlorpyrifos
		5855	Chrysene
		5862	Cresols, Total
		6065	Di(2-ethylhexyl) phthalate (bis(2-Ethylhexyl)phthalate, DEHP)
		7405	Diallate
		9354	Dibenz(a, h) acridine
		5900	Dibenz(a, j) acridine
		5895	Dibenz(a,h) anthracene
		5890	Dibenzo(a,e) pyrene
		5905	Dibenzofuran
		6070	Diethyl phthalate
		7475	Dimethoate
		6135	Dimethyl phthalate
		5925	Di-n-butyl phthalate
		6200	Di-n-octyl phthalate
		8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)
		6210	Diphenyl ether (Diphenyl Oxide)
		6205	Diphenylamine
		8625	Disulfoton
		4810	Ethyl methacrylate
		6260	Ethyl methanesulfonate
		7580	Famphur
		6265	Fluoranthene
		6270	Fluorene
		6275	Hexachlorobenzene
		4835	Hexachlorobutadiene
		6285	Hexachlorocyclopentadiene
		4840	Hexachloroethane
		6295	Hexachloropropene
		6312	Indene
		6315	Indeno(1,2,3-cd) pyrene
		7725	Isodrin
		6320	Isophorone
		6325	Isosafrole
		7740	Kepone
		6345	Methapyrilene
		6375	Methyl methanesulfonate
		7825	Methyl parathion (Parathion, methyl)
		6443	n, n-Dimethylacetamide
		5005	Naphthalene

Solids	EPA 8270C	5875	n-Decane		
		6300	n-Hexadecane		
		5015	Nitrobenzene		
		6525	n-Nitrosodiethylamine		
		6530	n-Nitrosodimethylamine		
		5025	n-Nitroso-di-n-butylamine		
		6545	n-Nitrosodi-n-propylamine		
		6535	n-Nitrosodiphenylamine		
		6550	n-Nitrosomethylethylamine		
		6555	n-Nitrosomorpholine		
		6560	n-Nitrosopiperidine		
		6565	n-Nitrosopyrrolidine		
		6580	n-Octadecane		
		8290	o,o,o-Triethyl phosphorothioate		
		3960	o-Phenylphenol		
		7955	Parathion, ethyl		
		6590	Pentachlorobenzene		
		5035	Pentachloroethane		
		6600	Pentachloronitrobenzene		
		6605	Pentachlorophenol		
		6610	Phenacetin		
		6615	Phenanthrene		
		6625	Phenol		
		7985	Phorate		
		9663	p-Phenylenediamine		
		6650	Pronamide (Kerb)		
		6665	Pyrene		
		5095	Pyridine		
		6670	Quinoline		
		6685	Safrole		
		8155	Sulfotepp		
		8235	Thionazin (Zinophos)		
		6750	Thiophenol (Benzenethiol)		
		8262	Tributyl phosphate		
	EPA 8270D			10186002	Semivolatile Organic compounds by GC/MS
		6703	1,1'-Biphenyl (BZ-0)		
		6705	1,2,3,4-Tetrachlorobenzene		
		6710	1,2,3,5-Tetrachlorobenzene		
		5150	1,2,3-Trichlorobenzene		
		6715	1,2,4,5-Tetrachlorobenzene		
		5155	1,2,4-Trichlorobenzene		
		4610	1,2-Dichlorobenzene		
		6221	1,2-Diphenylhydrazine		

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4101 Shuffel Street NW

Certificate: 4062 - 008

North Canton, OH 44720 Issue Date: 2/24/2019 Expiration Date: 2/23/2020

As of 2/24/2019 this list supersedes all previous lists for this certificate number.

Solids	EPA 8270D	6800	1,3,5-Trichlorobenzene
		6885	1,3,5-Trinitrobenzene (1,3,5-TNB)
		4615	1,3-Dichlorobenzene
		6160	1,3-Dinitrobenzene (1,3-DNB)
		4620	1,4-Dichlorobenzene
		6165	1,4-Dinitrobenzene
		4735	1,4-Dioxane (1,4- Diethyleneoxide)
		6420	1,4-Naphthoquinone
		6630	1,4-Phenylenediamine
		5790	1-Chloronaphthalene
		6380	1-Methylnaphthalene
		6425	1-Naphthylamine
		5754	1-Phenoxy-2-propanol
		6735	2,3,4,6-Tetrachlorophenol
		6740	2,3,5,6-Tetrachlorophenol
		6835	2,4,5-Trichlorophenol
		6840	2,4,6-Trichlorophenol
		6000	2,4-Dichlorophenol
		6130	2,4-Dimethylphenol
		6175	2,4-Dinitrophenol
		6185	2,4-Dinitrotoluene (2,4-DNT)
		6005	2,6-Dichlorophenol
		6190	2,6-Dinitrotoluene (2,6-DNT)
		5515	2-Acetylaminofluorene
		5735	2-Chloroaniline
		5795	2-Chloronaphthalene
		5800	2-Chlorophenol
		6360	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-2 -methylphenol)
		5145	2-Methylaniline (o-Toluidine)
		6385	2-Methylnaphthalene
		6400	2-Methylphenol (o-Cresol)
		6430	2-Naphthylamine
		6460	2-Nitroaniline
		6490	2-Nitrophenol
		5050	2-Picoline (2-Methylpyridine)
		6412	3 & 4 Methylphenol
		5945	3,3'-Dichlorobenzidine
		6120	3,3'-Dimethylbenzidine
		5995	3,4-Dichloronitrobenzene
		6355	3-Methylcholanthrene
		6405	3-Methylphenol (m-Cresol)
		6465	3-Nitroaniline
		6365	4,4-Methylenebis(2-chloroaniline)

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

TestAmerica Canton

EPA CODE: OH00048

4101 Shuffel Street NW

Certificate: 4062 - 008

North Canton, OH 44720 Issue Date: 2/24/2019 Expiration Date: 2/23/2020

As of 2/24/2019 this list supersedes all previous lists for this certificate number.

Solids	EPA 8270D	5540	4-Aminobiphenyl
		5660	4-Bromophenyl phenyl ether (BDE-3)
		5700	4-Chloro-3-methylphenol
		5745	4-Chloroaniline
		5825	4-Chlorophenyl phenylether
		6105	4-Dimethyl aminoazobenzene
		6410	4-Methylphenol (p-Cresol)
		6470	4-Nitroaniline
		6500	4-Nitrophenol
		6510	4-Nitroquinoline 1-oxide
		6516	4-tert-Butylphenol
		6570	5-Nitro-o-toluidine
		6112	6-Methylchrysene
		6115	7,12-Dimethylbenz(a) anthracene
		6125	a-a-Dimethylphenethylamine
		5500	Acenaphthene
		5505	Acenaphthylene
		5510	Acetophenone
		4330	Acrylamide
		5545	Aniline
		5555	Anthracene
		5560	Aramite
		7065	Atrazine
		5562	Azobenzene
		5570	Benzaldehyde
		5567	Benzenethiol (Phenylmercaptan)
		5595	Benzidine
		5575	Benzo(a)anthracene
		5580	Benzo(a)pyrene
		5590	Benzo(g,h,i)perylene
		5600	Benzo(k)fluoranthene
		5585	Benzo[b]fluoranthene
		5610	Benzoic acid
		5630	Benzyl alcohol
		5760	bis(2-Chloroethoxy)methane
		5765	bis(2-Chloroethyl) ether
		5780	bis(2-Chloroisopropyl) ether
		5670	Butyl benzyl phthalate
		7180	Caprolactam
		5680	Carbazole
		7260	Chlorobenzilate
		7300	Chlorpyrifos
		5855	Chrysene

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

TestAmerica Canton

EPA CODE: OH00048

4101 Shuffel Street NW

Certificate: 4062 - 008

North Canton, OH 44720 Issue Date: 2/24/2019 Expiration Date: 2/23/2020

As of 2/24/2019 this list supersedes all previous lists for this certificate number.

Solids	EPA 8270D	5862	Cresols, Total
		6065	Di(2-ethylhexyl) phthalate (bis(2-Ethylhexyl)phthalate, DEHP)
		7405	Diallate
		9354	Dibenz(a, h) acridine
		5900	Dibenz(a, j) acridine
		5895	Dibenz(a,h) anthracene
		5890	Dibenzo(a,e) pyrene
		5905	Dibenzofuran
		6070	Diethyl phthalate
		7475	Dimethoate
		6135	Dimethyl phthalate
		5925	Di-n-butyl phthalate
		6200	Di-n-octyl phthalate
		8620	Dinoseb (2-sec-butyl-4,6-dinitrophenol, DNBP)
		6210	Diphenyl ether (Diphenyl Oxide)
		6205	Diphenylamine
		8625	Disulfoton
		4810	Ethyl methacrylate
		6260	Ethyl methanesulfonate
		7580	Famphur
		6265	Fluoranthene
		6270	Fluorene
		6275	Hexachlorobenzene
		4835	Hexachlorobutadiene
		6285	Hexachlorocyclopentadiene
		4840	Hexachloroethane
		6295	Hexachloropropene
		6312	Indene
		6315	Indeno(1,2,3-cd) pyrene
		7725	Isodrin
		6320	Isophorone
		6325	Isosafrole
		7740	Kepone
		6345	Methapyrilene
		6375	Methyl methanesulfonate
		7825	Methyl parathion (Parathion, methyl)
		6443	n, n-Dimethylacetamide
		5005	Naphthalene
		5875	n-Decane
		6300	n-Hexadecane
		5015	Nitrobenzene
		6525	n-Nitrosodiethylamine

Solids

EPA 8270D	6530	n-Nitrosodimethylamine		
	5025	n-Nitroso-di-n-butylamine		
	6545	n-Nitrosodi-n-propylamine		
	6535	n-Nitrosodiphenylamine		
	6550	n-Nitrosomethylethylamine		
	6555	n-Nitrosomorpholine		
	6560	n-Nitrosopiperidine		
	6565	n-Nitrosopyrrolidine		
	6580	n-Octadecane		
	8290	o,o,o-Triethyl phosphorothioate		
	3960	o-Phenylphenol		
	7955	Parathion, ethyl		
	6590	Pentachlorobenzene		
	5035	Pentachloroethane		
	6600	Pentachloronitrobenzene		
	6605	Pentachlorophenol		
	6610	Phenacetin		
	6615	Phenanthrene		
	6625	Phenol		
	7985	Phorate		
	9663	p-Phenylenediamine		
	6650	Pronamide (Kerb)		
	6665	Pyrene		
	5095	Pyridine		
	6670	Quinoline		
	6685	Safrole		
	8155	Sulfotepp		
	8235	Thionazin (Zinophos)		
	8262	Tributyl phosphate		
EPA 8315A			10188008	Determination of Carbonyl Compounds by HPLC/UV-VIS
	4815	Formaldehyde		
EPA 9012A			10193405	Total and Amenable Cyanide (automated colorimetric with off-line distillation)
	1510	Amenable cyanide		
	1645	Total cyanide		
EPA 9012B			10243206	Total and Amenable Cyanide (automated colorimetric with off-line distillation)
	1510	Amenable cyanide		
	1645	Total cyanide		
EPA 9023			10195003	Extractable Organic Halides (EOX) in Solids
	1720	Extractable organics halides (EOX)		

OREGON

Environmental Laboratory Accreditation Program

ORELAP Fields of Accreditation

ORELAP ID: 4062

TestAmerica Canton
4101 Shuffel Street NW
North Canton, OH 44720

EPA CODE: OH00048
Certificate: 4062 - 008

Issue Date: 2/24/2019 Expiration Date: 2/23/2020

As of 2/24/2019 this list supersedes all previous lists for this certificate number.

Solids

EPA 9030B			10195605	Acid-Soluble and Acid-Insoluble sulfides: Distillation
	2005	Sulfide		
EPA 9034			10196006	Titrimetric Procedure for Acid-Soluble and Acid-Insoluble Sulfides
	2005	Sulfide		
EPA 9040B			10197203	pH Electrometric Measurement
	1900	pH		
EPA 9040C			10244403	pH Electrometric Measurement
	1900	pH		
EPA 9045C			10198400	Soil and Waste pH
	1900	pH		
EPA 9045D			10244607	Soil and Waste pH
	1900	pH		
EPA 9050A			10198808	Specific Conductance
	1610	Conductivity		
EPA 9056A			10199607	Determination of Inorganic Anions by Ion Chromatography
	1540	Bromide		
	1575	Chloride		
	1730	Fluoride		
	1810	Nitrate as N		
	1840	Nitrite as N		
	2000	Sulfate		
EPA 9065			10200405	Phenolics (Spectrophotometric, Manual 4-AAP with Distillation)
	1905	Total phenolics		
EPA 9095A			10204203	Paint Filter Liquids Test
	8031	Extraction/Preparation		
EPA 9095B			10245600	Paint Filter Liquids Test
	8031	Extraction/Preparation		
Walkley-Black 1969			60012002	Total Organic Carbon in Soils and Sediments by Titration
	2040	Total organic carbon		
WI(95) DRO			90019457	Wisconsin DNR - Modified Method for Determination of Diesel Range Organics by GC-FID
	9369	Diesel range organics (DRO)		
WI(95) GRO			90019468	Wisconsin DNR - Modified Method for Determining Gasoline Range Organics GC-FID
	9408	Gasoline range organics (GRO)		

AIHA Laboratory Accreditation Programs, LLC

acknowledges that

Eurofins EMLab P&K

3000 Lincoln Drive East, Suite A, Marlton, NJ 08053

Laboratory ID: 103005

along with all premises from which key activities are performed, as listed above, has fulfilled the requirements of the AIHA Laboratory Accreditation Programs (AIHA-LAP), LLC accreditation to the ISO/IEC 17025:2017 international standard, *General Requirements for the Competence of Testing and Calibration Laboratories* in the following:

LABORATORY ACCREDITATION PROGRAMS

☐	**INDUSTRIAL HYGIENE**	Accreditation Expires:
☐	**ENVIRONMENTAL LEAD**	Accreditation Expires:
✓	**ENVIRONMENTAL MICROBIOLOGY**	Accreditation Expires: February 01, 2021
☐	**FOOD**	Accreditation Expires:
☐	**UNIQUE SCOPES**	Accreditation Expires:

Specific Field(s) of Testing (FoT)/Method(s) within each Accreditation Program for which the above named laboratory maintains accreditation is outlined on the attached **Scope of Accreditation**. Continued accreditation is contingent upon successful on-going compliance with ISO/IEC 17025:2017 and AIHA-LAP, LLC requirements. This certificate is not valid without the attached **Scope of Accreditation**. Please review the AIHA-LAP, LLC website (www.aihaaccreditedlabs.org) for the most current Scope.

Beth Bair

Elizabeth Bair
Chairperson, Analytical Accreditation Board

Cheryl O. Morton

Cheryl O. Morton
Managing Director, AIHA Laboratory Accreditation Programs, LLC

Revision 17 – 09/11/2018

Date Issued: 08/21/2019

AIHA Laboratory Accreditation Programs, LLC
SCOPE OF ACCREDITATION

Eurofins EMLab P&K
3000 Lincoln Drive East, Suite A, Marlton, NJ 08053

Laboratory ID: **103005**
Issue Date: 08/21/2019

The laboratory is approved for those specific field(s) of testing/methods listed in the table below. Clients are urged to verify the laboratory's current accreditation status for the particular field(s) of testing/Methods, since these can change due to proficiency status, suspension and/or withdrawal of accreditation.

Environmental Microbiology Laboratory Accreditation Program (EMLAP)

Initial Accreditation Date: 02/01/2013

EMLAP Category	Field of Testing (FoT)	Method	Method Description (*for internal methods only*)
Fungal	Air - Culturable	EM-MY-S-1043	Preparation and Analysis of Air Samples for Culturable Fungi
	Bulk - Culturable	EM-MY-S-1040	Preparation of Bulk, Dust/Soil, Swab/Wipe, and Water/Liquid Samples for Quantitative Fungal and/or Bacterial Analysis
		EM-MY-S-2584	Analysis of Dust, Swab, Water and Bulk Samples for Culturable Fungi
	Surface - Culturable	EM-MY-S-1040	Preparation of Bulk, Dust/Soil, Swab/Wipe, and Water/Liquid Samples for Quantitative Fungal and/or Bacterial Analysis
		EM-MY-S-2584	Analysis of Dust, Swab, Water and Bulk Samples for Culturable Fungi
	Air - Direct Examination	EM-MY-S-1038	Preparation and Analysis of Spore Trap (Air) Samples for Fungal Spores, Other Biological and Non-Biological Particles
	Bulk - Direct Examination	EM-MY-S-1039	Preparation and Analysis of Tape, Swab, Wipe, Bulk and Dust - Soil Samples for Qualitative Direct Microscopic Examination
		EM-MY-S-1041	Preparation and Analysis of Tape, Swab, Wipe, Bulk and Dust/Soil Samples for Quantitative Direct Microscopic Examination
	Surface - Direct Examination	EM-MY-S-1039	Preparation and Analysis of Tape, Swab, Wipe, Bulk and Dust - Soil Samples for Qualitative Direct Microscopic Examination

EMLAP Category	Field of Testing (FoT)	Method	Method Description (*for internal methods only*)
Fungal	Surface - Direct Examination	EM-MY-S-1041	Preparation and Analysis of Tape, Swab, Wipe, Bulk and Dust/Soil Samples for Quantitative Direct Microscopic Examination
Bacterial	Air - Culturable	EM-BT-S-1051	Enumeration and Gram Stain Identification of Aerobic Bacteria in Air
		EM-BT-S-1221	Speciation of Aerobic Bacteria utilizing the MIDI Sherlock Instant FAME System
		EM-BT-S-1576	Tests to Aid in Bacterial Identification
		EM-BT-S-1583	Bacterial and Yeast Identification using the API System
	Bulk - Culturable	EM-BT-S-1050	Enumeration & Gram Stain Identification of Aerobic Bacteria & Thermophilic Actinomycetes in Contact Plates, Swab, Bulk, Dust & Water Samples
		EM-BT-S-1221	Speciation of Aerobic Bacteria utilizing the MIDI Sherlock Instant FAME System
		EM-BT-S-1576	Tests to Aid in Bacterial Identification
		EM-BT-S-1583	Bacterial and Yeast Identification using the API system
		EM-PR-S-1040	Preparation of Bulk, Dust/Soil, Swab/Wipe, and Water/Liquid Samples for Quantitative Fungal and/or Bacterial Analysis
	Surface - Culturable	EM-BT-S-1050	Enumeration & Gram Stain Identification of Aerobic Bacteria & Thermophilic Actinomycetes in Contact Plates, Swab, Bulk, Dust & Water Samples
		EM-BT-S-1221	Speciation of Aerobic Bacteria utilizing the MIDI Sherlock Instant FAME System
		EM-BT-S-1576	Tests to Aid in Bacterial Identification
		EM-BT-S-1583	Bacterial and Yeast Identification using the API System
		EM-PR-S-1040	Preparation of Bulk, Dust/Soil, Swab/Wipe and Water/Liquid Samples for Quantitative Fungal and/or Bacterial Analysis
	Legionella	EM-BT-S-1045	Detection and enumeration of Legionella (based on ISO 11731:2017 method)
		EM-BT-S-1687	Detection and enumeration of Legionella bacteria (based on CDC method Procedures for the Recovery of Legionella from the Environment, 2005)

A complete listing of currently accredited Environmental Microbiology laboratories is available on the AIHA-LAP, LLC website at: http://www.aihaaccreditedlabs.org

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 200844-0

Eurofins EMLab P&K

Marlton, NJ

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Asbestos Fiber Analysis

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

2019-10-01 through 2020-09-30

Effective Dates

For the National Voluntary Laboratory Accreditation Program

386

National Voluntary Laboratory Accreditation Program

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

Eurofins EMLab P&K
3000 Lincoln Drive East, Suite A
Marlton, NJ 08053
Mrs. Claudia Palermo
Phone: 856-334-1002 Fax: 856-334-1040
Email: cpalermo@emlabpk.com
http://www.emlab.com

ASBESTOS FIBER ANALYSIS — NVLAP LAB CODE 200844-0

Bulk Asbestos Analysis

Code	*Description*
18/A01	EPA -- 40 CFR Appendix E to Subpart E of Part 763, Interim Method of the Determination of Asbestos in Bulk Insulation Samples
18/A03	EPA 600/R-93/116: Method for the Determination of Asbestos in Bulk Building Materials

For the National Voluntary Laboratory Accreditation Program

AIHA Laboratory Accreditation Programs, LLC

acknowledges that

TestAmerica Laboratories, Inc.

4625 East Cotton Center Blvd., Suite 189, Phoenix, AZ 85040-8874

Laboratory ID: LAP-154268

along with all premises from which key activities are performed, as listed above, has fulfilled the requirements of the AIHA Laboratory Accreditation Programs (AIHA-LAP), LLC accreditation to the ISO/IEC 17025:2017 international standard, General Requirements for the Competence of Testing and Calibration Laboratories in the following:

LABORATORY ACCREDITATION PROGRAMS

☑	**INDUSTRIAL HYGIENE**	Accreditation Expires: October 01, 2021
☑	**ENVIRONMENTAL LEAD**	Accreditation Expires: October 01, 2021
☐	**ENVIRONMENTAL MICROBIOLOGY**	Accreditation Expires:
☐	**FOOD**	Accreditation Expires:
☐	**UNIQUE SCOPES**	Accreditation Expires:

Specific Field(s) of Testing (FoT)/Method(s) within each Accreditation Program for which the above named laboratory maintains accreditation is outlined on the attached Scope of Accreditation. Continued accreditation is contingent upon successful on-going compliance with ISO/IEC 17025:2017 and AIHA-LAP, LLC requirements. This certificate is not valid without the attached Scope of Accreditation. Please review the AIHA-LAP, LLC website (www.aihaaccreditedlabs.org) for the most current Scope.

Beth Bair

Elizabeth Bair
Chairperson, Analytical Accreditation Board

Cheryl O. Morton

Cheryl O Morton
Managing Director, AIHA Laboratory Accreditation Programs, LLC

Revision 17: 09/11/2018

Date Issued: 11/30/2019

AIHA Laboratory Accreditation Programs, LLC

SCOPE OF ACCREDITATION

TestAmerica Laboratories, Inc.
4625 East Cotton Center Blvd., Suite 189, Phoenix, AZ 85040-8874

Laboratory ID: LAP-154268

Issue Date: 11/30/2019

The laboratory is approved for those specific field(s) of testing/methods listed in the table below. Clients are urged to verify the laboratory's current accreditation status for the particular field(s) of testing/Methods, since these can change due to proficiency status, suspension and/or withdrawal of accreditation.

The EPA recognizes the AIHA-LAP, LLC ELLAP program as meeting the requirements of the National Lead Laboratory Accreditation Program (NLLAP) established under Title X of the Residential Lead-Based Paint Hazard Reduction Act of 1992 and includes paint, soil and dust wipe analysis. Air and composited wipes analyses are not included as part of the NLLAP.

Environmental Lead Laboratory Accreditation Program (ELLAP)

Initial Accreditation Date: 02/01/2015

Component, parameter or characteristic tested	Technology sub-type/Detector	Method	Method Description *(for internal methods only)*
Airborne Dust	ICP	NIOSH 7300	N/A
		NIOSH 7303	N/A
Paint	ICP	EPA SW-846 3050B	N/A
		EPA SW-846 6010B	N/A
Settled Dust by Wipe	ICP	NIOSH 9100	N/A
		NIOSH 9102	N/A
Soil	ICP	EPA SW-846 3050B	N/A
		EPA SW-846 6010B	N/A

A complete listing of currently accredited ELLAP laboratories is available on the AIHA-LAP, LLC website at: *http://www.aihaaccreditedlabs.org*

FERNDALE

July 13, 2020 Community & Economic Development

CITY OF FERNDALE
REQUEST FOR COUNCIL ACTION

FROM: Erin Quetell

SUBJECT: Consideration of a Resolution Declaring a Climate Crisis and Requesting City and Regional Collaboration on an Immediate, Just Transition and Urgent Effort to Restore a Safe Climate

INTRODUCTION
Staff and the Ferndale Environmental Sustainability Commission (FESC) recommend that City Council adopt the resolution to declare a climate crisis and request city and regional collaboration on an immediate, just transition and urgent effort to restore a safe climate.

SUMMARY & BACKGROUND
A Michigan Department of Health and Human Services report titled "Climate and Health Adaptation Profile Report" determined significant public health risks of climate change including an increase in respiratory diseases, water-borne diseases, vector-borne diseases, heat-related illnesses, and injuries. Marginalized populations including indigenous, people of color, and low-income communities and residents, and residents with pre-existing conditions, outdoor workers, and the elderly, often bear a disproportionate burden of the impacts of climate change and have fewer resources to accommodate extreme events or disruptions.

Specifically, for the City of Ferndale, the community has experienced the direct impacts of extreme weather and climate change in the historic August 2014 flooding event that devastated thousands and cost millions. Furthermore, the entire world has been impacted by a global viral pandemic and social, environmental, and economic unrest exacerbated by climate change. Despite the City's goals and progress to date, the global climate is changing at a rate that necessitates bolder action to reduce greenhouse gas emissions, including getting to net zero emissions as soon as possible.

The term "Just Transition" is a framework for a fair shift to an economy that is ecologically sustainable, equitable, and just for all its members. Core to a just transition is equity, self-determination, culture, tradition, deep democracy, and the belief that people around the world have a fundamental human right to clean, healthy, and adequate air, water, land, food, education, and shelter.

The intent of this declaration is to both affirm existing commitments, including the participation in Climate Mayors and the Global Covenant of Mayors to combat climate change, and further support City staff in their efforts to conduct a comprehensive greenhouse gas emission inventory and to develop a climate action plan that recognizes the climate crisis and sets forth aggressive measurable goals and effective implementation.

BUDGETARY CONTEXT
N/A

CIP#
N/A

ATTACHMENTS
07132020 Climate Crisis Resolution NEW DRAFT 07082020.doc

Great-Lakes-Climate-Change-Report.pdf

MDHHS_MI Climate Health Profile_2015.pdf

STRATEGIC PLANNING CONTEXT
Strong Regional Partnerships

RECOMMENDED ACTION
Approve the Resolution declaring a climate crisis and requesting city and regional collaboration on an immediate, just transition and urgent effort to restore a safe climate.

FERNDALE

City of Ferndale Resolution

Declaration of a Climate Crisis and requesting city and regional collaboration on an immediate, just transition and urgent effort to restore a safe climate.

At a regular meeting of the City Council of the City of Ferndale, Oakland County, Michigan, held virtually in the Council Chambers at 300 E 9 Mile, Ferndale, MI 48220 on the 13th of July 2020, the following resolution was moved, and supported:

In April 2016 world leaders from 175 countries recognized the threat of climate change and the urgent need to combat it by signing the Paris Agreement, agreeing to keep warming "well below 2 degrees Celsius above pre-industrial levels" and to "pursue efforts to limit the temperature increase to 1.5 degrees Celsius". Global warming of approximately 1 degree Celsius has already increased and intensified flooding, wildfires, rising seas, diseases, droughts, and other extreme weather events. Climate change and the global economy's conflict with ecological limits are contributing to mass extinction of species, which could devastate much of life on Earth for the next 10 million years.

A recent study published by scientific experts titled "An Assessment of the Impacts of Climate Change on the Great Lakes," concluded that the effects of climate change on the Great Lakes is occurring at a much faster pace than other parts of the country and that if not properly mitigated, climate change has the potential to degrade economic, aesthetic, recreation, and ecological factors in Midwestern communities.

A Michigan Department of Health and Human Services report titled "Climate and Health Adaptation Profile Report," determined significant public health risks of climate change including an increase in respiratory diseases, water-borne diseases, vector-borne diseases, heat-related illnesses, and injuries. Marginalized populations including Indigenous, people of color, and low-income communities and residents, and residents with pre-existing conditions, outdoor workers, and the elderly, often bear a disproportionate burden of the impacts of climate change and have fewer resources to accommodate extreme events or disruptions.

Specifically, for the City of Ferndale, the community has experienced the direct impacts of extreme weather and climate change in the historic August 2014 flooding event that devastated thousands and cost millions. Furthermore, the entire world has been impacted by a global viral pandemic and social, environmental, and economic unrest exacerbated by climate change. Despite the City's goals and progress to date, the global climate is changing at a rate that necessitates bolder action to reduce greenhouse gas emissions, including getting to net zero emissions as soon as possible.

The term "Just Transition" is a framework for a fair shift to an economy that is ecologically sustainable, equitable, and just for all its members. Core to a just transition is equity, self-determination, culture, tradition, deep democracy, and the belief that people around the world have a fundamental human right to clean, healthy, and adequate air, water, land, food, education, and shelter.

FERNDALE

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF FERNDALE RESOLVE AS FOLLOWS:

RESOLVED: That the City of Ferndale declares the Climate Crisis requires urgent efforts to address the inherent threat to our city, region, state, nation, civilization, humanity, and the natural world; and be it

FURTHER RESOLVED: That the intent of this declaration is to both affirm existing commitments, including the participation in Climate Mayors and the Global Covenant of Mayors to combat climate change, and further support City staff in their current efforts to conduct a comprehensive greenhouse gas emission inventory and to develop a climate action plan that recognizes the climate crisis and sets forth aggressive measurable goals and effective implementation; and be it

FURTHER RESOLVED: That the City of Ferndale work collaboratively and urgently to reverse global warming, reduce citywide greenhouse gas emissions as quickly as possible towards zero net emissions, and accelerate adaptation and resiliency strategies in preparation for intensifying climate impacts; and be it

FURTHER RESOLVED: That the City of Ferndale implement at least two economically viable renewable energy or energy efficiency projects, policies, and practices annually now until 2030; and be it

FURTHER RESOLVED: That the City of Ferndale will aggressively seek any available state, federal, philanthropic, and private funding for this effort and form alliances with other Michigan cities and organizations that have declared climate emergencies and climate crises, or have written climate action plans to lobby for such funding; and be it

FURTHER RESOLVED: That the City of Ferndale commits to educating our residents about the climate crisis and working to catalyze a just transition and urgent climate mobilization effort at the local, state, national, and global levels to provide maximum protection for our residents as well as the people and species of the world; and be it

FURTHER RESOLVED: that the City of Ferndale underscores the need for full community participation, inclusion, and support, and recognizes that the residents of Ferndale, as well as community organizations, faith, youth, labor, business, academic institutions, homeowners' associations and environmental, economic, science-based, racial, gender, family and disability justice, and Indigenous, immigrant and women's rights organizations and other such allies will be integral to and in the leadership of the mobilization of this effort; and be it

FURTHER RESOLVED: That the City of Ferndale commits to keeping the outcomes of vulnerable communities central to all just transition and urgent climate mobilization efforts, planning processes, and invites and encourages such communities to actively participate in order to advocate directly for their needs; and be it

FURTHER RESOLVED: That the City of Ferndale joins a nationwide call for a regional just transition and urgent climate mobilization collaborative effort focused on transforming our Metro Detroit region, enacting policies that dramatically reduce heat trapping emissions, and rapidly catalyzing a mobilization at all levels of government to restore a safe climate; and be it

FURTHER RESOLVED: That the City of Ferndale calls on the State of Michigan, the United States of America, and all local governments and peoples worldwide to initiate a just transition and urgent climate mobilizations effort to reverse global warming by restoring near preindustrial global average temperatures and greenhouse gas

concentrations, that immediately halts the development of all new fossil fuel infrastructure, rapidly phases out all fossil fuels and the technologies which rely upon them, ends human induced greenhouse gas emissions as quickly as possible, initiates an effort to safely draw down carbon from the atmosphere, transitions to regenerative agriculture, ends the potential for a sixth mass extinction, and creates high quality, good paying jobs with comprehensive benefits for those who will be impacted by this transition.

APPROVED AND ADOPTED by the City Council of the City of Ferndale in regular session this 13th day of July 2020.

AYES:

NAYS:

Absent:

Mayor

I, Marne McGrath, the duly appointed City Clerk of the City of Ferndale, Oakland County, Michigan, do hereby certify that the foregoing is a true and complete copy of a resolution duly adopted by the City Council of the City of Ferndale at a meeting held on August 26, 2019, the original of which is on file in the City Clerk's Office.

IN WITNESS WHEREOF, I have hereunto affixed my official signature on this 26th day of August 2019.

Marne McGrath, City Clerk

ENVIRONMENTAL LAW & POLICY CENTER

An Assessment of the Impacts of Climate Change on the Great Lakes



The Environmental Law & Policy Center, in concert with the Chicago Council on Global Affairs, commissioned the following scientists and experts to produce this report pro bono to educate policymakers and the public about the significant changes affecting the Great Lakes, and the vital importance of taking actions now to protect our natural resources.

Donald Wuebbles, *University of Illinois*
Bradley Cardinale, *University of Michigan*
Keith Cherkauer, *Purdue University*
Robin Davidson-Arnott, *University of Guelph, Ontaria, Canada*
Jessica Hellmann, *University of Minnesota*
Dana Infante, *Michigan State University*
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Executive Summary

Introduction

Climate change is causing significant and far-reaching impacts on the Great Lakes and the Great Lakes region. In recent years, our planet has experienced some of the warmest temperatures ever recorded, record-breaking weather extremes, powerful storms, increasing tragic flooding from rising sea levels and associated storm surge, huge wildfires, and continued melting of glaciers and polar sea ice. The accelerating pattern of changes in the Earth's climate is affecting the Great Lakes. Here, we draw on the array of existing research to assess how the shifting global climate impacts the unique Great Lakes region.

The Great Lakes have an enormous impact, seen and unseen, on the 34+ million people who live within its Basin. These millions of people rely on the freshwater lakes for drinking water, fisheries, recreation, and commerce and industry. The Great Lakes contain 5,500 cubic miles of freshwater, one of the very largest freshwater resources in the world. The Great Lakes support one of the world's largest regional economies similar to those of whole developed nations. Agriculture, industrial manufacturing, fishing, and recreation together form an economic engine. Regional fisheries alone represent a $7 billion per year industry. Tourism generates $16 billion more.

Heavy human use over the past two centuries has taken its toll in the forms of habitat loss and fragmentation, influxes of invasive species, and polluted air, water, and sediments. Soil and nutrient runoff from agricultural fields and concentrated animal feedlot operations (CAFOs) imperil water quality and wildlife populations in many parts of the basin, threatening public and wildlife health and the economic vitality of the region. Climatic changes now underway further stress these ecosystems, alternatively raising and lowering lake levels and threatening the region in new ways.

The Great Lakes sustain remarkable populations of fish and habitats for wildlife. More than 170 species of fish live in the lakes, streams, rivers, and connecting waterways. Trout, sturgeon, walleye, lake whitefish and other varieties of fish are once again becoming plentiful among the five Great Lakes. The basin's ecosystems support wolves and moose while providing resting and breeding grounds for large flocks of migratory birds and waterfowl. More than 3,500 species of plants and animals use its large network of streams, lakes, inland wetlands, coastal marshes and forests. Many of these species are rare or are found nowhere else.

The Great Lakes are large enough to themselves influence weather in the region. The Lakes moderate temperatures throughout the year, helping to cool nearby lands in the summer and warm them in winter. Their humidity feeds cloud cover and precipitation both over the lakes and downwind. That causes both "lake effect" snowstorms, and summer rainfall that provides ideal growing conditions for orchards in Michigan's "fruit belt."

Climate change presents challenges to the Great Lakes, with complicated effects and inter-relationships.

Air Temperature Increases

The Great Lakes region has tracked global increases in temperature and outpaced trends in some parts of the contiguous United States. Between 1901-1960 and 1985-2016, the Great Lakes basin has warmed 1.6°F in annual mean temperature, exceeding average changes of 1.2°F for the rest of the contiguous United States. By the end of the 21st century, global average temperatures are expected to rise an additional 2.7°F to 7.2°F, depending on future greenhouse gas emissions, with corresponding changes in the Great Lakes region.

Heavy Precipitation and Flooding

A warmer atmosphere holds more moisture, increasing the frequency and intensity of heavy rain and snow events. Overall U.S. annual precipitation increased 4% between 1901 and 2015, but the Great Lakes region saw an almost 10% increase over this interval with more of this precipitation coming as unusually large events. In the future, precipitation will likely redistribute across the seasons. We expect wetter winters and springs, while summer precipitation should decrease by 5-15% for most of Great Lake states by 2100.

These increases in precipitation will likely increase flooding across the Great Lakes region. In cities with abundant roofs, concrete, and other impermeable surfaces, this will likely

damage homes, roadways, and other infrastructure. In rural areas, intense rains and melting snows will increase runoff and erode soils. In rural areas, increased flooding will also cause soil erosion. In combination with more unpredictable precipitation and warmer temperatures, these effects could seriously curtail Midwestern agricultural production.

Extreme Weather

Climate change is causing more extreme weather across the United States. Heat waves have become more common since the 1960s while extreme cold temperatures have generally decreased. Intense summer storms occur more often as temperatures rise.

Extreme weather events have already taken their toll on the Midwest. The 2012 Midwestern heat wave and drought caused more than $30 billion in economic damage, 123 deaths, and harmful long-term health impacts across most of the central and western United States.

Extremely warm days (above 90°F) will increase for states bordering the Great Lakes, especially in the southern parts of the region. By century's end, the region will experience 30 to 60 additional days each year of these extremely warm temperatures. Areas within the Great Lakes Basin will see an increase of 17 to 40 extremely warm days as annual average temperatures continue to rise.

Meanwhile, in states surrounding the Great Lakes, the number of extremely cold days (with temperature less than 32°F) will decrease significantly. Lake effect snowfalls could be even more dramatic, particularly across the Lake Ontario snowbelt in upper western areas of New York state where three- and four-feet snowstorms are already routine.

Agriculture, Irrigation, and Decreased Crop Yields

Changes in seasonal precipitation are already affecting farmers in Midwestern states, with planting delays caused by spring flooding and excessively wet soil conditions. Delayed planting puts crops at greater risk during hotter and drier conditions later in the growing season, and that increases the demand for irrigation to mitigate crop losses. Hot temperatures interfere with pollination in corn and other crops, thereby reducing yields.

Yet, even with increased water management in agricultural watersheds, climate change will likely reduce crop yields for both soybean and maize by 10% - 30% by mid-century in the southern parts of the Great Lakes watershed. Soybean and maize production will likely move northward.

Urban Issues

In the summer, high temperatures and heat waves cause poorer air quality, which harms public health, especially for the most vulnerable people – the elderly and children with asthma. For the many millions of people living in urban areas across the Great Lakes states, heat waves and summer air pollution events increase the risk for heat-related illness, respiratory diseases, and death.

Projected increases in extreme precipitation will likely exacerbate flooding, especially in winter, spring, and during summer thunderstorms. Extreme winter rain events in 2017 and 2018 led to serious flooding. Rain events exceeding 6 inches now occur regularly, exceeding the capacity of culverts and storm sewers to handle runoff. Under-resourced communities in low-lying, flood-prone areas have become vulnerable to infrastructure damage, transportation barriers, and displacement from homes due to these intensified floods.

Water Quality and Consumption

Climate change will likely threaten drinking water quality and place great stress on water infrastructure. For example, in southern Wisconsin, extreme precipitation could rise by 10% to 40%, overloading water treatment infrastructure, increasing sewer overflows, and increasing the quantity of water-born pathogens flowing into streams, rivers, and Lake Michigan.

The Great Lakes have higher levels of E. coli bacteria than other U.S. coastal regions. This untreated effluent is a public health hazard and economically costly to mitigate. Cities like Chicago have spent enormous sums to protect against water pollution. Nutrients (primarily nitrogen and phosphorous) run off from farms into surface waters during intense rain events. These excess nutrients threaten human health both directly (e.g., "blue baby" syndrome) and

indirectly by contributing to toxic harmful algal blooms in shallow water bays of the Great Lakes and the "dead zone" in the Gulf of Mexico that has decimated shellfisheries.

In 2011, Lake Erie experienced the largest harmful algal bloom in its recorded history, with peak intensity more than three times greater than any previously observed blooms. In 2014, 500,000 people in the Toledo area were without safe local drinking water supplies for 72 hours because of toxic algae blooms in western Lake Erie. Algal blooms will likely become more frequent in the future as higher temperatures and heavy precipitation mix heavy nutrient loads with warmer waters. These pollutants have dramatically raised the cost of water treatment.

Lake Ecology

Climate change has already increased bacteria levels in the Great Lakes, as the water warms earlier in the spring and warming contributes to vertical mixing that changes lake ecosystems. Sewer overflows, the dumping of ship ballast water, and nutrient runoff from agriculture and industry all contribute to growth of bacteria and several invasive species in the lakes. Heavier rainstorms and warmer weather exacerbate these challenges.

Hundreds of new species of pathogenic bacteria, viruses, protozoa, and non-native species could be introduced and flourish in the warming conditions, displacing local native species. While climate change may not directly drive lake species extinct, the persistence of many native species will be threatened as they confront more invasive species, species replacements, and proliferating pest and disease organisms.

Fish

Fish respond sensitively to water temperature, assembling in distinct cold, cool, and warm water groupings. This means that warmer temperatures, seasonal weather shifts, and storms that bring a quick influx of water will all affect fish species. The geographic ranges of fish, demographics within species, system productivity, species-specific productivity, the spatial arrangement of species, and their physiological state and performance will all change in response.

For example, game fish like bluegill, smallmouth bass, largemouth bass, and brown bullhead have migrated poleward as water warms in those areas. This may increase diversity of species in some Ontario lakes by as much as 81% by the end of the century. Growth rates of yellow perch, lake whitefish, and many others, however, are likely to decrease.

Wildlife

The Great Lakes region supports many species of mammals, birds, amphibians, reptiles, and macroinvertebrates. As air temperatures increase and precipitation patterns shift, habitat conditions, soil moisture, and other conditions will shift, thereby driving some wildlife species northward and others westward. Individual species however, will respond in different ways to local conditions such as ice cover on lakes and specific patterns of regional precipitation.

Among mammals, moose may be especially vulnerable to climate change. In Minnesota, moose populations have already declined precipitously. Moose density is expected to also decline at southern parts of the Ontario region and increase at northern extents. Milder winters increase overwinter survival in white-tailed deer allowing them to expand northward into habitats historically dominated by moose.

With water levels falling and temperature rising, diseases like botulism will increase, spreading more disease and killing more birds that consume fish. Birds could also suffer from phenological mismatch, as the insect species they relied on for food hatch earlier with warmer springs or decline as vegetation shifts northward.

Shipping, Power Generation and Shorelines

Fluctuating lake levels resulting from climate change greatly affect the ability of ships to safely navigate shallow portions of the Great Lakes' channels and harbors. Both lower lake levels and higher water temperatures pose technical challenges for power generation. Changing lake levels affect marinas, docks, and shoreline homes and other buildings.

Recreation and Beach Closures

The Great Lakes Commission estimated that boating contributed approximately $9 billion to the Great Lakes economy in 2003. Boating activities such as skiing could be affected by warming temperatures, shifts in the length of seasons, and changes in lake levels.

It's become common in recent years for beaches in Chicago and Michigan to close or be under swim advisories because of bacterial contamination. Beach closures are expected to increase as heavy precipitation exacerbates issues associated with runoff and pushes up bacterial counts as well as algal blooms and E. coli alerts.

Conclusion

We should not and cannot take the vast natural resources of the Great Lakes for granted. Allowing the Great Lakes to be degraded through human activities, including climate change, is not an option. For economic, aesthetic, recreational, and ecological reasons, the Great Lakes should be restored to be healthy, unpolluted, and productive. We must reduce the effects of climate change on the Great Lakes.

Public support for protecting the Great Lakes is strong across the region. Scientific analyses clearly show that climate change has already greatly affected the region and that these impacts will continue and expand as the pace of climate change accelerates. It is critical that we recognize the importance of one of the world's most abundant freshwater resources and ensure its protection for generations to come.

1. Introduction

The North American Great Lakes are amongst the largest freshwater resources on our planet. The five Great Lakes (Superior, Michigan, Erie, Huron, and Ontario) cover a total area of more than 94,000 square miles (243,000 square kilometers) with over 9,000 miles (14,500 kilometers) of shoreline. They hold 5,500 cubic miles (22,700 cubic kilometers) of freshwater, which is enough water to cover the area of the continental United States with almost 10 feet (3 meters) of water. They also include 5,000 tributaries and have a drainage area of 288,000 square miles. The watersheds comprising the Great Lakes Basin span major areas of the United States and Canada (see Figure 1).

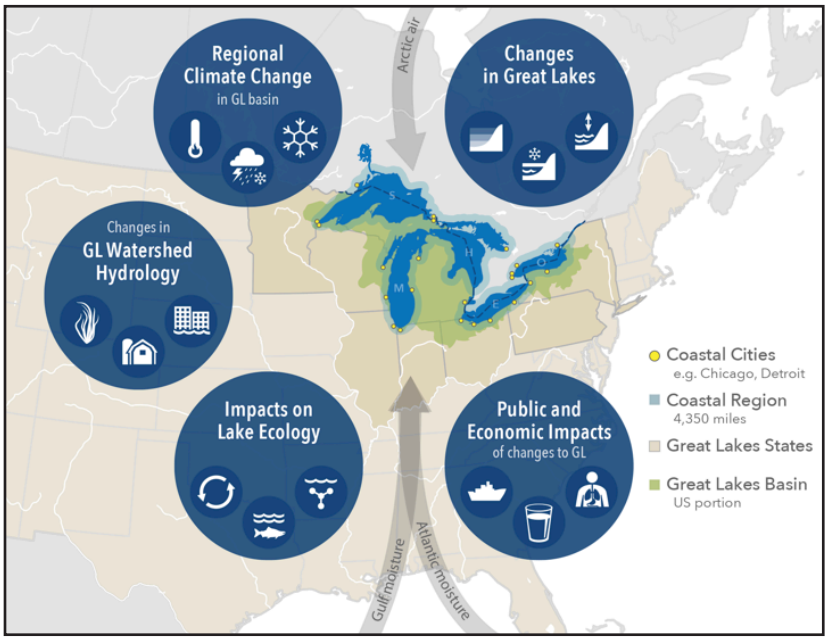


Figure 1. A schematic diagram highlighting the focus areas and themes of the assessment and the major impact pathways.

The Great Lakes are extremely important both to humans and to wildlife – they are an abundant freshwater resource for water supplies, industry, shipping, fishing, and recreation, as well as a rich and diverse ecosystem. However, over the last two centuries, the Great Lakes and the broader basin have been significantly affected by human activities, leading to habitat loss and fragmentation, invasive species, and an influx of biological and chemical pollutants that present substantial environmental challenges (e.g., Riley, 2014). These impacts have impaired water quality, threatened wildlife populations, and jeopardized the health and economic vitality of the region. Now, climate change is adding new challenges and significant additional stress to conditions in and surrounding the Great Lakes (Melillo et al., 2014; Sharma et al., 2018).

This report assesses the current and projected impacts of climate change on the Great Lakes. This assessment aims to evaluate the effects of climate change on the Great Lakes, its shorelines, regional land use, biodiversity, and urban cities on the lakes. The assessment does not aim to address all of the basins feeding the lakes or the states around the lakes. This study provides an update on prior analyses of such impacts – including GLISA (2016), McDermid et al. (2015), Walsh et al. (2014), Pryor et al. (2014), Wuebbles et al. (2010), Wuebbles and Kling (2006), Wuebbles and Hayhoe (2004), Kling et al. (2003), and Lofgren et al. (2002). The Midwest chapter from Volume II of the 4th National Climate Assessment (USGCRP, 2018) also includes some discussion of the impacts of climate change on the Great Lakes; this assessment is intended to be a more thorough look at those current and potential impacts.

1.1 Importance of the Great Lakes

By total area, the Great Lakes is the largest group of freshwater lakes on Earth, and second largest by total volume, containing 21% of the world's surface fresh water by volume. They contain 95% of the surface water in the United States and 84% of the surface fresh water available in North America (https://www.epa.gov/greatlakes/great-lakes-facts-and-figures).

About 34 million people rely on the Great Lakes for drinking water, jobs, and their way of life (their choices for recreation, etc.) — about 24 million people in the U.S. and about 9.8 million in Canada. That's roughly 8 percent of the U.S. population and 32 percent of Canada's (University of Wisconsin Sea Grant Institute 2018). The United States draws more than 40 million gallons (151 million liters) of water from the Great Lakes every day – more than half used for electrical power production, with the rest used for drinking water, industrial production, and agriculture.

The Great Lakes support one of the world's largest regional economies, including a $7 billion fishing and $16 billion tourism industry. Accounting for agricultural production within the region, commercial and sport fishing, industrial manufacturing, and tourism and recreation, the Great Lakes' economic activity surpasses that of most developed nations. A third of the basin's land is used for agriculture. Tourists spend hundreds of millions of dollars each year in the basin with more than 60 million people annually visiting the many parks that dot the shores. The lakes and their waterways serve as shipping conduits to transport bulk cargo from the basin to the markets of the world. Canals, rivers, straits, locks and channels connect the lakes together to form one of the busiest shipping areas in the world. Over 150 million tons of cargo are transported over the Great Lakes each year, supporting 44,000 jobs (https://www.mlive.com/news/muskegon/index.ssf/2009/03/sat_transporting_goods_by_ship.html). Since 1959, more than 2 billion metric tons of iron, coal, steel, oil, grains, and other products have been shipped over the Great Lakes.

A large variety of fish and wildlife species is supported by the waters and lands of the Great Lakes Basin. More than 170 species of fish inhabit the Great Lakes, their tributaries, and connecting waterways. These include lake trout, lake sturgeon, lake whitefish, walleye, landlocked Atlantic salmon, and associated forage fish species. The Great Lakes basin also provides critical breeding, feeding, and resting areas, as well as migration corridors, for waterfowl, colonial nesting birds, neotropical migrants, and many other species of migratory birds. In general, the region of the Great Lakes contains an immense network of streams, lakes, inland wetlands, coastal marshes, and forests. These habitats support more than 3,500 species of plants and animals, including more than 200 globally rare species and 46 species found nowhere else in the world. The Great Lakes Basin provides the diverse habitats needed by more than 180 fish species to complete their life cycles. A critical stopover region for more than 350 migratory bird species, the basin provides resources to sustain hundreds of millions of birds along their migratory routes each year. In addition to supporting fish and wildlife populations, the diverse habitats of the basin provide numerous critical ecological services, including water filtration and storage, flood control, nutrient cycling, and carbon storage. These diverse habitats are also important to the culture of the native people in the Great Lakes region.

The Great Lakes also play an important role in influencing local weather patterns across the region. The Great Lakes influence daily weather by 1) moderating temperatures in all seasons, producing cooler summers and warmer winters; 2) increasing cloud cover and precipitation over and just downwind of the lakes during winter; and 3) decreasing summertime convective clouds and rainfall over the lakes (Scott and Huff, 1996; Notaro et al., 2013).

These effects range from moderate (e.g., mild cooling breezes that help lakeshore orchards and vineyards flourish) to extreme (e.g., harsh lake effect snow and ice storms that close airports, shut down interstate freeways, and knock out power grids). The Great Lakes therefore provide diverse benefits and challenges to the weather of the surrounding urban and rural landscapes.

1.2 Climate change: From global to the Great Lakes region

The global climate continues to change rapidly compared to the pace of natural variations that have occurred throughout Earth's history. Trends in globally averaged temperature, sea level rise, upper-ocean heat content, land-based ice melt, Arctic sea ice, depth of seasonal permafrost thaw, and other climate variables provide consistent evidence of a warming planet. These observed trends are robust and have been confirmed by multiple independent research groups around the world (USGCRP, 2017; IPCC, 2013).

The global annual-average temperature has increased by 1.8°F (1.0°C) from 1901 through 2016 (as calculated from instrumental records over both land and oceans) (USGCRP, 2017). Sixteen of the 17 warmest years in the measurement record (which spans over 130 years) occurred in the period from 2001 to 2017. (The one exception in the highest 17 warm years was 1998, a major El Niño year.). The global average temperature for 2016 was the warmest on record, surpassing 2017 and 2015 by a small amount. The years 2017 and 2015 far surpassed the 4th warmest year on record, 2014, by 0.29°F (0.16°C), four times greater than the difference between 2014 and the next warmest year, 2010 (NCEI, 2016).

The frequency and intensity of extreme heat and heavy precipitation events are increasing throughout most of the world, including the Great Lakes region. These trends are consistent with the expected response to a warming climate and are likely to continue. Observed and projected trends for some other types of extreme events, such as floods, droughts, and severe storms, have more variable regional characteristics. The shift to warmer winters, greater winter precipitation, and more intense rainfall is likely to increase flooding in Great Lakes cities.

The 4th U.S. National Climate Assessment (USGCRP, 2017), building upon prior assessments of the science (e.g., IPCC, 2013; Melillo et al., 2014) and extensive new evidence, concludes that it is extremely likely that human activities, especially emissions of greenhouse gases and land use change, are the dominant cause of global warming since at least the mid-20th century. For the last century, there are no convincing alternative explanations for the observed warming supported by observational evidence. Natural variability cannot account for the amount of global warming observed over the industrial era. Changes in solar output and internal variability can only contribute marginally to the changes in climate observed over the last century, and there is no convincing evidence for natural cycles that could explain the changes in climate over the last century. The warming over recent decades cannot be attributed to the Sun; in fact, extremely accurate satellite observations show that solar output has declined slightly over the last four decades (USGCRP, 2017).

Global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse (heat-trapping) gases emitted globally and on the remaining uncertainty in the sensitivity of Earth's climate to those emissions. With significant reductions in the emissions of greenhouse gases, the global annually averaged temperature rise could be limited to 3.6°F (2°C) or less. Without major reductions in these emissions, the increase in annual average global temperatures relative to preindustrial times could reach 9°F (5°C) or more by the end of this century (USGCRP, 2017).

Similarly, annual average temperature over the contiguous United States increased by 1.8°F (1.0°C) for the period 1901–2016 and is projected to continue to rise. As with the global changes, there have been marked increases in temperature extremes across the United States. The number of high temperature records set in the past two decades far exceeds the number of low temperature records. Heavy precipitation events in most parts of the United States have also increased in both intensity and frequency since 1901. There are important regional differences in these trends, with the largest increases occurring in the U.S. Northeast and Midwest.

1.3 Potential risks and vulnerabilities for the Great Lakes

Prior studies have shown that global climate change is already affecting both the climate of the Great Lakes region and the physical behavior of the Great Lakes themselves (e.g., Melillo et al., 2014, and other reference above). Regional weather extremes in temperature and precipitation are intensifying (Winkler et al., 2012). In recent decades, a number of changes in the climate of the Great Lakes region have been documented, including a significant warming trend (Schoof, 2013; Zobel et al., 2017a,b), an increase in extreme summertime precipitation (Kunkel et al. 2003, 2012; Zobel et al., 2018), changing lake levels (Gronewold et al., 2013a), and changing trends in lake-effect snows (Norton et al., 1993; Kunkel et al., 1999; Bard and Kristovich, 2012; Notaro et al., 2013; Clark et al., 2016; Suriano and Leathers, 2017). The region has also recently witnessed unprecedented extreme changes in the timing of precipitation and runoff, with important implications for flooding, soil erosion, nutrient export, and agricultural practices (Carpenter et al., 2017; Kelly et al., 2017). Warm, wet winters are producing extensive early-season flooding, which threatens people and infrastructure. Associated runoff and soil erosion are also a concern for future agricultural productivity.

Further changes in climate projected over the coming decades are likely to add significantly to the vulnerabilities and risks to the Great Lakes and the Great Lakes Region. There are many vulnerabilities and risks discussed in this assessment, including potential changes in lake water levels and their effects on coastal erosion and wave damage, effects on lake temperature and stratification, effects on water quality, effects on the ecology and wildlife in both the lakes and the region, and effects on the public and the economy of the Great Lakes region. Figure 1 highlights the basic topics and themes that are covered throughout the rest of this report.

1.4 Public perception of the Great Lakes: Value and vulnerability

A binational poll conducted by the International Joint Commission's Water Quality Board in 2015 indicates that the vast majority (85%) of the residents in the Great Lakes basin feel it is important to protect the Great Lakes, largely for the provision of drinking water and the fact that they are a valuable resource with economic, recreational, and environmental importance (IJC, 2016). Residents were less certain whether the health of the Great Lakes is increasing, getting worse, or staying the same. The poll indicated that 56% believe the lakes are getting worse or staying the same. When asked about problems facing the Great Lakes and the surrounding tributaries, residents were most likely to identify pollution (roughly 50%), while a significant minority (31%) did not know what the biggest threat might be. Although the majority of respondents (78%) felt they personally played a role in protecting the Great Lakes through their own education and decision making, many (30%) were unsure what specifically they could do. These high levels of concern and personal responsibility exist despite the fact that only 42% of residents in the basin use the lakes for leisure or recreational purposes.

Residents responding to the poll did not directly identify climate change as a threat to the Great Lakes. However, many of the top issues mentioned by residents are exacerbated by climate change, in particular the trends in the

region for increasing temperature and precipitation moving into the future. For example, residents were concerned about pollution (including runoff) and invasive and endangered species, threats that become greater under the impacts of a changing climate. Agricultural runoff, a major threat to lakes, and in particular Lake Erie, occurs during spring storms and will worsen as the intensity of spring rainfall events increases (Michalak et al., 2013). Similarly, the movement and loss of species is often exacerbated by shifting habitat needs as the climate warms (Ryan et al., 2018).

This binational poll was replicated in 2018 (IJC, 2018), affirming that public support for protecting the Great Lakes remains high (up by 3% points to a total of 88%). This report also indicated that 55% of residents are willing to pay more for consumer products as a result of regulations designed to restore and protect the Lakes. In a new question about the top ten issues facing the Great Lakes, 73% of residents ranked climate change as having an extremely negative impact, just behind other issues exacerbated by climate change (e.g., invasive species, algae blooms, and runoff). Residents in the Great Lakes were not keen to engage socially or politically in these issues (only ~30%), but the majority were willing to be more careful about what they dispose down the drain (83%) and with their water use (74%).

An annual poll on climate change perception in the United States finds that 70% of Americans believe global warming is happening, and these beliefs are becoming increasingly certain over time (Leiserowitz et al., 2018; Howe et al., 2015). For the Great Lakes states and provinces, these numbers ranged from a low of 64% (in Indiana) to a high of 77% (in New York) (Marlon et al., 2018). In addition, approximately 60% of Americans were worried about global warming and believe that it is affecting weather in the United States (increasing extreme heat, droughts, flooding, and water shortages) (Leiserowitz et al., 2017). For the Great Lakes states, this sense of worry about climate change ranged from a low of 49% (in Indiana) to a high of 67% (in New York). At the county level, concern and belief increased more in urban areas than in rural areas (Marlon et al., 2018). In general, beliefs about climate change were largely driven by political orientation and ideology (Hornsey et al., 2016), explaining why we see this variation in the Great Lakes states where political ideology is more evenly divided among liberals, moderates, and conservatives relative to portions of the rest of the country (IJC, 2016).

2. Regional climate change in the Great Lakes

The climate is changing over the Great Lakes and is projected to change much more over the coming century. This section summarizes the observed and projected changes in climate variables such as near-surface air temperature and precipitation over the Great Lakes and bordering U.S. states. The methodology used in these analyses is similar to that used in the 4th National Climate Assessment (USGCRP, 2017), and is based on the analyses of observational datasets for past changes and from modeling and downscaled datasets for projections produced for NCA4. Projections use a weighting system for global climate models, that are then statistically downscaled for temperature and precipitation at about 6 km resolution across the continental United States. The methodology is described in more detail in the Supplementary Material.

The projected global average temperatures are expected to rise an additional 2.7°F to 7.2°F if greenhouse gas emissions from fossil fuels in energy and transportation systems continue to rise over the 21st century (see Figure 2). Future pathways range from assuming continued large dependence on fossil fuels as a high scenario, called Representative Concentration Pathway 8.5 W/m2 (RCP8.5), to a low scenario, RCP4.5, assuming rapid reductions in the use of fossil fuels after mid-century, to a very low RCP2.6 scenario, assuming major emissions-

reduction actions. As discussed below, the Great Lakes regional climate shows strong signals of weather extremes that get even stronger in the future (refer to the Supplementary Material for details on the selection of historical observational datasets and the ensemble of statistically downscaled future projections).

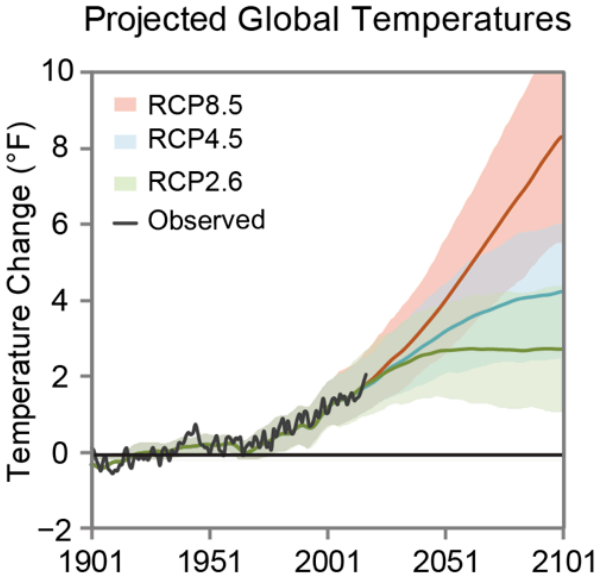
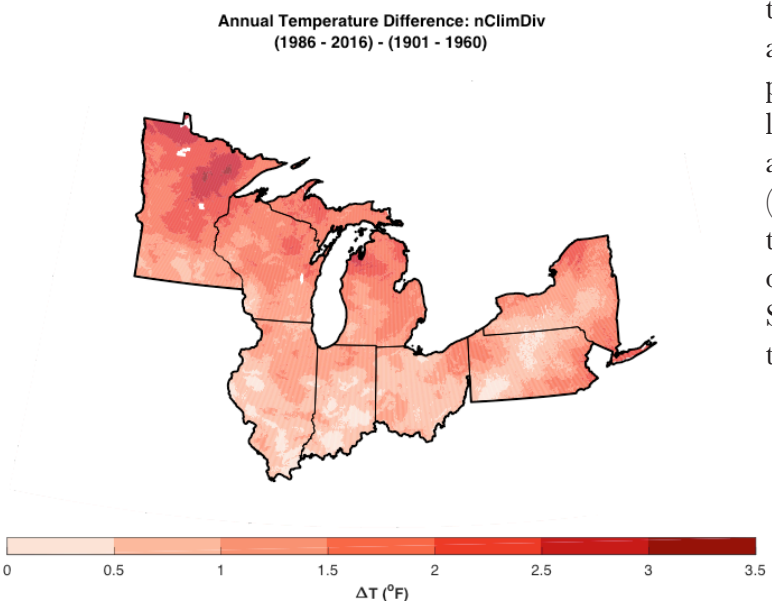


Figure 2. Multi-model simulated time series from 1900 to 2100 for the projected change in global annual mean surface temperature relative to 1901–1960 for a range of the Representative Concentration Pathways (RCPs). These scenarios account for the uncertainty in future emissions from human activities (as analyzed with the 20+ models from around the world used in the most recent international assessment [IPCC, 2013]). Source: USGCRP (2017)

2.1 Air temperature changes and trends

Of the many indicators of climate, temperature is one of the most important, because it affects our lifestyles and our decision-making. For example, temperature data are used by builders and insurers for planning and risk management and by energy companies and regulators to predict demand and to set utility rates. As the most widely and consistently observed climate variable, air temperature is very convenient for users. Long-term temperature trends are also an important indicator of the changes occurring in climate.



In the Great Lakes region, the U.S. states bordering the Great Lakes have seen an overall increase in annually averaged temperature of 1.4°F for the period 1985-2016 relative to 1901-1960, with the largest changes at the higher latitudes (see Figure 3 and Table 1). For the extent of the Great Lakes Basin (see Figure 1), the temperature change is 1.6°F over this time period. These trends are higher than the overall change of 1.2°F over the contiguous United States (and found globally) for the trends over these time periods (USGCRP, 2018).

Figure 3. Observed changes in annually-averaged temperature (°F) for the U.S. states bordering the Great Lakes for present-day (1986–2016) relative to 1901–1960. Derived from the NOAA nClimDiv dataset (Vose et al. 2014). Source: NOAA/NCEI.

	U.S. States Bordering the Great Lakes	Great Lakes Basin
Observed trend	1.4	1.6
2016-2045 Lower Scenario	3.0	3.0
2016-2045 Higher Scenario	3.3	3.3
2036-2065 Lower Scenario	4.4	4.4
2036-2065 Higher Scenario	5.5	5.6
2070-2099 Lower Scenario	5.7	5.8
2070-2099 Higher Scenario	9.8	10.1

Table 1. Change in annually-averaged temperature (°F) for U.S. states bordering the Great Lakes and for the smaller area of the Great Lakes basin. The observed trend is the difference for annually-averaged temperature for 1986-2016 period relative to 1901-1960. The future projections for annually-averaged temperature due to emissions from the higher (RCP8.5) and lower (RCP4.5) scenarios are shown for the periods 2030 (2016-2045), 2050 (2036-2065), and 2085 (2070-2099) time periods.

	U.S. States Bordering the Great Lakes	Great Lakes Basin
Observed trend	9.6	10.0
2016-2045 Lower Scenario	4.0	4.5
2016-2045 Higher Scenario	4.0	4.2
2036-2065 Lower Scenario	5.5	6.4
2036-2065 Higher Scenario	6.2	7.0
2070-2099 Lower Scenario	6.2	7.2
2070-2099 Higher Scenario	9.8	11.4

Table 2. Change in annual precipitation (as equivalent rainfall) (%) for U.S. states bordering the Great Lakes and for the smaller area of the Great Lakes basin. The observed trend is the difference for annual precipitation for 1986-2016 period relative to 1901-1960. The future projections for annual precipitation due to emissions from the higher (RCP8.5) and lower (RCP4.5) scenarios are shown for the periods 2030 (2016-2045), 2050 (2036-2065), and 2085 (2070-2099) time periods.

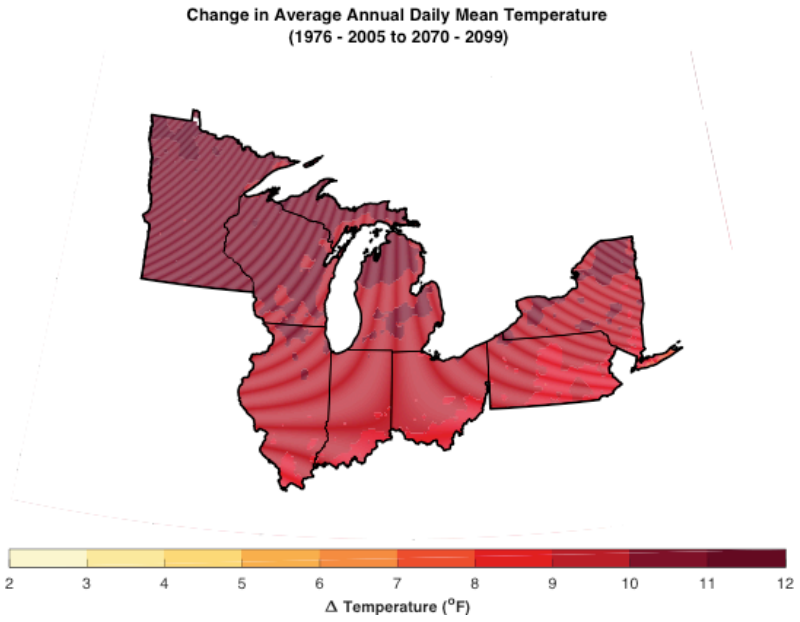
	U.S. States Bordering the Great Lakes	Great Lakes Basin
Observed (1984-2013 vs 1954-1983)	-1.93	-2.25
2020s RCP4.5	-16.49	-15.65
2020s RCP8.5	-17.87	-17.04
2050 RCP4.5	-27.94	-26.18
2050 RCP8.5	-33.17	-31.56
2080 RCP4.5	-30.48	-28.15
2080 RCP8.5	-49.08	-47.46

Table 3. Change in annual snowfall (%) for U.S. states bordering the Great Lakes and for the smaller area of the Great Lakes basin. The observed trend is the difference for annual snowfall for 1986-2013 period relative to 1954-1983. The future projections for annual snowfall are calculated based on the ensemble mean of 10 statistically-downscaled GCMs by Hybrid Delta for the higher (RCP8.5) and lower (RCP4.5) scenarios (Byun and Hamlet, 2018) associated with three 30-yr periods centered on 2020s, 2050s, and 2080s. Also, the values for the future periods represent the projected changes relative to observed mean for 1976-2005.

Land Use/Land Cover Class	% Basin	% Change 2000-2011
Developed	10.52	0.38
Agriculture	38.02	-0.27
Forest	29.55	-0.50
Grass/Shrub	3.62	0.35
Wetland	15.80	0.01
Barren	0.35	0.02
Water	2.15	0.01

Table 4. Land use and land cover for the Great Lakes basin, based on data for year 2011. Change from 2001 to 2011 is also shown. Data derived from U.S. National Land Cover Database (NLCD) for the U.S. side, and the Ontario Land Cover Compilation V2.0 for the Canadian side of the basin. (Data from SOLEC, in review).

The projected changes in annual average temperature for the U.S. states bordering the Great Lakes are shown in Figure 4 for the higher (RCP8.5) and lower (RCP4.5) emissions scenarios for the 2085 (2070-2099) time period relative to 1976-2005. The patterns of warming over these states for the 2030 (2016-2045) and 2050 (2036-2065) time periods are similar but with smaller temperature changes. Averaged over the entire Great Lakes region, slightly greater increases are projected in summer than winter, and average maximums are expected to rise slightly faster than average minimums. These seasonal variations are reversed in the northern Great Lakes region, with winter temperature rising more than summer and average minimums warming more than average maximums (WICCI, 2011; IPCC, 2013; USGCRP, 2017). Table 1 shows that projected changes in temperature for these scenarios are 3.3, 5.5, and 9.8°F (1.8, 3.1, and 5.4°C) for the 2030, 2050, and 2085 time periods for the higher scenario, and 3.0, 4.4, and 5.7°F (1.7, 2.4, and 3.2°C) for the 2030, 2050, and 2085 time periods for the lower scenario. The projected changes in temperature for the Great Lakes Basin are similar but slightly higher for the same time periods and scenarios (see Table 1). Not surprisingly, there is little difference in the projected effects on temperature over the next few decades between the different scenarios, but large differences between the scenarios by the end of the century. Similar projections along with monthly changes were found by Zhang et al. (2018). The potential societal and ecological impacts on our planet, including those associated with the Great Lakes, are likely to increase in proportion to annual average temperature (Stern et al., 2006; Melillo et al., 2014).



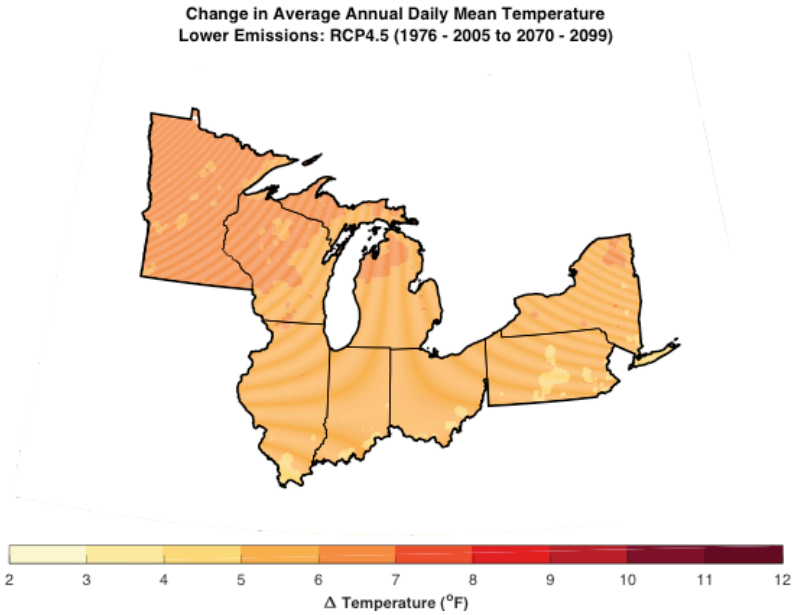


Figure 4. Projected change in annually-averaged temperature (°F) for U.S. states bordering the Great Lakes from the (a) higher (RCP8.5) and (b) lower (RCP4.5) scenarios for the 2085 (2070-2099) time period relative to 1976-2005. Source: NOAA/NCEI

2.2 Precipitation trends

Annual precipitation averaged across the United States has increased by approximately 4% from 1901 to 2015 (USGCRP, 2017). Figure A1 shows that there is a generally positive trend for U.S. states bordering the Great Lakes in annual precipitation for present-day (1986–2016) relative to 1901–1960, but with strong local variations in the trend across the states. There is a 9.6% increase in annual precipitation averaged over these states (Table 2), while the Great Lakes Basin shows a comparable 10.0% increase. The largest increasing trends are for fall-season (~15.8% for the bordering states), with summer (9.9%) precipitation also being larger relative to winter precipitation (7.7%) and spring precipitation (7.0%).

The patterns of projected future annual precipitation changes over the U.S. states bordering the Great Lakes states and for the Great Lakes Basin for the earlier periods are similar but with smaller changes (Figure A2; Table 2). The greatest differences arise in how precipitation change is distributed across seasons, with future increases concentrated in winter and spring months for both emission scenarios, while summer precipitation decreases by 5% to 15% for most of the Great Lake states by the end of the century (Byun and Hamlet, 2018). The likely reason for this trend is that increasing warming with time will allow the atmosphere to hold more moisture and thus generate higher precipitation. As in temperatures, there is little difference in the effects between scenarios over the next few decades, but larger differences between the scenarios by the end of the century. The likely reason for this trend is that increasing warming with time will allow the atmosphere to hold more moisture and thus generate higher precipitation.

2.3 Extreme events

Along with the overall changes in climate, there is strong evidence of an increasing trend in the intensity in some types of extreme weather events over recent decades. Changes in the characteristics of extreme weather events are particularly important for human safety, infrastructure, agriculture, water quality and quantity, and natural ecosystems. For example, heatwaves have become more frequent in the United States since the 1960s, while extreme cold temperatures and cold waves have become less frequent (USGCRP, 2017). These extreme temperature conditions provide a direct risk to the public of the Great Lakes region (Patz et al., 2014). For example, the 2012 Midwestern heat wave and drought caused more than $30B in economic damage, and 123 direct deaths. It contributed to considerable long-term health impacts across most of the central and western United States (Rippey, 2015). The chances for record-breaking high temperature extremes have increased and will continue to increase as the global climate warms. Recent record-setting hot years are projected to become common in the near future for the United States, as annual average temperatures continue to rise.

Heavy rainfall is increasing in intensity and frequency across the United States and globally and is expected to continue to increase (Karl and Knight, 1998; O'Gorman and Schneider, 2009). The largest observed changes in extreme precipitation in the United States have occurred in the Midwest and Northeast. Changes in climate are increasing the likelihood for these types of severe events. Past and projected trends remain uncertain for some types of severe storm events, including the intensity and frequency of tornadoes, hail, and damaging thunderstorm winds. Tornado activity in the United States has become more variable, particularly during the 2000s, with a decrease in the number of days per year with tornadoes and an increase in the number of tornadoes on days when they do occur (USGCRP, 2017).

The number of future extremely warm days (with temperature greater than 90°F) is projected to increase for the states bordering the Great Lakes, especially in the southern parts of the region, but less so near the Lakes (Figure

A3). By the end of the century there is a projected increase of 60 extremely warm days in the Great Lakes states for the higher scenario and 30 days for the lower scenario. Areas within the Great Lakes Basin show similar trends, with an increase of 40 extremely warm days projected for the higher scenario and 17 for the lower scenario, based on an average over the basin. For midcentury, 2050s, the number of days greater than 90°F for the U.S. states bordering the Great Lakes is projected to increase by 30 days for the higher scenario and 21 for the lower (17 for the Great Lakes basin with the higher scenario and 11 for the lower). For 2085, hot days with >100°F are projected to increase by 17 days for the higher scenario and 5 for the lower scenario (8 for the Great Lakes basin with the higher scenario and 2 for the lower, relative to none in the recent 30-year period).

The number of extremely cold days (with minimum temperature less than 32°F) is projected to decrease dramatically over the century because of wintertime warming in the states bordering the Great Lakes (Figure A4). The largest decrease in freezing days is projected for the most northern states and for the Great Lakes Basin, consistent with regional variations in winter temperature trends. There is a projected decrease of 33 days for the higher scenario and 21 for the lower scenario (42 for the Great Lakes Basin with the higher scenario and 27 for the lower scenario). For midcentury, 2050, the number of days less than 32°F for the U.S. states bordering the Great Lakes is projected to decrease by 20 days for the higher scenario and 17 for the lower (25 for the Great Lakes Basin with the higher scenario and 21 for the lower). By the 2030s, the Great Lakes Basin is projected to see 15-16 fewer freezing days per year. Similarly, the frost-free season (and the corresponding growing season) should also lengthen throughout the century for these scenarios.

The number of days projected to have high temperatures under 32°F (these are days that do not get above freezing, so different than the previous paragraph) are also projected to decrease, by as many as 56 days in the Great Lakes Basin by the end of the century for the higher scenario and 31 days for the lower scenario.

The amount of precipitation coming in extreme events has already increased over the last five decades in the Great Lakes region (USGCRP, 2017), and is projected to increase further over the coming decades. The amount of precipitation occurring in storms with a 5-year return period is projected to increase by 18.7% by 2085 for the higher scenario and 10.8% for the lower scenario (20.8% and 11.3%, respectively, for the Great Lakes Basin) (Figure A5). The amount of precipitation in such extreme storms is projected to increase by 7-8% by the 2030s and by 9-12% by the 2050s. The precipitation from what are currently considered to be 1 in 50 and 1 in 100-year storms are projected to increase similarly, meaning that very large amounts of precipitation are expected from these once-unusual events.

2.4 Cold-season processes (snow and ice)

With a changing climate, both rain and snow precipitation patterns are expected to change over the Great Lakes, complicating projections of snow processes. While the increase in precipitation may lead to more snow fall in individual events, the winter warming trend across the United States will lead to a reduction in the number of snow events compared to rain events. Further, warming can lead to shifts in seasonal distributions of snow cover in the Great Lakes. As a result, rising temperatures in the Great Lakes states have had little effect on historical total annual snowfall across the region (Figure A6 and Table 3), but their effect on reducing seasonal duration of snow cover is more pronounced (Brown and Mote, 2009; Notaro et al., 2014). Some areas affected by lake effect snows have actually experienced significant increases in seasonal snowfall in recent decades (e.g., Burnett et al., 2003). Despite small overall trends in snow fall during the historical record, by the end of the century, annual total snowfall

over Great Lakes states is projected to decrease by 50% for the higher scenario and 30% for the lower scenario (Figure A7 and Table A1). This results in substantial reductions in snow cover, with days of snow depth greater than 5.9 inches (15 cm) reduced from the historical average of 61 days for the entire region to 19 days for the higher scenario or 35 days for the lower scenario by the end of the century (Chin et al, 2018; results are consistent with findings of Notaro et al., 2014). The projected snowfall reductions are not uniform in the Great Lakes states. The snowfall amounts are projected to decrease slightly less within the Great Lakes Basin in comparison to the total Great Lakes states, possibly due to lake-effect snow in the basin. Lake-effect snow is largely limited to Michigan (the upper peninsula and western parts of the lower peninsula), upper Indiana, northern Ohio, parts of Ontario to the east of Lakes Superior and Huron, and parts of New York and Pennsylvania to the east of Lakes Erie and Ontario. More southerly states in the basin will have more reduction in snow than more northerly states because of the (climatological) greater frequency of days when mean daily temperature goes above 32°F. Similarly, far northern latitudes may experience less reduction in snow cover due to the (climatological) greater frequency of days when the mean temperature stays below 32F.

Projections suggest that more precipitation will fall as rain and less as snow during the cold season, particularly in southern Great Lakes states under the high emission scenario. Changing climate is expected to shift the hydrological cycle in several ways simultaneously: increasing temperatures, decreasing snowfall, and increasing spring rainfall. This would lead to early spring snowmelt and increasing flood risks in many watersheds (Byun et al., 2018; Cherkauer and Sinha, 2010). During periods of colder temperatures, lower snow accumulations could also cause greater freezing of soils, at least in the near term, further exacerbating winter and spring flood risk, especially following rain on snow events (Sinha and Cherkauer, 2010).

LAKE EFFECT SNOWS

Some of the heaviest snowfalls on record in the United States were generated by the Great Lakes. For example, three- to four-foot snowstorms are routine in the Lake Ontario snow belt, including the upper western areas of New York in the fall and winter. On January 8, 2011, a snowband spanning virtually the entire north-south length of Lake Michigan curled into South Bend, Indiana, hammering the city with some of the highest snowfall rates ever seen outside of the Lake Ontario snow belt (https://weather.com/storms/winter/news/great-lakes-snowbelts-lake-effect-snow-records). Lake Erie has also had large effects from northeast Ohio to western New York. Prior to the U.S. Thanksgiving in 2014, a multi-day event covering the Buffalo area with up to 88 inches of lake-effect snow, bringing city activity to a grinding halt.

The ingredients for lake effect snow are straightforward and come together a number of times each fall and winter. Cold air from Canada pours over the still unfrozen, relatively warm Great Lakes. The lake moisture and instability from this temperature contrast build one or more bands of snow, which are then deposited over locations downwind from the lakes. Climate change, including warmer lake temperatures, could enhance these effects when the conditions are appropriate for snowfall. The observed trend of precipitation tending to occur in larger events throughout the Great Lakes basin could also mean larger lake effect snowfalls when the conditions are ripe.

3. Changes in the Great Lakes

Climate is a coupled surface-atmosphere process. This means that climate change alters the exchange of heat between the atmosphere and the Great Lakes. This changes the overall temperature and ice cover of the lakes, and also changes the timing of overturnings (seasonal mixing of lake water) associated with seasonal thermal changes. Although projections of climate change show increases in both precipitation and evapotranspiration in the Great Lakes Basin, observations to date have not shown significant long-term trends. The state of science on the projection of the net effect on lake level has undergone a major change of course in the last several years, changing from projections of large drops in lake level under older methodologies to smaller drops on average and the possibility of a small rise in lake levels through the end of this century.

3.1 Changes in lake temperature and stratification

Climate change in the Great Lakes involves both direct input of heat to the Lakes by increased downward longwave emissions by greenhouse gases, and inhibited loss of heat to the air by turbulent heat fluxes associated with the effects of the lakes. This should be expected to increase water temperatures within the lakes, but will also have particular influences on the temperature profile within the lakes and the phenology (timing) of the lakes' temperature structure (i.e., timing of particular events that occur during the seasonal cycle). Figure 5b shows the change in summer temperatures in the Great Lakes from 1994 to 2013 (USGCRP, 2018) – all of the Great Lakes show a significant increase over the 20 year period, especially Lake Superior.

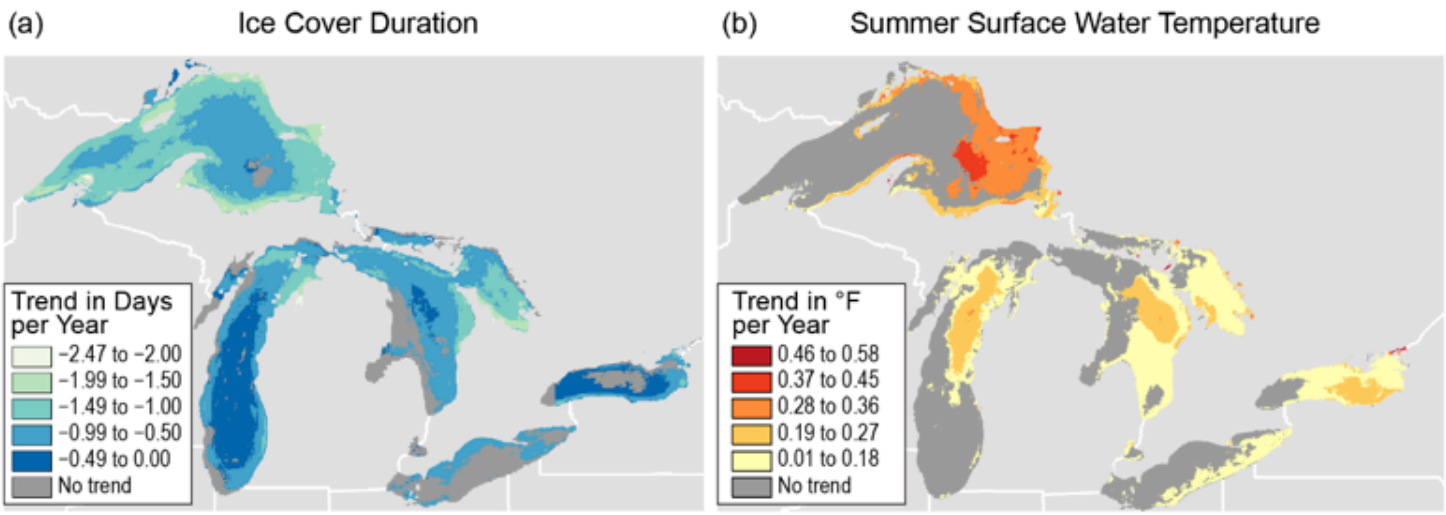


Figure 5. The duration of seasonal ice cover decreased in most areas of the Great Lakes between 1973 and 2013, while summer surface water temperature (SWT) increased in most areas between 1994 and 2013. (a) The map shows the rate of change in ice cover duration. The greatest rate of decrease in seasonal ice cover duration is seen near shorelines, with smaller rates occurring in the deeper central parts of Lakes Michigan and Ontario, which rarely have ice cover. (b) The map shows the rate of change in summer SWT. The greatest rates of increase in summer SWT occurred in deeper water, with smaller increases occurring near shorelines. Source: USGCRP 2018); adapted from Mason et al. (2016) by Kaye Lafond of NOAA GLERL.

Fresh water has its maximum density at a temperature of 4°C (39°F). This means that water at temperatures above or below this value can form a stable layer above deeper water that is closer to this temperature. Historically, the surface water of the Great Lakes has passed through this temperature threshold twice during each year. As the surface water cools from its maximum temperature of the year (usually during September), it begins to mix with warmer and less dense water at greater depths. Continued cooling makes this mixing reach even deeper into the water column until it reaches the 4°C threshold, after which further cooling produces less dense water that can form a stable layer at the surface. Ice may form, but eventually the water will warm, again causing it to mix downward until complete mixing occurs when it approaches 4 °C.

Temperature changes in the lake-atmosphere system are expected to shift the timing of these overturning episodes, as well as the timing of ice formation and melting. Lake surface temperatures simulated by Xiao et al. (2018) show that points in Lakes Superior, Michigan, and Erie reach the 4°C mixing threshold earlier in the spring and later in the fall (other lakes were not analyzed). This also leads to suppressed mixing once the temperature threshold is passed in the spring, yielding stronger vertical gradients of water temperature, and an earlier, more stable thermocline.

Lake Superior summer surface temperatures have increased more quickly than the air temperatures over land in the region (Austin and Colman 2007, Desai et al. 2009). This is believed to be due to earlier onset of summer stratification (initiated by warming beyond the 4 °C threshold, after which the warmest water is at the surface), which reinforces itself by inhibiting mixing of colder water from deeper in the lake. This mechanism is likely to continue, causing reduced stability of the lower atmosphere in the Great Lakes' vicinity during the summer.

3.2 Great Lakes ice cover trends

Ice cover on the Great Lakes has seen a slight decreasing trend between the time when systematic observations began in 1973 and 2018 based on data from NOAA GLERL. Figure 5a shows a significant decrease in duration of ice cover over many parts of the Great Lakes from 1973 to 2013. Figure 6a shows the overall time series of maximum ice coverage over the entire Great Lakes from 1973 to 2018 while Figure 6b shows the long-term trends based on this data. Lake Erie typically has the highest percentage of ice cover during a given season due to the shallow nature of the lake. Superior, Huron, and Erie are losing ice cover more quickly than the other Great Lakes over this time period.

The winters of 2013-14 and 2014-15 had plentiful ice cover and decreased the time trend found in earlier studies (e.g., Wang et al., 2012). There have been efforts to connect the extreme cold spells during those two winters with anthropogenic climate change, specifically its tendency to reduce the equator-to-pole temperature gradient by warming the poles more than the tropics (Francis and Vavrus, 2012, 2015). The understanding of these connections still has major uncertainties, however (e.g., Wallace et al., 2014). The ice cover data can be found in the online Great Lakes Ice Atlas at https://www.glerl.noaa.gov/data/ice/atlas/.

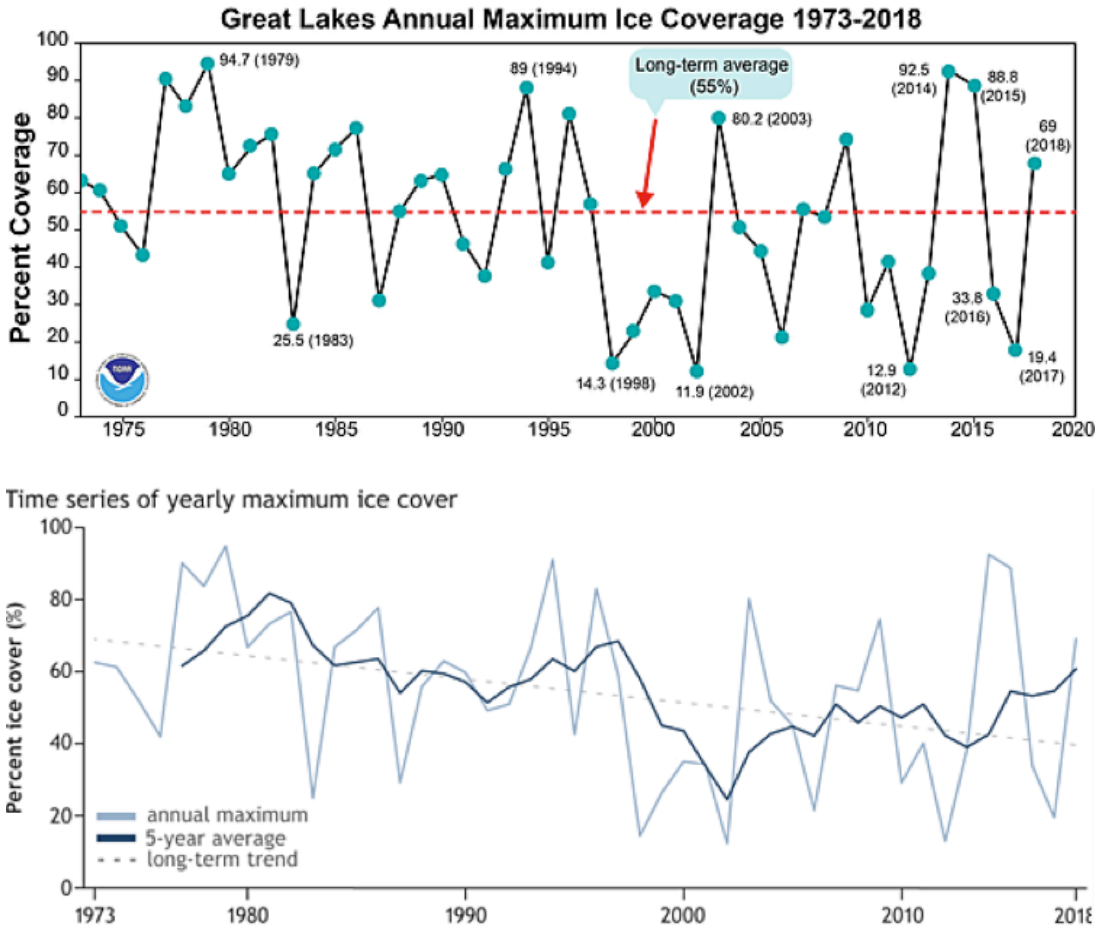


Figure 6. (a) Time series of the maximum ice coverage over the entire Great Lakes from 1973 to 2018. (b) Time series for the same data with solid line added for the 5-year running mean and a dashed line for the long term linear trend. Source: NOAA GLERL.

Ice cover is projected to decrease over the remainder of the 21st century. Croley (1990) showed reduced ice cover in spatially lumped models of each lake (i.e. without any spatial divisions within the lake). Notaro et al. (2015) showed reduced ice cover and a retreat of ice to the shallowest parts of the lakes even when complete removal is not indicated, but the model used by Notaro et al. did not consider transport of ice.

3.3 Hydrologic trends (over-lake evaporation, precipitation, runoff, groundwater, and inter-lake flows)

The recent release of the North American Great Lakes hydrometeorological database (Hunter et al., 2015; Smith et al., 2016) makes it possible to assess historical changes in the hydrometeorology over the Great Lakes. Inflows to the lakes include direct over-lake precipitation and discharge from the surrounding watersheds into each lake. Between the periods 1954-1983 and 1984-2013, over-lake precipitation decreased by 7.9% over Lake Superior, 6.8% over Lake Erie, and by 2.0% over Lakes Michigan and Huron (treated as a single lake in the database because they are hydrologically one water body). An increase of 3.5% was found over Lake Ontario. The decreases over Lakes Huron, Michigan, and Erie are strictly based on over-lake precipitation, while precipitation over both the Lakes themselves and the surrounding Great Lakes Basin increased for the same periods. The decrease in

Lake Superior precipitation corresponds to the decrease in annual precipitation over the upper peninsula of Michigan. Runoff from the lake watersheds into each lake has decreased by 8.6% for Lake Superior, and increased by 7.3% for Lake Erie and by 9.8% for Lake Ontario.

Evaporation of lake water is driven by the gradient of water vapor mixing ratio between the surface (the saturation vapor pressure corresponding to the surface water temperature) and a reference level in the atmospheric boundary layer, along with mixing by wind and turbulence. Evaporation requires energy, known as the latent heat of evaporation, and therefore is constrained by the amount of energy that the lake receives by input of shortwave radiation from the Sun, longwave radiation exchanged with the atmosphere, and sensible heat flux. This latter is heat that is transferred directly between surface and atmosphere by direct contact between molecules of different temperatures and, similar to evaporation, it is driven by a gradient of temperature between surface and atmosphere, along with strength of mixing. Because lakes have significant heat capacity, they can store energy to be released later through evaporation and other means. Thus, maximum evaporation from deep lakes occurs when the lake water is still relatively warm, while the air is much cooler, i.e., in fall and early winter. Van Cleave et al. (2014) proposed that evaporation is aided by pre-conditioning, so there is unusually high evaporation during cold periods that were preceded by unusually warm seasons or years. Annual over-lake evaporation has increased for all of the Lakes, with a minimum increase of 2.3% for Lake Ontario and a maximum increase of 7.8% for Lake Erie. Air temperature has increased most rapidly over Lake Superior and, combined with a decrease in ice cover, has resulted in a 6.5% increase in evaporation.

The Net Basin Supply (NBS) is quantified as precipitation + runoff – evaporation for each lake. Lake Superior, with decreasing precipitation and runoff and increasing evaporation has experienced a 17.5% decrease in NBS. Increases in runoff into Lake Erie have not entirely offset decreased precipitation and increased evaporation, resulting in a 7.3% decrease in NBS. Lakes Michigan and Huron have experienced a 3.0% increase in NBS, while Lake Ontario has increased by 9.5%. Change in NBS can also affect the movement of water between the lakes, with flows from Lake Superior into Lakes Michigan and Huron decreasing by 9.7%. There is little to no change between the other lakes. Discharge from Lake Ontario to the St. Lawrence River has increased by 2.8%. Connecting channel flows must, in the long run, balance the net basin supply. On shorter time scales (a few years), the net basin supply can lead to changes in lake level, which then affect connecting channel flow until an equilibrium is reached.

Three inter-basin diversions were identified by Hunter et al. (2015) as being large enough to have a potentially significant impact on basin-scale runoff. Two of these, the Ogoki Diversion and the Long Lac Diversion, shift water into the Lake Superior watershed from the Hudson Bay watershed. Historically this inflow varies from 120 to 200 m3/s, and there has been a 5.9% decrease in discharge into Lake Superior through these diversions for the period of record. The other significant diversion transfers 80 to 110 m3/s of water from Lake Michigan to the Illinois and Mississippi River basins via the Chicago Sanitary and Ship Canal. Water removed from Lake Michigan through this system has decreased by 2.5% in the period of observation.

In the future, annual precipitation is expected to increase with a general shift to wetter winter and spring conditions (Section 2.2) and more variable summers that are likely to become hotter and drier by the end of the century. Less ice cover and warmer air temperatures will continue to increase evaporation. Runoff will increase in the winter and spring, and it will decrease in the summer (Section 4). The effect of these changes on NBS is critical to determining future lake levels (Gronewold et al., 2013).

3.4 Changes in lake level

Water levels have fluctuated considerably over multi-decadal time scales. Figure 7 shows annual changes in the water levels for the Great Lakes from 1860 to 2015. The combined Lake Michigan and Lake Huron are the most variable among the Great Lakes. Lake Superior has smaller variability, especially because of its large size relative to its drainage basin. Superior's outflow is one of the drivers of Lake Michigan-Huron water level. Lake Erie's water levels generally fluctuate along with Lake Michigan-Huron's but with somewhat smaller amplitude, and causing a backwater effect by influencing the slope of the connecting channels.

Water levels across all of the Great Lakes have risen over the past several years following a period of record low levels. Lake Ontario, the farthest downstream, is driven mostly by inflow from the Niagara River but also by its own watershed. Its outflow is also regulated, dampening the water level variability somewhat, but extremely high levels in Lake Ontario during 2017 led to conflicting interests of lakeshore property owners, who wanted maximum release of water to lower water levels, and shipping interests downstream in the St. Lawrence River, who wanted at least some periods of lower flow for safer shipping. Record-breaking heavy precipitation in the basin appears to have largely driven the increases in lake levels and may have exceeded the capacity of the regulatory system to respond. The major variability in lake levels in recent years demonstrates the need for better understanding of the drivers of water level variability towards improving regional water resources management and policy (Gronewold and Rood, 2018).

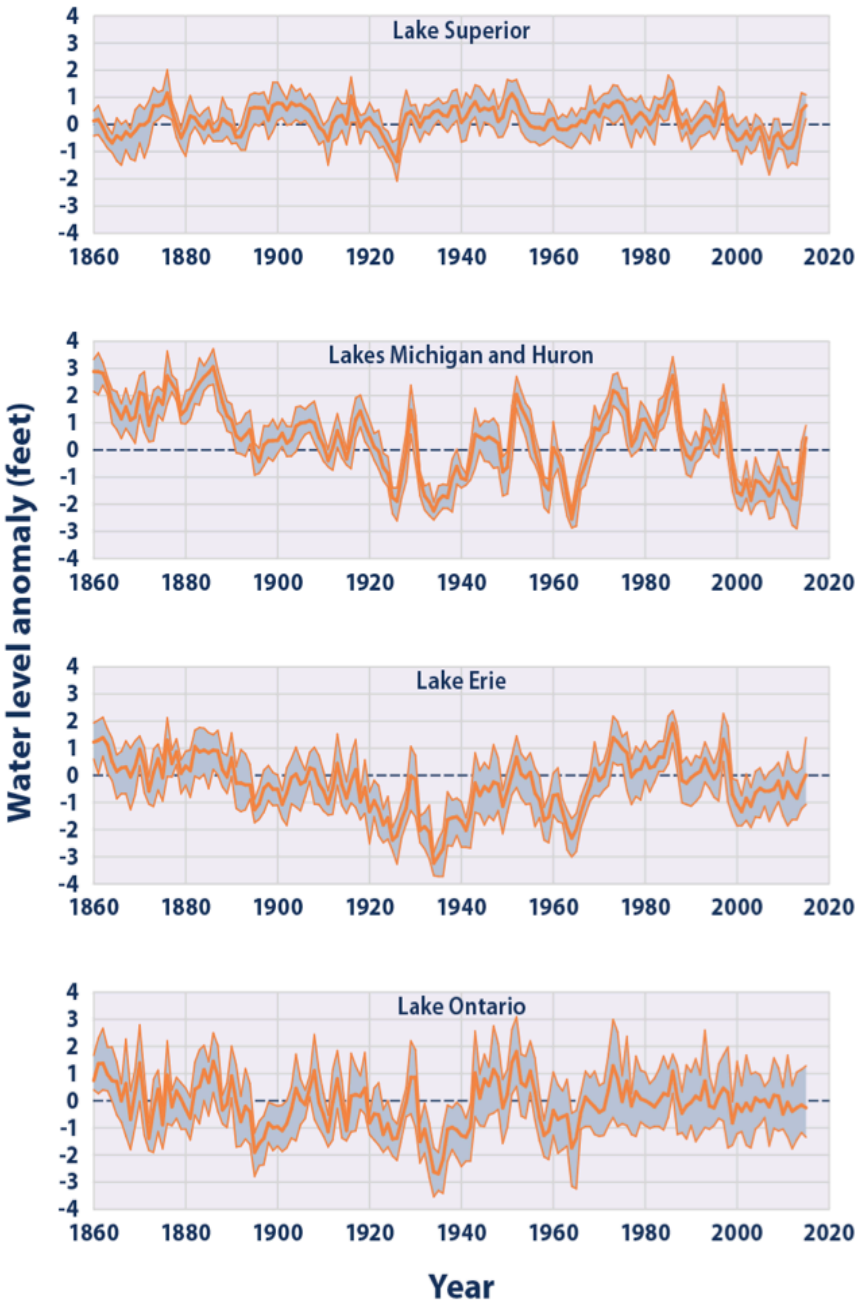


Figure 7. Water levels of the Great Lakes from 1860 to 2015 as an anomaly relative to the 1981-2010 average. The shaded band shows the range of monthly average water levels, and the line in the middle shows the annual average. Choosing a different baseline period would not change the shape of the data over time. Lakes Michigan and Huron are shown together, because they are connected at the same water level. Source: Data from NOAA as reported by https://www.epa.gov/climate-indicators/great-lakes.

Methods of projecting lake levels in the mid to late 21st century have undergone a revolution in recent years. Lofgren et al. (2011) and Lofgren and Rouhana (2016) have shown that evapotranspiration from land (part of the calculation of runoff) was depicted in older models (as used in Angel and Kunkel, 2010; Lofgren et al., 2002; and many others) as extremely sensitive to climate change. We now know that those earlier analyses tended to overestimate the evapotranspiration effects. Results using other methodologies (Milly et al., 2005; MacKay and Seglenieks, 2012; Notaro et al., 2015; Lofgren et al., 2016) have generally projected very modest drops in lake levels and appreciable probability of small rises, in contrast to the large drops in lake level projected by the prior methods.

LAKE LEVELS

Comparison between historical trends in variables related to Great Lakes Basin hydrology and model-predicted results at the time scale of a century have differing levels of agreement, and historical time series often have issues of signal-to-noise ratio (i.e. they show trends, but variability over the decades of record is also highly significant in comparison). Trends in lake surface temperature are quite notable, with interactions between the lake surface temperature and the stability of the lake temperature profile helping to amplify the surface temperature trends. Trends in ice cover are also robust, with large decreases since the beginning of record in 1973, despite some reversals in this trend from some recent cold winters. Precipitation, evaporation, and runoff show more mixed results, with precipitation and evaporation generally increasing, with specific locations as exceptions, and runoff differing significantly among the individual lakes. The trend in Net Basin Supply also differs from lake to lake. Records of lake level over several decades show that trends are small and variability is high. Newer model-based projections of lake level (since 2011) foresee a central tendency toward small drops in lake levels to the end of the 21st century, with appreciable probability of small rises in lake levels, in contrast to the large drops projected using the older, now-defunct methodology.

4. Changes in Great Lakes watershed hydrology

Regional watershed hydrology will be driven by change in climate and land use, as well as by changes in demand. Warmer and wetter conditions will prevail on average, but increasing evaporative demand coupled with potential decreases in summer precipitation will likely lead to increased irrigation demand during the growing season. Continued expansion of urban land use will increase the need for stormwater management. Both agriculture and urban land use will continue to affect water quality in the future.

This section reviews some of the main ways in which climate will affect Great Lakes watershed hydrology and how that may be exacerbated by land use / land cover change occurring throughout the basin. Additionally, more specific impacts that may result from agricultural and urban land use are also reviewed to provide key insights for these dominant human landscape stressors.

4.1 Climate change effects on lake hydrology

Historically, precipitation increases have been relatively well distributed across the year. Future climate projections, however, suggest that precipitation will continue to increase in the winter and spring months. Summer and fall precipitation will be more variable in the near term but tending towards decreases by the end of the century.

Drier summer conditions are most likely under high emission scenarios. Increased winter and spring precipitation will directly increase river discharge in winter and spring months (Cherkauer and Sinha, 2010; Byun et al., 2018).

With less precipitation falling as snow, there is a decrease in flooding associated with spring snow melt, but mean streamflow will still be higher during those months because of greater overall precipitation (i.e., more rain). For larger watersheds this is expected to shift annual peak flows earlier in the season (Byun et al., 2018), while for smaller watersheds the increased frequency and magnitude of storms in the late spring will compete with snow melt as the primary driver of annual peak flow events, potentially shifting some peak flows later in the year (Cherkauer et al., 2018). Flood risk is also projected to increase in the future (Cherkauer and Sinha, 2010; Byun et al., 2018). Water storage in the landscape, as soil moisture, aquifer recharge, and the refilling of wetlands and small lakes will also increase during the winter and spring (Cherkauer et al., 2018; Byun et al., 2018), though water storage as snow will decrease.

Higher summer and fall air temperatures will increase evaporation during the growing season. Coupled with summer precipitation that is increasingly variable and likely lower, summer river flows will be lower than historical observations by the end of the century (Byun et al., 2018). The increased intensity of summer storm events is likely to contribute to an increase in the flashiness, or day-to-day variability, of river discharge (Cherkauer and Sinha, 2010). Increased evaporation during the growing season will also reduce water stored in the landscape, increasing soil moisture deficits in the fall (Byun et al., 2018; Cherkauer et al., 2018). This will increase the difference in water storage between wet and dry seasons. For example, Byun et al. (2018) project that soil moisture storage will decrease by about 8% in September and October by the end of the century under the high emissions scenario. For the same scenario, they project soil moisture storage to increase by around 10% in February and March by the end of the century.

4.2 Land use / land cover change

Land use and land cover influences climate by changing regional temperatures, precipitation, vegetation, and the patterns of thunderstorms (Pielke, 2005). Land use is projected to remain an important contributor to local changes in climate (Sala et al., 2000; Pielke et al., 2002; Pielke, 2005; Mahmood et al., 2010) and often occurs concurrently with hydrologic change (see Lee et al., 2011; Jarsjö et al., 2012, Destouni et al., 2013). Urban areas, in particular, have a disproportionate influence on climate, hydrology, and water quality (Price, 2011).

Table 4 summarizes the current land use and land cover for the Great Lakes Basin. Over 34 million people reside in the Great Lakes Basin, with two-thirds in urban settings (IJC, 2009). These urban areas cover around 10% of the basin, but represent the fastest growing land use type (Wolter et al., 2006, SOLEC, in review). Changes in land cover and land use are difficult to track for the entirety of the Great Lakes Basin due to differences in timing of land cover mapping, map resolution, and classification across the United States and Canada (SOLEC, 2017). For the period 2000 – 2011, the SOLEC (2017) Land Use Change indicator reported a net conversion of only 0.05% for the entire basin, but the majority of that change reflected an increase in developed areas (+0.38%) and a decrease in forest area (-0.5%). Data from a remote sensing study of the U.S. side of the basin (Wolter et al., 2006) reported a 2.5% change in land use from 1992 – 2001, with the greatest increases occurring in low intensity development (+33.5%), road area (+7.5%), and decreases of about -2.3% each in agricultural and forest lands. Increases in urbanization were concentrated in coastal areas of the Great Lakes.

There is strong evidence that forest ecosystems are already responding to climate change in the Great Lakes region (e.g., Iverson et al., 2008; Woodall et al., 2009; Zhu et al., 2012; Fei et al., 2017). In general, evidence suggests that individual tree species are moving northward and westward at 10-15 km per decade, with relatively strong shifts northward in northern hardwood forests around the Great Lakes (Woodall et al., 2009; Fei et al., 2017). However, some studies have also shown some eastern tree species are susceptible to range contraction due to climate change (Zhu et al., 2012; Iverson et al. 2017). Similarly, recent studies examining potential range shifts over a decade in the eastern United States found little evidence of range shifts, despite underlying changes in climatic conditions, raising concerns about range contraction.

One important factor that will influence land use and land cover change, and resulting effects on hydrology, is carbon fertilization. The Free Air Enrichment Studies (FACE) illustrated that elevated CO2 would increase net primary productivity in forests (e.g., Norby et al., 2005; Norby and Zak, 2011). Keenan et al. (2013) find strong increases in water use efficiency, suggesting that as CO2 levels increase, forested ecosystems will use water differently, potentially shifting watershed hydrology. There are important feedbacks between land use, land cover, and hydrologic response in the Great Lakes that are only poorly understood at present.

Policy responses to climate change could also have strong influences on land use change. Stavins (1999), Plantinga et al. (1999), Adams et al. (1999), Sohngen and Mendelsohn (2003), Murray et al. (2005), and recently Fargione et al. (2018) have suggested that implementation of natural climate solutions, including expansion of forests to sequester carbon, are economically feasible at costs comparable to energy sector mitigation options. According to these studies, there are significant opportunities to establish forests throughout the Great Lakes watershed, and policy efforts aimed at mitigating climate change could strongly influence future land use and land cover throughout the region. In general, these changes would involve expansion of forests at the expense of agriculture and grazing land.

4.3 Agricultural watersheds and agricultural impacts

The Fourth National Climate Assessment (USGCRP, 2018; Angel et al., 2018) illustrates key changes in Midwestern climate conditions that will affect crop productivity, including lengthening growing seasons; changes in precipitation patterns; shifts in minimum, maximum, and average temperatures; shifts in humidity levels, etc. These changes are already affecting crop production and are expected to continue shifting in the future. For instance, changes in seasonal precipitation are already affecting farmers in Midwestern states, with planting delays related to spring flooding and excessively wet soil conditions (Bowling et al., 2018). Outflow from subsurface drainage, historically at its peak in winter and spring months, is expected to increase in the future (Cherkauer et al., 2018). This is in part due to increased precipitation during those months, but also due to warming via the decreasing influence of snow and soil frost on infiltration.

Delayed planting puts crops at greater risk under hotter and drier conditions later in the growing season. This increases the demand for irrigation to mitigate crop losses (Bowling et al., 2018). Increased irrigation is already appearing in many Great Lake states. Groundwater is increasingly being used for irrigation throughout the Midwest, and in some cases pumping is lowering groundwater levels (e.g., Cherkauer et al., 2018). There is growing awareness that water storage must increase in the region to capture more of the plentiful winter and spring precipitation, and store it until needed to reduce summer losses. Increased storage on farms distributed across the landscape will have an effect not yet quantified, related to flood risk and water availability, discussed in Section 4.1.

A number of empirical studies have examined the influence of weather and climate on crop yields, focusing on the U.S. Midwest given its global importance. These studies have suggested that climate change could have significant impacts on corn and soybean yields in the Great Lakes region (e.g., Schlenker and Roberts, 2009; Urban et al., 2012; Lobell et al., 2014; Gustafson et al., 2015; Bowling et al., 2018; and Jin et al., 2017). Depending on climate mitigation efforts and adaptation, climate change could reduce crop yields by 10-30% by the middle to latter parts of this century. The largest negative effects will occur in the southern Great Lake states (Urban et al., 2012; Bowling et al., 2018), as maize in particular is increasingly at risk to drought stress (Lobell et al., 2014). Despite potential falling productivity in currently important crops in the region, agriculture is expected to remain in important land use in the Great Lakes region due to adaptation (Haim et al., 2011).

Efforts to adapt with irrigation, adaptation of new varieties, and alternative management approaches can help mitigate some of the yield losses experienced by growers. Climate change will also encourage farmers to adapt their management by switching to new crops, among other approaches (Mendelsohn et al., 1994; Easterling et al., 2000; Deschenes and Greenstone, 2007; Massetti et al., 2016; Mendelsohn and Massetti, 2017). For some areas, this may include double cropping where more than one crop is grown in a field per year, increased use of cover crops, and changes to new mixtures of crops better suited for the future climate (recognizing the large differences in soil productivity across the Great Lakes region). There is evidence that important crops, in particular corn and soybean, will shift northward (e.g., Easterling et al., 2000; Laingen, 2017).

4.4 Urban watersheds and urban impacts on the Great Lakes

Land use impacts on climate are well documented (Mahmood et al., 2010), as are effects of land use / land cover on hydrology (e.g., Mao and Cherkauer, 2009). Interacting effects of climate, land use, and human population are difficult to quantify independently, and the simultaneous effects have rarely been studied. Direct impacts of urban land use on hydrology stem from water diversions. These include massive infrastructure projects such as the Chicago Water Diversion, which in 1900 reversed the flow of the Illinois River to drain to the Mississippi River instead of to Lake Michigan (Annin, 2018), and more modest diversions resulting from shallow groundwater withdrawals, rerouted stormwater runoff, or smaller wastewater systems exported outside catchments (Price, 2010). The Great Lakes Compact, signed in 2008, is designed to protect the basin from further withdrawals, through a set of protocols that define the geographic boundaries and the conditions under which water is withdrawn and then returned (Annin, 2018). Unfortunately, this agreement does not address the potential impacts of climate change on groundwater and surface water quantity and quality.

There is emerging understanding that the hydrologic behavior of urban areas is more complex than was previously known. The dogma that vegetation removal and replacement with impervious surfaces decreases baseflow due to changes in recharge has been challenged by more recent studies that demonstrate both increased and decreased recharge associated with urban areas (Price, 2010). Some effects of urban development are well known: decreased groundwater recharge from impervious surface and soil compaction, rapid transmission of stormwater to waterways, shallow groundwater leakage to stormwater sewers, shallow stormwater withdrawal, and rerouted wastewater. But increased groundwater recharge can result from changes in surface distribution of imported water from irrigation and outdoor water use, infrastructure leakage, stormwater detention in artificial structures, and movement of stormwater to shallow groundwater via storm sewers (Lerner, 2002; Price, 2010). Green infrastructure such as parks, green street corridors, rain gardens, and natural areas, are increasingly being

examined as cost-effective strategies for cities to increase water storage in soil and groundwater, thereby decreasing stormwater runoff (Hopton et al., 2015; Carlson and White, 2017).

Increasing variability in precipitation patterns, especially during early spring when grounds are frozen or when rainfall occurs onto snow, are likely to exacerbate stormwater runoff and flooding events. However, these processes will have variable results on baseflow and groundwater recharge depending on the regional geology, type and status of infrastructure repair, and stormwater and wastewater management practices. Direct effects of climate on baseflow are likely to be highly variable depending on regional conditions. For example, higher summer time temperatures are likely to result in increased convective precipitation and more intense storms. Modeling studies suggest that seasonality of flow regimes, combined with warmer temperatures are likely to reduce base flow (e.g., Choi, et al., 2009). An empirical study in Wisconsin showed that climate change was the dominant driver of baseflow timing, but land use change interacted with climate to alter the magnitude of changes (Juckem et al., 2008). The amount of impervious surface and compacted soil are likely to be strong determinants of those responses (Smakhtin, 2001; Easterling et al., 2000). Vegetation type and distribution have a strong impact on both local and regional hydrology, and land use conversion can either increase or decrease runoff as a result (Mao and Cherkauer, 2009).

4.5 Water quality impacts on the Great Lakes

Urban influences on water quality are strongly linked to hydrology and climate, especially to changing precipitation patterns (IJC, 2009). Globally, increases in climate-mediated precipitation are predicted to result in increased total nitrogen loads to rivers, although much of this is due to agricultural activities rather than urban inputs. Future cross-model mean projections of nitrogen loading for the Great Lakes region show the large regional increases (+21%) for the 2071-2100 period under the high emission scenario (RCP8.5) (Sinha et al., 2017). An additional concern for the Great Lakes lies in loading of dissolved phosphorus from watersheds, with a special concern for its effect on harmful algal blooms and dissolved oxygen concentrations (Scavia et al., 2014; Burlakova et al., 2018). Since the 1990's algae blooms, benthic algae, and extensive hypoxia zones have re-emerged as problems in Lake Erie (Scavia et al. 2014), and have been linked to phosphorus loading from agricultural sectors. SPARROW model output for the U.S. tributaries of the Great Lakes have identified sources of phosphorus to the Great Lakes from a wide variety of sources including point sources (industrial, commercial, and sewage), confined and unconfined manure, farm fertilizer, nonpoint sources from urban and developed land, as well as forest and wetland areas (Robertson and Saad, 2011; ELPC, 2018). Across the Great Lakes, inputs from urban and agricultural sources were similar for all lakes except Lake Superior, which supports little agricultural activity. Around 50% of phosphorus inputs were derived from point sources and urban sources for all Great Lakes except Lake Superior. Manure was an important source of phosphorus in Lakes Michigan and Ontario (Robertson and Saad, 2015). Sources of nitrogen were mainly attributed to agricultural practices and atmospheric deposition. From the standpoint of climate change impacts, nutrient delivery via tributaries is the dominant input to the Great Lakes, thus climate-driven patterns influencing flow regimes are likely to have a large impact on future nutrient delivery to the Great Lakes (Robertson and Saad, 2015). Large storms are likely to increase the incidence of sewage bypass in urban areas (i.e., combined sewer overflows) and flooding of manure management systems, thereby increasing the input of phosphorus into the Great Lakes.

URBAN ISSUES IN THE GREAT LAKES REGION

In the Midwest and Great Lakes regions, high weather variability, high-intensity urban development, and undersized infrastructure yield severe and accelerating vulnerability to urban areas as a result of such extreme events (Borden et al., 2007; Wilson et al., 2010; Pryor et al. 2014, Kristovich et al. [in review]). Interaction of the Great Lakes with coastal urban environments modify the lake breeze and shifts the urban heat island inwards (Sharma et al., 2017). Heat waves and poor air quality often co-occur because they are both associated with air stagnation (Schnell and Prather 2017; Sharma et al., 2016). The combination of high heat and poor air quality produces severe adverse impacts on public health, including considerable numbers of deaths during heat waves (Changnon et al., 1996; Palecki et al., 2001; Anderson and Bell, 2011). Increasing urban temperature and development of hot-spots adversely affect vulnerable low-income urban communities (Sharma et al., 2018). Projected increases in extremely warm and hot days, described previously, indicates that these risks are increasing in Great Lakes cites (Luber and McGeehin, 2008). Green infrastructure is likely to reduce urban stress in the Great Lakes region. However, an aggressive implementation of an adaptive strategy may reduce lake breeze and vertical mixing during daytime and could lead to stagnation of air near the surface causing poor air quality (Sharma et al., 2016). Thus, green infrastructure such as green and cool rooftops can provide relief for hot Great Lakes cities, but should be sited carefully (https://theconversation.com/green-and-cool-roofs-provide-relief-for-hot-cities-but-should-be-sited-carefully-60766).

Increased precipitation in extreme storms is also expected to present particular hazards to cities. Many Great Lakes cities experience frequent flooding from intense, localized storms (CNT, 2013; Winters et al., 2015). Under-resourced communities suffer a disproportionate burden of storm impacts, owing to the confluence of low property values and lack of infrastructure in low-lying flood-prone areas (Wilson et al. 2010, CNT 2013). The projected increase in extreme precipitation events in this region, as documented previously, is likely to exacerbate these problems, leading to increased flooding in the winter and early spring, as well as increased flooding from summer thunderstorms. These effects are already being seen, for example in extreme winter rain events and associated flooding in 2017 and 2018 (e.g., https://www.nbcchicago.com/news/local/flood-photos-chicago-south-suburbs-474717273.html, https://www.npr.org/sections/thetwo-way/2018/02/22/587881723/widespread-flooding-brings-misery-to-midwest).

5. Impacts on ecology of the Great Lakes and the region

The ecology of the Great Lakes region is already being affected by climate change, and these impacts are likely to strengthen in the future as the climate in the region continues to change. This section explores the understanding of these current and potential impacts.

5.1 Mixing and oxygenation

As mentioned in section 3.1, since fresh water has its maximum density at 4°C, the water column becomes unstable when surface water that was previously at a temperature farther away from that temperature moves closer toward it (e.g. after the surface water has reached its maximum temperature for the year and starts cooling, it becomes denser than the water below it and will start mixing). The water column typically passes through the 4°C threshold and mixes completely twice each year, on the way up in the spring and on the way down in the fall (they are "dimictic"). The spring overturning has become earlier with warming and the fall overturning later. Since the spring overturning represents the initiation of a stable configuration of the water column with the warmest water on top, inhibiting deep mixing as time goes on and enhancing the warming at the surface, this is noted as a mechanism for summer surface water temperatures to be increasing at a greater rate than air temperatures over adjacent land areas (Austin and Colman 2007). Animations available at https://coastwatch.glerl.noaa.gov show that there are parts of southern Lake Michigan and of Lake Ontario whose surface temperature stayed above 4°C during the winters of 2011-12 and 2016-17, so their water columns presumably did not mix fully during those years.

That vertical mixing brings nutrients up from the sediment at the bottom of the lake, and oxygen down from the surface, so it is crucial for ecosystems. In addition to altering the seasonal character of vertical mixing, the observed (and expected continuing) trend toward rainfall being concentrated in very heavy events is likely to increase the amount of nutrients reaching the lakes. Scavia et al. (2014) and Bosch et al. (2014) show this as one of the influences leading to increased nutrient load into the lakes, along with practices surrounding agricultural fertilizer application and drainage. This is particularly serious in the central basin of Lake Erie, because the water depth is such that not much mixing occurs to the bottom, yet the mass of water below the thermocline is small enough that decomposition of organic matter in the sediment can consume the oxygen within that layer. Michalak et al. (2013) document a major algal bloom in western Lake Erie that made Toledo, Ohio's municipal water unsafe to drink for weeks. This occurred following sudden increased water flow in tributary rivers in that area that transported a heavy load of nutrients, in particular from the Maumee River. Such events could become more likely given the intermittent, but very heavy rainfall events expected under a warming climate.

5.2 Biodiversity and invasive species

Over geologic time-scales, the Earth's climate has been the single most important factor controlling the distribution of the world's species and the biodiversity of species in any given location (Parmesan and Yohe 2003). Climate sets the physiological limits of species range distributions, controls the co-evolutionary processes that cause species to become mutually dependent, and influences the spread and interactions among species that control community membership. Therefore, climate change is predicted to have significant impacts on the biodiversity of all ecosystems, with these impacts occurring on short time-scales matching the timing of changes projected to occur through the current century.

The ultimate impact of climate change on biodiversity in the Great Lake ecosystem will depend on how the various components of climate change (warming, increased CO2 concentrations, changes in water acidity and oxygen levels, altered frequency and intensity of storms, etc.) collectively impact four factors that regulate biodiversity: (1) invasion rates by new, non-native species, (2) replacement of widespread or abundant species by those that are presently uncommon or rare, (3) emergence or proliferation of new pests and disease that might impact established species populations, and (4) extinction rates of the existing established species assemblage (Figure 8).

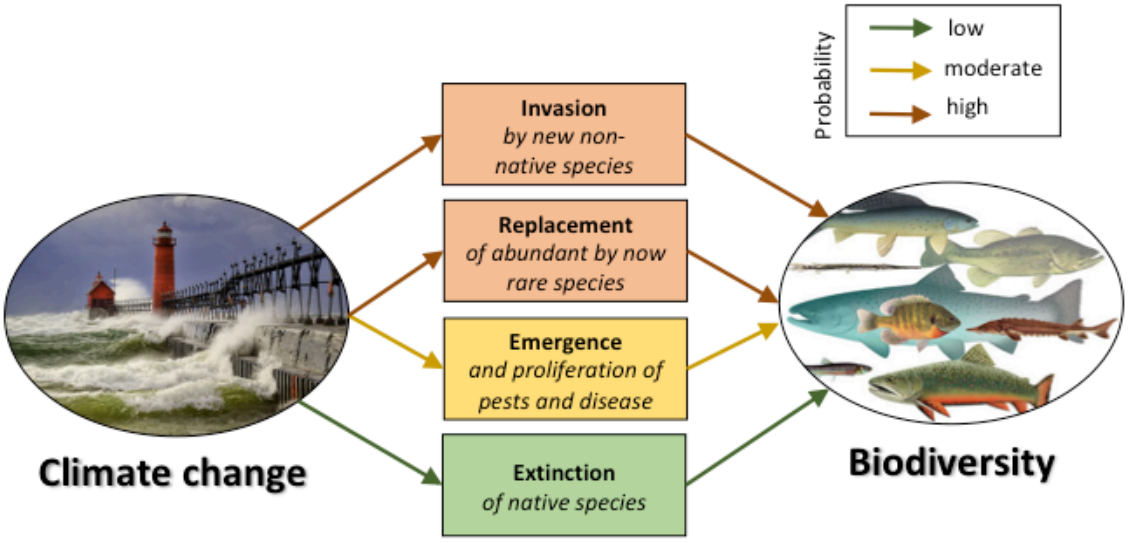


Figure 8. The impact of climate change on biodiversity in the Great Lakes will depend on how climate change impacts four factors that contribute to diversity: (1) invasion by new, non-native species, (2) replacement of currently dominant species by those that are now rare (i.e. species turnover), (3) the emergence and proliferation of pest and disease species that impact of native populations, and (4) extinction of currently native species. These are ranked from their highest to lowest probability or risk.

The greatest effects of climate change are expected to occur from the redistribution of flora and fauna that lead to the introduction of non-native species (Pecl et al., 2017). There are already well-documented examples of climate change altering the range distributions of species, leading to introduction of novel species into ecosystems. Indeed, 87% of all species monitored have displayed range shifts as they have migrated towards the poles at rates exceeding 3.7 miles (6 km) per decade (Parmesan and Yohe, 2003).

Within the Great Lakes watershed, one of the best examples of range shifts altering biological communities comes from surveys of sport and baitfish populations. The range boundaries of numerous sportfish have shifted northward at a rate of 8 to 11 miles (12.9 to 17.5 km) per decade over the past 30 years, which has led to widespread introductions of formerly "southern" warm-water fish species into northern latitude lakes (Alofs et al., 2013).

There is also good evidence that climate change has initiated species 'turnover' as formerly rare or uncommon species have benefited from climate change and begun to proliferate (Collingsworth et al., 2017). For example, smallmouth bass (Micropterus dolomieu) have historically been limited in their northern distribution by the length of the ice-free growing season and overwinter survival of their young-of-the-year (yoy). As the ice-free season has increased, and as warming has improved young of year survival, populations of smallmouth bass have proliferated in lakes that they currently occupy, and expanded to waterbodies throughout the Great Lakes watershed they did not formerly occupy (Alofs et al., 2013; Alofs and Jackson, 2014). Because smallmouth bass are voracious predators, their expansion has reduced more than 25,000 populations of northern redbelly dace (Phoxinus eos), finescale dace (Phoxinus neogaeus), fathead minnow (Pimephales promelas), and pearl dace (Margariscus margarita) throughout lakes in Ontario (Jackson and Mandrak, 2002).

In Lake Superior, white perch (Morone americana) and alewife (Alosa pseudoharengus) have historically been rare, but are expected to expand their distributions with continued climate warming (Bronte et al., 2005), likely

owing to reduced overwinter mortality (Hook et al., 2007). The invasive round goby (Neogobius melanostomus) is also expected to gain more beneficial habitat with continued warming across the Great Lakes (Kornis et al., 2012), as may the flathead catfish (Pylodictis oliverus) (Fuller and Whelan, 2018).

Climate change is also likely to exacerbate the emergence and proliferation of pest and disease species. For example, bioenergetics modeling has demonstrated how sea lamprey (Petromyzon marinus) have benefitted from the warming of Lake Superior since 1979 by growing larger and more fecund (Cline et al., 2013). These trends are problematic because invasive sea lamprey have already had large negative effects on fisheries by parasitizing and killing recreationally important piscivores and commercially important lake whitefish (Coregonus clupeaformis) as adults (Bence et al., 2003). Larger more fecund individuals are likely to inflict even higher mortality rates on their hosts.

Patz et al. (2008) suggested the prevalence of water-born pathogens will increase with climate change. They showed that climate change models predict an increase of extreme precipitation events by 10% to 40% in southern Wisconsin, which will result in a 50% to 120% increase in the frequency of combined sewer overflows into Lake Michigan. Those overflows are projected to introduce hundreds of new species of pathogenic bacteria, viruses, and protozoa.

Although climate change will undoubtedly affect Great Lakes biodiversity by promoting invasion by non-native species, replacement of common by formerly rare species, and the proliferation of pests and disease, the risk of extinctions caused directly by climate change is uncertain. Even while climate change is often touted as a great risk to biodiversity (Thomas et al., 2004), few empirical examples of extinctions have ever been directly linked to climate change (the first was reported by Gynther et al., 2016). Nor have any extinctions of native species that we know of have been directly attributed to climate change in the Great Lakes.

While extinctions caused directly by climate change are likely to be rare, the potential of extinctions caused indirectly through climate change's impact on invasive species, species replacement, or the proliferation of new pests and disease are possible. However, the importance of these indirect effects is currently controversial, and has a high degree of uncertainty. For example, while it has historically been assumed that invasive species are a leading cause of native species extinction (Wilcove et al., 1998), recent evidence suggests that invasive species rarely cause extinctions (Gurevitch and Padilla, 2004) and, in fact, non-native introductions often cause biodiversity to increase as invasion rates outpace extinction rates (Sax and Gaines, 2003; Dornelas et al., 2014). Therefore, the cumulative impact of climate change on extinctions (direct and indirect effects) is presently unknown.

5.3 Nutrient loading and algal blooms

Harmful algal blooms (HABs) are increasing in frequency and severity worldwide. Many of the variables that control the frequency and severity of HABs – such as nutrient loading, water temperature, and stratification -- are directly influenced by climate change (Wells et al. 2015). As such, climate change is expected to alter the frequency and severity of HABs. Increased nutrient loading caused by agricultural fertilizers, urban wastewater, and soil erosion is the primary cause of HABs in water bodies throughout the world (Heisler et al. 2008), including in the Great Lakes (Watson et al., 2016). Nutrient loading to Great Lakes coastal zones is generally expected to increase as a result of climate change, mostly due to a greater frequency of large precipitation events that increase runoff from agricultural landscapes in the surrounding watersheds. For example, Cousino et al. (2015) incorporated

predictions from recent climate change models into a Soil & Water Assessment Tool (SWAT model) of the Maumee River to predict the effects of climate change on water, sediment, and nutrient yields. The Maumee River, which is a dominant source of nutrients to the western basin of Lake Erie that experiences frequent HABs, is expected to experience more extreme precipitation and runoff events in the future. Unless nutrient and sediment loads are offset by improved land management practices (Scavia et al., 2017), models predict that climate change will increase eutrophication of western Lake Erie with greater nutrient loading by the Maumee River.

There is some evidence that extreme climatic events have already contributed to HAB formation in the western basin of Lake Erie (Figure 9). Michalak et al. (2013) studied the record-setting 2011 algal bloom in Lake Erie, which was caused by the toxin-forming cyanobacteria Microcystis (July and August) and Anabaena (September and October). Although agricultural runoff is the normal cause of the routine blooms that form in the basin, several climactic anomalies contributed to the 2011 event being unusually large. In particular, a May 2011 storm caused the Maumee River to reach the 99.8th percentile for its daily discharge, leading to an abnormally high amount of nutrient runoff. Then, after the bloom started, weather conditions were unusually conducive for growth – with "warm and quiescent conditions" for 62% of the time after bloom onset, relative to 35%-36% in other years. This study suggests that the increasing frequency of large precipitation events in the Great Lakes region and general warming patterns could increase the probability of particularly large or severe blooms.



Figure 9. In 2011, Lake Erie experienced the largest harmful algal bloom in its recorded history, with a peak intensity over three times greater than any previously observed bloom. Climate change is expected to increase the frequency of these large algal blooms
Source: MERIS/ ESA Satellite photo, processed by NOAA/NOS/NCCOS; https://www.canr.msu.edu/news/lake_erie_harmful_algae_bloom_threatens_drinking_water_supplies.

In addition to nutrient loadings, higher water temperatures are known to preferentially favor growth by certain types of bloom-forming algae and cyanobacteria (O'Neil et al., 2012). At water temperatures above 20°C, the growth rates of freshwater eukaryotic phytoplankton stabilize or decrease, while growth rates of many bloom-forming cyanobacteria increase (e.g., Microcystis, Anabaena, and Cylindrospermopsis). Warming water temperatures may have been responsible for an unprecedented algal bloom in Lake Superior that spread across 50 miles of Lake Superior shoreline in 2018, from Superior, WI to the Apostle Islands (https://www.nytimes.com/2018/08/29/science/lake-superior-algae-toxic.html)

Increased water temperature can also increase the frequency of toxin production by bloom-forming species. For example, Davis et al. (2009) found that enhanced temperatures yielded significantly increased growth rates of toxic Microcystis in 83% of the experiments conducted, but did so for non-toxic Microcystis in only 33% of experiments. This suggests that elevated water temperatures may yield more toxic blooms.

Climate change is also increasing the duration and intensity of lake stratification (Kraemer et al., 2015), which is expected to promote HABs. Lehman (2002), for example, used nested physical and biological models to simulate future stratification and mixing conditions for the Great Lakes that are projected under climate change through 2090. Those models predicted elevated mixed layer and bottom temperatures in all five Great Lakes by as much as 5 °C this century, with longer duration of thermal stratification, stronger stability of stratification, and deeper daily mixing depths during peak thermal stratification. Many HAB species uniquely adapted to exploit stratified conditions. For example, most bloom-forming cyanobacteria contain gas vesicles that provide buoyancy, enabling them to form dense surface blooms in stratified waters where they can take advantage of high levels of irradiance to optimize photosynthesis (Paerl and Paul, 2012). Many surface-dwelling cyanobacteria also contain photoprotective accessory pigments (e.g. carotenoids) and UV-absorbing compounds (mycosporine-like amino acids [MAAs], scytonemin) that ensure long-term survival under high irradiance conditions, while suppressing non-buoyant species through competition for light (Paerl and Paul, 2012).

5.4 Fish

Fish species in the Great Lakes region will be directly affected by climate change phenomena including temperature increases, increases in storm intensity and frequency, and shifting seasonal patterns. Many Great Lakes fishes are influenced by water temperature, for example, which contributes to distinct cold, cool, and warm-water assemblages throughout the region (e.g., Magnuson et al., 1997; Wehrly et al., 2003). Additionally, shifting seasonal patterns of precipitation and ice formation can similarly affect species whose behavior is cued to those events. Besides these direct changes, effects of climate change phenomena on fish habitats will further impact species. Changing precipitation patterns and storm impact hydrology will impact drainage patterns, connectivity, water levels, and the extent and quality of littoral habitat. Increases in water temperature, along with earlier warming in spring, will increase the depth and duration of stratification. This, in turn, will promote depletion of upper oxygenated layers of water, resulting in more widespread and profound periods of bottom anoxia (Trumpickas et al., 2009; Collingsworth et al., 2017). Together, these changing environmental drivers will have multiple effects on Great Lakes fishes by changing 1) geographic ranges, 2) overall system productivity, 3) species-specific productivity, 4) spatial arrangement within a system due to changing habitat suitability (Shuter et al., 2012; Poesch et al., 2016; Lynch et al., 2016) and 5) changes in physiological state and performance (Whitney et al. 2016).

Many modeling studies have been conducted predicting impacts of climate change on fish (e.g., Jackson & Mandrak, 2002; Sharma et al., 2007; Sharma and Jackson, 2008; Herb et al., 2016; Van Zuiden et al., 2016), with

many of these focused on coldwater fish species or assemblages. Fewer studies have reported empirical observations of climate change impacts. Such studies (reviewed by Comte et al., 2013; Lynch et al., 2016) have documented shifts in geographic range, changes in demographics (abundance, growth, recruitment), increased occurrence of diseases, phenological shifts (earlier migration, spawning), extirpation (especially of coldwater species), and hybridization resulting from novel species interactions (Lynch et al., 2016; Collingsworth et al., 2017). Comte et al. (2013) compared predicted versus observed responses and found that in general, the observed effects of climate change are much greater (mean of 8x) than those derived from model predictions. Overall positive impacts from empirical observations were found on Cyprinidae, Percidae, Ictaluridae, and Salmonidae; although Salmonidae showed more mixed effects than the other families. In general, predicted studies reported a high proportion of negative effects for coldwater species. In Lake Superior, the coldwater fish assemblage was predicted to experience little change, with the exception of the lake siscowet (a variety of lake trout [Salvelinus namaycush]), which have extreme cold thermal tolerances (Magnuson et al. 1997).

Range expansions have been among the most commonly observed changes that indicate climate change impacts on fish. At mid-latitudes (40°N to 50°N), warm- and coolwater species have exhibited increased presence, abundance, and distribution (Johnson and Evans, 1990; Alofs et al., 2014). Within the Great Lakes Basin in Ontario, range expansions have been documented for game fish (mainly bluegill [Lepomis macrochirus]), largemouth bass [Micropterus salmoides], smallmouth bass [Micropterus dolomieu], and brown bullhead [Ameiurus nebulosus]), which have migrated poleward at the rate of 13 km per decade over a recent 30 year period. In contrast, there were no statistically significant changes observed in the range of preyfish species, although the trend was towards range contraction (Alofs et al., 2014). Studies assessing factors that control establishment of novel species suggest that abiotic factors (habitat, water temperature) are the primary drivers at regional scales, but that biotic factors are more important on a lake by lake basis (Alofs and Jackson, 2015).

Many studies have predicted northward expansion of warmwater species (e.g., Jackson and Mandrak, 2002; Chu et al., 2011; Sharma et al., 2007, Van Zuiden et al., 2016). As geographic ranges expand, community composition is expected to be altered, with greater diversity expected as cool and warm water species invade cold water habitats. In addition to altering predator-prey interactions as a result of these novel species interactions, Biwas et al. (2017) predict an increase in species richness in Ontario lakes of 60-81% by the end of the century, along with changes in the functional traits of the fish community. These include changes in the average thermal guild of species present, smaller body length and weight, lower fecundity, and shorter trophic breadth by 2070 under both a business as usual and best-case emission scenario. Under the best-case emission scenario, 10-40% of Ontario lakes are expected to be impacted by major shifts in community composition. Species that will be affected include lake trout, northern pike (Esox lucius), walleye (Sander vitreus), whitefish (Coregonus clupeaformis) and yellow perch (Perca flavescens). Jackson and Mandrak (2002) predict that range expansion of smallmouth bass will be extremely detrimental to the populations of forage fish; a pattern confirmed by Vander Zanden et al. (2004) and Alofs et al. (2014). This pattern was also confirmed by Robillard and Fox (2006), who reported declines in walleye relative abundance and increases in relative abundance of smallmouth bass in conjunction with decreases in phosphorus concentrations, increased water clarity, and increased water temperature. The later study highlights the difficulty of isolating the impact of climate change versus other environmental stressors such as land use change, which can lead to nutrient loading and the presence of invasive species.

In addition to range expansion and community realignment, climate change has been shown to influence recruitment and spawning behavior, with both "winner" and "loser" species throughout the basin and with some results varying by region. For example, increased temperatures and altered aquatic conditions have facilitated increased recruitment and abundance for some warmwater species (e.g., black basses [Robillard and Fox, 2006]), with increased temperature contributing to declines in cisco (Coregonus artedi) abundance in Minnesota glacial lakes (Jacobson et al., 2012). In Lake Michigan near Milwaukee, yellow perch have been observed to be spawning earlier, by 6.2 days per decade (for the period 1988-2012), while in Green Bay, earlier spawning occurs by 1.8 d/decade (1983-2016; Lyons et al., 2015). In Lake Erie, the timing of yellow perch spawning has not changed despite shorter, warmer winters; however, females are producing smaller eggs that both hatch at lower rates and produce smaller larvae than females exposed to long winters (Farmer et al., 2015). This effect may be explained by shifts in the peak of zooplankton production, a key food for yellow perch larvae. However, there is some evidence that increased river discharge and associated turbidity plumes in Lake Erie may benefit larval yellow perch (reviewed by Collingsworth et al., 2017). Trends for lake trout spawning in Lakes Superior and Michigan are unclear. Lyons et al. (2015) speculate that spring spawning species are likely to be more strongly affected than fall spawning species due to the high variability in water temperature changes during spring, compared to fall. In some Minnesota lakes, walleye are also spawning earlier, in conjunction with earlier ice out patterns (Schneider et al., 2010). In Lake Erie, greater variability in spring warming has been shown to be associated with more variability in spring spawning species such as walleye, and the same pattern was observed for summer spawning smallmouth bass in Lake Opeongo in Ontario. Furthermore, increased summer water temperatures were associated with greater growth rates in walleye (Shuter et al., 2002). These authors predict that fish species that are most sensitive to winter conditions (e.g., alewife [Alosa pseudoharengus]) could be expected to be most sensitive to warming climate in the region, due to the prevalence of winter warming that has characterized the shifting climate patterns

In addition to observed and predicted changes in phenology, simulations of fish growth using bioenergetics models for yellow perch and lake whitefish under different climate scenarios predict that growth rates will decrease more for yellow perch than lake whitefish (Kao et al., 2015). This study also concluded that prey availability may offset the effects of climate change in terms of regulating fish growth rates. This finding provides a caution that temperature tolerance is not the only consideration when predicting effects of climate change on fish.

In conjunction with climate change impacts, the Great Lakes fisheries are heavily impacted by the presence of nonnative invasive species such as the quagga mussels (Dreissena bugensis) and zebra mussels (Dreissena polymorpha), which have dramatically influenced nutrient dynamics and the food web in general (Karatayevet al., 2015; special issue edited by Burlakova et al., 2018). In Lake Erie, in particular, dissolved phosphorus concentrations have increased, and harmful algal blooms and water column anoxia are prevalent, especially in the western and central basins (Scavia et al., 2014). In Lakes Michigan, Huron, and Ontario, nearshore benthic algal production is of special concern, especially for residents of the coastal areas; but offshore, declining phosphorus concentrations and productivity threaten the collapse of the food web (Bunnell et al., 2014; Dove and Chapra, 2015; Barbiero et al., 2018). The importance of water temperature as a key driver of fish distributions was recently highlighted in a study that assessed the major environmental factors explaining distributions of individual fish species in coastal areas of the Great Lakes. In the northern ecoprovince of the Great Lake, an analysis of the main drivers explaining fish presence / absence in coastal areas identified cumulative degree days as the most consistent predictor in models of 12 out of 13 fish species (Kovalenko et al., 2018). In the southern ecoprovince of the Great Lakes, primary drivers were related to water quality and physical habitat factors associated with

habitat structure. The confounding effects of climate change and further land use change (especially in the coastal zone) have not yet been addressed in the context of these issues. Future studies are encouraged to incorporate an ecosystem approach, account for the interaction of multiple, interacting stressors, and to consider the effects of predator-prey interactions as well as availability of prey (Collingsworth et al., 2017).

5.5 Wildlife

Wildlife in the Great Lakes region includes many species of mammals, birds, amphibians, reptiles, and macroinvertebrates. Due in large part to warming air temperatures, but also due to changes in types and patterns in precipitation, soil moisture, and the specific physiology of different organisms (Inkley et al., 2004), geographic ranges of many Great Lakes wildlife species are generally expected to shift northward (Gitay et al., 2002). This broad trend, however, will vary due to local conditions including changes in ice cover and regional precipitation. Additionally, the ability of wildlife to adapt to changing climate will be exacerbated by habitat loss, habitat fragmentation, competition from invasive species, threats from new and emerging diseases, and altered ecological processes (Hoving et al., 2013; Merila and Hendry, 2014). To aid efforts to proactively manage or mitigate for those changes, many attempts have been made to anticipate the vulnerability of key wildlife species to changes in climate, or describe how species distributions may change throughout the Great Lakes region and nationally in the U.S. and Canada (e.g., Frelich and Reich, 2009; Hellman et al., 2010; Hoving et al., 2013; Lawler et al., 2013; Culp et al., 2017). Due to uncertainties in climate change impacts on wildlife habitats and in how those changes could lead to changes in wildlife communities, it is challenging to fully anticipate how individual species may respond to changes in climate. Here, we provide a broad overview of current understanding of how climate has or will affect select wildlife species in the Great Lakes region, with the goals of emphasizing how different groups of taxa may be vulnerable, and to highlight some of the complex mechanism by which species and communities may be affected.

Mammals

Currently, nearly half of the 80 species of native Great Lakes mammals occur at either their southern or northern distributional limits (Kurta, 2017; Myers et al., 2009). This is due in part to the transition that exists between boreal forests in portions of the northern Great Lakes region with systems more common in southern regions like eastern oak hickory woodland, oak savannas, and prairies. In a recent study focused on distributions of 9 common woodland rodent species in Michigan, several species with ranges centered south of the state (white-footed mouse [Peromyscus leucopus], eastern chipmunk [Tamias striatus], southern flying squirrel [Glaucomys volans], common opossum [Didelphis virginiana] were found to have expanded northward into Michigan, while species with northern ranges (woodland deer mice [Peromyscus maniculatus gracilis], southern red-backed vole [Myodes gapperi], woodland jumping mouse [Napaeozapus insignis], least chipmunk [Tamias minimus], northern flying squirrel [Glaucomys sabrinus]) showed range declines in the state (Myers et al., 2009). The authors of this study acknowledge that regeneration of forests and changes in human population may be partially responsible for observed distributional changes, but they assert that warming temperatures are likely the leading factor due to the co-occurring increase in multiple species with historically southern-centered ranges and a decrease in their northern counterparts. In some cases, consequences of range changes are known to have greater impacts than just species replacement. A focused investigation of the white-footed mouse attempted to predict its range expansion in Quebec through the year 2050 (Roy-Dufresene et al., 2013). The white-footed mouse is a carrier of Borrelia burgdorferi, the known pathogen for Lyme disease. The study concluded that warmer, shorter winters will allow the mice to colonize new areas, including southern Quebec, and this is likely to have public health impacts in northern regions that have not currently been exposed to Lyme disease.

Large mammals are also being affected in the Great Lakes region. In Ontario, changes in forest type resulting from changes in climate are expected to affect wildlife species with larger body sizes more substantially than species with smaller body sizes (Thompson et al., 1998). Moose (Alces alces) may be especially vulnerable to climate change. In Minnesota and other part of their range, moose populations have declined precipitously, resulting in an elimination of the moose hunting season in some parts of Minnesota. Changes in climate will affect moose directly; their ability to thermo-regulate in both winter and summer may change with changes in air temperature and precipitation (Rempel et al., 2011). Hoy et al. (2018) have shown a decrease in moose size on Isle Royale, Michigan that they attribute to warming winter temperatures. Compounding these effects, changes in climate will have indirect effects on moose. Preferred habitat and available browse may change with changes in forest cover (e.g., Thompson et al., 1998). Additionally, white-tailed deer (Odocoileus virginianus) are expected to expand northward into habitats historically dominated by moose. White-tailed deer carry the parasite Paralaphostrongylus tenuis which is fatal to moose (Thompson et al., 1998; Murray et al., 2006). Parasites, particularly ticks, are surviving in greater number and have been found to provide yet another stress factor for moose. Finally, increased mortality from wolves may be an additional factor leading to declines in moose populations, and evidence for how changing climate is altering behavior of wolves and increasing mortality of moose has been described on Isle Royale (Post et al., 1999).

Dynamics among Isle Royale grey wolves (Canis lupis) and moose have been studied extensively since 1959 when wolves colonized the island. Pack size of wolves increases with snow depth to increase hunting efficiency, leading to more moose killed by wolf packs per day on the island. These increased kills include more calves and old moose, with kills of old moose being further facilitated by deeper snows (Post et al., 1999). Deeper snows are a consequence of more lake effect snowfall that occurs with an absence of ice cover throughout the Great Lakes, a trend that has been observed around Lake Superior and that is expected to continue in the region (GLISA, 2018). In Ontario, a recent modeling effort attempted to predict moose population dynamics in Ontario through mid-century (Rempel et al., 2011) by accounting for some of the direct and indirect effects of climate change influences on moose, including greater heat stress and parasite loads, reductions in habitat carrying capacity, and more predation by wolves under the A2 climate scenario. All models predicted a decline of moose density at the southern limits of the Ontario range and an increase in density at northern extents.

Birds

Coastal marshes of the lower Great Lakes are among the most biologically significant wetland types in the Great Lakes region, in part due to their role as habitat for staging, nesting, and wintering waterfowl (Hagy et al., 2014) and as stopover sites for migratory birds (Ewart et al., 2012). In coastal marshes of Lake Erie and Ontario, researchers characterized the degree to which fluctuating water levels and associated changes in vegetation affected marsh bird communities (Chin et al., 2014). They found that an index characterizing integrity of bird communities decreased with decreasing water levels. In Lake Erie, the reduced index resulted from a loss of specialist bird species, which include obligate marsh-nesting birds. These findings followed those of an earlier study which showed that habitat suitability for American bittern (Botaurus lentiginosus), American coot (Fulica americana), black tern (Chlidonias niger), least bittern (Ixobrychus exilis), marsh wren (Cistothorus palustris), pied-billed grebe (Podilymbus podiceps), sora (Porzana carolina), swamp sparrow (Melospiza georgiana), and Virginia rail (Rallus limicola) decreased with decreasing water levels in Lakes Erie and Huron-Michigan (Timmermans et al., 2008), in part because marsh bird species tend to avoid dry patches of marsh (e.g., Manci and Rusch, 1988). While expected changes in lake levels described previously in this report include only modest drops overall (e.g., Lofgren et al., 2016), impacts of potential decreases will vary around the basin due to lake bathymetry, unique characteristics of the shoreline, and

other regional influences. This may yield some coastal marsh habitats and their bird communities vulnerable to water level changes that may occur with changing climate.

Lower water levels and higher summer water temperatures are also affecting some Great Lakes birds by encouraging spread of disease. Recent deaths of fish eating birds within the Great Lakes region including red-breasted mergansers (Mergus serrator), ring-billed gulls (Larus delawarensis), and common loons (Gavia immer) have been attributed to the birds ingesting fish infected with a type of avian botulism, Clostridium botulinum (Culligan et al., 2002; Michigan SeaGrant, 2018). While botulism has long been present in the Great Lakes region, outbreaks are occurring more frequently, with researchers attributing those increases to changes in environmental conditions that will be exacerbated by climate change. Lafrancois et al. (2011) described the increased frequency of botulism outbreaks in Lake Michigan from 1963 to 2008 and showed that the outbreaks were related to higher summer water temperatures and lower water levels. They suggested that the frequency and magnitude of outbreaks should increase through the coming century and they called for more comprehensive monitoring of bird communities in response.

5.6 Coastal ecosystems

Like other coastal regions around the world, human activities are concentrated near the ~16,000 km of coastline in the Laurentian Great Lakes. These low-lying areas are particularly vulnerable to the effects of climate change, especially with respect to effects of intense storms and precipitation regimes that influence water level regimes (see Coastal Processes Section below). Water level interacts with geology to determine the extent and type of structural features at the shoreline (e.g., beaches, dunes, barriers, wetlands, and bluffs). Each of these structural features has a particular set of vulnerabilities associated with effects of changing climate as a result of changes in water level regimes, storm patterns and precipitation, ice cover and temperature regimes. These climate stressors and vulnerabilities of coastal ecosystems were reviewed by Mackey (2012).

Due to the long history of concentrated human activity in coastal areas of the Great Lakes, many of the larger ports and estuaries are highly disturbed 43 such sites have received designations as "Areas of Concern" (https://www.epa.gov/great-lakes-aocs) due to degradation of beneficial uses associated with physical, chemical or biological features. As of 2018, restorations have been completed for five sites and are ongoing for a similar number. It is unclear the extent to which climate change is a consideration in these restorations.

Among the coastal ecosystem types, wetlands have received the greatest attention, due largely to their importance as productivity and biodiversity "hotspots" (Cardinali et al., 1998; Vandeboncoeur et al., 2011; fish: Jude and Pappas, 1992; Trebitz and Hoffman, 2015; wetland vegetation: Wilcox, 1995, Lougheed et al., 2001; algae: McNair and Chow-Fraser, 2003; Reavie et al., 2007; birds, waterfowl, amphibians: Timmermans et al., 2008; amphibians: Houlahan and Findlay, 2003; functional richness and traits: Kovalenko et al., in revision). Coastal wetlands are among the most vulnerable ecosystem types in the Great Lakes as a result of changing water level regimes, increased storm frequency and intensity, and increased surface water temperatures. Increased water levels and storm surges are detrimental to aquatic vegetation communities, and open shoreline wetlands are likely to be the most directly impacted. However, such storms are also associated with increased nutrient, sediment, and contaminant loading from tributaries and increased coastal erosion, which can directly impact habitat and biota in coastal areas. While phosphorus loading is anticipated to increase as a result of higher spring flow and increased storm events (LaBeau et al., 2015), phosphorus reduction targets for Lake Erie, in particular, are

expected to ameliorate this loading (Scavia et al., 2014), but current efforts may not be sufficient to prevent future cyanobacteria blooms and accompanying challenges to municipal water systems. Additional stressors impacting coastal areas include wetland drainage and diking, shoreline hardening, and human activities associated with shipping and recreation (Allan et al., 2013).

Warming water temperatures are expected to cause increases in primary production (Magnuson et al., 1997), but it is now clear that these changes are associated with changes in assemblage composition (Reavie et al., 2014). In shallow, coastal areas, increased primary production and warmer water temperatures will lead to more rapid decomposition, leading to the potential for summer hypoxia to develop (Nelson et al., 2009); increased hypoxia would exert a negative influence on the invertebrate community (Collingsworth et al., 2017).

Although water level fluctuation is a component of the natural hydrology of the Great Lakes, low water levels are a special concern in coastal systems especially when it leads to reduced hydraulic connectivity between tributaries and the lakes. This has multiple impacts on ecosystem structure and function affecting, for example, fish migration, flow of organic matter and other materials, and dispersal of invasive species (Januchowski-Hartley et al., 2013). Connectivity losses due to low water levels are exacerbated by physical structures in the watershed, such as dams and culverts, which impede movement between critical habitats during migration periods and when conditions are less than optimal, i.e., during periods with elevated water temperatures, and low dissolved oxygen (Nagrodski et al., 2012; Januchowski-Hartley et al., 2013).

Ice cover has declined across the Great Lakes region, with declines of 5 days per decade reported over the period 1974-2004 (Jensen et al., 2007). In coastal areas, ice cover serves to reduce wave action in shallow areas, thereby stabilizing the spawning habitat for fall and winter spawning species (e.g., lake whitefish). Lack of ice cover is also associated with further warming during summer months (Austin and Colman, 2007; Gronewold et al., 2015). Exposed shorelines and reduced ice protection increase the vulnerability of beaches, shorelines and bluffs to erosion (Mackey et al., 2012). Further, because human activity is so heavily concentrated along coastal regions, these areas are increasingly exposed to hazards that pose a threat to both infrastructure and human well-being.

5.7 Coastal processes

Hard rock shorelines in the Great Lakes such as those along the Canadian Shield on Lake Superior and eastern Georgian Bay, and the limestone and dolomites of the Niagara Escarpment in northern Lakes Huron and Michigan will for the most part not be significantly affected by climate change over the next 100 years. However, there is the potential for significant impacts on two types of shoreline that are especially important in southern Lake Huron, and much of Lakes Michigan, Erie and Ontario. These shoreline types are: 1) soft rock shorelines – bluff coasts developed in lacustrine silts and clay, glacial till, outwash sediments, and relatively weak shale bedrock; and 2) sandy beach and dune coasts, especially those formed on spits and baymouth barriers with their associated wetland systems. On both shoreline types, changes to wave characteristics over time (i.e., the wave climate) in each of the lakes is likely to have the greatest impact, and changes in mean lake level could be significant depending on the magnitude of the change.

The average annual wave climate at any point on the lake reflects primarily: 1) the shape of the lake and the fetch length for all onshore directions; 2) the average annual frequency and magnitude of winds by direction; and 3) the presence of ice during the winter which may act to reduce the open water fetch and/or to protect the beach

and parts of the nearshore from wave action (Barnes et al., 1994; Forbes and Taylor, 1994). The first factor is considered fixed and, because wave generation during large storm events is usually fetch-limited on all of the lakes, it acts to limit the potential impact of modest changes to the wind climate. As a result, the most important potential impact of climate change on the wave climate is the reduction in the duration and extent of winter ice cover due to global warming, and in particular warmer winter temperatures. This manifests itself as the increasing occurrence of open water conditions into January or February and the disappearance of ice cover in April and as early as March. There will also be more frequent years in which there is virtually no ice cover. This means that the coast will be exposed to a greater number of storm events each year and the effect is heightened by the fact that this additional open water occurs during a period of the year when storm intensity is generally greatest.

As discussed in Section 3.2, there was a significant reduction in the mean winter ice cover on Lakes Superior, Huron, and Michigan for the period 1973-2010 and similar trends have been noted for maximum ice coverage (Wang et al., 2012). In terms of the effectiveness of wave action on beaches and nearshore, a better measure is one that is linked to the ability of waves to reach the toe on cohesive bluff shorelines or the base of the stoss slope of sand dunes on sandy coasts. Here, 10% ice cover is used as a measure of the transition from unrestricted wave action to restricted wave action and 20% ice cover as the transition to complete protection of the shoreline and nearshore from wave action and severe restrictions on wave generation within the lake. The number of days with ice cover on Lake Erie greater than 10% and 20% for the winter-seasons 1973-74 to 2017-18 have decreased by 23 and 24 days, respectively over the 44 year time period (based on data from NOAA/GLERL, https://www.glerl.noaa.gov/data/). Winter ice cover >10% now averages about two months a year, and since 1997 there have been 6 years with fewer than 30 days with ice cover exceeding 20%.

An increase in the average number of storms in the winter months will have a direct impact on erosion of cohesive bluff shorelines and lead to an increase in the rates of bluff recession on all of the lakes. Because lake levels are generally low in the winter months, there may be limited increases in short-term bluff toe erosion, but erosion of the nearshore profile will be enhanced. In turn this will lead to an increase in the long term recession rate (e.g., Davidson-Arnott and Askin, 1980; Davidson-Arnott and Ollerhead, 1995; Trenhaile, 2009; Geomorphic Solutions, 2010a, b; Sunamura, 2015). It is likely that the increase in long-term recession rates will be on the order of 20-30% by the middle of the century. This is similar to the impact of reduced ice cover documented for areas such as the Gulf of St. Lawrence (Manson et al., 2016a) and the Arctic (Overeem et al., 2011; Irrgang et al., 2018). The increased rate of downcutting also puts additional stress on shore protection structures along these shores, leading to a reduction in lifetime expectancy (Keillor, 2003; Coldwater Consultants, 2010). Indirectly, warmer temperatures also lead to a decrease in the extent and duration of frost and snow cover on the bluff face and an increase in precipitation in the form of rain at a time when vegetation cover is at its lowest. This will enhance erosion of the sub-aerial bluff face due to overland flow and rill and gulley development and may also enhance the rate of shallow slumping (Mickleson et al., 2004).

Reduced ice cover in early and late winter may have an impact on sandy beach systems as a result of increased frequency of intense storm events generating large waves and extreme storm surge. There is therefore a greater probability of major dune erosion on mainland beaches, particularly during periods of high lake level. There is also increased potential for overwash and breaching of barriers, particularly at vulnerable locations such as the proximal end of spits, e.g., Presque Isle and Long Point on Lake Erie (Davidson-Arnott and Fisher, 1992; Matheus, 2016) and along baymouth barriers, e.g., those enclosing Sodus Bay and Hamilton Harbour on Lake Ontario.

The effects of an increase in the number of winter storms generating waves can also change the magnitude and direction of littoral drift within littoral drift cells along the lakes. Locally this may lead to a change from accretion to erosion and vice versa at some locations along the shoreline. However, because of the restrictions imposed by the size, shape and alignment of lakes, the potential impacts on the littoral sediment budget are generally relatively small. Pinpointing these locations will require generating an ice-free wind climate and using this to model the wave climate and in turn to use this as input to sediment transport models (e.g., Manson et al., 2015, 2016b).

There is now a good understanding of the effects of seasonal and long-term lake level fluctuations on the dynamics of cohesive bluff shorelines (e.g., Quigley et al., 1977; Geomorphic Solutions, 2010b) and of sandy beach shorelines (Olsen, 1956; van Dyck). Based on this, a decrease in mean lake level will result in reduced bluff recession rates for a period of several decades and dune progradation of sandy shores. Conversely, an increase in the mean lake level will result in an increase in the rate of bluff recession for several decades and landward migration of the shoreline and foredune on sandy beaches. In addition, we can use shoreline response in areas of ongoing isostatic uplift or drowning in parts of the Great Lakes basin as a proxy for shoreline response to an increase or decrease in the mean lake level resulting from climate change. The issue here is that it will likely take several decades to separate a change in mean level from the long-term fluctuations.

WATER SUPPLY DISRUPTIONS (LAKE ERIE/TOLEDO)

Lake Erie is the source of drinking water for many communities in northern Ohio, including Cleveland and Toledo. In 2014, the drinking water in Cleveland and 28 other water systems in Northeast Ohio were found to contain chromium, a cancer-causing toxin, in very small quantities that still met federal standards. In 2015, almost all of the water systems in Ohio produced tap water with detectable levels of the same seven or eight contaminants, sufficient to exceed health guidelines, but within federals standards.

A much bigger problem occurred in Toledo and parts of southeast Michigan in 2014 as a result of a harmful algae bloom in the water supply itself (Jane Herbert, https://www.canr.msu.edu/news/the_toledo_water_supply_shut_down._why_boil_water_advisories_were_not_enoug). Warming water temperatures and nutrient loading in Lake Erie were responsible. And boiling the water would have been insufficient – it would kill the organism but not eliminate the toxin. As a result, Toledo and other communities had to scramble to find alternative water sources.

Public and economic impacts of changes to the Great Lakes

The Great Lakes have an enormous number of impacts—seen and unseen—on the well-being of the more than 34 million people who live within the basin. We drink, play in, and rely on the Lakes for commerce and industry. Investments in ensuring long-term resilience to climate change are investments in the future stability and productivity of the region. While it is tempting to limit ourselves to studying more easily measurable strictly natural phenomena, there is ultimately no way to fully remove human social activities from our understanding of how climate change is affecting and will affect the Lake system. This section considers a selection of important public and economic activities influenced by the impacts described above.

6.1 Shipping

If lake level changes result from climate change, it can affect the ability of ships to safely navigate shallow portions of the Great Lakes' channels and harbors. The most important research in this area is primarily concerned with the "salties" that traverse the oceans in addition to the Great Lakes. Because of the distance these ships travel, the light loading needed to travel through shallow spots in the Great Lakes system during times of low water becomes particularly expensive in terms of tons of cargo hauled relative to time and fuel required.

Because the water level of Lake Michigan-Huron is especially sensitive to changes in the water budget, it largely determines the need for light loading. Millerd (2011) found that as much as a 1 meter decrease in the levels of Lake Michigan-Huron results in 3.6% to 12.2% increases in shipping costs (1.9% to 7.4% increase for a 0.7 m drop). The ranges result from differences in the types of goods shipped, as well as whether the cargo was inbound or outbound to the United States or Canada. Based on Lofgren and Rouhana (2016), the drops in lake levels used by Millerd (2011) should be regarded as very high-end estimates of water level drops within the 21st century. Shlozberg et al. (2014) found that any significant decrease in lake levels, like those found in the earlier studies, would have significant economic impacts, not only on shipping, but also through effects on hydroelectric generation, water use, and waterfront property values.

6.2 Water supply

Consumptive use is the amount of water withdrawn from groundwater or surface water that is not returned to the environment. Consumptive use data are more readily available for states than drainage basins such as the Great Lakes basin. The U.S. Geological Survey (USGS 2008) aggregated the withdrawal and consumptive use data for the eight Great Lakes states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin by categories of use. The largest consumptive use is public supply — 1,200 million gallons per day (Mgal/day), or 4,540 million liters per day (Ml/d). This is out of a withdrawal of 10,200 Mgal/d (38,600 Ml/d), with the rest returned to the environment after treatment by a sewer system. This is the largest consumptive use category. It is followed by thermoelectric power at 1,100 Mgal/d (4,160 Ml/d), irrigation at 860 Mgal/d (3,260 Ml/d), industrial at 640 Mgal/d (2,420 Ml/d), livestock at 200 Mgal/d (757 Ml/d), self-supplied domestic at 130 Mgal/d (492 Ml/d), and mining at 94 Mgal/d (356 Ml/d). Compare this to a typical value of 16,000 Mgal/d (60,500 Ml/d) of outflow from Lake Ontario into the St. Lawrence River. The consumptive use seems to represent a highly significant fraction of the ultimate outflow from the Great Lakes.

Water consumption and climate change are related. The consumptive-use coefficient is the ratio of the amount of water consumed to the amount withdrawn, and its value by use category ranges from a median of 2% for thermoelectric use to a median of 90% for irrigation. The irrigation category is most likely to be strongly affected by climate change because of its high consumptive-use coefficient and increased evaporative demand in projected future climates. Fischer et al. (2007) examine evaporative demand from irrigated land on a global basis, and results differed considerably between the two global climate models that they used. In the UK Hadley center model, North America's irrigation needs were less than other parts of the world; while the Australia's CSIRO model show irrigation needs were comparable or larger. Fischer et al. (2007) also show that North America is generally more responsive to mitigation of human-generated greenhouse gas emissions and concentrations than most parts of the world. Globally, they estimate that US$10 billion in irrigation costs can be saved between 1990 and 2080 by shifting from a high emission scenario to a lower emission scenario.

The Great Lakes region and the eastern United States have particularly large percentage increases in irrigation water demand when comparing projections for the 2080s with a baseline in the 2000s (Wada et al., 2013). This is likely partially due to low irrigation water demand in the baseline period. With the amount depending on which scenario is followed, much of the Great lakes region has projected increases in irrigation –in the high scenario, nearly all of the eastern United States has increases greater than 25%.

Caution is warranted, however. Some of the offline hydrologic models used by Wada et al. formulate evapotranspiration very strongly based on temperature, rather than also including sunlight and other forms of radiation, and so overstate the influence of climate change on evapotranspiration (Milly and Dunne, 2016). In the Great Lakes Basin, these models overestimate the sensitivity of evapotranspiration to climate change at a much greater magnitude (Lofgren and Rouhana, 2016). Non-climatic drivers, such as development, changes in electrical power generation, and changes in agricultural and industrial practices, can also be expected to affect consumptive use in the future.

6.3 Infrastructure

Changing weather and climatic conditions in the Great Lakes put predictable stresses on existing physical infrastructure, such as roads and sewers. However, the fact that the condition and resilience of this infrastructure is heavily dependent on human investment and maintenance makes the long-term consequences of climate change on infrastructure less clear.

Climate change is very likely to have significant negative effects on source water quality that will put great stress on drinking water infrastructure. Nutrient runoff, primarily nitrogen and phosphorus washed off of farms and into surface waters, accumulates rapidly in a small number of intense rain events (Carpenter et al., 2018; Kleinman, 2006). These excess nutrients are directly hazardous for humans and feed massive algae blooms that dramatically raise the cost of water treatment (Michalak et al., 2013). The extra organic matter can react with water disinfectants, especially chlorine, to produce toxic disinfection byproducts (USEPA, 2015). Higher mean temperatures and more heavy precipitation events are favorable for this algal growth (Shigaki et al., 2007; Drake and Davenport, 2011).

Urban wastewater and stormwater systems also deliver significant nutrient loads to surface and groundwater (Preston, et al., 2011). Some of the largest cities in the Great Lakes region have combined sewer systems, which aggregate stormwater runoff and sewage. While this allows them to capture and treat this water collectively, it also creates a risk of combined sewer overflows (CSOs) when the sewer system is overwhelmed. This is most common during intense rain events in which large amounts of rain fall on areas with a high percentage of impervious surface. In these cases, the collected wastewater may be released untreated directly into surface water systems. The Great Lakes region has high numbers of federal action level exceedances for E. coli bacteria compared to other U.S. coastal regions (Hobbs and Mogerman, 2014; Patz, et al., 2008). This untreated effluent is a public health hazard and economically costly to mitigate.

Consider Chicago, the largest point source emitter of phosphorus in the Mississippi River Basin (Robertson et al., 2009). The city has made enormous investments in containment infrastructure designed to decouple intense rain events from CSOs (Hawthorne, 2018). However, the high percentage of impervious surface (59%) and increasing number of intense rain events associated with climate change make containing pollution difficult and expensive (Neuman et al., 2015). One can see that this is partially climate-driven by trends in river system "reversals" into

Lake Michigan (see Figure 10). The direction of the Chicago River was reversed in 1900 to shunt waste away from Lake Michigan. During periods of very heavy rain, water levels in the river system become high enough that they flow back into the lake. The volume of these reversals has continued over the last 25 years despite large gains in catchment capacity (USEPA, 2016; MWRD, 2017).

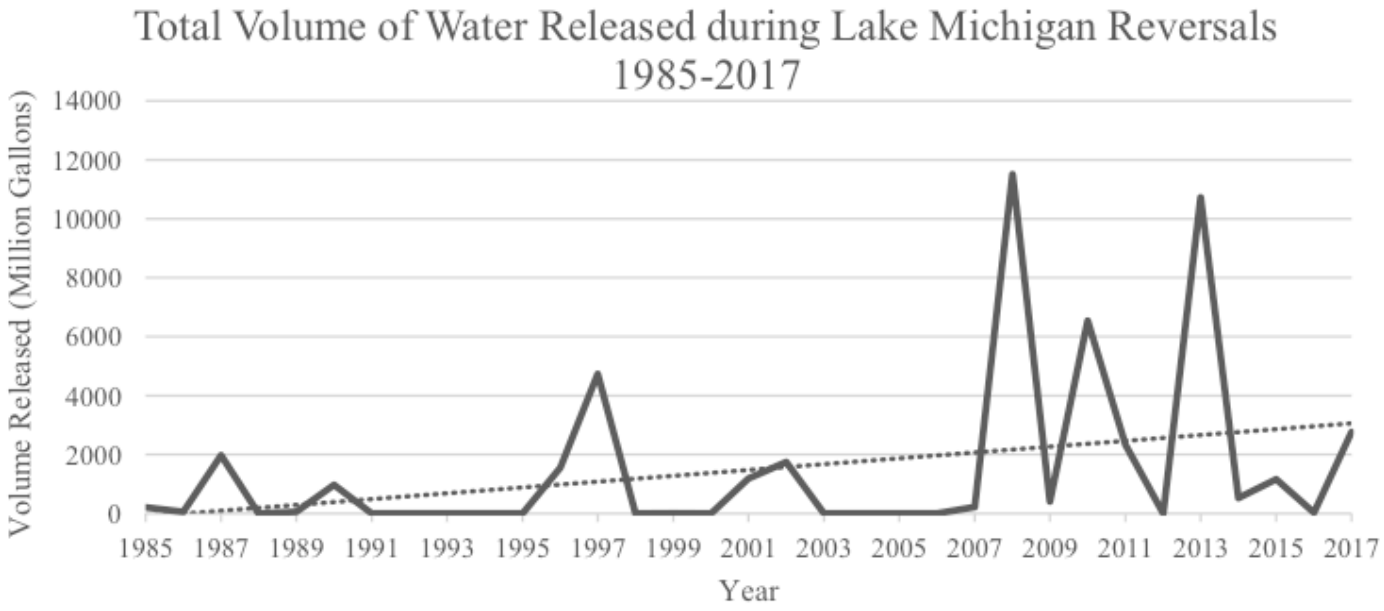


Figure 10. Combined volume of water released into Lake Michigan (Millions of Gallons) for the period 1985-2017 from O'Brien Lock, Chicago River Controlling Works (CRCW), and the Wilmette Gate. (Data source: Metropolitan Water Reclamation District)

Preparing water infrastructure for climate change in the Great Lakes region is expensive. Higher rates of HAB activity associated with climate change are likely to increase future treatment costs (Michalak et al., 2013). Investment for updating and maintaining water infrastructure has nevertheless decreased over the last few decades, at the same time as costs related to managing the effects of climate change are beginning to rise (Neumann, et al., 2015). Water treatment (both drinking water purification and waste treatment) accounts for 30%-40% of a municipality's energy costs (Copeland, 2014). Higher treatment demands resulting from climate-exacerbated runoff and sedimentation therefore translate rather directly into a higher carbon footprint (Cisneros, 2014). However, biological water treatment has been shown to be more efficient at higher water temperatures (Tchobanoglous, et al., 2003). Higher temperatures and longer dry periods also have the potential to reduce soil moisture to levels that can be harmful to buried pipe infrastructure through subsidence.

Other forms of infrastructure located on Great Lakes coastal areas are also affected by climate change. The Great Lakes coastlines include some of the densest road networks in the United States. Coastal roads are vulnerable to erosion from higher amounts of precipitation and wave heights, as well as damage from extreme heat (Swenson, et al., 2006). The high cost associated with updating these road systems for climate change result largely from the need to change the composition of asphalt binders in roads in order to handle higher temperatures and different freeze-thaw patterns (Chinowsky et al., 2013). Yet warmer winter temperatures and less ice on roadways

potentially have some positive effects including extending the life of road surfaces and reducing the need to use salt or ice-melting chemicals which wash into the water system.

Changes in precipitation and lake levels can have serious consequences for the health of fixed infrastructure. While projections of future lake levels are disputed, whether rise or fall, there are negative consequences for infrastructure (see Angel and Kunkel, 2010; cf. Lofgren and Rouhana, 2016). On a business-as-usual response to climate change and generally wetter future, 28.9% of road bridges within the U.S. Great Lakes Basin are vulnerable to damage from increased peak flows following rain events (Neumann et al., 2015). Not all of these bridges lie along coastal areas, but those face the additional threat of increased runoff and coastal erosion (Lofgren and Rouhana, 2016). Flood events make bridge scour—erosion around a bridge's supports caused by swiftly moving water—more likely. Scour is among the leading causes of bridge failure (Transportation Research Board, 2008).

Dropping lake levels and increasing temperatures pose a risk to electrical power production critical to the functioning of many other infrastructure systems, such as wastewater management. Most energy production in the Midwest U.S. is built along waterways, and the largest portion of water withdrawals from the Great Lakes (64.8%) is for once-through cooling for thermoelectric power plants (GLC, 2016). Lower lake levels and higher water temperatures both pose technical challenges for power generation. There is a concern about potential interruptions in thermoelectric power generation associated with decreased water levels, which may drop below water intake levels and increase energy required to pump water up to facilities. Increased temperatures reduce heat-transfer efficiency for cooling, which can limit power production to the level necessary to avoid overheating. Power plants along tributary waterways and the Great Lakes themselves are vulnerable to these effects. A critical issue is that energy infrastructure is built for long-term operation, and current energy infrastructure was built based on historical water levels and temperature regimes. Changes in climate that decrease water availability or effectiveness for cooling are therefore likely to decrease regional energy production.

6.4 Recreation

The outdoor recreational sector has grown to over 2% of value-added activity in the United States, and since 2014, growth in the outdoor recreational sector has outpaced growth in the economy as a whole (U.S. Bureau of Economic Analysis, 2018). The largest single activity is boating and fishing, accounting for around $38 billion in economic activity nationwide. Estimates have not been down-scaled to the Great Lakes, although some estimates of the economic contribution of various sectors have been made in the past. The Great Lakes Commission (2007) estimated that the economic contribution of boating in the Great Lakes was around $9 billion in 2003. A similar number of boats are registered in the region now, over 4 million according to the U.S. Coast Guard (2017), so the level of economic activity in boating is likely of similar scale (adjusted for inflation) at present. The effect of climate change on boating activities such as skiing or recreational boat driving will be driven by temperature changes, shifts in the length of seasons, and lake levels. The effects of these various changes could drive aggregate impacts upward or downward, however, no studies to our knowledge have attempted to assess the range of effects of climate change on recreational boating alone.

In contrast, there is significantly more information available on sports angling. The U.S. Fish and Wildlife Service (2017) estimates that 1.8 million anglers fish in the Great Lakes and its tributaries each year and they take 7.4 trips per year on average in the region for a total of 13 million trips. Nationally, anglers spend $10 per day on fishing related items, suggesting annual expenditures of about $133 million per year. The largest share of Great

Lake trips occurs in Lake Michigan, followed by Lake Erie. According to data collected by the U.S. Fish and Wildlife Service (2017), the number of anglers has increased over the last decade in the Great Lakes, but overall fishing days have declined. It is not clear what has caused these trends to emerge. Burkett and Winkler (2018) show a declining trend in license sales due to demographic shifts (e.g., aging cohort of male anglers). However, environmental factors cannot be ruled out as a causal factor related to declining participation. For instance, Wolf et al. (2017) have recently shown how HAB activity in Lake Erie reduces license sales.

While climate change could affect participation and expenditures in fishing, it may have more important effects on the value of ecosystem services related to recreational fishing in the Great Lakes. There is a large and robust literature valuing Great Lakes recreational activities, ranging from boating and fishing to beach recreation, as well as estimating how environmental changes affect recreational value (e.g., Provencher and Bishop, 1997; Murray et al., 2001; Provencher and Bishop, 2004; Yeh et al., 2006; Lupi et al., 2003; Melstrom and Lupi, 2013; Wolf et al., 2017; Zhang and Sohngen, 2017; Ready et al., 2018). Recent estimates of recreational fishing values in the Great Lakes region range from $20 per day to over $75 per day (Loomis and Richardson, 2008; Melstrom and Lupi, 2013; Ready et al., 2012). These estimates suggest that, at present, recreational fishing in the region provides ecosystem services values ranging from $0.3 to over $1.0 billion per year. These ecosystem service values exceed the effects of fishing on local economies, and imply that if climate change reduces the quality of ecosystem services, value could be lost even if the number of trips does not.

In preparing this review, no studies were found that directly addressed the role of climate change on fishing. Nonetheless, many of the stressors existing studies have addressed – invasive species, harmful algal blooms, e. coli contamination – are also likely strengthened by climate change. Ready et al. (2018), for instance, find that establishment of Asian carp in the Great Lakes could reduce anadromous fish populations in some of the most valuable parts of the fishery, namely Lake Michigan, reducing economic value by $139 million per year. The ranges of many fish species likely will change due to climate change (see section 5.4), shifting both trip intensity and economic value. For instance, coldwater fishing is more valuable than warmwater fishing, and anadromous fishing is the most valuable form of fishing the Great Lakes (Melstrom and Lupi, 2013; Ready et al., 2018). If climate change shifts the relative abundance of species composition towards warm-water types and away from cold-water types, then the overall value of fishing may decline over time. For instance, according to Melstrom and Lupi (2013), increasing the catch rate of coldwater species by 1 fish per trip enhances day trips by $40-$80 per trip, while increasing the catch rate of warm water species by one fish per trip enhances day trips by $1-$24 per trip.

Climate change could also have effects on recreation by altering aesthetic components unrelated to catch rates. Zhang and Sohngen (2017), for instance, show that fishing trip value in Lake Erie could be reduced by $40 per trip due to the presence of HABs. These reductions in value are driven by the lost amenity value associated with recreating in waters with diminished environmental quality rather than the effect of lost catch. Climate change is expected to exacerbate HAB activity in many parts of the Great Lakes (Section 5.3), potentially reducing the value of recreational activity.

Climate change could also influence beach recreation, either directly through temperature or indirectly through the effects on HABs and other pathogens that influence recreational activity. Murray et al. (2001) estimates that Lake Erie beach trips were worth $15-$25 per trip. Chen (2013) estimates that beach recreation in the lower peninsula of Michigan was worth $32-$39 per trip for day trips, and around $50 per day for multiple day trips,

for a total value of $400 million per year in recreational use value. It is not clear how climate change would affect beach recreation, given that warmer temperatures and longer seasons could spur increased visitation. However, if climate change reduces water quality and makes beach closures more likely, damages could grow. Murray et al. (2001) found that a single beach closure due to a pathogen like E. coli reduces recreational value by around $2 per trip, or around 10%. Palm-Forster et al. (2015) estimated the impact of HABs on beach recreation in Lake Erie, finding impacts of up to $2 million per year in lost recreational value if all beaches are affected.

Other recreational opportunities in the Great Lakes region, such as birding, are likely to be affected by climate change, although the effects are not known. What is known is that a large share of the population engages in bird and wildlife viewing, with 30-35% of the population engaged in this activity within a mile of their home in the Great Lakes States, and 8-12% engaged in this activity further than a mile from their home in the Great Lakes States (U.S. Fish and Wildlife Service, 2017). Loomis and Richardson (2008) suggest an average per day value of $25. Based on these two studies, there are around 139 million wildlife viewing trips away from home in the Great Lakes States each year, with an annual value of over $3 billion per year. The large majority of these trips involve birding, although it is difficult to know how many of these trips occur explicitly along the shores of the Great Lakes or within them. Climate change could affect the local habitat or the migratory patterns of many bird species frequenting the region, but integrated assessments need to be undertaken to determine how these would affect the avid population of people who engage in birding or other wildlife viewing activities.

Winter activities could experience the largest impacts of climate change. For instance decreases in the depth and duration of winter snow cover will result in fewer opportunities for winter recreation, including skiing, snowmobiling, and snowshoeing. Of the 122 resort-style businesses in the Great Lakes states currently identified as supporting winter recreation, only 80 are currently in areas that receive enough snow now to regularly support such activities (Chin et al., 2018). By the end of the century, under the highest emission scenario, all existing ski resorts in the region will become non-viable due to lack of snow and the conditions required to make snow. Duration and thickness of ice on small lakes is also decreasing (Mishra et al., 2011), potentially limiting the availability of sites suitable for ice fishing within the Great Lakes watershed.

6.5 Public health

As mentioned in section 4 and amplified upon in this section, the key vulnerabilities to public health as a result of climate change in the Great Lakes Region include those associated with rising temperatures and hydrologic extremes (Pryor et al., 2014; Patz et al., 2005). For those living across the Great Lakes Basin, heat waves and summertime air pollution events will increase the risk for heat-related illness and death, as well as respiratory diseases that often threaten the most vulnerable (elderly, those with existing conditions, children with asthma, etc.) (Luber and McGeehin, 2008; Kovats and Hajat, 2008; Bell et al., 2007; Mickley et al., 2004). Vector-borne disease is also expected to increase as conditions become more favorable for insects that carry disease (i.e., shifts in the range of mosquitos, ticks, etc.) (Gubler et al., 2001). Increasing variability in rain events will lead to seasonal flooding and drought events, creating issues with the availability of high quality water for drinking and other human uses (see Section 6.3 and 6.6). Issues with flooding and standing water can also increase the incidence of water-borne disease (Patz et al., 2008; Curriero and Patz, et al., 2001). Finally, the indirect effect of climate change on the Great Lakes region may be through the psychological or mental health impacts of social, demographic and economic disruption (Clayton et al., 2017; McMichael et al. 2006).

Of particular concern within the Great Lakes themselves are the microcystin, pathogens, and bacteria that increase in downstream water bodies during intense rain events. Extensive harmful algal blooms are expected to increase in frequency and severity under climate change, and they present multiple threats to public health. Cyanobacteria-dominated HABs can produce several toxins, such as anatoxins, saxitoxins, cylindrospermopsin, nodularins, and microcystins (Cheung et al., 2015). Exposure to cyanotoxins can occur through ingestion, inhalation, and dermal contact pathways. Ingestion during recreation and consumption of contaminated drinking water are the most common exposure cases (USEPA, 2017). However, increased concern has been raised over the ingestion of contaminated seafood and vegetables, which can accumulate cyanotoxins (Lee et al., 2017; Wituszynski et al., 2017). Furthermore, interaction with soils irrigated with HAB contaminated waters, can lead to dermal exposure and possibly irritation and rash development. Finally, cyanotoxins can accumulate in fish tissue, therefore consumption of fish from frequently blooming waters may lead to additional cyanotoxin exposures (Wituszynski et al., 2017). Inhalation is another route of exposure to cyanotoxins. It happens by breathing in bioaerosol and mist from a HAB-affected water body. Those who regularly work on or near water get exposed via inhalation (boaters, anglers and lifeguards, for example). Further research is recommended to better understand the chronic effect of toxin inhalation (Backer et al., 2010).

6.6 Impacts on Indigenous people in the Great Lakes Basin

There are many communities of Indigenous people and tribes within the Great Lakes region, especially within the Great Lakes Basin. Though they may also be affected by climate change in ways that are similar to others in the United States, Indigenous peoples can also be affected uniquely and disproportionately (USGCRP, 2018). Climate impacts to lands, waters, foods, and other plant and animal species threaten cultural heritage sites and practices that sustain intra- and intergenerational relationships built on sharing traditional knowledges, food, and ceremonial or cultural objects. The 4th National Climate Assessment (USGCRP 2018, and references therein) found that "Climate change threatens Indigenous peoples' livelihoods and economies, including agriculture, hunting and gathering, fishing, forestry, energy, recreation, and tourism enterprises. Indigenous peoples' economies rely on, but face institutional barriers to, their self-determined management of water, land, other natural resources, and infrastructure that will be impacted increasingly by changes in climate." They also found that Indigenous health is based on interconnected social and ecological systems that are being disrupted by a changing climate.

6.7 Industrial needs for water

The freshwater resources of the Great Lakes underwrite a significant portion of the region's economic productivity (Campbell et al., 2015). Considering both the United States and Canada, consumptive industrial uses represent 4,465 million gallons per day (mgd) or 10.8% of total withdrawals for consumptive use, outpaced only slightly by public drinking water consumption at 5,537 mgd or 13.1% (GLC, 2016). The amount of water consumed by industry over the last thirty years, however, has remained relatively stable (see Figure 11). Given that water resources have become progressively more regulated and competitive over time, there is little indication that water will, in general, become cheaper for industry. Some have speculated that businesses currently located in less water-secure places will begin to migrate toward the region (e.g., Austin and Steinman, 2015). But because the price of water is heavily mediated by policy and regional economics, local scarcity or abundance does not tell us much about the attractiveness of water development all by themselves (Shaw, 2007). Midwestern Great Lakes states, because of their historical contributions to transportation equipment, heavy manufacturing, energy production, and agriculture produce more than a quarter of national greenhouse gas emissions (Livingston et al., 2009).

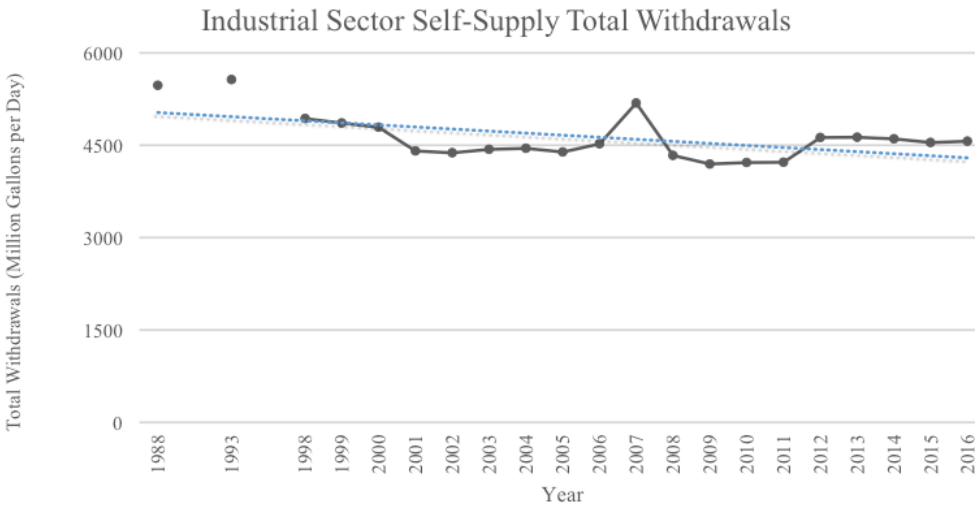


Figure 11. Total volume of water withdrawn from the Great Lakes for the period of 1988-2016 by the industrial sector. Data source: Great Lakes Regional Water Use Database

There has long been speculation that the water itself would become a major commodity—bottled and shipped as bulk water or pumped out of the region via inter-basin transfers. This is unlikely as large interbasin transfer schemes to move water long distances from the lakes are economically impractical (Annin, 2018). Bottled water has not represented a significant stress compared to other regional consumptive uses, especially given the amount of water diverted into the lake system (IJC and CMI, 2000). A large portion of bottled water is packaged tap water, however, and is thus folded into public drinking water consumption (Hu et al., 2011).

Existing industrial demands in a variety of sectors are very sensitive to changes in water availability and quality related to climate change. Agriculture, refineries, and commercial fishing offer examples of impact. Agricultural consumption generally increases with higher temperatures and longer dry periods (Schoengold and Zilberman, 2007). If regulatory action is taken to control nutrient pollution flows from farm and livestock operations created by more intense rainfall, it will increase the cost of farm operations (Rathinasamy et al., 2015). Fuel refineries along Great Lakes coastlines continue to represent a large portion of industrial withdrawals (USGS, 2008; Wu et al., 2009). While the number of refineries operating in the region has declined over the last 30 years, as these refineries increase in size, water consumption will increase in proportion to their overall crude processing capacity (US EIA, 2018; Wu, et al., 2009). The commercial fishing industry is directly impacted by climate related changes in water quality in particular. Invasive species and oxygen level changes have produced an average of 3.5% decline in yield per year across all the Great Lakes (Brenden et al., 2012; see 6.4 above).

It is unclear whether regional diversion regulations will constrain future industrial uses. The 2008 Great Lakes—St. Lawrence River Basin Water Resources Compact ("Great Lakes Compact"), severely restricts the amount of water that can be diverted out of the Great Lakes Basin and puts environmental review conditions on large new consumptive uses within the basin. However, it was designed mainly to control the expansion of municipal uses beyond the basin line by regulating new consumption by utilities, rather than new large industrial uses.

The most recent high-profile test of this by water intensive industry relocating to the Great Lakes Basin is the planned development of a Foxconn liquid crystal display factory in the Village of Mount Pleasant, Wisconsin. The Wisconsin Department of Natural Resources has granted the southwest portion of the City of Racine a diversion allowance of up to 7 mgd, much of which is expected to go to the Foxconn plant (Thomas, 2018). The State of

Wisconsin, in order to encourage the construction of the plant, waived or weakened diversion restrictions, air pollution control permits, stormwater permits, and pretreatment requirements (MEA, 2018). Foxconn ultimately pulled out of the deal. So far, this is an isolated case, but if it were to become a general trend in the region, it would create intense new demands on water resources given that individual factories can consume about the same amount of water every day as a small city.

BEACH CLOSURES AND RISKS OF GETTING SICK DURING RECREATION.

Fifteen Michigan beaches were either closed or are under advisories because of bacterial contamination during the 2018 Labor Day weekend. In June 2018, 24 Michigan beaches were closed because of elevated bacteria levels, just when a heat wave made it especially desirable for people to head to the beach. This is not an uncommon occurrence, especially during the summer months, on the coastlines of the Great Lakes.

Summer is also the time of algal blooms and E.coli alerts -- and that can put a damper on plans to cool off. While various studies (e.g., Never et al., 2018) have shown that fecal matter from gulls and pets are a major contributor, climate change is also a factor. The increase in the frequency and intensity of extreme precipitation events are likely to exacerbate the issues associated with runoff and the associated effects on bacterial counts.

Conclusions

Allowing the vast, natural resource of the Great Lakes to be taken for granted and degraded through human activities, including the effects of climate change, is not an option. For economic, aesthetic, and ecological reasons, we need the Great Lakes to remain healthy, unpolluted, and productive. Climate change is already having an impact on the region, and there is evidence that such impacts may increase under expected future climate change. Responding to these stressors requires both adaptations to the impacts that cannot be avoided (e.g., improving agricultural land management to decrease nutrient loading), as well as mitigation to reduce the possibility of experiencing the most extreme impacts (e.g., decreasing carbon emissions from the household to the industrial sector). Public support for protecting the Great Lakes is strong across the region, and despite differing concern about climate change as a threat, overall public support for action to address climate change is high. It is critical that we recognize the importance of this freshwater resource and ensure its protection for generations to come.

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Supplementary Material
An Assessment of the Impacts of Climate Change on the Great Lakes

Development of the Graphics

While some of the graphics in the Assessment are based on existing peer-reviewed publications or on websites associated with observational datasets, some of the graphics is produced for this assessment based on other datasets. The analyses of the past and projected climate changes are derived based on the analyses of observational datasets for past changes and from modeling and downscaled datasets for projections produced for NCA4 (USGCRP, 2017, 2018). The reference periods used in these analyses are the same as those used in NCA4. Projections use a weighting system for global climate models, that are then statistically downscaled for temperature and precipitation at about 6 km resolution across the continental United States based on the LOcalized Constructed Analogs approach (LOCA; Pierce et al. 2014) that spatially matches model-simulated days, past and future, to analogs from observations.

Until NCA4, assessments used a simple averaging of the multimodel ensemble. NCA4 uses model weighting to refine future climate change projections. In NCA4, model independence and selected global and North American model quality metrics are considered in order to determine the weighting parameters (Sanderson et al., 2017, building upon the earlier study by Knutti et al., 2017). The weighting approach takes into account the interdependence of individual climate models as well as their relative abilities in simulating North American climate. Understanding of the calculated time history, together with the fingerprints of particular model biases, has been used to identify model pairs that are not independent. Thus, this approach considers the skill in the climatological performance of the models for the area over North America as well as the inter-dependency of models.

Projections are based on global models and downscaled products from CMIP5 (Coupled Model Intercomparison Project Phase 5) using a suite of Representative Concentration Pathways (RCPs). Figure 1 shows the projected changes in globally averaged temperature for a range of future pathways that vary from assuming strong continued dependence on fossil fuels in energy and transportation systems over the 21st century (the high scenario is Representative Concentration Pathway 8.5, or RCP8.5) to assuming major emissions-reduction actions (the very low scenario, RCP2.6).

Most of the graphics in this report will use either the high RCP8.5 scenario or the low RCP4.5 scenario. At the higher end of the range, the RCP8.5 scenario corresponds to a future where carbon and methane emissions continue to rise as a result of fossil fuel use, albeit with significant declines in emission growth rates over the second half of the century, significant reduction in aerosols, and modest improvements in energy intensity and technology (Riahi et al., 2011, USGCRP, 2017). RCP8.5 reflects the upper range of the open literature on emissions, but is not intended to serve as an upper limit on possible emissions. RCP4.5 assumes a rapid movement away from the fossil fuels over the coming decades. Under the RCP8.5 scenario, CO¬2 concentrations are projected to reach 936 ppm by 2100. Under the lower RCP4.5 and RCP2.6 scenarios (van Vuuren et al., 2011; Thomson et al., 2011), atmospheric CO2 levels remain below 550 and 450 ppm by 2100, respectively.

For future projections, 30-year periods are used. Projections are centered around 2030, 2050, and 2085 with an interval of plus and minus 15 years (for example, results for 2030 cover the period 2015–2045). The reference period for these projections is the recent past, from 1976–2005. The choice of a 30-year period is chosen to account for natural variations and to have a reasonable sampling in order to estimate likelihoods of trends in extremes; this period is consistent with the World Meteorological Organi¬zation's recommendation for climate statistics.

Additional figures on Climate Changes in the Great Lakes region

Figure A1 shows observed percentage changes in precipitation for the U.S. states bordering the Great Lakes for present day (1986-2016) relative to 1901-1960. All of these states show an increasing trend except for a few isolated locations in Michigan (especially the Upper Peninsula), Ohio, and Pennsylvania that show a minor decrease in precipitation. However, future precipitation for 2085 period (2070-2099) relative to 1976-2005 for both RCP 8.5 and 4.5 show increases in precipitation all across the Great Lakes states (Figure A2). With the high emission scenario (RCP8.5), the precipitation is projected to generally increase 8-10% evenly across all of the Great Lakes states, but with a strong seasonal dependence (especially more in winter and spring, less in summer). The RCP4.5 scenario projects an overall increase of 6-10% for the Great Lakes basin and the eastern Great Lakes states by the end of the century. The rest of the region shows a more moderate 2-4% increase in annual precipitation.

For extreme events related to temperature, the projections show high variability across the Great Lakes states. For example, an increasing trend for future extreme warm days with temperature greater than 90°F is projected for both RCP 8.5 and RCP4.5 (Figure A3). However, due to the presence of the Great Lakes, the basin region shows relatively less number of extreme warm days in comparison to the rest of the region. In general, it is projected that the southern Great Lakes region will have more than 100 days with a temperature greater than 90°F for RCP8.5. For the lesser emissions of the RCP4.5 scenario, parts of southern Illinois and Indiana project 60-70 extreme warm days and the rest of region projects a smaller increase in extreme warm days. In general as rule of

thumb, the upper limit in the uncertainty range for RCP4.5 wprojects to be about the same as the lower limit for the higher emissions RCP8.5 scenario for future extreme warm days in the Great Lakes states.

Likewise, future climate warming will reduce the extreme cold days with temperature less than 32°F (Figure A4). The decrease in extreme cold days is projected to be much larger for RCP8.5 in comparison to RCP4.5 – the Great Lakes basin is greatly affected for both future scenarios. Similarly, the future extreme events with a 5-year return period show an increase (Figure A5). This increase is as high as 25% in many parts of the Great Lakes region for RCP8.5. For the lower RCP4.5 scenario, most of region projects about a 10% increase by the end of the century, with about a 15% increase in eastern Pennsylvania and New York.

For snow analysis, snowfall was determined using a criterion of daily mean temperature below −0.5°C for any precipitation days for both the observed and the statistically-downscaled climate model-based data (Byun and Hamlet, 2018). A decrease in annual snowfall in the Great Lakes states for the period from 1984 to 2013 has been observed (Figure A6). Future snow projections are calculated based on the ensemble mean of statistically-downscaled analyses of ten global climate models for the RCP8.5 and for RCP4.5 scenarios. With a significant warming in future during the winter months, both the RCP 8.5 and 4.5 scenarios project a substantial decrease in snowfall over the ground by the end of the century (Figure A7). Minnesota is likely to get less reduction in snow in comparison to all other Great Lakes states.

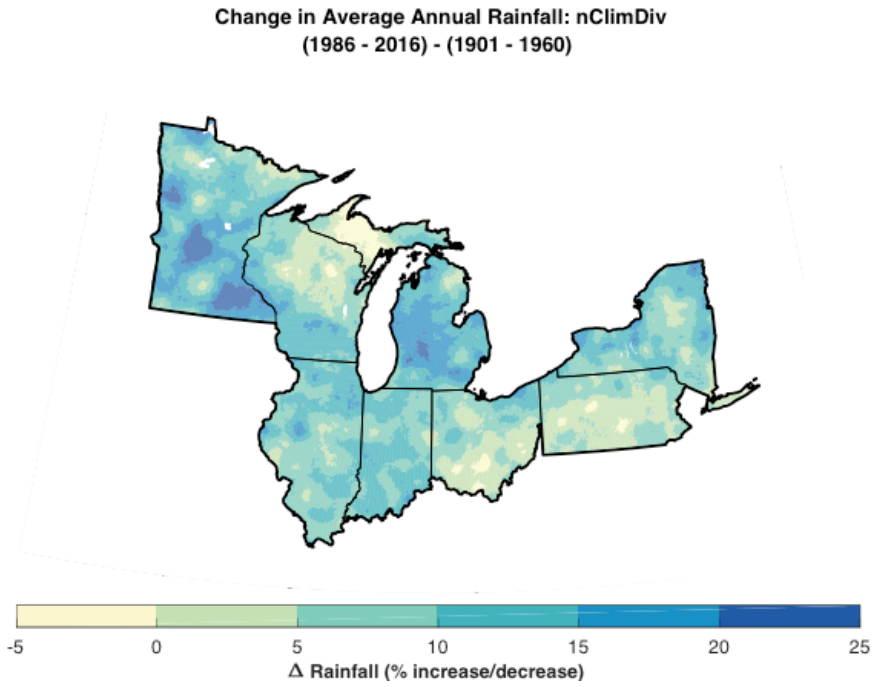


Figure A1. Observed changes in annual precipitation (as equivalent rainfall) (%) for the U.S. states bordering the Great Lakes for present-day (1986–2016) relative to 1901–1960. Derived from the NOAA nClimDiv dataset (Vose et al., 2014). (Figure source: NOAA/NCEI)

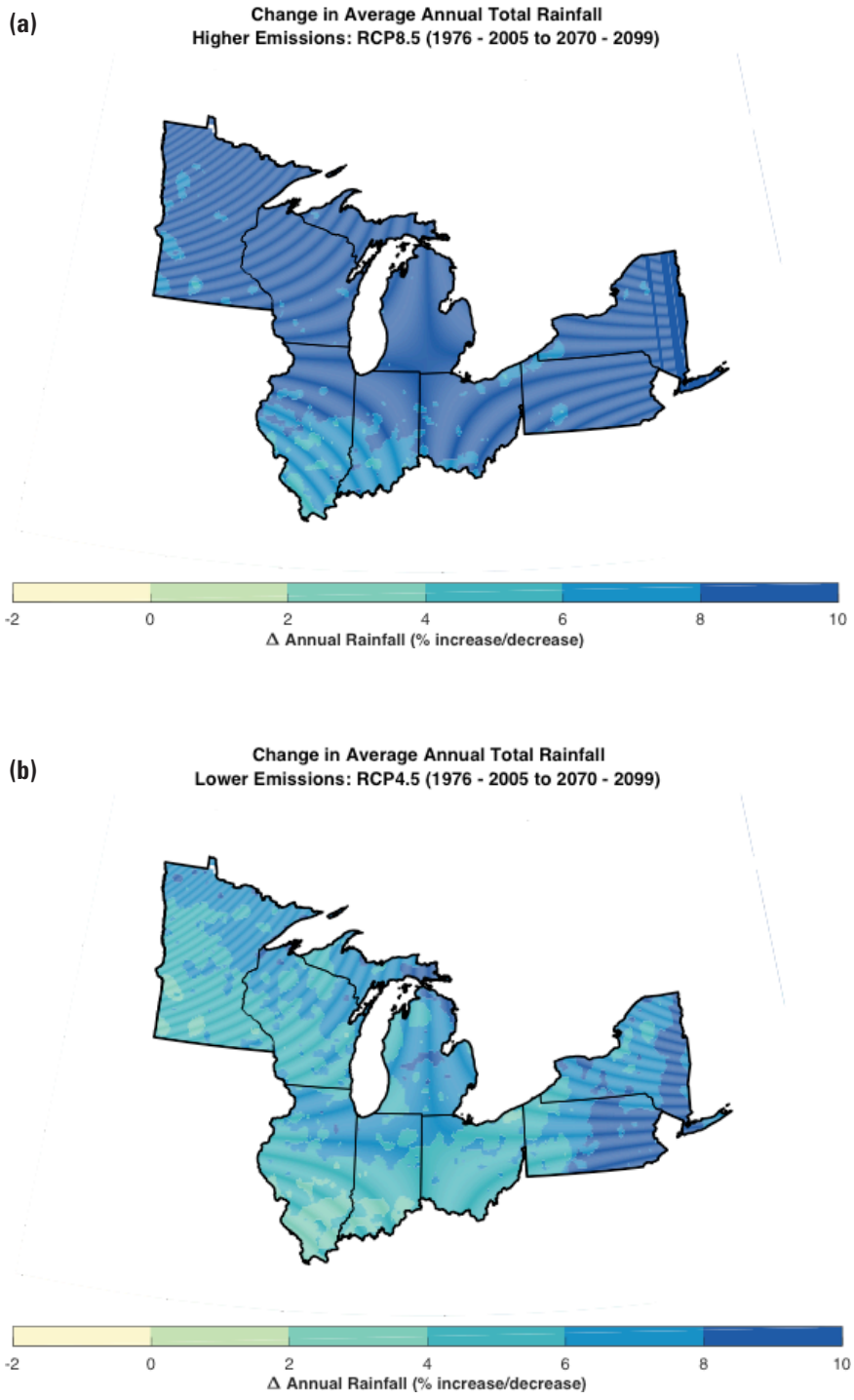


Figure A2. Change in annual precipitation (as equivalent rainfall) (%) for U.S. states bordering the Great Lakes from the (a) higher (RCP8.5) and (b) lower (RCP4.5) scenarios for the 2085 (2070-2099) time period relative to 1976-2005. (Figure source: NOAA/NCEI)

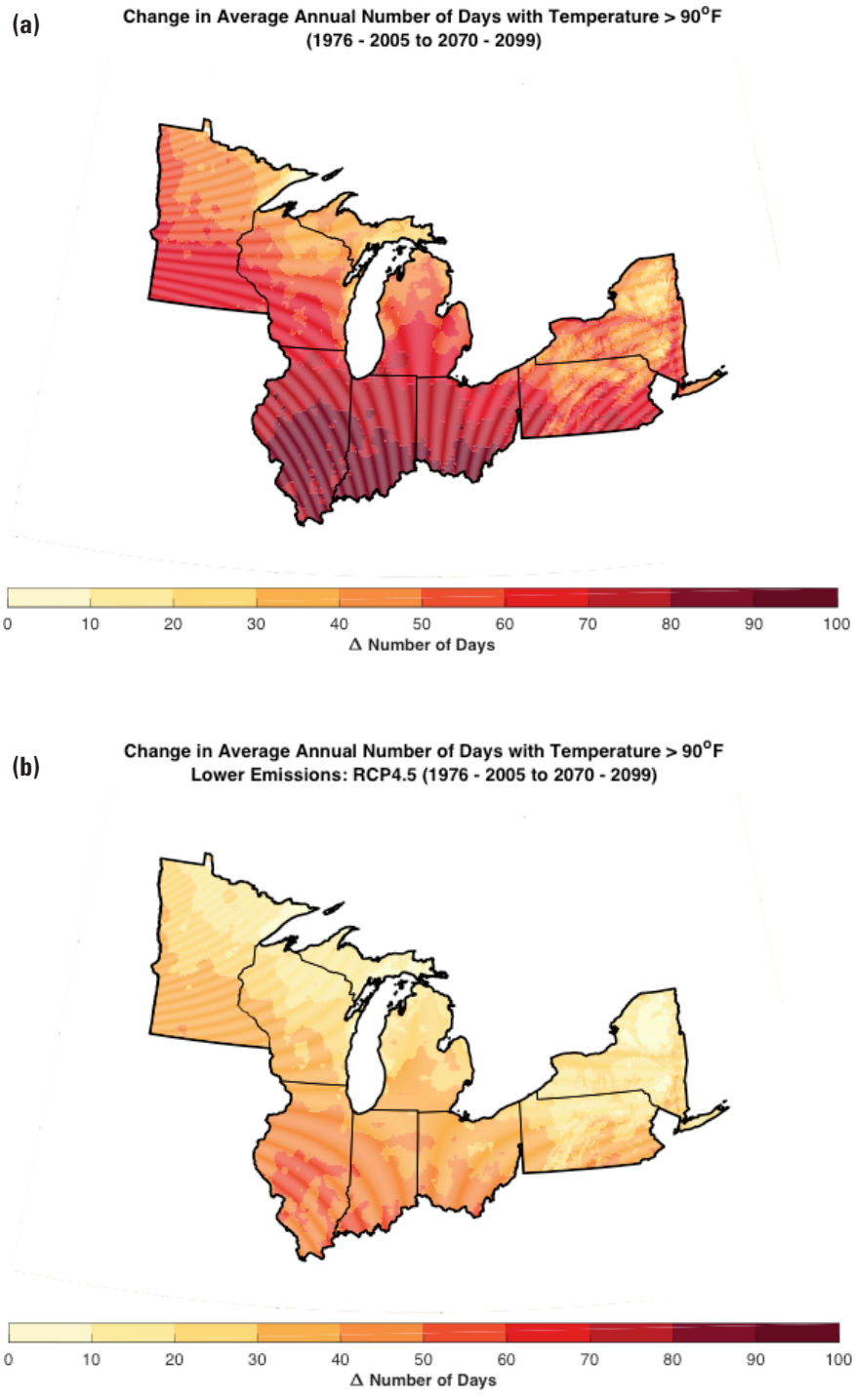


Figure A3. Change in the number of days with temperature greater than 90°F for U.S. states bordering the Great Lakes from the (a) higher (RCP8.5) and (b) lower (RCP4.5) scenarios for the 2085 (2070-2099) time period relative to 1976-2005. (Figure source: NOAA/NCEI)

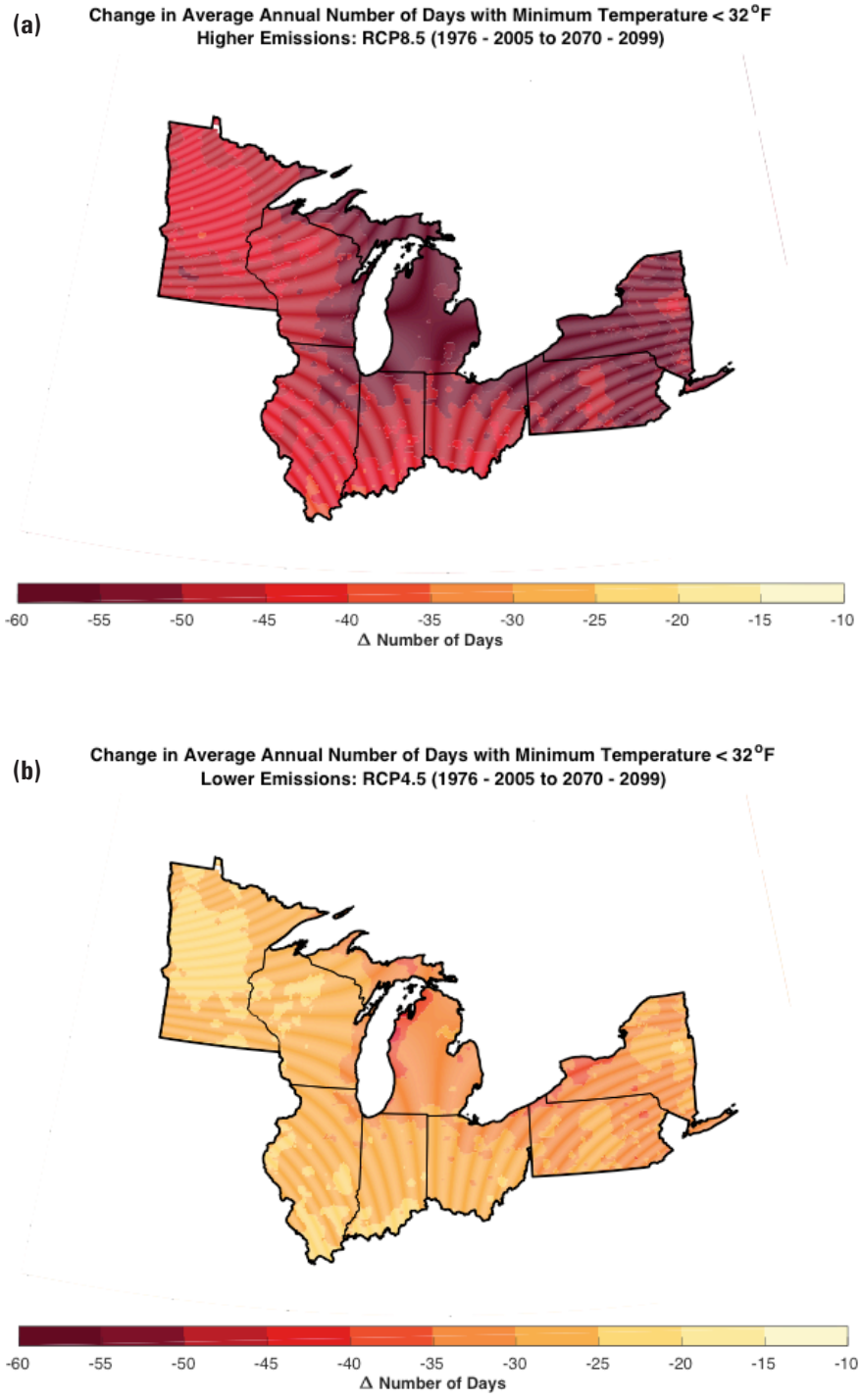


Figure A4. Change in the number of days with temperature less than 32°F for U.S. states bordering the Great Lakes from the (a) higher (RCP8.5) and (b) lower (RCP4.5) scenarios for the 2085 (2070-2099) time period relative to 1976-2005. (Figure source: NOAA/NCEI)

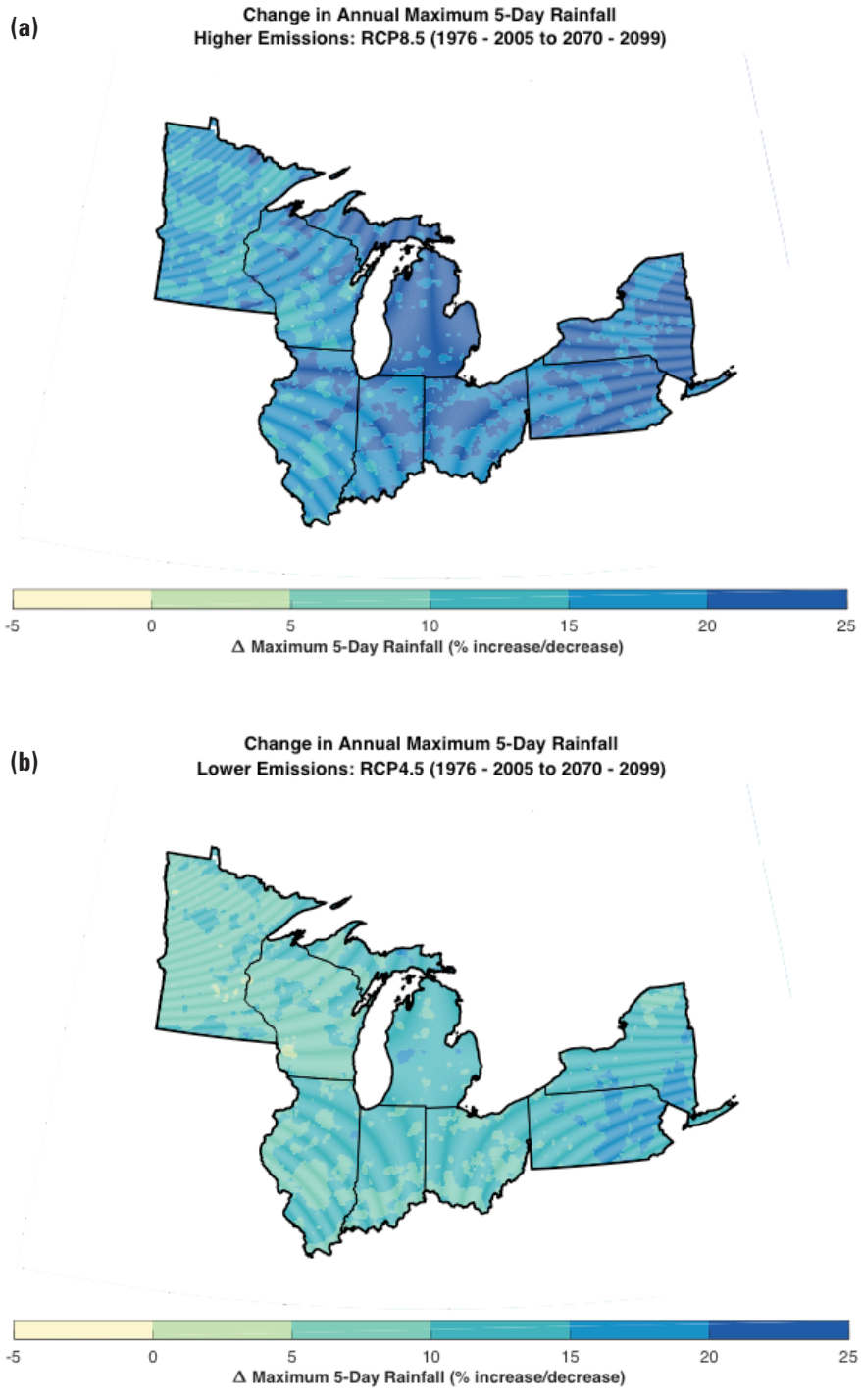


Figure A5. Percentage change in annual maximum five-day rainfall amounts for U.S. states bordering the Great Lakes from the (a) higher (RCP8.5) and (b) lower (RCP4.5) scenarios for the 2085 (2070-2099) time period relative to 1976-2005. (Figure source: NOAA/NCEI)

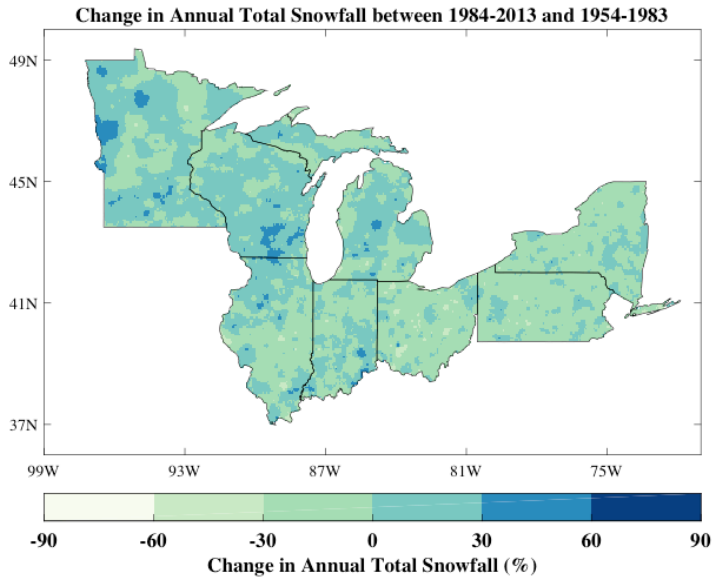


Figure A6. Observed changes in annual snowfall (%) for the U.S. states bordering the Great Lakes for present-day (1984-2013) relative to 1954-1983. Derived from bias corrected and gridded observational station dataset (Byun and Hamlet, 2018).

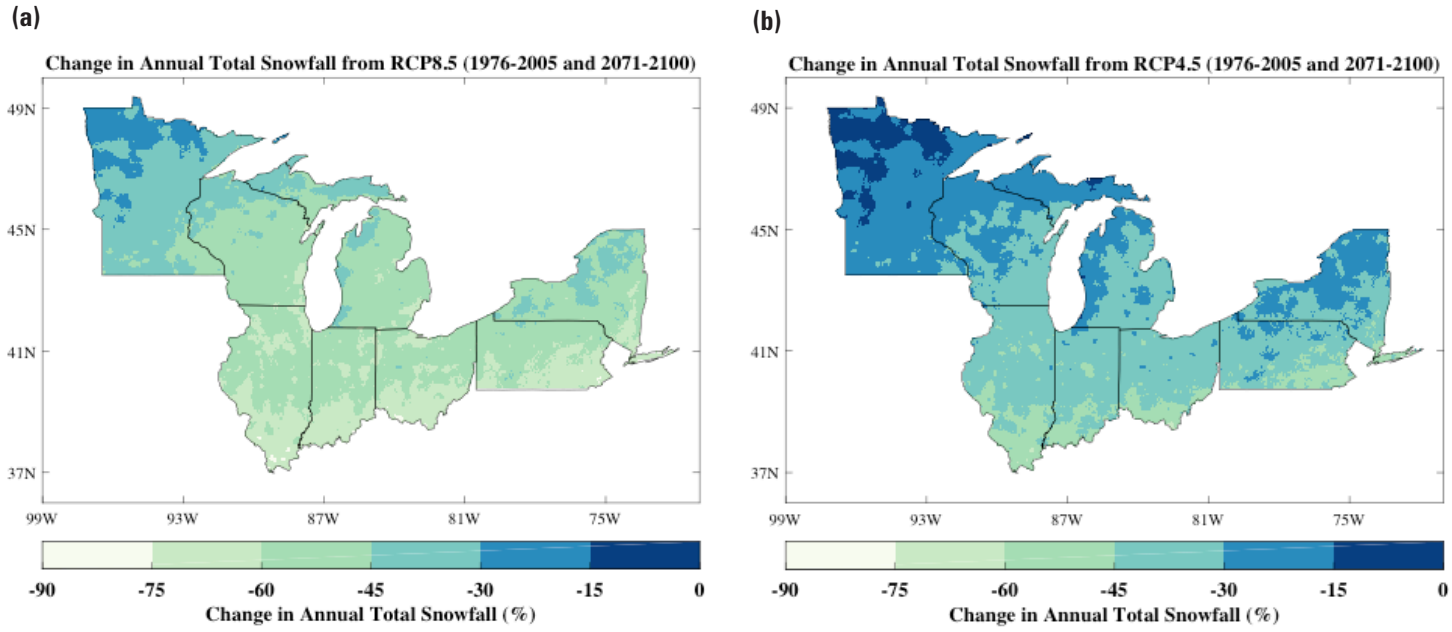


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Michigan Climate and Health Profile Report

2015

Building Resilience Against Climate Effects on Michigan's Health



Michigan Department of Health and Human Services
Division of Environmental Health
Climate and Health Adaptation Program (MICHAP)

&

Great Lakes Integrated Sciences Assessments Program (GLISA)

MDHHS
Michigan Department of Health & Human Services
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None

List of Acronyms

AMU	Air Monitoring Unit
AQD	Air Quality Division
AQI	Air Quality Index
ASTHO	Association of State and Territorial Health Officials
BRACE	Building Resilience Against Climate Effects
BRFSS	Behavioral Risk Factor Surveillance System
CAA	Clean Air Act
CAP	Climate Action Plan
CDC	Centers for Disease Control & Prevention
CHPR	Climate and Health Profile Report
CMAQ	Community Multi-scale Air Quality
CMIP3	Climate Model Inter-comparison Project phase 3
CO	Carbon Monoxide
CRSCI	Climate Ready States & Cities Initiative
CSO	Combined Sewer Overflow
CSTE	Council of State and Territorial Epidemiologists
CWS	Community Water System
DCAC	Detroit Climate Action Collaborative
DEJ	Detroiters for Environmental Justice
DEQ	Michigan Department of Environmental Quality
DS	Downscaler
DVRHS	Division for Vital Records and Health Statistics
ED	Emergency Department
ENSO	El Niño-Southern Oscillation
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GCM	Global Climate Models
GHG	Greenhouse Gas Emissions
GLISA	Great Lakes Integrated Sciences + Assessments Program
HAAS	Haloacetic Acids
IPPC	The United Nations Intergovernmental Panel on Climate Change
LHD	Local Health Department
LIAA	Land Information Access Association
MALEHA	Michigan Association of Local Environmental Health Administrators
MAP	Michigan Association of Planners
MCC	Michigan Climate Coalition
MDHHS	Michigan Department of Health and Human Services
MDHHS-DEH	Michigan Department of Health and Human Services Division of Environmental Health
MDHHS-MICHAP	Michigan Department of Health and Human Services Climate and Health Adaptation Program

MDSS	Michigan Disease Surveillance System
MGC	Michigan Green Communities
MiBRFS	Michigan Behavioral Risk Factor Survey
MICHAP	Michigan Climate & Health Adaptation
MIDB	Michigan Inpatient Database
MiSWIMS	Michigan Surface Water Information Management System
MML	Michigan Municipal League
MPHA	Michigan Public Health Association
MRLC	Multi-Resolution Land Characteristics
MSSS	Michigan Syndromic Surveillance System
MSU	Michigan State University
NAAQS	National Ambient Air Quality Standards
NARCCAP	North American Regional Climate Change Assessment Program
NLCD	The National Land Cover Database
NNDSS	National Notifiable Diseases Surveillance System
NOAA	National Oceanic and Atmospheric Administration
NTNCWS	Non-Transient Non-Community Water System
NWS	National Weather Service
OPHP	Office of Public Health Preparedness
RCM	Regional Climate Models
RTB	Retention Treatment Basin
SDWIS	Safe Drinking Water Information System
SES	Socio-Economic Status
SSO	Sanitary Sewer Overflows
TNCWS	Transient Non-Community Water System
TTHM	Trihalomethanes
U of M	University of Michigan
WICCI	Wisconsin Climate Change Initiative's
WMEAC	West Michigan Environmental Action Council
WNV	West Nile Virus
WRD	Water Resources Division

Executive Summary

Through the 20th and into the 21st century, Michigan's climate has changed in measurable and impactful ways. Since 1951 the average annual temperature has increased by 0.6°F in the southeastern Lower Peninsula, and up to 1.3°F in the northwestern Lower Peninsula. During that same period total annual average precipitation across the state increased by 4.5%, or 1.4 inches. Additional changes include an increased frequency of some types of weather extremes such as heavy precipitation events. These changing climate conditions have had an impact on both environmental and human systems, representing an emerging threat to public health in Michigan. In response, the Michigan Department of Health and Human Services Climate and Health Adaptation Program (MDHHS – MICHAP) in partnership with the Great Lakes Integrated Sciences Assessments Program (GLISA) is using the Centers for Disease Control and Prevention's (CDC) Building Resilience Against Climate Effects (BRACE) framework to build capacity for public health adaptation at the state and local levels. This Climate and Health Profile Report is the initial step of the BRACE framework, laying the foundation for future assessments of vulnerability, disease burden, and interventions.

Based on current trends and projections of the most recent period for which information is available, 2021 – 2050, the most likely impacts from climate change in Michigan are extreme heat events, defined as prolonged periods of increased temperatures and humidity; changes in precipitation patterns, including excess rain leading to flooding; and extreme weather such as heavy snow and freezing rain. For Michigan, five priority climate-related health outcomes have been identified: respiratory diseases, heat related illnesses, waterborne diseases, vector-borne diseases, and injuries, specifically carbon monoxide (CO) poisoning. Conceptual pathways were created to describe how each climate impact directly and indirectly affects those priority health outcomes based on Michigan's vulnerabilities that were identified and classified as either relating to *exposures* or *sensitivities*. Combining the vulnerabilities, priority health outcomes, and climate projections, a qualitative synthesis of the relationship between expected future climate conditions and the likely health burden on Michigan's communities was created. A summary of findings is shown here:

1. **Respiratory Diseases**: Overall, projected conditions favor increased air pollution and worsening respiratory disease. Climate projections also favor earlier and longer growth period for plants indicating increased pollen levels, which could increase allergies and exacerbate symptoms including asthma.
2. **Heat Illness**: Air mass stagnation events may increase in frequency if high humidity occurs with high temperature and low winds, leading to increased heat stress-related morbidity and mortality. Projected increasing numbers of high heat days by mid-century suggest there will likely be large direct impacts on human health, especially if occurring simultaneously with other variables such as urban heat island effect.
3. **Water-borne Diseases:** In general, climate conditions leading to flooding will be the same or more intense in the future. This leaves areas vulnerable to sewage/septic failures and runoff at an increased risk for waterborne diseases and in certain areas, development of harmful algal blooms.
4. **Vector-borne Diseases:** Projections point to warmer winters, earlier springs, and warmer summers, conditions suitable for West Nile Virus and its mosquito vector. Similarly, current and future conditions are suitable for Lyme disease and its tick vector although there is greater difficulty in projecting the burden based on the complex sequence of climate conditions and the tick's life cycle needs.
5. **Injury and CO Poisoning:** Extreme weather events conducive to power outages are projected to increase, especially in winter, leading to increased use of generators and thus increased risk of CO poisoning. Clean up after an event utilizing power washers may also increase risk of CO poisoning. Freezing rain and flooding increases will raise traumatic injury risk.

I. Building a Resilient Public Health System



"The systemic reaction resulting from changing climate conditions has impacted environmental and human processes; representing an emerging threat to public health in Michigan. This threat requires altered response strategies from public health officials to confront the new pathways for disease and illness as well as the added stress placed on many existing public health problems." (pg. 10)

Introduction

The United Nations Intergovernmental Panel on Climate Change (IPPC) in their *Fifth Assessment Report* concludes that, "warming of the climate system is unequivocal and many of the observed changes are unprecedented over decades to millennia" (IPCC, 2014). The U.S. Global Change Research Program's *Third National Climate Assessment*, conducted by more than 300 experts guided by a 60-member Federal Advisory Committee from 13 Federal Departments, formed similar conclusions finding that "Temperatures at Earth's surface, in the troposphere (the active weather layer extending up to about 5 to 10 miles above the ground) and in the oceans, have all increased over recent decades. This warming has triggered many other changes to the Earth's climate" (Walsh, et al., 2014). What is of greatest concern for decision makers at all levels and across all sectors is that "Worldwide, the observed changes in average conditions have been accompanied by increasing trends in extremes of heat and heavy precipitation events, and decreases in extreme cold" (Walsh, et al., 2014). This has led to "shorter duration of ice on lakes and rivers, reduced glacier extent, earlier melting of snowpack, reduced lake levels due to increased evaporation, lengthening of the growing season, changes in plant hardiness zones, increased humidity, rising ocean temperatures, rising sea level, and changes in some types of extreme weather" (Walsh, et al., 2014).

The systemic reaction of global changes in precipitation and temperature leading to environmental and human system impacts represents an emerging threat to public health. This threat requires altered response strategies from public health officials to confront the new pathways for disease and illness as well as the added stress placed on many existing public health problems (Luber et al., 2014). Furthermore, officials will have to consider more than ever how their communities and citizens are vulnerable and if the health care infrastructure and delivery systems are capable of meeting those new challenges. This will require cooperation and action between multiple sectors as climate change poses indirect threats to health through impacts on fish and wildlife populations, energy and industry demands, natural features, transportation systems, tourism and recreation, water quality and quantity, and agriculture (Luber et al., 2014).

Acknowledging the need for a strategic and action oriented response, in 2010 the Michigan Department of Health and Human Services' Division of Environmental Health (MDHHS-DEH) established the Michigan Climate & Health Adaptation Program (MICHAP) following a one-year strategic planning activity funded by a grant from the Association of State and Territorial Health Officials (ASTHO). MICHAP was charged with protecting the health of Michigan's citizens from threats related to climate change, with the support and guidance of the Centers for Disease Control & Prevention's (CDC) - Climate Ready States & Cities Initiative (CRSCI).
(www.cdc.gov/climateandhealth/climate_ready.htm)

After successfully creating and implementing Michigan's climate and health strategic plan (MDHHS, 2011) from 2010 to 2013, the MDHHS - DEH was awarded a second grant from the CDC called *Building Resilience Against Climate Effects (BRACE) in State Health Departments.* The CDC's BRACE framework builds upon the planning and preliminary implementation work completed from the two previous grants. Their framework is composed of five steps which are described in Table 1.1.

Rationale and Objectives

This Climate and Health Profile Report (CHPR) establishes the foundation upon which the five steps of the BRACE framework will be completed and implemented at the State and local levels in Michigan.

The alignment of the BRACE framework with MICHAP's activities and ultimate outcomes is further explained in Table 1.1.

As the initial step in the BRACE framework the CHPR is intended to: (1) Inform internal and external stakeholders of the most current climate science as it relates to existing and future temperature and precipitation changes in Michigan leading to environmental and health impacts; (2) Describe the direct and indirect pathways by which climate changes impact health outcomes; (3) Characterize the variables that will be used to assess the vulnerabilities of the people and places within the State; (4) Explore the relationships between current vulnerabilities, future climate change projections, and the potential pathways of impact to better understand the additional burden to new and existing health outcomes; (5) Identify MICHAP's key collaborators and stakeholders, how they can be engaged and how these partnerships will lead to successful implementation of BRACE at the State and local levels.

Table 1.1: Michigan Climate & Health Adaptation Program BRACE Goals and Objectives

Goal: Enhance local, regional, and state capacity to predict, assess, and effectively respond to extreme weather and climate events to reduce and prevent the negative public health impacts associated with climate change.		
BRACE Steps	**MICHAP Objectives (3 year)**	**Purpose & Application**
1. Data analysis and climate projections	- Create MI *Climate and Health Profile Report (CHPR)* - Develop comprehensive *Vulnerability Assessment*	- Describe state climatology, related exposures, health factors and health outcomes of concern, and the populations and systems most vulnerable to these changes - Identify and describe communities and geographic areas at greatest risk for climate-related health outcomes - Act as resource for local public health decision makers and communities in developing plans and for adaptation and emergency response
2. Project health impacts and disease burden	- Create *Burden of Disease Report*	- Describe the magnitude, trend and estimation of additional burden of health outcomes due to climate change.
3. Identification of best intervention strategies	- Develop *Climate & Health Intervention Assessment*	- Identify and prioritize the most appropriate interventions to address vulnerabilities and health impacts for each region in Michigan
4. Adaptation planning and implementation	- Assist local health departments (LHDs) to plan for relevant health impacts and vulnerable populations - Work with regional research partners to strengthen existing/develop new climate related tools - Develop and deliver BRACE framework training	- Advance the application of climate science to public health practice - Develop and put in place a process for ensuring that climate change factors are considered adequately in public health program operations. - Promote consideration of public health in climate adaptation planning in other sectors - Support local climate health adaptation planning
5. Evaluate and revise adaptation plan	- Update existing *Climate & Health Adaptation Plan*	- Incorporate BRACE approach. - Prepare principal climate and health preparedness guideline for local health departments

History of MDHHS Engagement with Climate and Health

The Michigan Department of Health and Human Services received funding from ASTHO in 2009 to conduct a statewide needs assessment and develop an adaptation plan for Michigan. The planning process focused on two specific deliverables; a Needs Assessment and Strategic Plan. In 2010, MDHHS received a three-year grant from CDC that funded MICHAP to implement the Strategic Plan as part of the national CRSCI. The MICHAP made great progress to build capacity in the state to address climate and health issues through both the planning and implementation grants. Table 1.2 reflects the objectives and results of those projects. Grant Final Reports and products are available from MICHAP staff upon request or by visiting www.michigan.gov/climateandhealth.gov.

Table 1.2: Previous Michigan Climate and Health Program Grants: Objectives & Key Findings

Grant	Objective	Findings and Results:
Strategic Planning	Understand existing community stakeholder interest in, capacity to, and knowledge of climate & health impacts and implementing adaptation strategies.	**Key stakeholder feedback** - Widespread interest but lack of knowledge regarding health impacts of climate change - Strong desire to identify partners with other organizations to address the issue
	Identify long-term goals, objectives, strategies to form the impetus for future initiatives	**Advisory Committee agreed upon goals** - Climate change is recognized as a public health issue & integrated into public health practice - Public health agencies have the tools, resources, and activities to respond to climate change impacts within existing programs - Vulnerable populations are explicitly considered in programs and policies addressing climate change impacts
	Identify the priority climate-driven health impacts	**Advisory Committee & Staff agreed upon priority issues** - Increasing number of heat events with related illnesses and deaths - Declining air quality as a result of increased production of ozone and particulate matter from heat and drought events - Adverse changes to water quality and quantity following severe weather events
Implementation	Integrate identified issues, resources, and strategies into state and local public health planning, assessments, outreach/education, partnerships, and tool development	**Advisory Committee & Staff agreed upon activities** - Incorporated extreme weather considerations into emergency planning - Supported climate-related Health Impact Assessments (HIA) in 3 communities and heat health surveys in two - Initiated health effects surveillance and calculated Indicators - Trained partners on climate health effects, HIA tool, and emergency response

Geographic Scope

MICHAP is a statewide initiative with a mandate to identify the unique health impacts from climate change for various communities and regions within Michigan and to integrate adaptation strategies and actions into their local health departments, municipalities, or other planning organizations depending upon the scale of the potential health impact and recommended interventions. This CHPR is intended to act as a resource to direct and inform this initiative, and is anchored in the breadth of political, social and physical characteristics of the state as summarized below.

Jurisdictional Features

Michigan is located in the eastern north-central United States. The state is composed of two peninsulas, the Upper and Lower. The Upper Peninsula is bordered by Lake Superior to the north, by Wisconsin on the west and on the south by Lake Michigan and Lake Huron. The Lower Peninsula is bordered on the west by Lake Michigan and on the east by Lake Huron and Lake Erie. On the south it is bordered by Indiana and Ohio. Michigan is divided into 83 counties, 257 villages, 276 cities and 1,240 townships. Additionally, the state is covered by 45 Local Public Health Departments with some encompassing several counties (Michigan Legislative Service Bureau, 2013). Figure 1.1 depicts the relevant jurisdictional boundaries of interest to MICHAP.

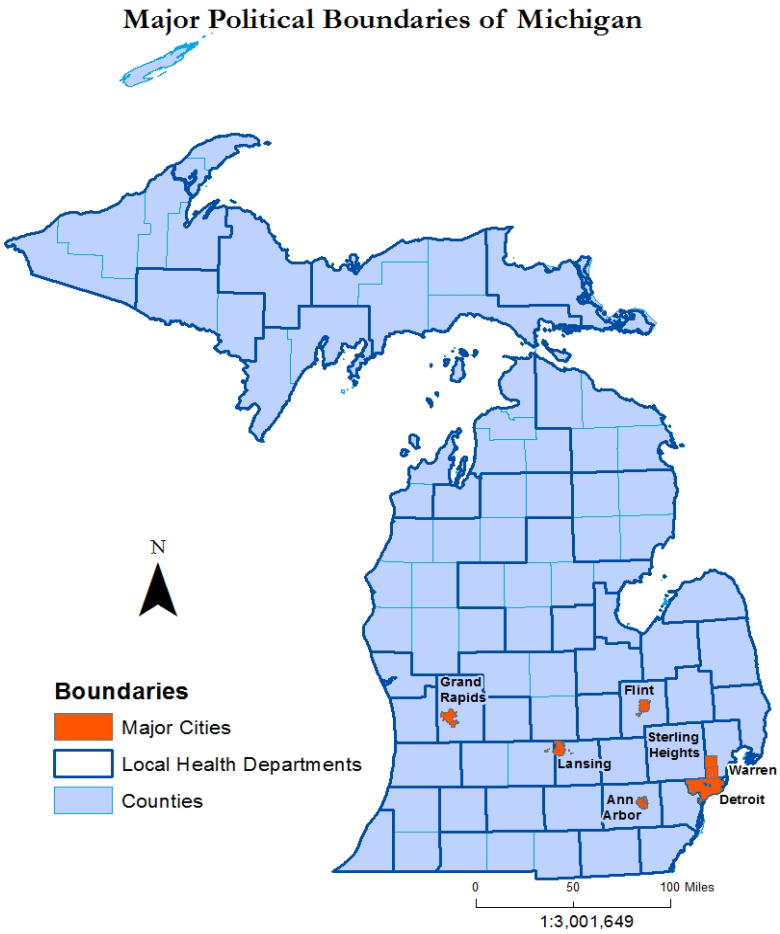


Fig. 1.1

Social Features

The 2010 U.S. Census identifies Michigan as the eighth most populous state in the U.S., with a total population of 9,883,640. County populations range from a low of 2,156 in Keweenaw County (North Western Upper Peninsula) to slightly less than two million persons in Wayne County (South Eastern Lower Peninsula). Michigan's largest city by population and area is Detroit (South Eastern Lower Peninsula) followed by Grand Rapids (Western Lower Peninsula), as shown in Table 1.3.

Table 1.3: Michigan's Largest Cities

City	Population	Area (sq. mi)
Detroit	688,701	142
Grand Rapids	192,294	45
Warren	134,873	34
Sterling Heights	131,224	36
Ann Arbor	117,025	28
Lansing	113,972	36
Flint	99,763	34

Source: U.S. Census Bureau, 2014 (estimated 2013)

Forty four percent of Michigan's total population is located in the Detroit Eligible Metropolitan Area (DEMA), which encompasses Wayne, Macomb, Oakland, Monroe, St. Clair, and Lapeer Counties (U.S. Census, 2013). Population density of Michigan by census tract is visualized in Figure 1.2.

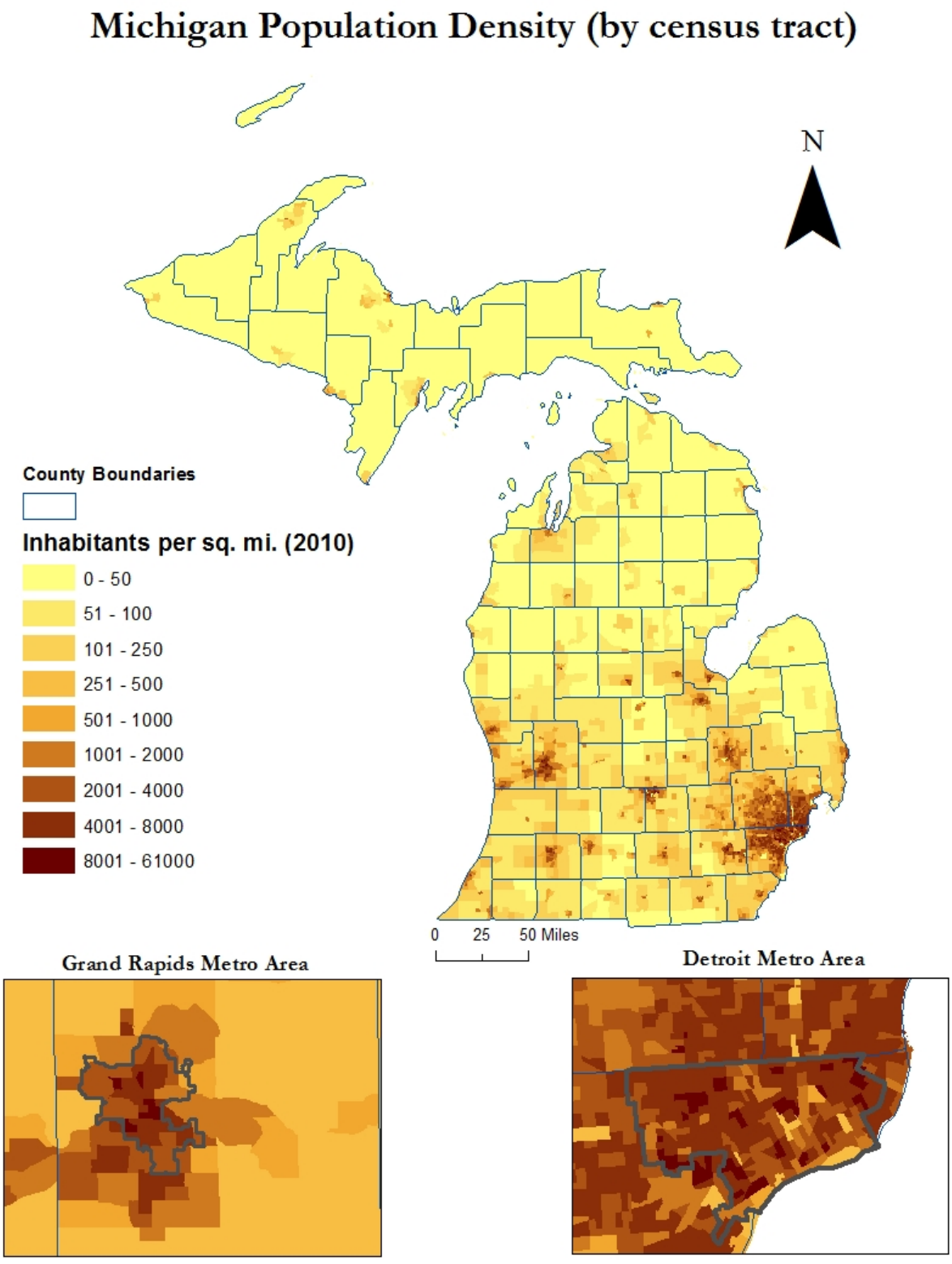


Fig. 1.2 (U.S Census Bureau, American Community Survey, 2010)

The racial and ethnic compositions and median ages of the State of Michigan and its two largest metropolitan areas, Grand Rapids and Detroit, are presented in Table 1.4. The percentage of non-white populations and the median ages within census tracts of Michigan are visualized in Figures 1.3 & 1.4.

Table 1.4: Demographic characteristics of Michigan and the two largest cities

Race (percent)	Michigan	Detroit	Grand Rapids
White	77.0	10.6	64.6
Black	14.0	82.7	20.9
Asian	2.0	1.1	1.9
American Indian	0.5	0.4	0.7
Other	6.5	5.2	11.9
Median Age (years)	38.9	31.0	30.8

Source: U.S. Census Bureau, 2014

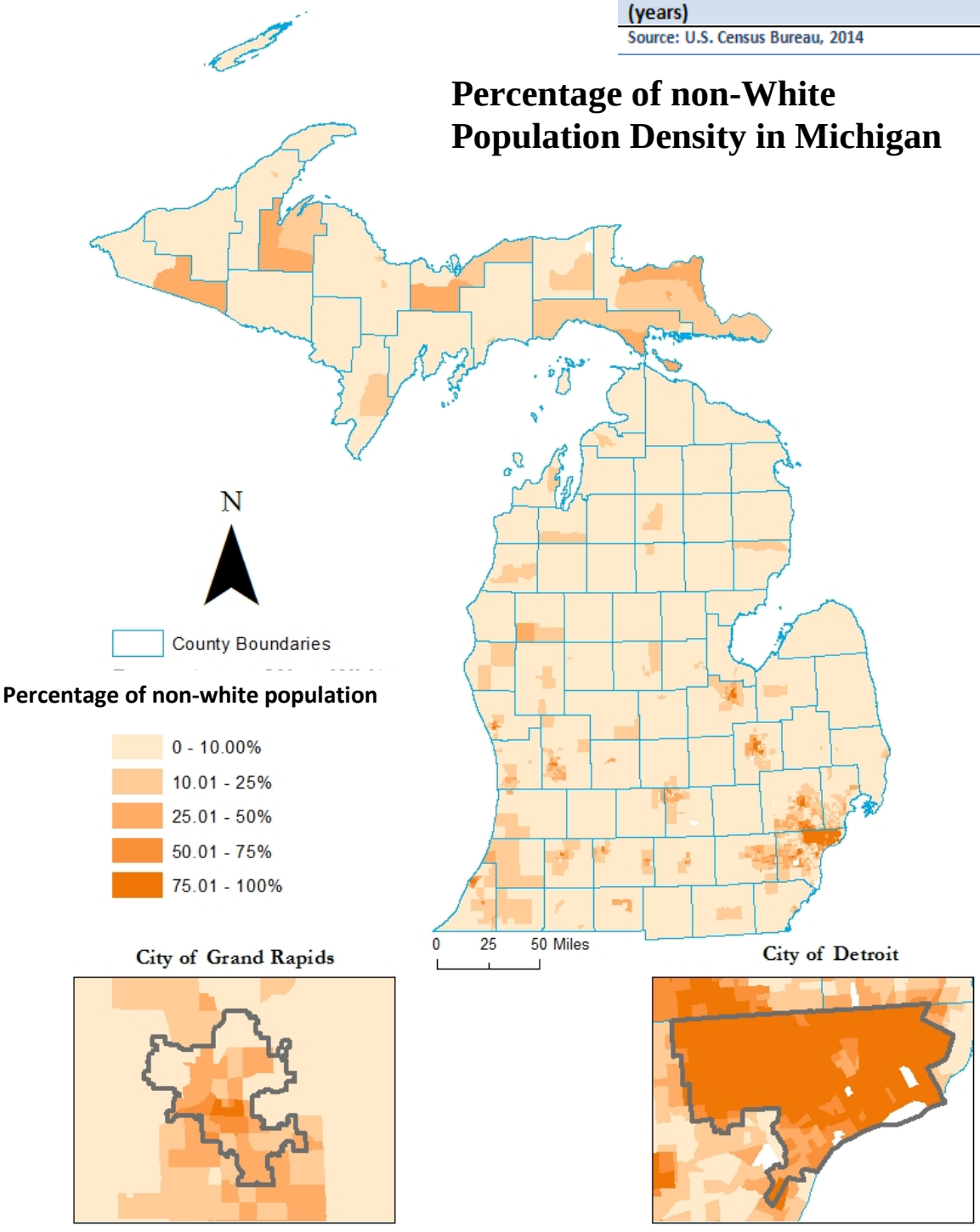


Fig. 1.3 (U.S Census Bureau, American Community Survey, 2010)

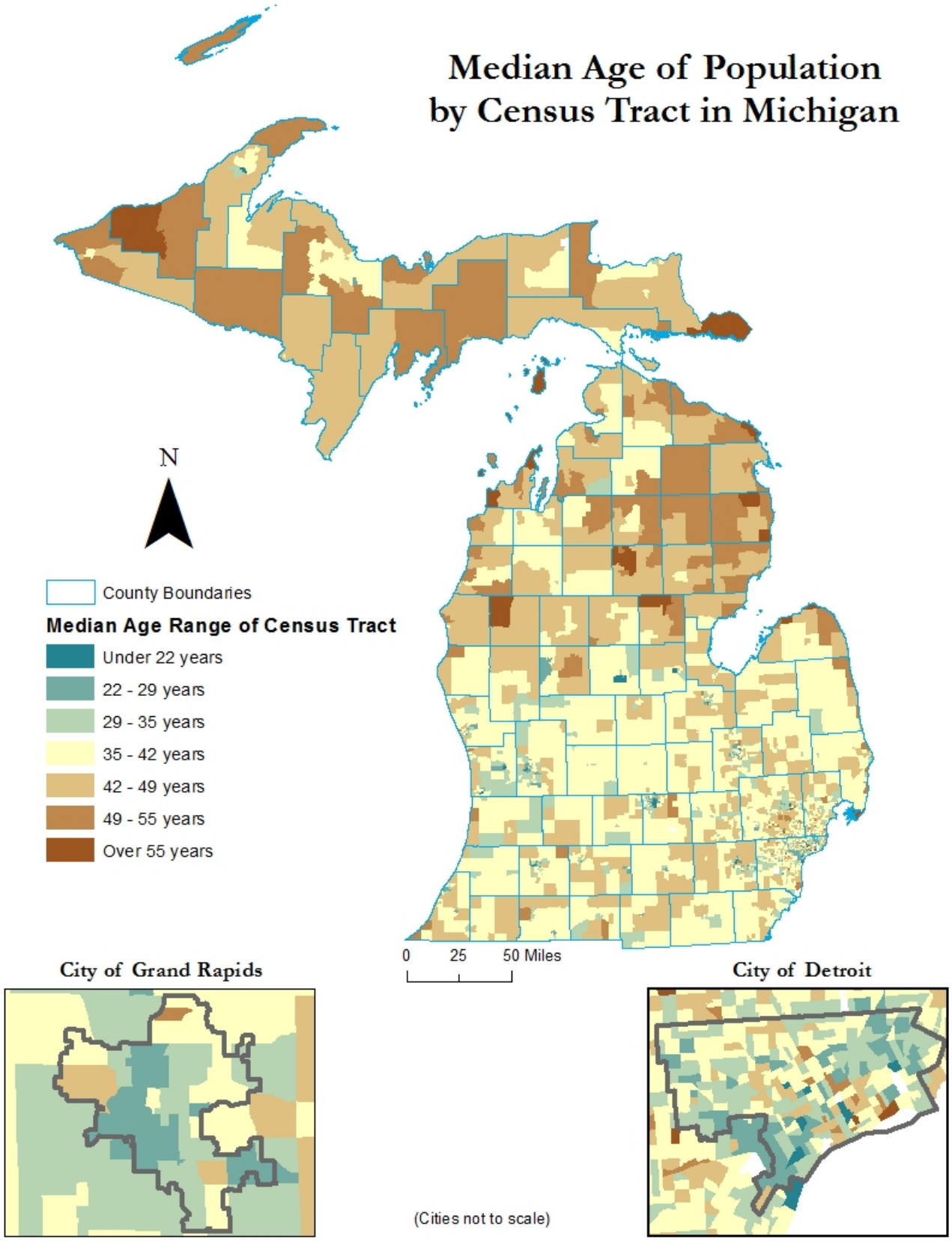


Fig. 1.4 (U.S Census Bureau, American Community Survey, 2010)

Economic Features

Michigan's economy is predominantly driven by the manufacturing, agriculture, tourism, and mining industries. Changes in temperature and precipitation from climate change can have significant impacts on these systems, including occupational health hazards and economic stressors. Four primary economic features are highlighted in Table 1.5.

Table 1.5: Michigan Industries' contributions to Gross Domestic Product, employment, and services

Category	Economic Output (billions)	Number of Jobs	Primary Contributions
Manufacturing	$58.2	> 470,000	Automobiles, chemicals, paper, furniture, breakfast foods
Food & Agriculture	$91.4	923,000	Farming, wholesale and retail distribution
Tourism	$20.9	> 150,000	Rural/urban recreation, freshwater recreation, hiking, winter activities
Mining	$2.4	N/A	Peat, bromine, calcium-magnesium chloride, gypsum & magnesium compounds

Source: MI Economic Development Corporation, 2014

Natural Features

Glaciers covered Michigan as recently as 14,000 years ago, leaving behind hills and valleys, snake-shaped eskers, patterned mounds of drumlin fields, steep end moraines, and old weathered mountain ranges. As the modern day Great Lakes receded about 4,000 years ago, broad flat lakebeds were exposed, sandy beaches were formed, and large sand dunes were created (Michigan Department of Natural Resources, 2014).

Michigan has over 19.3 million acres of forests covering more than half the land area of the state, mainly in the Upper Peninsula and northern Lower Peninsula. Michigan has the fifth largest amount of timberland (forestland that can produce commercial timber) in the United States. Hardwoods such as maple, aspen, and oak make up 75% of the trees in the state, while softwoods, including pine, spruce, and cedar comprise the remaining 25%. Distribution of forests, along with wetlands, developed land, bodies of water, etc. is displayed in Figure 1.5 (Michigan Department of Natural Resources, 2014).

Perhaps the State's greatest natural feature is the abundance of fresh water. The five Great Lakes and their connecting waterways that define the region hold 6 quadrillion gallons of water representing 90% of the United States' surface freshwater supply. The Great Lakes basin (the surface area of the Great Lakes and the land draining into the Lakes) covers more than 295,000 square miles and is home to over 33 million people in the United States and Canada Figure 1.6 (Great Lakes Information Network, 2014). Additional vital natural features are described in Table 1.6.

Table 1.6: Michigan Natural Feature Statistics

Total Land Area	58,110 sq. mi.
Total Great Lakes Water Area	38,575 sq. mi.
Total Inland Water Area	1,305 sq. mi.
Highest Point	Mount Arvon – 1,979 feet
Lowest Point	Lake Erie Surface – 571 feet
Rivers and Streams	36,600 miles
Freshwater Coastline	> 3,200 miles
Number of Inland Lakes	> 11,000

Source: Michigan Department of Natural Resources, 2014

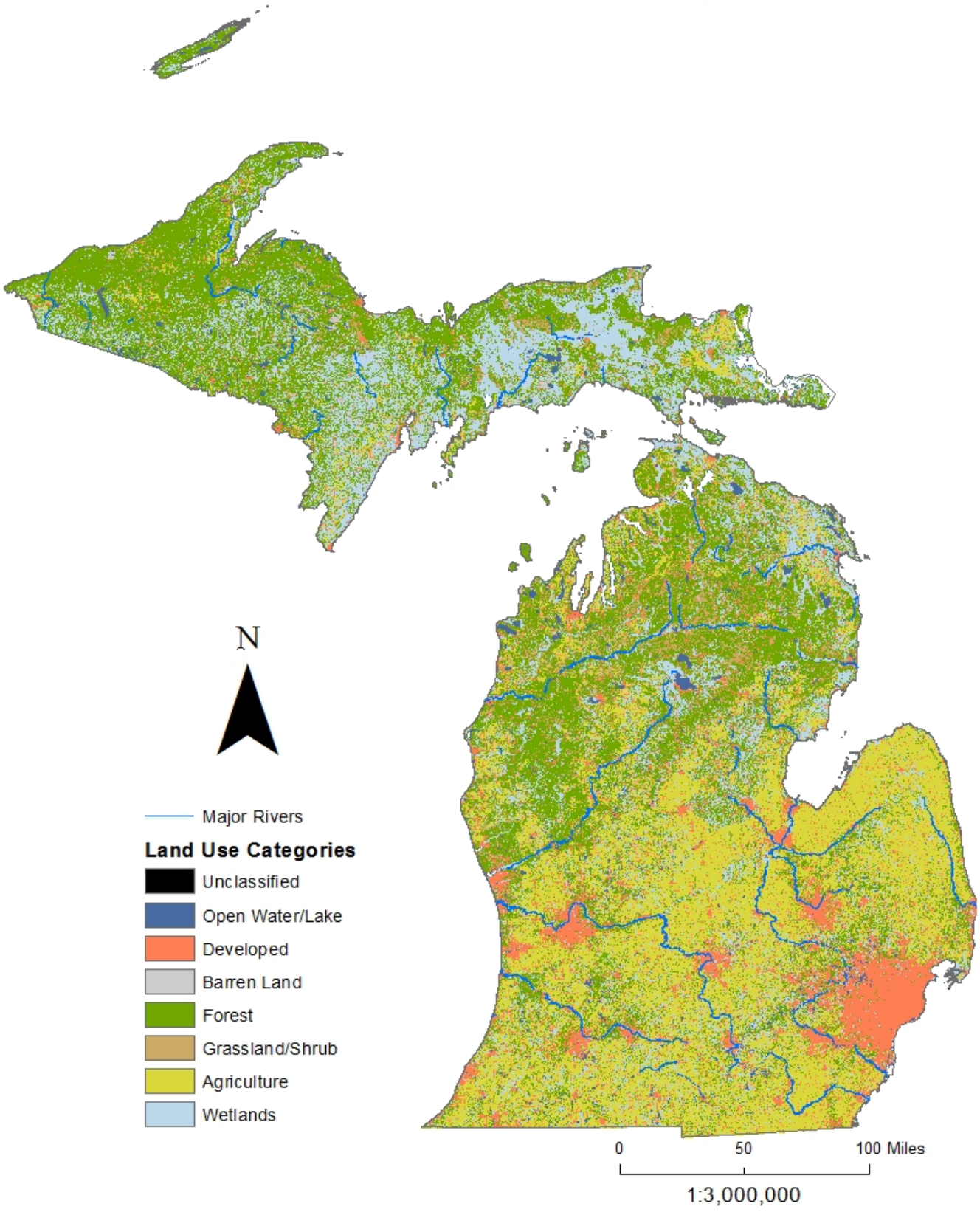

Natural Features of Michigan
N
Major Rivers
Land Use Categories
Unclassified
Open Water/Lake
Developed
Barren Land
Forest
Grassland/Shrub
Agriculture
Wetlands
0
50
100 Miles
1:3,000,000

Fig. 1.5

Topography of Michigan

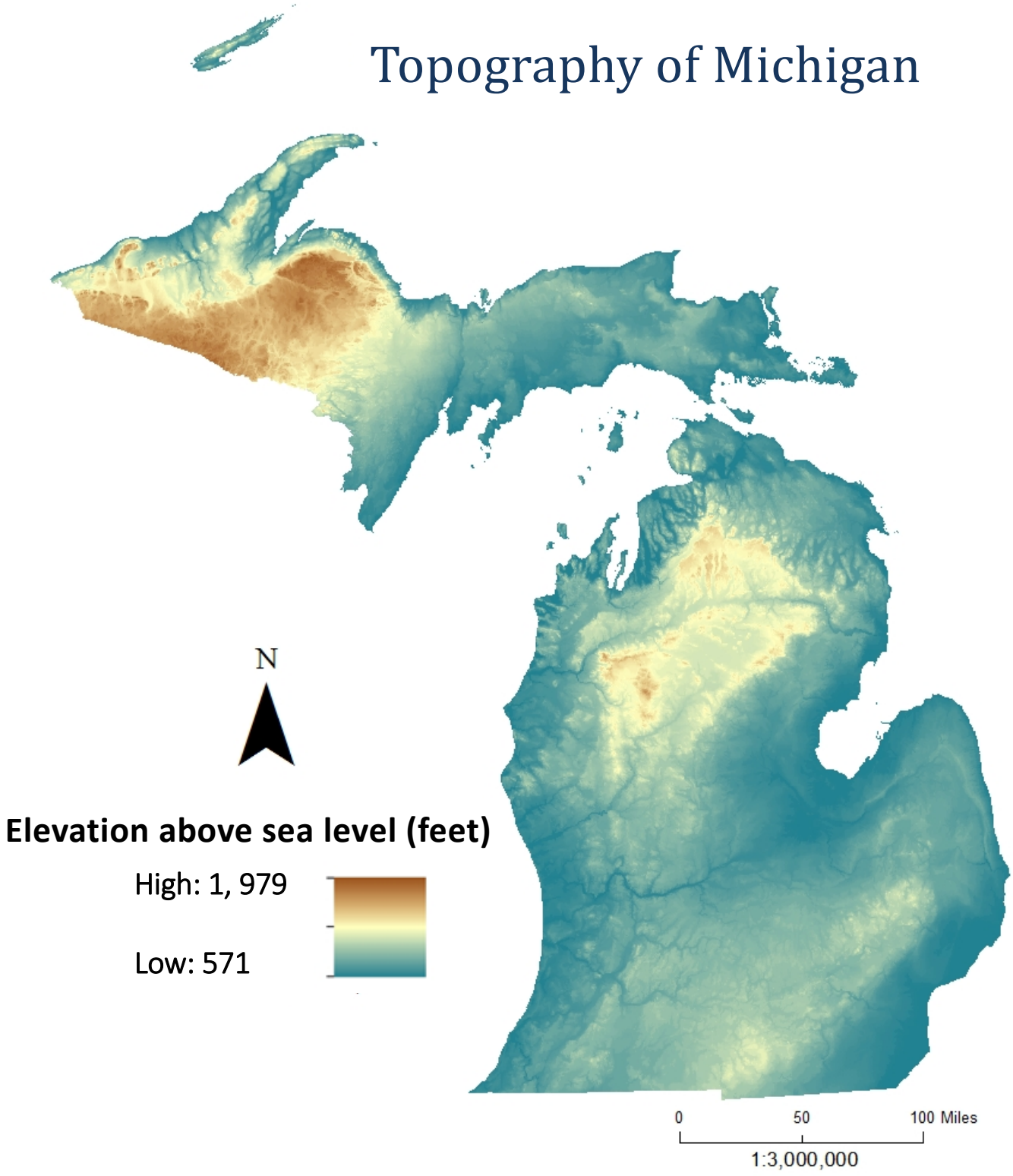


Fig. 1.6

Introduction to Michigan's Climate

Michigan's climate is influenced largely by the Great Lakes. The Lakes moderate the temperatures of the surrounding land, cooling the summers and warming the winters. Michigan has a humid continental climate, although there are two distinct regions. The southern and central parts of the Lower Peninsula have a warmer climate with hot summers and cold winters. The northern part of Lower Peninsula and the entire Upper Peninsula have a more severe climate, with warm, but shorter summers and longer, cold to very cold winters. For an in-depth description of Michigan's current and future climate statistics and trends see **Chapter II: Michigan's Current and Future Climate Conditions**.

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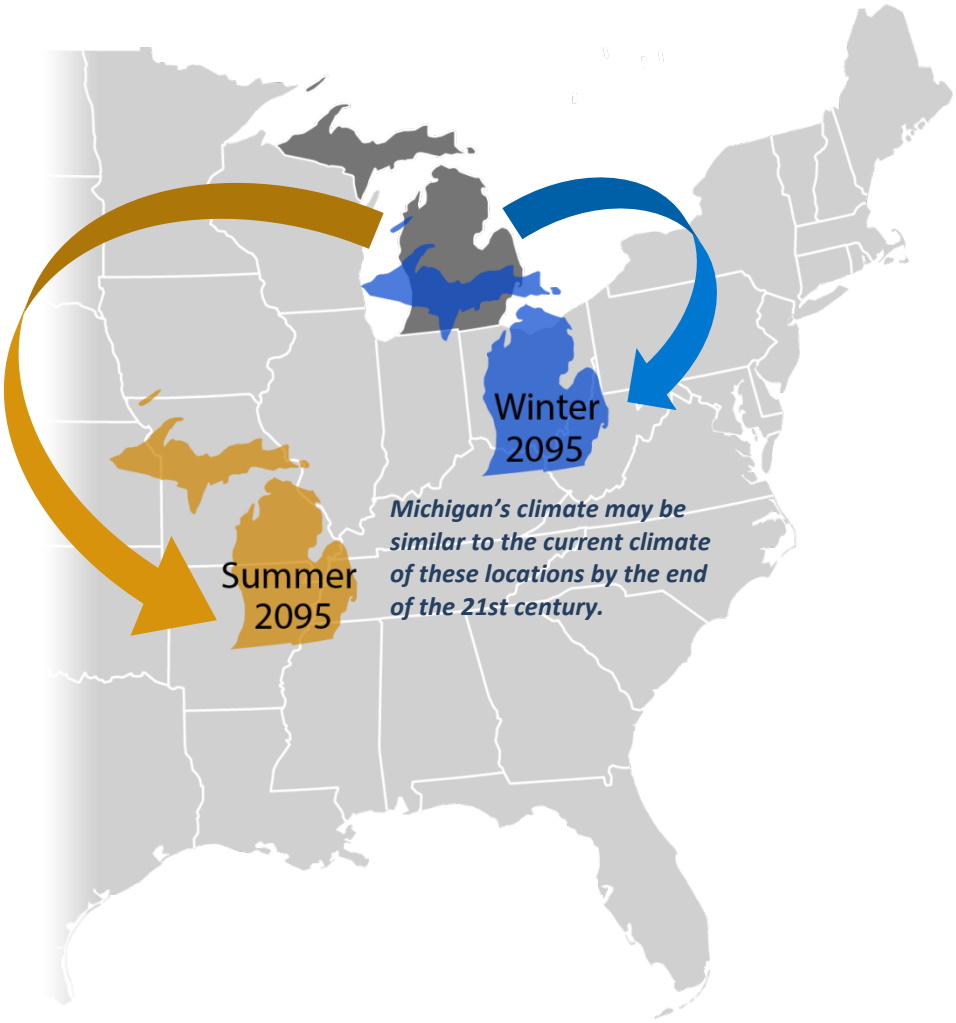
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II. Michigan's Current and Future Climate Conditions



Source: Hayhoe, VanDorn, Croley II, Schlegal, & Wuebbles. (2010), modified

"The projections should be considered only one piece of information about future climate that fits into a larger context of: 1) how climate has already changed based on observations and 2) what we know from expert knowledge and local/regional future climate research" (pg. 33).

Baseline Climate Description

Average weather conditions across the State of Michigan vary greatly as a result of the state's north-to-south latitude coverage and its unique positioning among several Great Lakes (see Figure 2.1). For example, the average annual temperature of Ironwood, Michigan in the Western Upper Peninsula (U.P.) is 40.1° F, while the annual average temperature of Adrian, Michigan in the Southeastern Lower Peninsula (L.P.) is 48.6° F. These vast differences point to the need for localized information, especially for planning purposes across the State of Michigan. In this chapter we summarize current climate conditions, the physical drivers of our State's weather and climate, and projected future climate changes for the State of Michigan using local observed weather data and climate model projections, respectively.

Observed Weather Data

Michigan's historic climate data in this report comes primarily from a series of twenty-two weather observation stations located throughout the state. **These stations have reliable temperature and precipitation measurements that have been systematically collected since 1950 and can be used to document historic changes annually and by season.** These point-based station data have been collected along with observational climate division data from the National Oceanic and Atmospheric Administration (NOAA) to produce historic averages for representative locations and all Michigan Climate Divisions. See Figure 2.2; map of climate stations and divisions. Findings are summarized below.

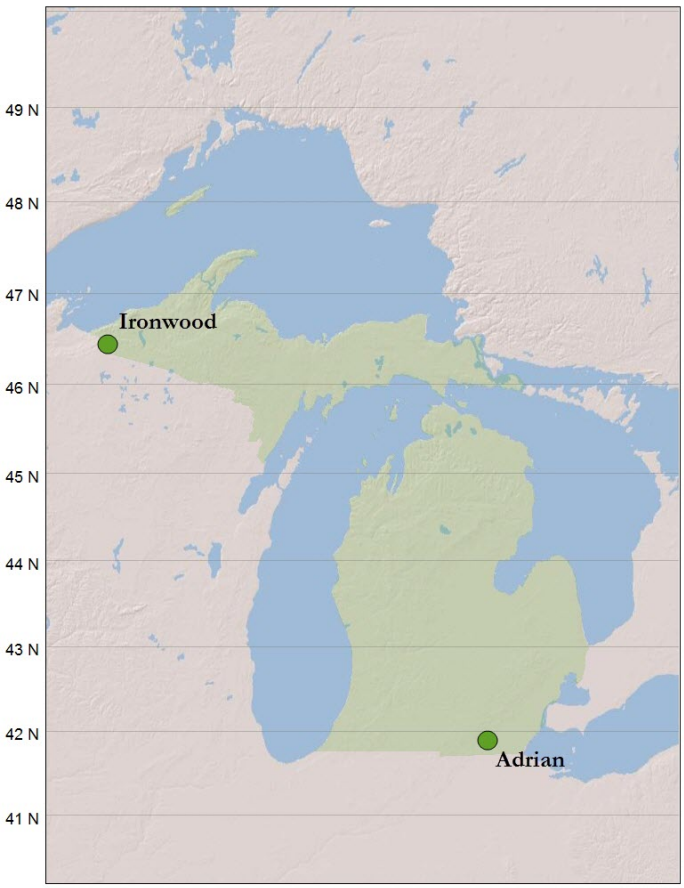


Fig. 2.1: Michigan reference map indicating the latitudinal coverage of the state and the geographic distance between the Southeast and Northwest areas of the State.

Current Climate Conditions

In general, the northwestern Upper Peninsula (U.P.) experiences harsh, long winters and mild summers, and the Lower Peninsula (L.P.) experiences milder winters with hot, humid summers. Winter temperatures often fall below 0°F, and the summers in the L.P., particularly the southern portion, commonly experience several humid days with temperatures upwards of 90°F. The greatest seasonal temperature difference from the summer occurs between December and February, with the coldest temperatures observed in northern inland areas away from the Great Lakes. Average annual precipitation (all precipitation types converted to their equivalent amount of liquid water) is somewhat consistent across the state, ranging from 30 inches per year in the northwestern L.P. to 38 inches per year in the southwestern L.P. The greatest contributions of precipitation generally occur during the summer, but frozen winter precipitation can have just as great or greater impact on society.

Snowfall in Michigan is usually associated with either large weather patterns or with lake effects, often leading to highly variable snowfall totals over short distances. Snowfall in the Keweenaw Peninsula commonly exceeds 240 inches per year, making it the snowiest region in the United States east of the Rocky Mountains. Municipal records from Delaware, Michigan, for example, report the seasonal snowfall total reached 390 inches during the winter of 1978-1979. This is a stark contrast to southern sections of Michigan where snowfall is often sparse, averaging a little over 30 inches per year.

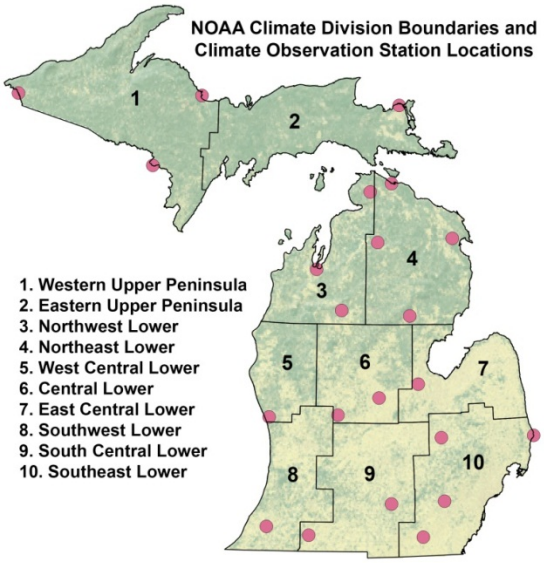


Fig. 2.2: NOAA Climate Divisions and high-quality climate observation stations. Red dots represent station locations that have consistent records since 1951.

Climate Changes Already Experienced

Through the 20th and into the 21st century, Michigan's climate has changed in measurable and impactful ways.

Warmer Temperatures

Average temperatures have increased in Michigan, roughly consistent with global trends over the past century. There is tremendous short-term variability in regional temperatures, however, and there have been multiple points in time when the multi-year regional trend did not reflect the global pattern. Annual mean temperature over the Midwest increased by approximately 0.11° F per decade during the 1900-2010 period, increased 0.22° F per decade for the period 1950-2010, and 0.47° F per decade for the period 1979-2010 (Brohan et al., 2006). For comparison, global temperatures have increased by about 1.4° F since 1850 (IPCC, 2007). Most locations throughout the state have warmed during the past century. Most stations in Michigan with reliable, long-term records show increases in average annual temperature from the 1951-1980 period to the 1981-2010 period. Overall, average low temperatures have increased slightly faster than high temperatures, but there is great variability across stations by season (see Table 2.1). **All Climate Divisions in Michigan experienced warmer average annual temperatures during the 1981-2010 period than during the 1951-1980 period. Increases ranged from 0.6° F in southeastern parts of the state up to 1.3° F in the Northwestern Lower peninsula.**

Table 2.1: Changes in average annual and seasonal temperatures (in degrees F) from the 1951-1980 period to the 1981-2010 period for Michigan's ten NOAA Climatic Divisions

Michigan Climate Division	Annual	Winter (Dec/Jan/Feb)	Spring (Mar/Apr/May)	Summer (Jun/Jul/Aug)	Fall (Sep/Oct/Nov)
Western Upper Peninsula (1)	1.0	2.0	1.1	0.6	0.2
Eastern Upper Peninsula (2)	1.1	1.8	1.3	0.9	0.4
Northwest Lower (3)	1.3	2.4	1.6	0.9	0.4
Northeast Lower (4)	1.2	2.1	1.4	0.9	0.3
West Central Lower (5)	1.0	2.3	1.2	0.4	0.1
Central Lower (6)	0.9	1.9	1.0	0.4	0.1
East Central Lower (7)	0.6	2.0	0.7	-0.2	-0.2
Southwestern Lower (8)	0.9	1.9	1.1	0.6	0.2
South Central Lower (9)	0.7	1.8	0.9	0.1	-0.1
Southeastern Lower (10)	0.6	1.4	0.9	0.3	-0.1
State Average (Area Weighted)	1.2	2.3	1.3	0.8	0.6

Across Michigan, average temperatures have increased faster during winter than other seasons. In some areas, mean summer and fall temperatures have actually decreased with time, possibly due to increased use of land for agriculture, which can have an overall cooling effect (Pan et al., 2004). Over the United States and the Midwest, much of the warming in recent decades has also been due to warmer nighttime (minimum) temperatures (Lorenz et al., 2009a; Easterling et al., 1997), (see Table 2.2) resulting in a narrower daily temperature range.

Table 2.2: Changes in average annual temperatures, average mid-day high temperatures, and average overnight low temperatures (in degrees F) from 1951-1980 to 1981-2010 for 22 weather observation stations in Michigan

Weather Station	Annual	Mid-Day High	Overnight Low
Adrian	0.0	0.2	-0.1
Alma	-0.5	-0.1	-0.9
Alpena	1.1	0.6	1.5
Ann Arbor	0.4	0.4	0.3
Cheboygan	-0.4	-0.5	-0.2
Eau Claire	1.3	1.1	1.4
Flint	1.0	1.2	0.8
Gaylord	0.5	-0.2	1.2
Greenville	0.0	0.4	-0.4
Iron Mountain	0.5	0.7	0.3
Ironwood	-0.3	-0.9	0.4
Jackson	0.6	0.6	0.6
Lake City	0.2	-0.2	0.6
Marquette	0.8	1.2	0.3
Muskegon	0.8	0.8	0.9
Pellston	1.6	1.3	1.8
Port Huron	0.0	-0.1	0.1
Saginaw	0.6	0.7	0.5
Sault Ste. Marie	1.4	1.4	1.4
Three Rivers	0.2	0.4	0.0
Traverse City	1.3	1.0	1.7
West Branch	0.3	1.1	-0.4
All station average	0.52	0.50	0.54

Changing Precipitation

Annual precipitation across the Midwest has increased overall during the past century (Groisman & Easterling, 1994; Andresen et al., 2013). The winter and fall months have seen the greatest relative changes in precipitation, while precipitation during the spring and summer has remained relatively stable or decreased slightly. **Overall, total annual precipitation in Michigan increased by 4.5% (or 1.4 inches) from the 1951-1980 average to the 1981-2010 average, but there has been large regional variation** (see Table 2.3).

Table 2.3: Percent change in mean total annual and seasonal precipitation from the 1951-1980 period to the 1981-2010 period for Michigan's ten NOAA Climate Divisions

Michigan Climate Division	Annual	Winter (Dec/Jan/Feb)	Spring (Mar/Apr/May)	Summer (Jun/Jul/Aug)	Fall (Sep/Oct/Nov)
Western Upper Peninsula (1)	-2.9	0.1	-7.8	-9.7	8.1
Eastern Upper Peninsula (2)	-2.8	-3.5	-9.6	-6.2	7.4
Northwest Lower (3)	5.6	6.6	3.9	2.4	10.1
Northeast Lower (4)	2.4	1.9	-1.3	1.4	7.9
West Central Lower (5)	6.8	-1.6	6.0	4.3	15.8
Central Lower (6)	8.6	10.0	8.8	2.3	15.4
East Central Lower (7)	11.5	5.3	8.4	7.9	23.8
Southwestern Lower (8)	7.0	3.8	3.0	4.1	16.9
South Central Lower (9)	10.1	8.4	5.4	4.9	24.8
Southeastern Lower (10)	9.5	7.3	2.0	4.5	27.7
State Average (Area Weighted)	4.5	3.5	0.5	0.1	14.6

Annual precipitation totals have declined or remained largely unchanged across the U.P. and the northernmost sections of the L.P. of Michigan, while southern areas of the state report increases of approximately 8-13%. The U.P. is also the only area to see declining precipitation in the spring and summer months. Similarly, when looking at station data, most locations across Michigan show increased annual precipitation. These changes are usually distributed unevenly throughout the year, with historically wet months seeing increases in precipitation and historically dry months seeing lesser increases or decreases (see Table 2.4). Ann Arbor is an extreme case, with 25% more precipitation per year during the 1981-2010 period than during the 1951-1980 period; while the northern city of Pellston showed the largest decline of 7.6%.

Table 2.4: Percent change in total annual precipitation from 1951-1980 to 1981-2010 for 22 Michigan weather observation stations

Weather Station	Change (%)
Adrian	9.3
Alma	11.2
Alpena	-4.3
Ann Arbor	25.0
Cheboygan	12.7
Eau Claire	7.3
Flint	8.4
Gaylord	5.6
Greenville	4.8
Iron Mountain	2.1
Ironwood	1.6
Jackson	8.0
Lake City	13.1
Marquette	-6.0
Muskegon	5.2
Pellston	-7.6
Port Huron	12.6
Saginaw	3.2
Sault Ste. Marie	-0.6
Three Rivers	13.4
Traverse City	8.3
West Branch	10.7
All station average	6.5

Lake Warming and Reduced Ice Cover

Great Lakes surface water temperatures, evaporation from the lakes, and the seasonality of lake freezing and thawing are key drivers of weather for many Michigan communities. Significant changes to any of these physical characteristics could have profound implications for Michigan's climate. **The Great Lakes have warmed faster than nearby air temperature in recent years. Lake Superior summer (July–September) surface water temperatures increased approximately**

4.5° F from 1979-2006, a significantly faster rate than regional atmospheric warming of 0.6 to 0.9^0 F. Declining winter ice cover is the largest driving factor of this amplified lake warming. The Lakes are freezing later in the year and thawing earlier, allowing a longer period to warm during the summer and amplifying the effects of warmer air temperatures (Colman & Austin, 2007). Aside from altering nearby air temperatures over land, warmer water temperatures can increase the risk of water contamination and increase the likelihood of algal blooms.

Table 2.5: Change in average number and percent of days per year with precipitation >1 inch from 1951-1980 to the 1981-2010 period for 22 Michigan weather observation stations

Weather Station	Number of Days	% Change
Adrian	0.9	14.1
Alma	0.8	16.2
Alpena	-0.6	-15.1
Ann Arbor	1.3	29.4
Cheboygan	0.0	0.4
Eau Claire	0.6	10.5
Flint Bishop	0.6	13.2
Gaylord	-0.1	-3.3
Greenville	0.5	9.7
Iron Mountain	-0.1	-1.8
Ironwood	0.8	15.7
Jackson	1.4	33.6
Lake City	1.0	24.7
Marquette	-0.1	-2.1
Muskegon	0.7	16.2
Pellston	-0.4	-8.1
Port Huron	0.4	7.2
Saginaw	1.4	32.8
Sault Ste. Marie	0.2	5.1
Three Rivers	1.7	26.9
Traverse City	1.3	36.1
West Branch	1.1	27.4
All Station Average	0.6	13.1

Extreme Precipitation

Across the Upper Midwest, extreme precipitation events have become more intense and more frequent over the past century. Several studies examining different thresholds of precipitation and varying durations of precipitation events have arrived at similar conclusions. Twenty-two percent of the stations considered in a study by Pryor et al., 2009, identified significant increases in the total accumulated precipitation during the top-10 wettest days of the year. The occurrence of intense precipitation events has also risen substantially in recent decades. In the Midwest, the number of 24 hour, 20% annual chance storms (storms that have a 20% chance of occurring in a given year, also known as 5-year storms) has increased by about 4% per decade since the beginning of the 20th century (Kunkel, 2003, updated), and the amount of precipitation falling in the 1% heaviest precipitation events has increased by 37%, (Walsh et al., 2014). **Michigan has experienced a similar change between the time periods of 1951-1980 and 1981-2010, with most observational stations recording increased number of days with precipitation exceeding 1 inch (see Table 2.5). The average change over the twenty-two stations was 13.1% or an increase of 0.6 days per year**; the greatest increases were reported from Traverse City (36.1%), Jackson (33.6%) Saginaw (32.8%), and Ann Arbor (29.4%). The trend towards heavier rainfall has amplified the risk of flooding across the region (Walsh et al., 2014), but in many urban areas the increased flood risk has been attributed more strongly to changes in land use than changes in climate (Scharffenberg & Fleming, 2006; Changnon et al., 1996).

Extreme Temperatures

The first few decades of the 20th century and the years from 1965-1995 were periods of relatively frequent intense cold waves, while they were infrequent from the 1920s through 1960 and from 1996 to present. Though there have been notable exceptions, extreme heat waves have also occurred less frequently in recent years in comparison to other historical periods (Andresen et al., 2013).

The number of days per year exceeding 90° F and 95° F has not changed significantly for most locations in Michigan. Although some locations have reported declines in the number of days exceeding 90°F, the overall average change was less than 0.1 days per year (see Table 2.6).

Alternatively, heat waves defined by both temperature and humidity driven by weather systems such as air masses have shown a different pattern of change. **The frequency of heat waves defined by the presence of tropical air masses has significantly increased in Southeastern Michigan; while the number of dry, cool days during summer has significantly declined (UCS, 2012).** From 1959 through 2011, Detroit saw slight but statistically significant increases in hot, humid days and hot, dry days. The effect of rising temperatures was more clearly seen in a decline of 10.5 cool, dry days per year during summer months (UCS, 2012).

Drought

As precipitation has increased across the region during the past several decades, the incidence and geographic extent of drought has decreased with time (Mishra et al., 2010). For the agricultural industry, the trend towards a wetter climate and decreasing drought frequency has generally been a positive impact, with relative increases in crop yields due to less moisture stress and more favorable growing conditions overall (Andresen et al., 2001).

Michigan's Weather and Climate Drivers

Weather for the State of Michigan is driven primarily by the characterization of air masses entering the region, large-scale atmospheric oscillations, and local influences from the Great Lakes. Each of these factors acts on different time scales and durations. Short-term weather patterns lasting less than a few weeks are generally driven by the polar jet stream in the winter, spring, and fall. Tropical air masses tend to influence weather in the southern parts of the state to a greater degree during the summer months (Andresen & Winkler, 2009).

Table 2.6: Change in average number of days with extreme heat (>90°F) and extreme cold (< 32° F) temperatures from 1951-1980 to 1981-2010 for 22 Michigan weather observation stations

Weather Station	Days > 90°F	Days < 32°F
Adrian	-2.5	-6.0
Alma	0.1	9.5
Alpena	0.2	-8.5
Ann Arbor	0.5	-2.8
Cheboygan	-0.2	-1.2
Eau Claire	1.5	-11.3
Flint Bishop	1.6	-3.6
Gaylord	-0.6	-3.8
Greenville	-0.7	4.7
Iron Mountain	2.4	-2.6
Ironwood	-0.4	0.9
Jackson	-3.9	-8.2
Lake City	-0.2	-1.1
Marquette	-0.7	-3.4
Muskegon	-0.9	-6.7
Pellston	0.7	-7.2
Port Huron	-0.5	-0.7
Saginaw	-0.4	-3.6
Sault Ste. Marie	0.2	-9.2
Three Rivers	-0.9	-1.1
Traverse City	-0.7	-10.7
West Branch	0.2	3.8
All station average	-0.2	-3.3



Fig. 2.3: Air masses over the United States. Source: www.srh.noaa.gov/jetstream/synoptic/airmass.htm

Three primary air mass types from three source regions dominate the climatic patterns of Michigan (Figure 2.3). Maritime tropical air

masses usually originate from the Gulf of Mexico. Continental polar air masses enter the region from Eastern Canada, and maritime polar air masses come from the Pacific Northwest/Northern Rockies (Shadbolt et al., 2006). In general, the tropical air masses carry more moisture with them than the continental air masses. Occasionally, airflow originates from the East Coast and western Atlantic or the Southwestern United States, but these air masses appear sporadically from year to year and are of lesser importance in the northern parts of the state.

Natural Variations

Natural drivers of weather variability over multi-year periods have far greater impact on the day to day weather Michigan experiences than human-caused climate change. El Niño and La Niña are opposite phases of what is known as the El Niño-Southern Oscillation (ENSO) cycle (Figure 2.4), a scientific term that describes the fluctuations in temperature between the ocean and atmosphere in the east-central Equatorial Pacific. During El Nino events, the Midwest tends to experience weaker winds, fewer storms and milder than average temperatures (Climate Prediction Center, 2005). La Niña events tend to bring either much above or below normal temperatures and enhanced precipitation in the southernmost parts of Michigan. Other large-scale oscillations may modify the magnitude of El Nino/La Nina (Birka et al., 2010, Rogers et al., 2004) and help drive multi-year temperature and ice cover patterns on the Great Lakes. (Wang et al., 2011) As a result, the state and region have experienced periods of intense heat even as long-term average temperatures have risen.

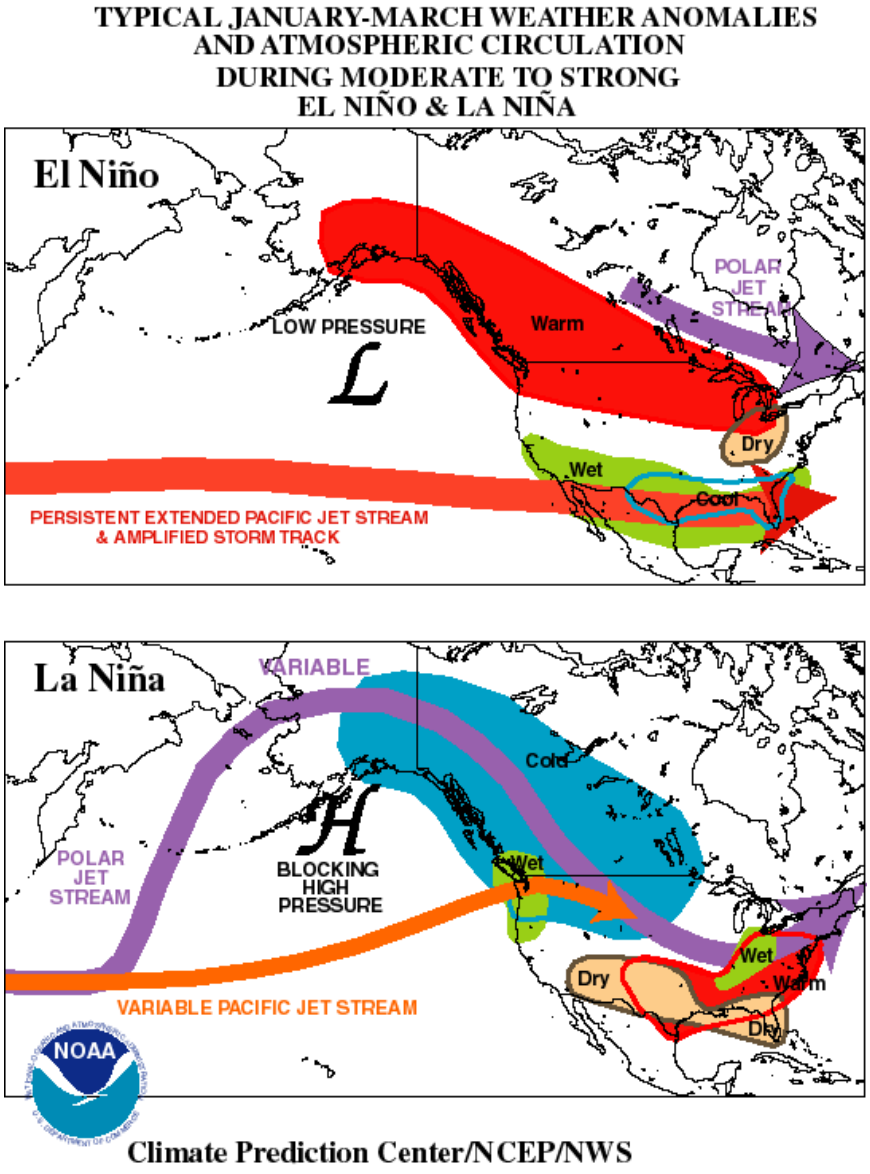


Fig. 2.4: El Nino- and La Nina-induced conditions over the U.S. Image Source: http://www.srh.noaa.gov/jan/?n=el_nino_and_la_nina

Lake Effects

Michigan's location among the Great Lakes has a profound influence on its climate (Scott and Huff 1996). 'Lake effects' in winter result in a cloudier, wetter, and more moderate climate in areas downwind of the Lakes. On average, areas downwind of the lakes receive 75% less solar insolation than

areas upwind of the Lakes at the same latitude, making many parts of Michigan some of the cloudiest areas of the country. During the late spring and summer, lake water temperatures are often cooler than nearby land surfaces, and the lake effect is reversed; cloudiness is suppressed over and immediately downwind of the lakes (Andresen & Winkler, 2009).

Air temperatures are also modified by the Lakes. Winters in lake effect zones are mildly warmer and summers are mildly cooler than areas further inland. **Estimated winter maximum and minimum temperatures downwind of the Lakes are both approximately 6% warmer than locations upwind of the Lakes. Summer maximum temperatures on the downwind side are 3% cooler than in upwind areas, and summer minimum temperatures are 2% cooler** (Changnon & Jones, 1972). The Lakes moderate extreme minimum temperatures more noticeably. Extreme minimum temperatures within 30 miles of the shores of the Great Lakes are as much as 20^0 F warmer than inland temperatures at the same latitude. Extreme minimum temperatures in the summer season experience less of an impact, but are still as much as 14^0 F cooler than those at inland locations (Eichenlaub et al., 1990).

Perhaps the most significant influences the Lakes have on the regional climate are altered precipitation patterns. Lake effect snowfall strongly amplifies the seasonal snowfall totals of areas within approximately 150 miles of the downwind shores of the Lakes (Norton & Bolsenga, 1993). Sections of Michigan affected by lake-effect snow are the western portion of the L.P. and the northern edge of the U.P. as illustrated in Figure 2.5. **An estimated 25-50% of annual snowfall totals along the eastern shores of Lake Michigan are attributed to lake-effect snowfall** (Braham & Dungey, 1984).

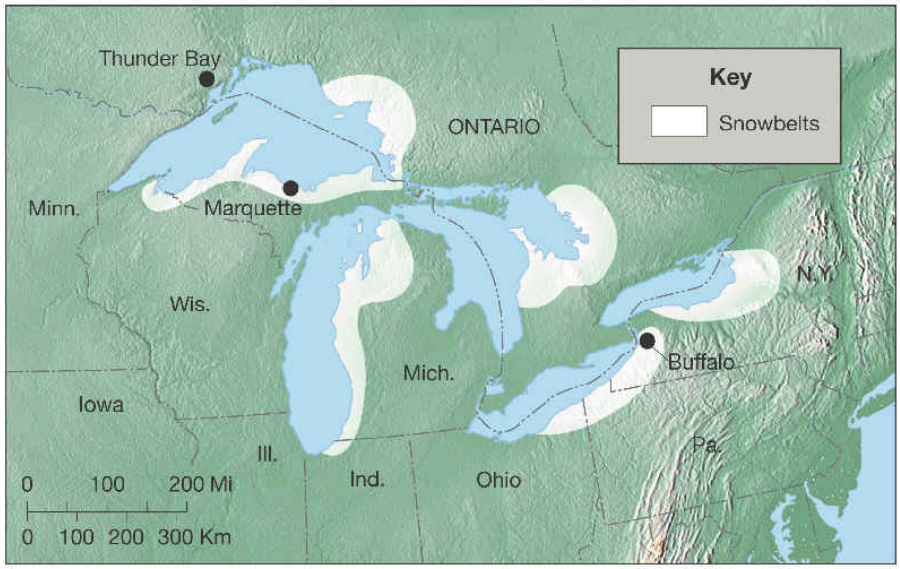


Fig. 2.5: Approximate extent of major lake-effect snow belts in the Great Lakes region. To read more about lake-effect snow please visit: http://glisa.umich.edu/resources/lake-effect-snow-great-lakes-region

Recent and future changes of Michigan's climate are in part related to how the physical drivers are changing in response to increasing CO_2. One of the greatest changes, as mentioned above, is how quickly the Great Lakes are warming and the subsequent impact on local weather patterns. In the next section we focus on information about future climate for Michigan based primarily on climate model data.

Summary of Climate Projections: Description and Rationale

Climate projections for Michigan highlighted in this report are taken from several sources to best represent the overall consensus of the future climate of the region. There are many variations in the design of individual climate models, and no single model performs the best at simulating all aspects of future climate. For this reason, *ensembles* (groups of models) with different strengths are used to identify consistent trends in future projections; this is the approach used for the National Climate

Assessment Midwest Report (Pryor et al., 2014). A summary of projected temperature and precipitation changes are presented in Tables 2.7 and 2.8, respectively, in the Appendix of this chapter.

Defining Global and Downscaled Models

Climate models use quantitative methods to simulate the interactions of the atmosphere, oceans, land surface, and ice. They are used for a variety of purposes from study of the dynamics of the climate system to projections of future climate.

Global climate models (GCMs)

These types of models are designed to project changes in climate at a global or continental scale. While the most prominent model ensembles in use offer a robust simulation of the climate and provide a sound range of projections in broad brush strokes, they generate output at a coarse resolution. In many cases, 4-6 output grids cover an area roughly the size of the state of Michigan. This resolution is too coarse to distinguish climate differences between two nearby cities, for example. The smallest appropriate spatial scale for the use of GCM simulations is at the U.S. Climate Division boundaries. For Michigan, this equates to areas of 5-10 counties each.

Downscaled Regional Climate Models

In comparison to GCMs, downscaled models attempt to identify trends in climate at a finer, more tangible resolution than what GCMs are able to provide. Output data are usually arranged in grids at roughly the size of large Michigan counties. There are tradeoffs to using downscaled data, however. Downscaled models may more accurately simulate smaller-scale weather systems, extreme events, and the effects of local topography on climate, but downscaled models still rely on global climate models to provide input from a global perspective, and these global inputs are downscaled over the region of interest. This process introduces an additional layer of uncertainty by requiring additional statistical observations and assumptions of local weather patterns, land cover, and geography. Downscaled models therefore depend on both the accuracy of the global climate simulation they are derived from, and the accuracy of other observations and assumptions used to downscale the global outputs to a finer scale. At a given location a downscaled model output may provide more accurate projections, but may also increase the margin of error when compared to global climate model outputs over the same area. Data downscaled or simulated at higher resolution does not necessarily imply a better representation of climate. An evaluation of the quality of information coming from each model product used in this report is discussed below.

Emissions Scenarios

Emissions scenarios are sets of assumptions based on the future rate of greenhouse gas emissions, human interaction with their environment, technological advancement, and population growth. They provide logical, quantitative pathways that describe how climate may change in the future.

The IPCC 4th Assessment Report (IPCC 2007) and the Third National Climate Assessment (Walsh et al.,. 2014) are based in part on widely-used, heavily scrutinized emissions scenarios. Of these scenarios some are more practical for describing plausible future conditions. The A2 scenario, sometimes referred to as a "high scenario," or “business-as-usual scenario," assumes greenhouse gas concentrations will continue to increase throughout the 21st century. The B1 scenario, sometimes referred to as a "low scenario," consists of relatively slight increases in greenhouse gases throughout the 21st century. This report focuses primarily on the higher scenario (A2), since it has been the best

indicator of greenhouse gas emissions during the recent past and atmospheric carbon dioxide trends continue to increase.

Future Timeframe Considered

Future projections are available for different 30-year periods out to the year 2100, and we focus on the most recent period (2021-2050) for which information is available, since most public health and community planning occurs over short time frames. Mid- and late-century period projections (2041-2070 and 2070-2099, respectively) are also common, and we bring in relevant information from them when earlier data are not available.

Climate projections used in this Climate and Health Profile Report

All of the climate projection products described here rely on information from the Climate Model Inter-comparison Project phase 3 (CMIP3) global climate models (Meehl et al., 2007). Statistically downscaled climate model projections were generated based on CMIP3 simulations to which are added regional observations and assumptions to create higher spatial resolution information. The North American Regional Climate Change Assessment Program (NARCCAP) dynamically-downscaled simulations use regional climate models (RCMs) that operate at higher spatial resolutions, but still require input from global climate models regarding changing conditions outside the region of interest. As stated below, there are tradeoffs with each approach regarding the quality of the model information versus the spatial scale.

Quality of Climate Projections

Before presenting the results of each set of climate projections, consider the quality of the information coming from each source. GLISA has extensively studied the CMIP3 GCMs for the Great Lakes region to better understand uncertainties coming from the models. Their findings for the Great Lakes region can be applied directly to the State of Michigan. One of the largest sources of uncertainty in the models is their poor representation of the Great Lakes. The low spatial resolution of GCMs does not allow them to accurately capture the spatial structure of the Great Lakes. Some of the GCMs use one body of water to represent all of the Great Lakes, or a swamp or moist soil classification to represent the land surface where the lakes would normally reside, and very few GCMs include any form of simulation of the lakes and their dynamics. A major consequence of the poor representation of the lakes in the climate models is that the lakes' influence on local and regional climate is not realistically simulated. The lakes are known to modify local and regional air temperatures and precipitation patterns and intensities. Lakeshore air temperatures are modified by the relative cool or warm influences of the Great Lakes. Lake water temperatures change more slowly than air temperatures, so relatively warm waters in winter increases local air temperatures, and relatively cool waters in summer decreases local air temperatures. Lakeshore precipitation effects are generally experienced on the downwind sides of the lakes. One of the most well-known lake-weather impacts is lake-effect snowfall. In Michigan, the greatest lake-effect precipitation occurs to the east of Lake Michigan and the southern shore of Lake Superior (see Figure 2.5). Lake-effect zones start at the lakeshore and extend inland about 50 miles and sometimes farther. Lake-effect precipitation is simply not detectable in GCMs because the model resolution is too coarse. At best, a GCM may be able to capture the large-scale regional effects of the lakes, such as a large reduction in precipitation over and around Lake Superior in the summertime. For a more in-depth discussion on these effects in Michigan, refer to the ***Lake Effects*** section above.

Even at higher spatial resolutions, the statistically-downscaled projections have the same lake-climate issues, because downscaling does not improve the physical representation of the lakes. Dynamically-

downscaled models may capture lake-effects since their simulations are performed at higher spatial resolutions, but even the NARCCAP simulations have caveats for the Great Lakes region. Lake temperatures are not well simulated in several of the NARCCAP RCMs, which negatively affects the simulation of lake-weather processes. Some RCMs assign the same temperature of the air to the lake surface, which is not realistic at most times and prevents the lake from modifying local air temperatures and precipitation in these models. Even RCMs that model lake surface temperatures do not include the impact of lake ice formation, a drawback since lake ice plays a major role in winter and early spring by suppressing lake-effects when ice completely covers the lakes.

Given the limitations and caveats in each set of climate projections for the Great Lakes region, there is little evidence that climate projections are taking into account the interaction of the lakes with local and regional weather. **The projections should be considered only one piece of information about future climate that fits into a larger context of: 1) how climate has already changed based on observations, and 2) what we know from expert knowledge and local/regional future climate research.**

The next sections discuss the climate parameters that were studied from the projections and the information that the models provide about how those parameters may change in the future. The last section integrates the information about the quality of the projections with the projections for each parameter to provide a more robust description of future climate for Michigan.

Summary of Climate Projections: Spatial and Temporal

This analysis starts by summarizing annual and seasonal trends for the most common climate parameters: mean temperature and precipitation. Additional parameters identified as highly valuable for the health sector include: heat events, extreme precipitation events, humidity levels, air stagnation events, snowfall, and wind patterns. Although each of these parameters will be discussed in the following section, the certainty surrounding each parameter is variable. Mean temperature is the most robust simulation in the climate models, and parameters related to precipitation and winds are more uncertain, because the models have greater difficulty simulating those variables. Each of these parameters, and combinations of parameters, contribute to increased risk of respiratory diseases, heat-related morbidity and mortality, CO poisoning, waterborne toxins, and vector-borne diseases.

The future state of Michigan's climate depends on many factors. Climate models incorporate information related to human activities and natural events that can cause changes to the climate. The primary mechanism for representing human-induced climate forcing in climate models is through the concentration of greenhouse gases and aerosols present in the atmosphere. For example, if fossil fuel based energy usage increases in the future, there will be greater concentrations of carbon dioxide in the atmosphere. Climate models are run under different scenarios for future greenhouse gas concentrations, and as previously mentioned, this report uses the highest emissions scenario A2 since this is the current measured trajectory. Choice of emission scenario is less critical for near-term climate simulations, so there is not a lot of added uncertainty from choosing the high scenario for this analysis.

Land use change is another human-induced factor that can greatly alter local and regional climate, but land use-related climate changes are often not captured well, if at all, in many climate models. Land use changes should be considered in addition to climate model projections.

Climate models do simulate non-human causes of climate change such as releases of greenhouse gases and aerosols from volcanic eruptions. However, atmospheric concentrations of these constituents have increased beyond the natural historical range as a result of human activities (IPCC, 2007). The human component of climate change, whether through release of greenhouse gases or through land use changes, is the primary driver of recent climate changes and it will likely continue to play a major role in the future.

One of the largest regional factors affected by climate change that will impact Michigan's climate is the response of the Great Lakes to warming temperatures. The Great Lakes are a major mechanism for modifying Michigan's climate, and warming air temperatures are changing the dynamics of the Lakes and how they interact with regional weather systems. One example of observed change is the trend of reduced lake ice during winter that allows the Lakes to continue interacting with the atmosphere by providing heat and moisture to fuel weather systems. The climate projections do not realistically capture the Lakes to show these relationships, so information about the Lakes' impact on climate is missing from the projections. Regional climate modeling studies are useful for filling the information gap that is present in the global climate models.

Although climate projections do not provide a complete and certain picture of future climate, they can provide a general foundation of information to build on and be further supplemented by expert guidance. Several sources of climate projections were consulted for the description of Michigan's future climate, but the CMIP3 GCMs are most important since they provide the foundational information for all of the other products used for this report.

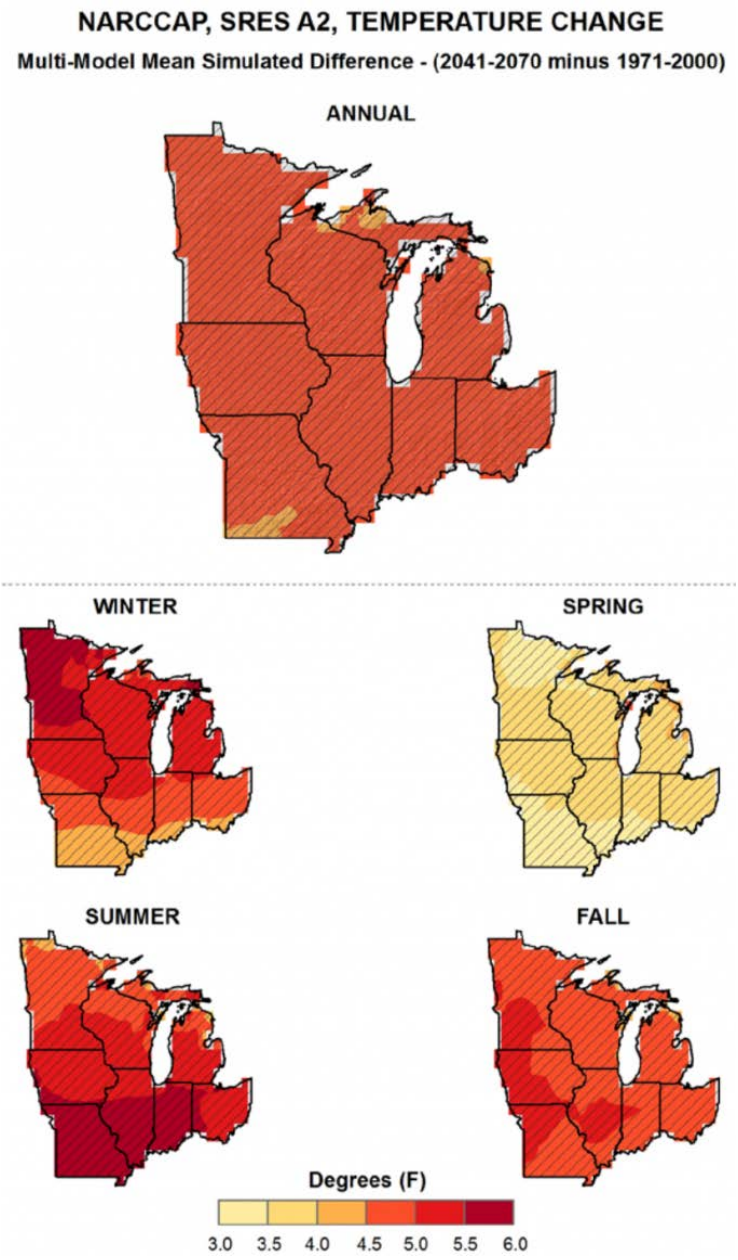


Fig. 2.6: Projected annual and seasonal temperature changes (degrees F) averaged from the NARCCAP models. Winter temperatures are projected to increase the most in the north and summer temperatures are projected to increase the most in the south. Spring is projected to have the smallest increases. Hatching (areas with slanted lines) indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source: Kunkel et al., 2013.

Temperature Projections

All projections show a consistent message of increasing average temperatures (Figure 2.6), but **there is variability in the magnitude of increase ranging from about 1.5 to 4.5º F by 2050. In the near term, temperature changes will be closer to the lower bound of the range.** Although the projections agree

that temperatures will increase on average, there is some uncertainty in the degree of warming for seasonal projections.

The global climate models show each season's temperature increasing by approximately the same amount with similar ranges of variability among individual models. **The NARCCAP models simulate twice as much warming in the winter and summer (6^0 F) compared to spring (3^0 F) across Michigan by mid-century, contrasting the downscaled CMIP3 projections by Hayhoe et al. (2010) that found larger increases in winter compared to spring and summer in the near-term and a reversal in the seasonal temperature trend by the end of the century.** Differences between each set of seasonal projections emphasize the uncertainty in relative seasonal temperature increases, but there is consistent evidence to suggest warmer temperatures during all seasons in the future.

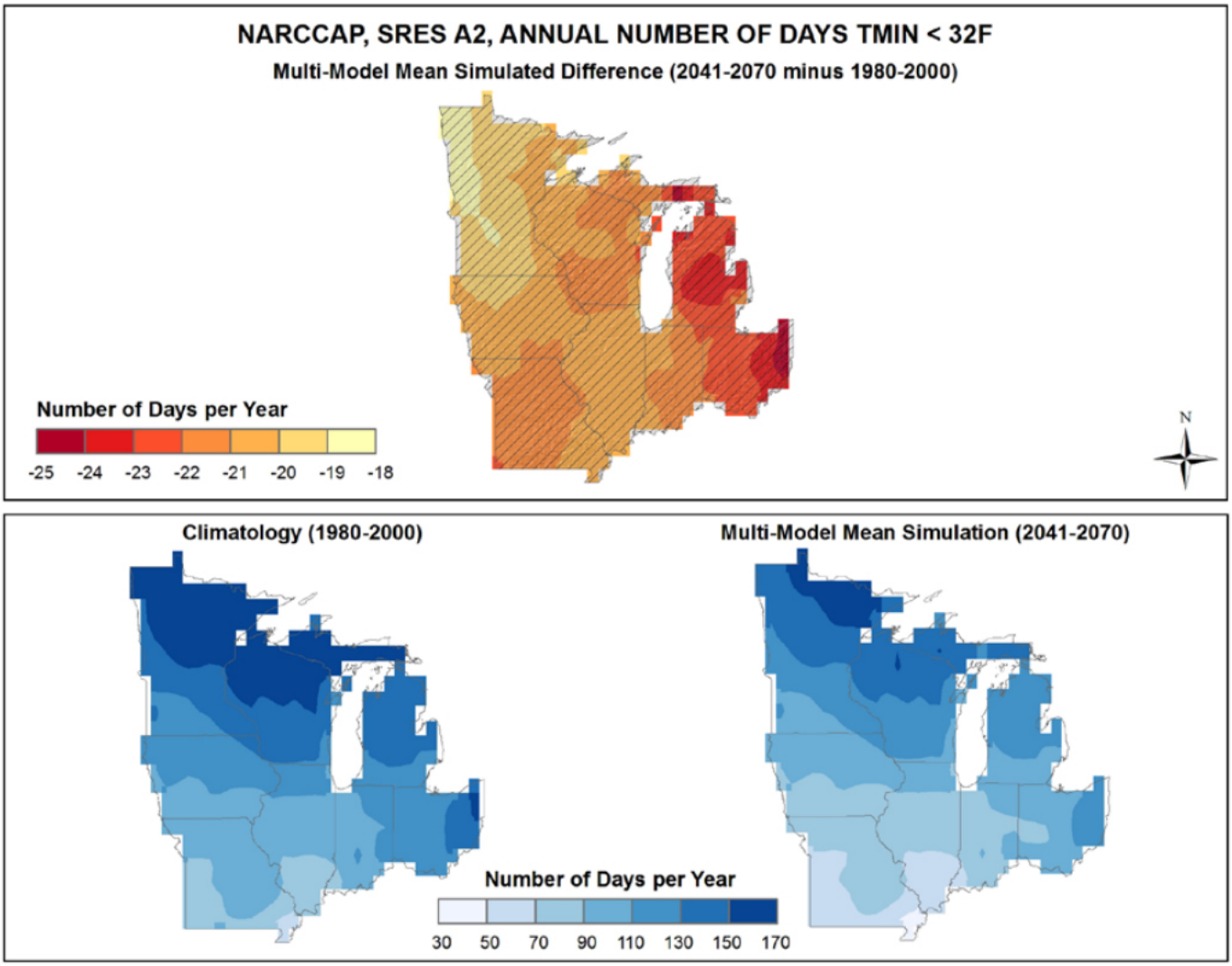


Fig. 2.7: Projected change in annual number of days falling below 32^0 F averaged from the NARCCAP models. The average number of cold days is projected to decrease across Michigan by 20-25 days per year. Observed values are shown in the lower left. Simulated values are shown in the lower right. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source: Kunkel et al., 2013.

Average temperatures are warming and **there are fewer below-freezing cold days (Figure 2.7) expected across Michigan by 20 days or more per year**, with the greatest decrease in central areas of the Lower Peninsula.

Days with maximum temperatures above 95^0 F (Figure 2.8) are projected to increase by five to 25 days, but most of the projections are for the lower bound of that range. In Michigan, the greatest increases for days above 95^0 F are in the southern half of the L.P., and the U.P. ranges from no change to a few additional days above 95^0 F per year.

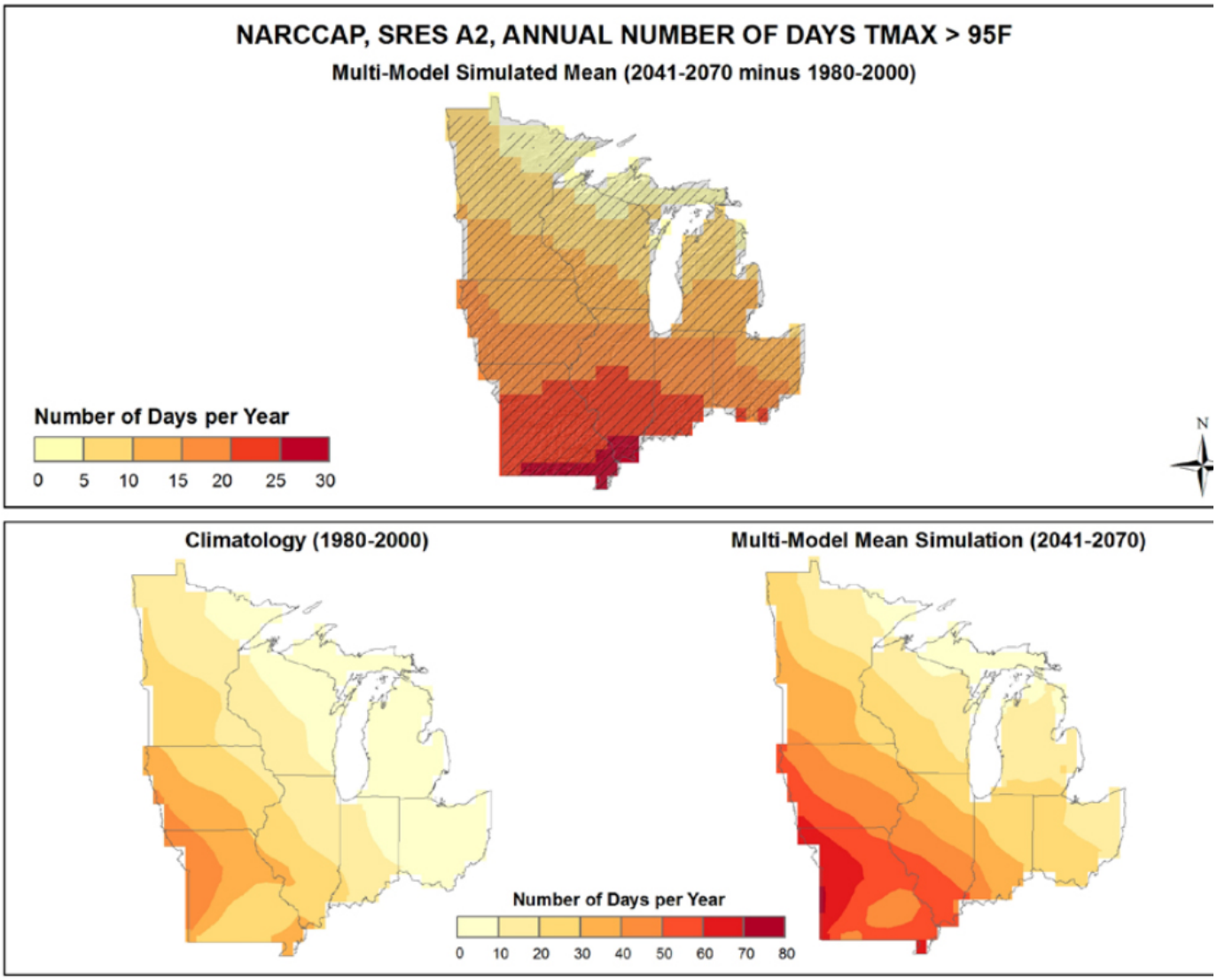


Fig. 2.8: Projected annual number of days exceeding 95^0 F averaged from the NARCCAP models. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source: Kunkel et al., 2013.

Projections indicate that 'heat waves', consecutive days with maximum temperatures over 95^0 F (Figure 2.9) will remain the same or increase by a few days across the state of Michigan. Summer heat index values are projected to increase, leading to increased heat stress, but most of the changes are related to increased humidity as opposed to increased temperatures.

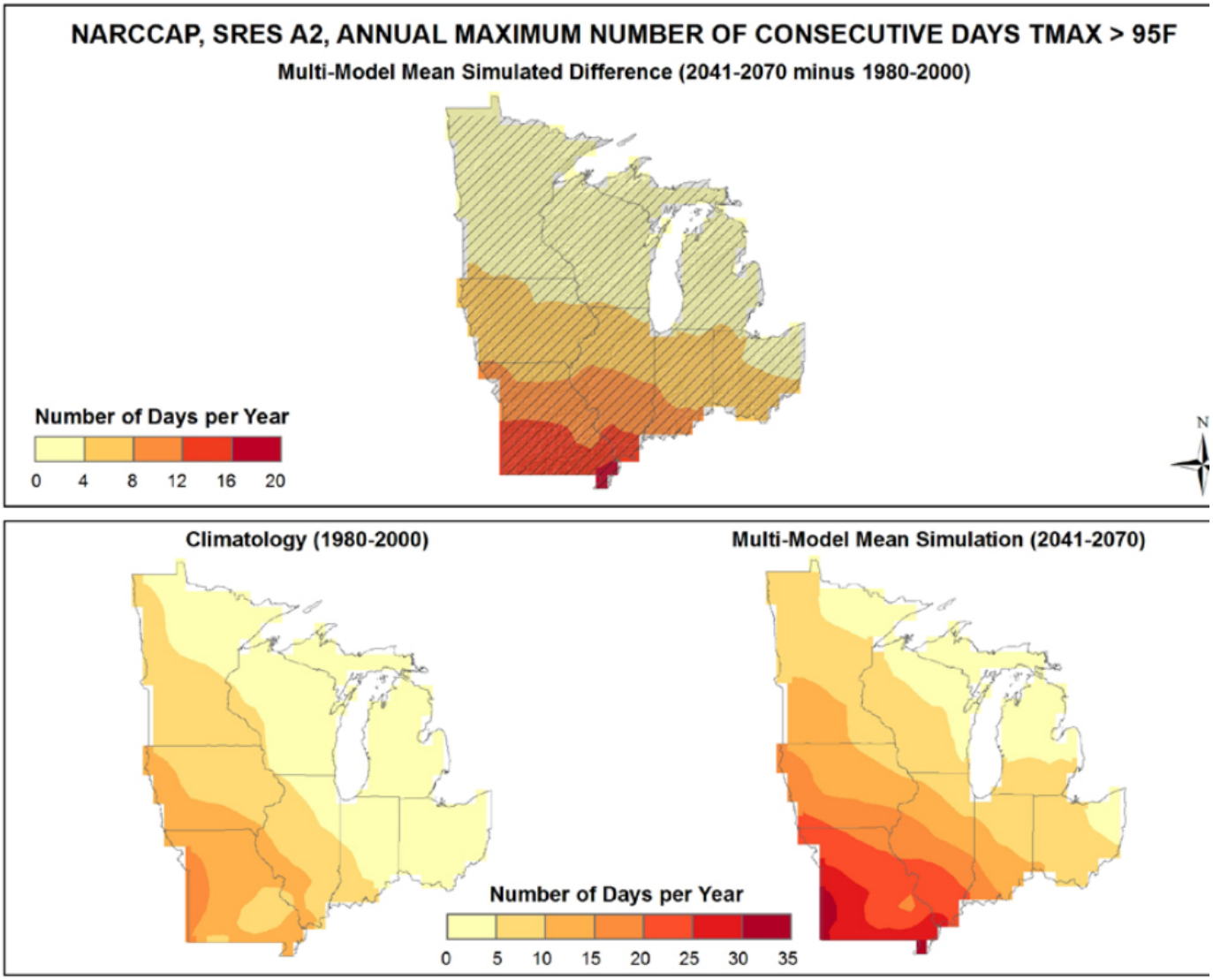


Fig. 2.9: Projected annual number of consecutive hot days exceeding 95^0 F averaged from the NARCCAP models. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source Kunkel et al., 2013.

As the number of days below freezing decrease, **the freeze-free growing season (Figure 2.10) is expected to increase by up to three weeks by mid-century.** Projected increases in the freeze-free season are not necessarily in locations where the historical freeze-free season has been longest. For example, the easternmost part of the U.P. has historically had a longer freeze-free period than the western U.P., but projections indicate that the western freeze-free season will increase by more days than in the east (Figure 9). On average, the last spring freeze is expected to occur about a week earlier by mid-century.

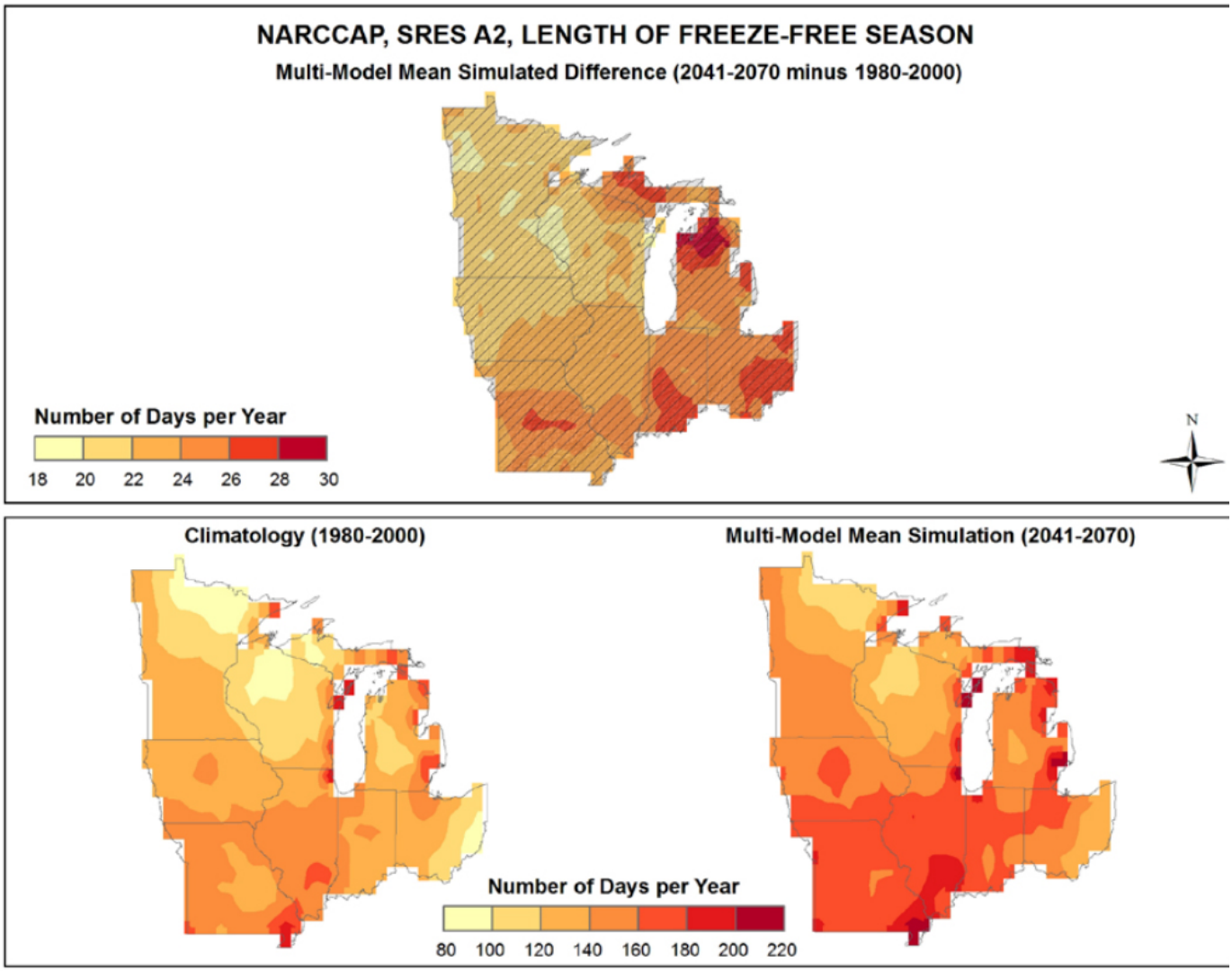


Fig. 2.10: Projected change in the number of days in the freeze-free season (top), and observed (bottom left) and simulated (bottom right) freeze-free days per year. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source: Kunkel et al., 2013.

Precipitation Projections

In the near-term, precipitation changes are not statistically significant across most of the collective Midwest. For Michigan however, projections are more consistent with the majority of models agreeing that annual mean precipitation will increase (Figure 2.11). **Most of Michigan is projected to experience increases of 3-6% in annual mean precipitation, with slightly less in the southernmost part of the state.** Michigan's annual precipitation pattern is projected to show greater increases moving from the southeast to the northwest, but there is a small region in southwest Michigan near Lake Michigan that is projected to experience the greatest rate of increase from the present.

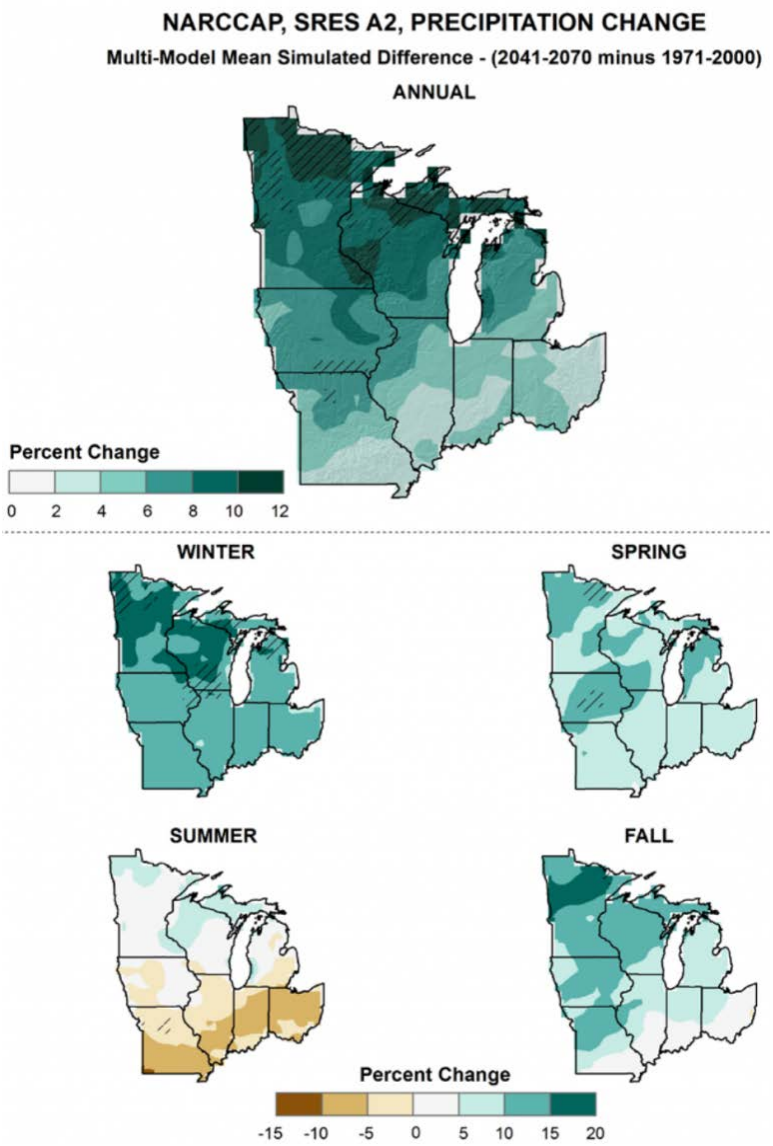


Fig. 2.11: Projected annual and seasonal precipitation changes (%) averaged from the NARCCAP models. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. In Michigan, the models are in the greatest agreement during winter in the north. Image Source: Kunkel et al., 2013.

Seasonal projections consistently show summer months having the greatest uncertainty, since the average change is near zero but the models range from about -10 to +10% change in precipitation. **Summer and fall precipitation projections indicate the greatest potential for decreasing trends. Summer is also when the pattern of change across the state is the most variable**: In summer, the U.P. has increases in precipitation while the Lower Peninsula has a small region of increase in the southwest along Lake Michigan and decreases in the southeast. Most of the L.P.'s spatial distribution of changing summer precipitation patterns is uncertain since some individual models show positive changes and others, negative changes. **Winter precipitation is consistently projected to increase in the Upper Peninsula among many different models, and more of that precipitation is expected to fall as rain or freezing rain.** Although seasonal averages (except for summer) indicate positive changes across the Midwest, the majority of models do not agree on the sign of precipitation change at any given location.

Projecting extreme precipitation events (i.e. daily precipitation totals that exceed 1 inch) is more challenging than annual or seasonal projections, because the models do not simulate the intensity of events well. In Michigan **the majority of models agree that the annual number of days with greater than one inch of precipitation (Figure 2.12) will increase by about 10% in the south and up to 40% in the north by mid-century.** The Wisconsin Climate Change Initiative's (WICCI) downscaled climate projections for Michigan further indicates that the more intense extreme precipitation events (those producing greater than 2 inches of rain) are projected to increase in frequency by a greater degree than those extreme events producing 1 – 2 inches (Saunders, Easley, Mezger, Findlay, & Spencer, 2014). One study indicated that intense precipitation events will stay the same or increase regardless of changes in annual precipitation.

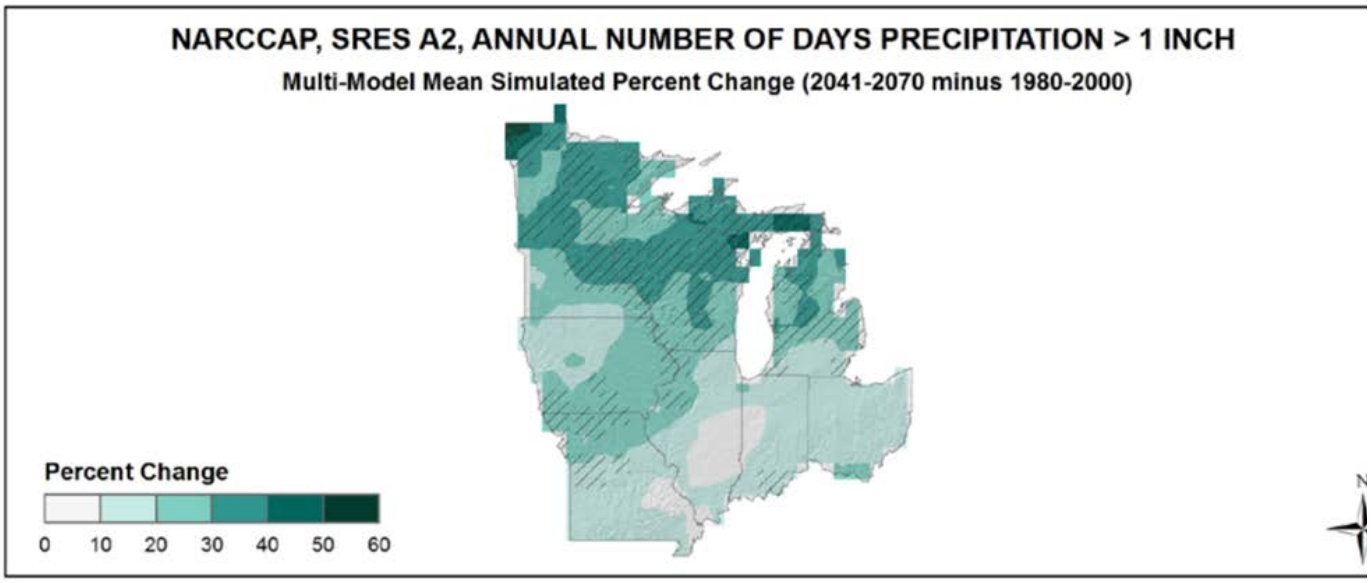


Fig. 2.12: Projected annual number of days with more than 1" of precipitation averaged from the NARCCAP models. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source Kunkel et al., 2013.

Drought conditions are estimated by projecting the number of consecutive 'dry' days with <3mm (0.01 in) precipitation. **The maximum number of consecutive 'dry' days (Figure 2.13) is projected to decrease in the Upper Peninsula, but the Lower Peninsula shows both increases and decreases.** There are no available projections on the timing of when these extreme events may occur.

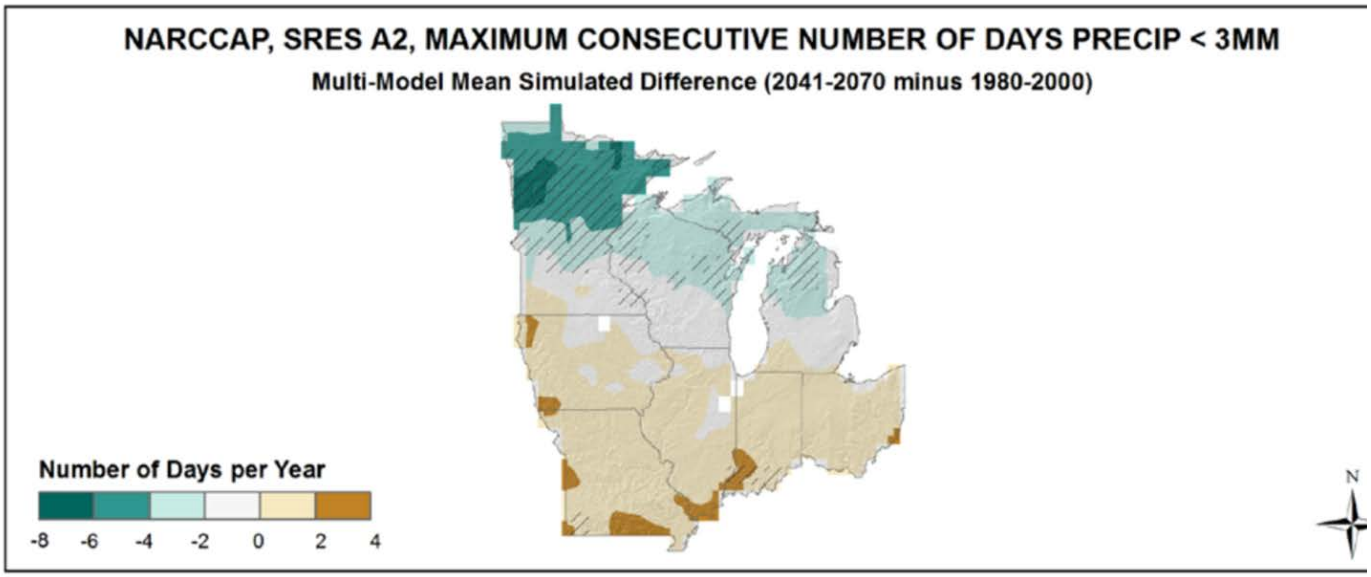


Fig. 2.13: Projected annual number of days with less than 3mm (0.1 in.) of precipitation averaged from the NARCCAP models. Hatching indicates that more than 50% of models show statistically significant changes and more than 67% agree on the sign of the change. Image Source: Kunkel et al., 2013.

Appendix

Table 2.7: Temperature Projection Summary for Michigan

Climate Parameter	Summary
Annual Mean Temperature	All projections show an increase in annual mean temperatures with greater increases farther into the future. Models range between increases of 1.5 to 4.5 degrees F by 2050. Annual changes are consistent across the Midwest.
Seasonal Mean Temperature	All seasons are expected to have increasing temperature, however, there is uncertainty as to which (if any) season(s) will warm more than the others. The downscaled models agree that summer warming will be greatest in the south and winter warming will be greatest in the north. The growing season is projected to increase up to three weeks by mid-century and the last spring freeze is projected to occur one week earlier.
Extreme Temperatures	There will be several fewer days with below freezing temperatures and a few more days above 95^0 F. Consecutive days above 95^0 F may increase by a few days in MI.

Table 2.8: Precipitation Projection Summary for Michigan

Climate Parameter	Summary
Annual Mean Precipitation	The amount of mean annual precipitation is expected to increase by 3-6% with slightly less in southern Michigan.
Seasonal Mean Precipitation	Winter precipitation is projected to increase in the Upper Peninsula with more precipitation falling as rain or freezing rain. Spring precipitation is projected to increase in most of the models; however, there is greater uncertainty at any given location. Summer and fall are when individual models show both strong negative and positive changes, so uncertainty is high.
Extreme Precipitation Events	There is great uncertainty in extreme precipitation projections, but intense precipitation events are projected to stay the same or increase, and consecutive days with very little precipitation are expected to decrease in the Upper Peninsula.

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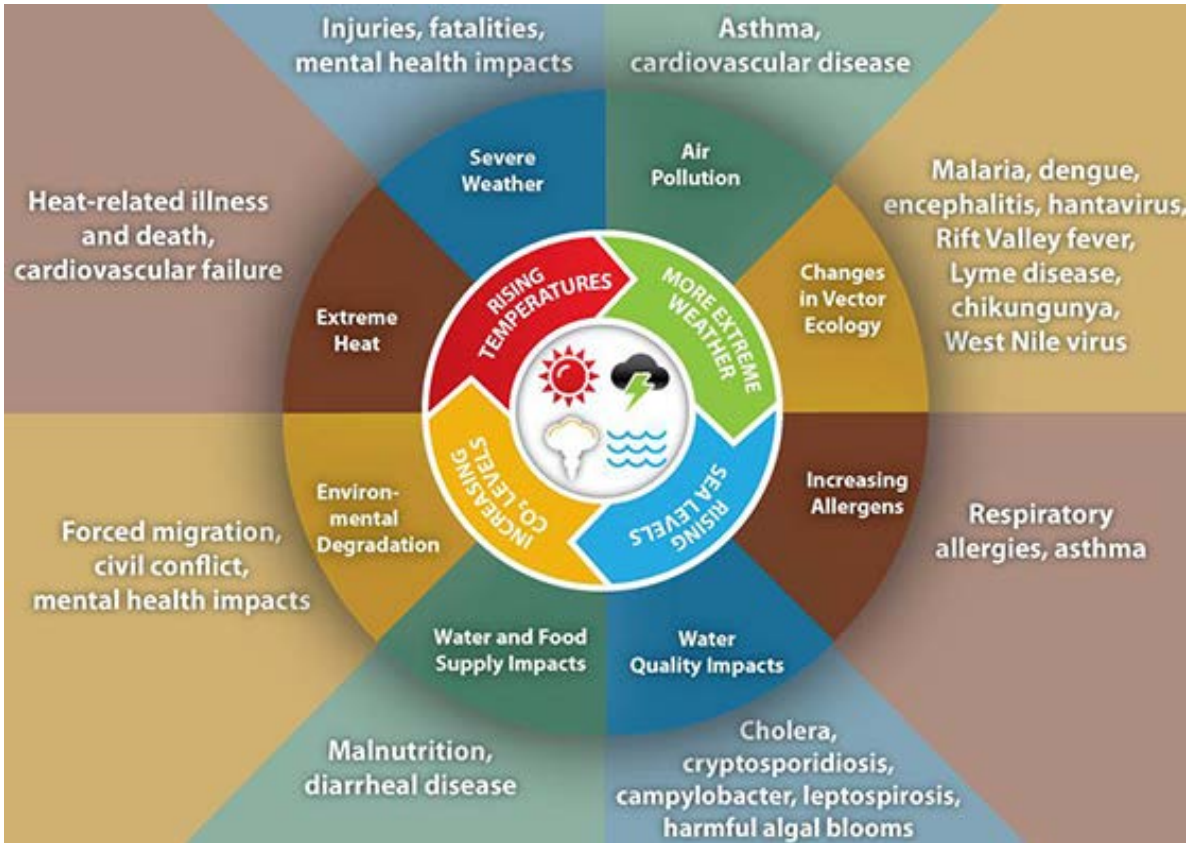
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III. Linking Climate Changes to Health Outcomes



Source: Centers for Disease Control and Prevention, http://www.cdc.gov/climateandhealth/effects/default.htm

"Many of the conceptual pathways using changing climate as an exposure have similar human health outcomes, but the route in which these exposures cause disease, both directly and indirectly, is varied and affect many natural and built environments (pg. 60)."

Introduction

This section reviews current knowledge regarding three key conceptual pathways that describe how climate impacts health, focusing on the key health outcomes for Michigan resulting from potential climate changes as identified in Chapter II. These three pathways - heat, precipitation, and extreme weather - model how exposure to a weather event can directly impact human health outcomes, and also how the relationship can be indirect, as when a weather event changes aspects of an environmental exposure which then impacts human health outcomes. For example, increasing heat (weather event) may lead to plant stress and less environmental green space (a change in the exposure environment). Less green space can then lead to elevated incidence of heat stress (health outcome) in an area. This review includes the range of anticipated health effects (mild, moderate, severe) resulting from the anticipated change in the weather event, as well as statistics on the current population rates, counts and trends for key health outcomes in Michigan. Finally, the data sources for monitoring both the key health outcomes and related exposures are summarized.

Climate Related Health Impact Pathway Descriptions

Heat Pathway

As described in Chapter II, Michigan is projected to become warmer over the next century. While this trend may represent a decrease in cold related morbidity and mortality, these reductions are not expected to offset the increase in heat related morbidity and mortality resulting from the projected increase in frequency and duration of extreme heat events (Hayhoe et al., 2010; Luber et al., 2014). During the July 2012 heat wave, for example, air temperatures were 102^0 F and 104^0 F in Grand Rapids and Detroit, respectively, and sustained above 90^0 F for several days (Evans, 2012). The heat wave also contributed to the record breaking 2012 North American drought, which impacted large areas of southeast Michigan (Andresen, 2012). Rising temperatures resulting in extreme heat events can directly and indirectly influence several health outcomes in Michigan residents as shown in Figure 3.1.

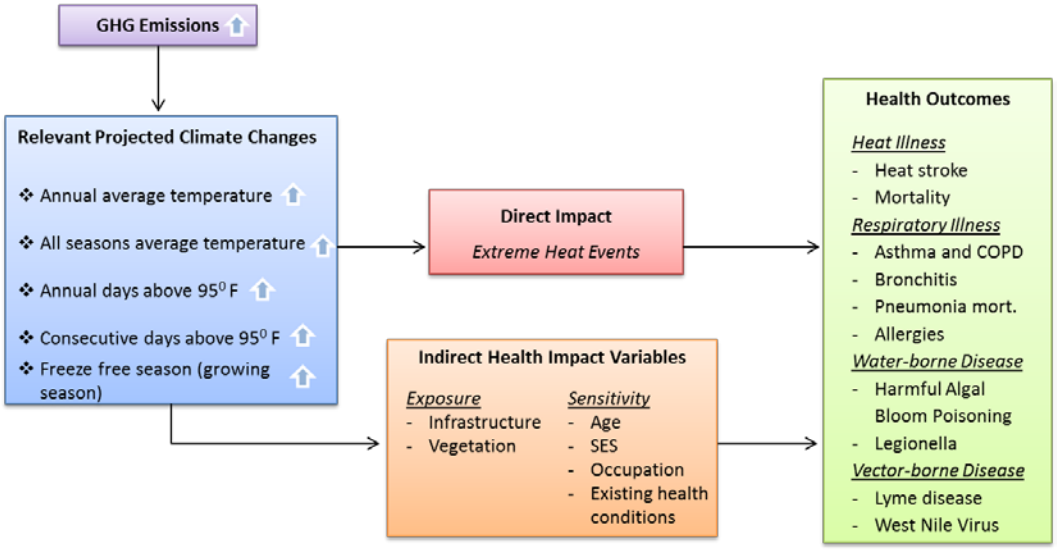


Fig. 3.1: Extreme heat related direct and indirect conceptual human health impact pathway based on climate changes resulting from increased Greenhouse Gas Emissions (GHG).

Heat Illness

Heat waves have several direct effects on health. Extreme heat events have been linked to increased all-cause mortality (Basu, 2009; Curriero et al., 2002). Individuals with pre-existing conditions including chronic obstructive pulmonary disease (COPD), congestive heart failure, myocardial infarction or diabetes are at increased risk of mortality during extreme heat events (Zanobetti et al., 2012). Increased hospitalization rates for respiratory and cardiovascular diseases can also occur as a consequence of extreme heat exposure (Ostro et al., 2009). Heat stress occurs when the body's means of controlling internal temperature starts to fail and can lead to a number of adverse health outcomes, resulting in illness, hospitalization, and even death (Luber et al., 2014).

Adverse health outcomes directly related to heat stress range from mild (heat cramps, heat edema, heat rash) to moderate (heat exhaustion, heat syncope characterized by dizziness and fainting) to severe heat stroke (body temperature of 104^0 F or higher and complete or partial loss of consciousness), hyperpyrexia (elevated body temperature) and death (CDC, 2014). These severe outcomes can result in damage to the brain, kidneys and heart and may require hospitalization (Mastrangelo et al., 2007).

Indirectly, prolonged periods of high temperatures can have adverse effects on plant life reducing green space and tree canopy coverage. In urban environments a lack of green space exacerbates the existing urban heat island effect, which has been reported to increase the detrimental effects of heat on health outcomes (Akbari et al., 1997).

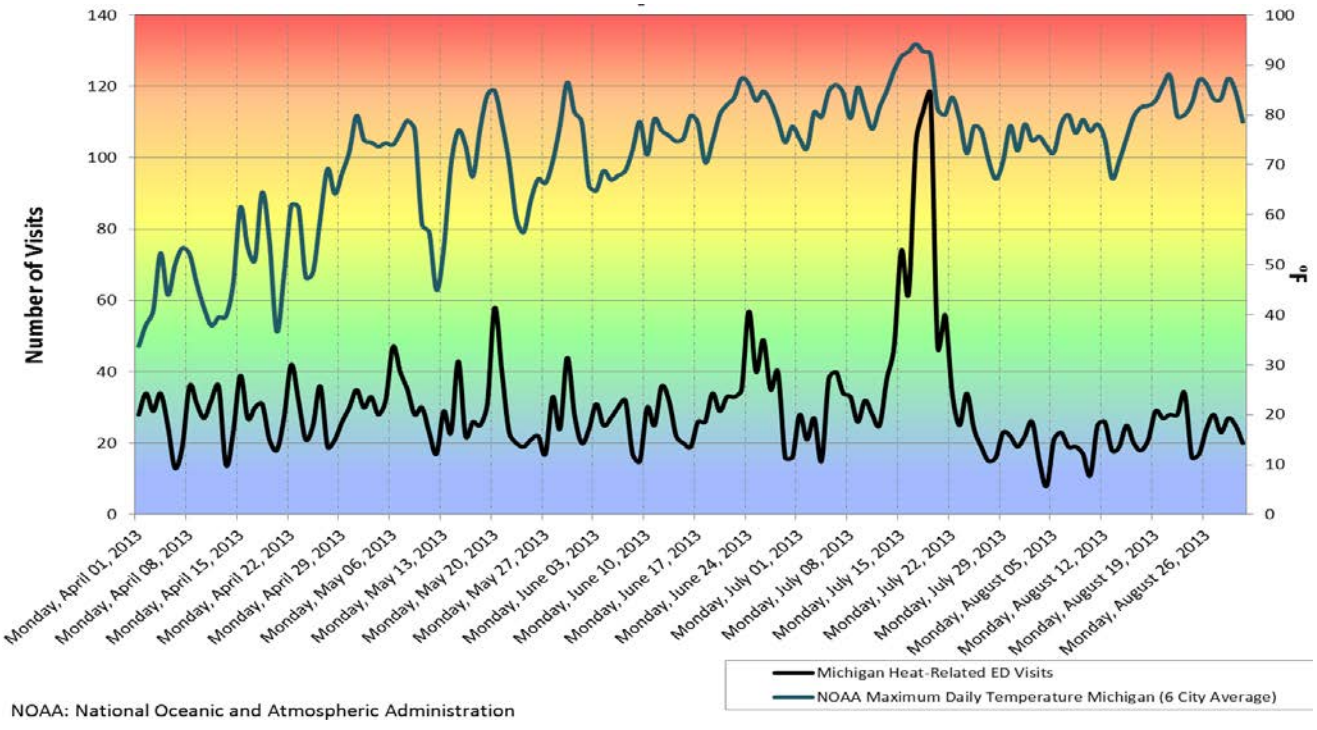


Fig. 3.2: Statewide Heat-Related ED Visits as reported to the Michigan Syndromic Surveillance System and National Oceanic and Atmospheric Administration (NOAA) Maximum Daily Temperature Averages for 6 Select Cities (April 1 – August 31, 2013) (Mamou et al., 2013)

Heat-related hospitalizations are monitored as one indicator of potential climate change related health effects among Michigan residents (Cameron et al., 2013). Since 2001, rates have varied from <1 per 100,000 in 2004 and 2009 to over 4 per 100,000 in 2011 and 2012 (Cameron et al., 2013). Figure 3.2 shows the relationship between rising temperatures and emergency department visits during the summer of 2013.

Respiratory disease and heat

Climate change can affect respiratory diseases as air quality is impacted by changes in temperature and wind patterns. For Michigan the most concerning of those includes increased concentrations of ground level ozone, particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), other fine particles, and the production of aeroallergens such as pollen and mold spores (Kinney, 2008; Irfan, 2012). Ozone production is directly related to temperature, while the relationship of particulate matter to future climate is more variable and depends on the frequency of stagnant air episodes, wildfires, precipitation and volatile emissions, as well as future energy demands (EPA 2009).

Air pollution exposure has been associated with a variety of health effects, such as respiratory diseases (including asthma and changes in lung function), cardiovascular diseases, adverse pregnancy outcomes (such as preterm birth), lung cancer and increased mortality (NIEHS 2015). Acute ground-level ozone exposure is linked to childhood Respiratory disease, exacerbations of asthma and, more specifically, increased emergency department visits for asthma (reviewed in Sheffield et al., 2011). For example, during the Atlanta Olympics in 1996 when peak daily ozone dropped by 28%, there was an 11% reduction in pediatric emergency department visits for asthma and an over 40% reduction in acute care asthma events (Friedman et al., 2001). The severity of health outcomes ranges from coughing and throat irritation (mild) to chest tightness, wheezing, or shortness of breath (moderate) to asthma attacks, resulting in emergency department visits, hospitalization or even death (severe).

$PM_{2.5}$ was estimated to cause approximately 7 million premature deaths in 2012, making it the 13th leading cause of mortality worldwide (WHO, 2014). $PM_{2.5}$ causes worsening respiratory symptoms (mild), more frequent medication use, decreased lung function (moderate), recurrent health care utilization and increased mortality (severe) (Anderson et al., 2012; Delfino et al., 2008; Barnett et al., 2005). More specifically, higher ambient levels of $PM_{2.5}$ are associated with worsening symptoms and lower lung function in adults with asthma (Balmes et al., 2014). The $PM_{2.5}$ health impacts are generally considered to be greater than those from the larger PM particles and are associated with increased risk of several asthma outcomes, cardiovascular disease mortality and hospitalizations, and cerebrovascular disease (McConnell et al., 2003; Brunekreef et al., 2009; Chen et al., 2008; Shah et al., 2013).

Along with increasing overall temperatures in Michigan, climate change is expected to cause seasonal shifts which could lead to earlier and longer growing seasons and later first frost. Already, the eastern U.S. has seen its growing season extend approximately eight days since the late 1980's. (EPA, 2013). This shift means plants are releasing pollen earlier and longer than in the past. In addition, as CO_2 increases it signals pollen producing plants to produce three to four times more pollen, and the pollen itself may actually be more potent (EPA, 2006). Consequently the prevalence of allergic rhinitis is also rising (Shea et al., 2008). A rise in seasonal hay fever and allergic asthma in the U.S. has also been reported, where the pollen season has lengthened up to 16 days since 1995 (Ziska et al., 2011). The allergy symptoms range from mild, such as itchy eyes and hives, to severe life-threatening events when airways swell shut. These allergic and asthmatic symptoms already afflict 40 - 50 million people in the

U.S. (AAFA, 2015). In Michigan, allergic disease hospitalizations have been steadily increasing from 700 per 100,000 in 2001 to nearly 1,200 per 100,000 in 2012 (see Figure 3.3); 90% of these hospitalizations are due to asthma (Cameron et al., 2013, with 2011 and 2012 data from HCUP).

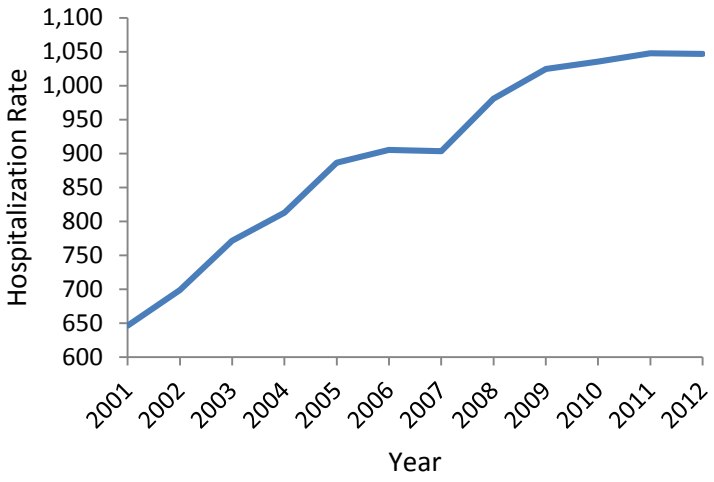


Fig. 3.3: Annual rate of allergic disease-related hospitalizations in Michigan

An increase in drought, defined as natural phenomena in which rainfall is lower than average for an extended period of time resulting in inadequate water supply, is expected as a consequence of increasing temperatures associated with climate change in parts of the U.S. Frequent or extended droughts are associated with environmental impacts such as loss of green space, lower amounts of rainfall, dust and wildfires. All four impacts can lead to an increase in air pollution. Loss of green space negatively affects individuals with asthma and COPD (Lovasi et al., 2008; Zanobetti et al., 2012), in part due to increased levels of air pollutants. Wildfires produce smoke which leads to increased air pollution, further loss of green space, mental distress and economic impacts (Luber, 2014). Consequently, a range of adverse health outcomes ensue including possible increase in respiratory irritation (mild), and respiratory diseases or exacerbations (asthma and COPD) (moderate), and emergency department visits, hospitalizations, and death (severe) may occur more frequently.

A recent review of the effects of climate change on indoor air quality noted that measures to reduce energy use by buildings, such as reducing reliance on air conditioning coupled with decreased air exchange, can concentrate indoor environmental problems such as humidity, allergen loads from pests and molds, and chemical air pollution (NRC, 2011).

Waterborne disease

Waterborne disease is a common cause of illness in the U.S. and in Michigan. For 2009 - 2010, CDC's National Waterborne Disease and Outbreak Surveillance System reported 33 outbreaks with 1,040 cases of illness and nine deaths associated with drinking water, and 12 outbreaks with 234 cases of illness and six deaths associated with water not intended for drinking. *Legionella* accounted for 58% of drinking-water outbreaks and 7% of illnesses; while *Campylobacter* accounted for 12% of outbreaks and 78% of illnesses. Other waterborne pathogens included *Giardia* with 2 outbreaks and 14 cases, and *Cryptosporidia* with 1 outbreak and 34 cases. A large proportion of drinking water outbreaks were associated with untreated ground water and deficiencies in public drinking water infrastructure (CDC, 2013). Many of these pathogens can cause disease by multiple routes of exposure; a CDC workgroup identified giardiasis, cryptosporidiosis, Legionnaires' disease, acute or malignant otitis externa and non-tuberculous pulmonary mycobacterial infection as the infections primarily (over 50%) transmitted by water (Collier et al., 2012). Roughly 500 cases of giardiasis are reported each year in Michigan, while cryptosporidiosis averages 150-300 reported cases (CDC, 2012-2014). Other enteric infections such as those caused by *Salmonella, E. coli* and enterovirus are much more common, but many of these illnesses go unreported and the source of these infections are often undetermined (Rose et al., 2001). Possible sources of waterborne infection may be via drinking water, recreational or other water

contact, or indirectly by consuming food contaminated in the field through contact with contaminated water (Rose et al., 2001).

Waterborne disease and heat

The warming climate may be increasing the risk of some infectious waterborne diseases in Michigan. *Legionella* is a common bacteria found naturally in the environment, usually in warm water. Exposure through inhalation of mists or vapors from contaminated water can cause lung infections known as Legionnaires' disease or (rarely) Pontiac fever, collectively known as legionellosis. *Legionella* is the most frequently reported cause of water-related disease outbreaks in the U.S., and is usually associated with exposure to water in conditions of heat, stasis, and aerosolization that optimize transmission. An estimated 8,000 to 18,000 people are hospitalized with Legionnaires' disease each year in the U.S. (CDC, 2013a), and roughly 200 cases of Legionellosis are reported to the CDC from Michigan each year (CDC, 2012-2014). *Legionella* species colonize outdoor water reservoirs including potable water systems and cooling towers, and the organisms grow rapidly at temperatures between 85 – 110 degrees F. Studies in the eastern U.S. and Europe suggest that Legionnaire's disease outbreaks may be associated with warm humid weather (Fisman et al., 2005; Philips, 2008), possibly due to increased *Legionella* growth stimulated by warming of potable water in reservoirs and plumbing. Another aquatic pathogen, *Naegleria fowleri,* is known to cause fatal primary amebic meningoencephalitis in recreational swimmers exposed to warm freshwater in the southern U.S. However, in 2010 a fatal case occurred after swimming in freshwater in Minnesota, 550 miles further north than any other known U.S. case. Consistently warmer summer temperatures have been suggested as means for an increased possibility of exposure in other northern water bodies (Kemble et al., 2012). On the other hand, warm temperatures may reduce the survival in water of some enteric pathogens such as *E. coli*, *Campylobacter*, and enteroviruses (Hunter, 2003). Warm temperatures may also increase population contact with recreational waters, increasing the opportunity for exposure to pathogens in the water.

Rising temperatures can have significant effects on aquatic ecosystems. An algal bloom is a rapid increase in the population of one or a few species of algae that occur naturally in an aquatic system, freshwater or marine. Any algal bloom has the potential to deplete oxygen levels in the water and block sunlight, which can lead to the death of other species in the water ecosystem. Certain blooms are composed of species that naturally produce biotoxins that are harmful to human, animal, and ecosystem health; these toxin-producing blooms are called harmful algal blooms (HABs). Recent research suggests that, in addition to nutrient contamination from anthropogenic sources, the impacts of climate change may promote the growth and dominance of HABs through a variety of mechanisms including, but not limited to: warmer water temperatures, increases in atmospheric carbon dioxide concentrations, and changes in rainfall patterns (EPA, 2015). Changes in meteorological patterns may have helped trigger a record-setting bloom of toxic algae that covered a remarkable and unprecedented one-fifth of Lake Erie in 2011, an event that may be a warning of more severe blooms in the future (Michalak et al., 2013). In August 2014, another HAB in Lake Erie contaminated the water supply for more than 400,000 people in Michigan and Ohio, resulting in states of emergency declarations in one Michigan and three Ohio counties, and activation of the Ohio National Guard. (Kozacek, 2014).

Harmful Algal Blooms in the Great Lakes region are typically made up of blue-green algae, or more accurately, cyanobacteria that contain chlorophyll similar to true algae. They reproduce rapidly, and are typically found at or near the surface of the water (Michigan Sea Grant, accessed 2015). All

cyanobacteria can produce dermatotoxins (skin irritants) under certain conditions, and some can produce multiple types of the more harmful toxins, including neurotoxins, liver toxins (hepatotoxins), and cell toxins. The most common species of toxic cyanobacteria in the Great Lakes are *Microcystis aeruginosa, Anabaena circinalis, Anabaena flos-aquae, Aphanizomenon flos-aquae*, and *Cylindrospermopsis raciborskii*. The most prevalent toxin in Michigan and U.S. waters is microsystin, a hepatotoxin which in humans causes abdominal pain, vomiting and diarrhea, liver inflammation and hemorrhage, pneumonia, dermatitis and potential tumor growth promotion (EPA, 2014). Sensitivity to all these toxins varies widely among individuals (GLERL, accessed 2015). The most common exposures to cyanobacteria and their toxins are believed to occur during recreational activities in contaminated bodies of water via oral, dermal, and inhalation routes. Other major routes of human exposure are through ingestion of cyanotoxin-contaminated drinking water, inhalation while showering, dietary intake via consumption of cyanotoxins in contaminated foods and algal dietary supplements, and exposure from water used in medical treatments (e.g., medical dialysis) (EPA, 2014).

Wildlife, domesticated, and farm animals can be sickened or killed by drinking water contaminated with HABs (IJC, 2014). Production of HAB neurotoxins also affects aquatic birds, turtles, and mammals, and can cause mass mortalities in fish. In Michigan, HABs can result in beach closures, loss of sport or commercial fishing, and disruption of drinking water supplies, with major economic consequences (IJC, 2014). Michigan is currently in the process of developing surveillance systems to capture HABs events and human cases of HABs-related illness (personal communication, L Tyndall-Snow 2014).

Please see the section, ***Waterborne disease and excess rain***, for discussion of other waterborne infectious diseases impacted by climate change.

Vector-borne disease and heat

Mosquitoes and ticks act as vectors for a variety of diseases. In the U.S. and in the Midwest, these insect vectors will likely survive in greater numbers as winters become milder and summers become longer and warmer. Climate-related changes in the vectors' habitat and host species populations will also influence future disease risk.

Mosquito species in Michigan are able to carry and transmit many harmful arboviruses, including: West Nile Virus, St. Louis Encephalitis Virus, LaCrosse Virus, and Eastern Equine Encephalitis Virus. Of these, West Nile Virus (WNV) has been the major public health concern since arriving in the U.S. in 1999 and in Michigan in 2002. Changes in temperature and precipitation have reportedly increased human infection. The *Culex* mosquito, which transmits West Nile, thrives on warm, wet winters and springs followed by hot, dry summer weather. With the heat and drought conditions in 2012, there were a large number of human WNV cases throughout the nation and in Michigan.

Approximately 80% of West Nile Virus (WNV) infections are believed to be asymptomatic and therefore not reported (CDC, 2013d). Even so, there have been more than 39,000 reported WNV cases in the U.S. and more than 1,100 in Michigan since 2002. In 2012 there was a peak of 202 cases and 17 deaths in Michigan (CDC 2014, Stobierski et al., 2014). The most common clinical condition is an acute systemic febrile illness (moderate). However, a few (≤ 1%) clinical cases proceed to a condition known as West Nile neuroinvasive disease (WNND), which typically manifests as encephalitis, meningitis, or acute flaccid paralysis (AFP) and has a mortality rate of approximately 10% (severe) (Barret, 2014). Most patients with meningitis or non-neuroinvasive West Nile infections recover completely, but this

may take months. Patients who recover from encephalitis or AFP often have residual neurologic sequelae.

Michigan residents may acquire other arboviral infections during travel to endemic areas; for example, Michigan had 16 imported cases of Dengue Fever in 2013 (USGS, 2013). However, local transmission of other emerging mosquito-borne diseases such as chikungunya and Dengue in Michigan is unlikely as the disease-transmitting *Aedes* mosquitoes have not been identified in the state (Anez & Rios, 2013).

Different from the previously mentioned viral diseases transmitted by mosquitoes, Lyme disease is a multisystem, multistage, inflammatory tick-borne disease caused by the spirochete bacteria *Borrelia burgdorferi*. Transmitted through bites from *Ixodes scapularis "*black legged" ticks, this Lyme vector is projected to expand throughout the U.S. and Canada as temperatures gradually increase (Brownstein et al., 2002, Ogden et al., 2013). Lyme disease is now endemic in the Northeast and much of the north central United States including Wisconsin, Illinois, Indiana, and Pennsylvania. in Michigan, Lyme is considered an emerging disease with over 1,000 human cases occurring since infected ticks were first detected in the state in 1992. Historically, the only endemic region in Michigan has been Menominee County in the Upper Peninsula, bordering a highly endemic region of Wisconsin. The tick vector is becoming established across the state (personal communication, E. Foster, 2014), and recently, populations of infected black-legged ticks have been found in southwest Michigan (Berrien, Cass, Van Buren, Allegan, and Ottawa Counties) as shown in Figure 3.4 (Foster 2014, Hamer et al., 2010; Michigan Lyme Disease Risk Map, 2015).

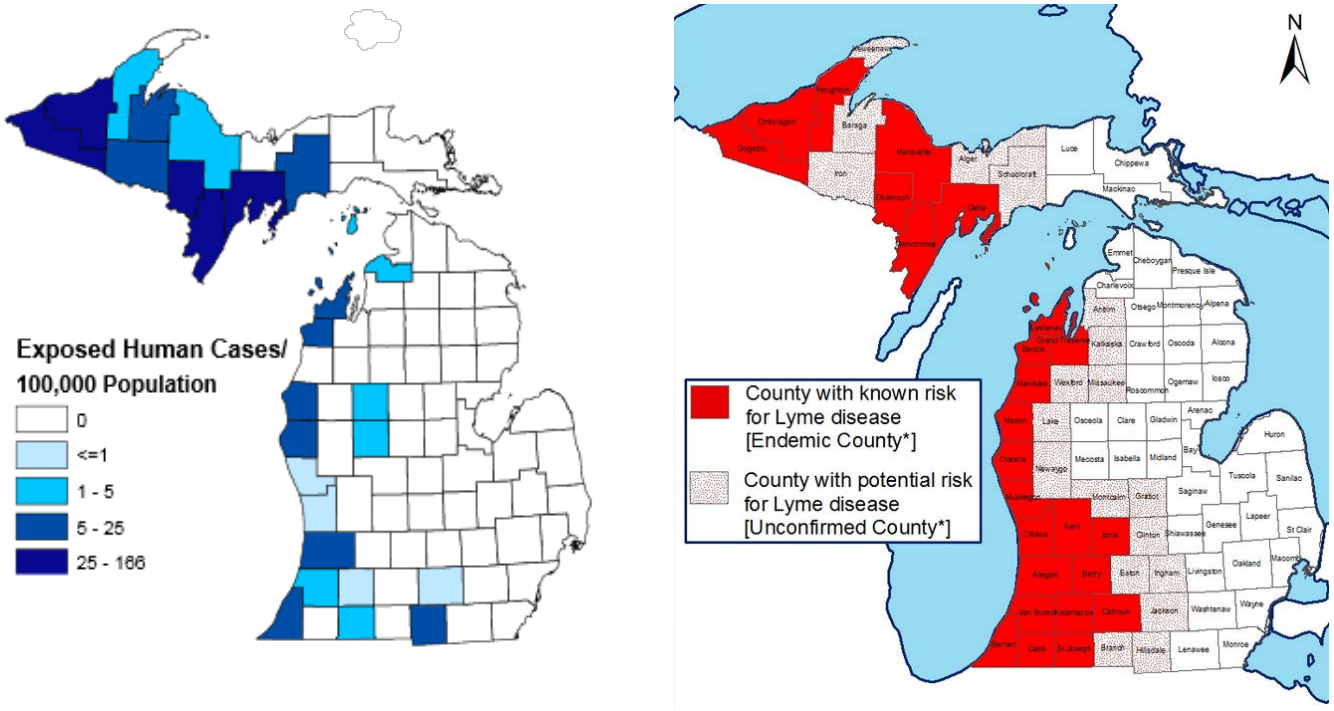


Fig. 3.4: Map of 2013 Michigan 'exposed' Lyme disease cases per 100,000 (Stobierski et al., 2014) (left), and 2015 map of risk of encountering infected ticks based on field surveys (MDHHS Emerging & Zoonotic Infectious Disease Section, 2015) (right). The endemic range of infected ticks has increased over time .

Lyme disease has three medically described phases: 1) early localized disease usually presenting with expanding rash called *erythema migrans* (mild); 2) early disseminated disease with heart and nervous system involvement, including palsies and meningitis (moderate); and 3) late disseminated stage of

disease which includes intermittent bouts of arthritis and severe joint pain and swelling (severe). Chronic neurological complaints may develop in about five percent of patients whose infections are untreated (CDC, 2015).

Each year, more than 30,000 cases of Lyme disease are reported to CDC, making it the most commonly reported tick-borne illness in the United States. However, an analysis of medical claims data led CDC to estimate that the actual number of people diagnosed with Lyme disease is roughly 10 times higher than the reported number indicates, or around 300,000 per year for the U.S. (CDC, 2013). In 2013, the highest on record, 165 human cases were reported in Michigan, with most exposures occurring in the Upper Peninsula and western L.P (Stobierski et al., 2014).

Other tick-borne diseases are emerging as serious public health concerns in Michigan. As black-legged tick populations expand in the state, diseases such as anaplasmosis, Ehrlichia muris-like (EML), deer-tick virus and babesiosis will become more frequent. The Lone Star tick *Amblyomma americanum* is also being detected more frequently in Michigan, however localized populations have yet to be discovered. This tick readily bites people and companion animals, and is the vector of ehrlichiosis and tularemia. Climate changes may be influencing the number and species of ticks directly or indirectly by impacting the numbers and movements of their animal hosts (deer, birds, rodents, etc.) or their habitat.

Precipitation Pathway

Flooding and excess rain events can cause a range of adverse human health effects via alterations of the built and natural environment as shown in Figure 3.5. These include injury and death from damage to housing and infrastructure and from Carbon Monoxide (CO) poisoning from improper generator use during power outages. Additionally, contaminated water resulting from infrastructural damage can

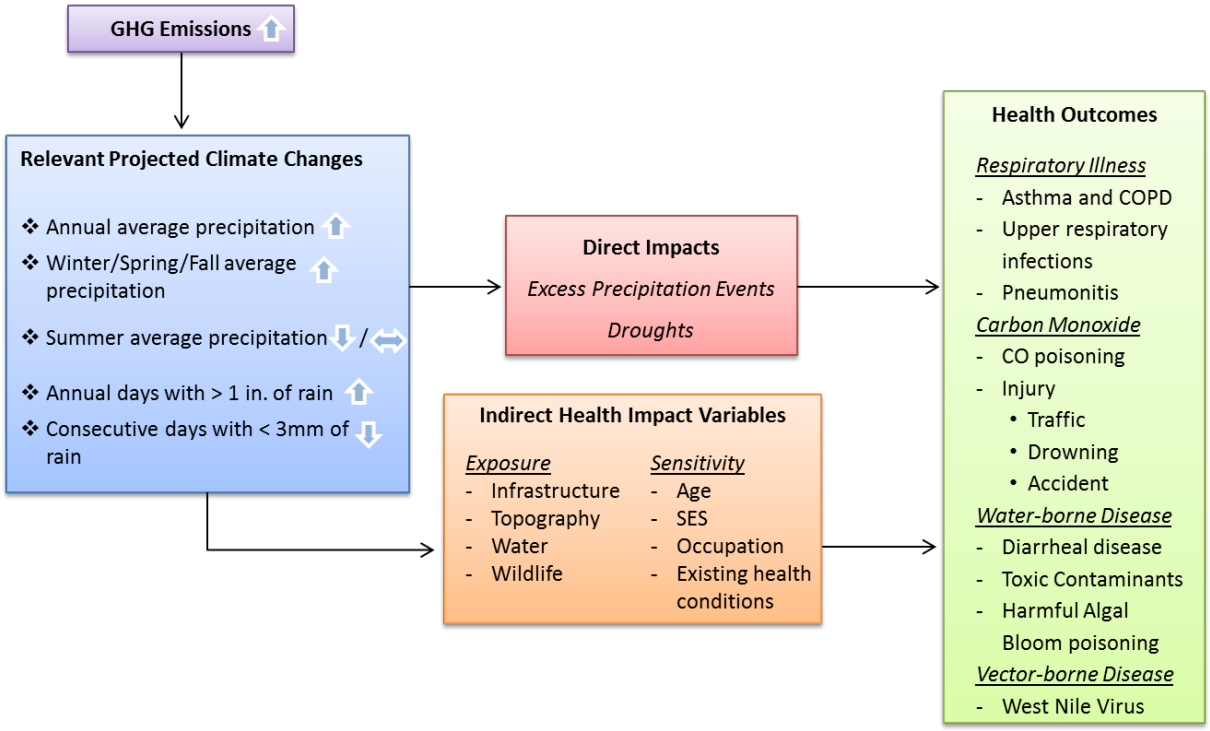


Fig. 3.5: Precipitation related direct and indirect conceptual human health impact pathway based on climate changes resulting from increased Greenhouse Gas Emissions (GHG).

carry a range of hazardous toxins, as well as human pathogens. There is also the risk of increasing the geographic range of disease-carrying insects and rodents and introducing dangerous molds within houses. Resulting social disruption from flooding and any of these occurrences can eventually lead to mental distress. Altered precipitation trends can result in floods and droughts that directly and indirectly influence several health outcomes in Michigan residents.

Respiratory disease and excess rain

Mold growth occurs when there is moisture from water damage, excessive humidity, water leaks, condensation, water infiltration, or flooding (CDC, 2010). Indoor exposure to mold has been linked to upper respiratory tract symptoms, cough, and wheeze in otherwise healthy people; symptom exacerbations in asthmatics; and onset of hypersensitivity pneumonitis in susceptible individuals (NRC, 2004). Runoff from rain events could also play a role in the growth of Legionella in water sources and thus increase risk of Legionnaire's disease (Fisman et al., 2005).

Carbon Monoxide poisoning and excess rain

Excess rain can lead to extreme precipitation events and flooding. The subsequent cleanup poses a variety of hazards including traumatic injuries (Du et al., 2010) and CO poisoning from gas-powered power washers and heaters (Waite et al., 2014). This topic is discussed in the section on ***Extreme weather events pathway***.

Water-borne disease and excess rain

As water infrastructure in Michigan communities ages and deteriorates, the risk for water-main breaks will increase along with the risk of pathogen introduction into community drinking water systems through those breaks. In addition, older cities like Detroit, Flint and Lansing with combined sewer systems (which carry sewage and rain water in the same pipes), are at greater risk for sewage spills or Combined Sewage Overflows (CSOs). During heavy rains, these pipes cannot handle the volume of both storm water and wastewater, and untreated sewage is often discharged into surrounding waterbodies that could be used for drinking, swimming and playing, or can back up through drains into basements. Residential septic systems are also common sources of water contamination in Michigan. Exposure to waterborne pathogens from sewage and unclean water can cause diseases like cryptosporidiosis, giardiasis, and infections by Salmonella, *E. coli* enteroviruses, and other enteric pathogens (Hunter 2003). These CSO discharge events have been projected to increase by 50 to 120% by 2100 for Lake Michigan alone, raising the risk of drinking water contamination substantially (Patz et al., 2008). A recent analysis of 'large' (i.e., 50 million gallons or more overflow) Michigan CSOs from 2008 - 2012 found that 76% were caused by storms of two inches or more of precipitation per day (Saunders et al., 2014). A review of 548 outbreaks in EPA's waterborne disease database found that 68% of outbreaks were preceded by precipitation events above the 80th percentile of intensity (Curriero et al., 2001). An English review paper summarized multiple studies which documented increased pathogen detection in surface waters after a rain event, due to contamination from runoff (Hunter, 2003).

Agricultural runoff after rain events is another source of water contamination and disease risk. An increasing source of runoff contamination in Michigan is waste from Concentrated Animal Feeding Operations, or CAFOs, which are becoming more common across the state. The sheer amount of manure produced by one large operation can exceed 1 million tons per year (NALBH, accessed 2015), much of it stored in pits and lagoons or sprayed on fields. Fecal microbial pathogens and other contaminants can be washed into surface waters and vulnerable private wells causing widespread contamination, increasing the potential for human disease. Even more concerning, CAFO livestock are

often treated with antibiotics and can be a source of antibiotic-resistant strains of E. coli and other pathogens. (Burkholder et al., 2007). Surface water contamination by agricultural runoff containing phosphorus and nitrogen can also contribute to algal blooms; see discussion in ***Waterborne disease and heat***, above. Flooding and contaminated runoff can also infiltrate the private wells that are a source of drinking water for over one million Michigan households (Saunders et al., 2014). Community exposure to disinfection by-products, many of which are potential carcinogens and asthma triggers, may increase as water treatment plants deal with increased turbidity and pathogen loads in source water by adding more disinfectants in the finishing process.

Waterborne disease and drought

Drought can put communities at risk of running out of drinking and irrigation water, as well as increase exposure to and use of contaminated water. Rural communities where residents rely on wells for drinking water are at particular risk as contaminants in the groundwater may become more concentrated with less water available to dilute them. Droughts can cause increased concentrations of effluent pathogens, overwhelming water treatment plants and contaminating surface water. Older water treatment plants are particularly at risk. (NIEHS, 2014). During droughts, the ground becomes hard and impervious; likely causing runoff during the next rain event and carrying viruses, protozoa, and bacteria which can pollute both groundwater and surface water. People who get their drinking water from private wells may also be at higher risk for drought-related infectious disease (CDC, 2012). *Water-washed diseases* are those caused or spread by lack of hygiene. *Salmonella* and toxin-producing *E. coli* are two common examples of infectious diseases more easily spread from person to person or by food handling when hand washing is compromised by a perceived or real lack of available water. Food contamination can also occur when water is scarce and farmers turn to recycled or alternative contaminated water sources for irrigation. During drought, drinking water supplies are also susceptible to harmful algal blooms and other microorganisms (CDC, 2012).

Vector-borne disease and precipitation

A change in rainfall patterns has been shown to influence the seasonal activity length of several Michigan mosquito species responsible for transmitting arboviruses such as West Nile. For more information on health conditions associated with these diseases, see the vector-borne disease section of the ***Heat Pathway***.

Extreme Weather Events Pathway

Climate change may be affecting the frequency and severity of some extreme weather events, while others are too complex to predict. However, Michigan experiences extreme wind, snow and ice storms throughout the seasons and they have significant public health impacts directly and indirectly as shown in Figure 3.6.

Summer weather events

As discussed previously the major summer events include extreme heat events, heavy rain, droughts, and floods. Besides these impacts, Michigan can experience tornadoes and high winds leading to systems disruptions such as infrastructure destruction, power outages, and social disruption. Health impacts include injuries, CO poisoning, mental distress and death. There have been 341 tornadoes and almost 7,500 high wind events in Michigan since NOAA's upgraded weather surveillance in 1996 (NOAA, 2014). However, the link between severe wind events and climate change is unclear and there is no real evidence of historic trends in frequency or severity of tornadoes (Anonymous, 2014).

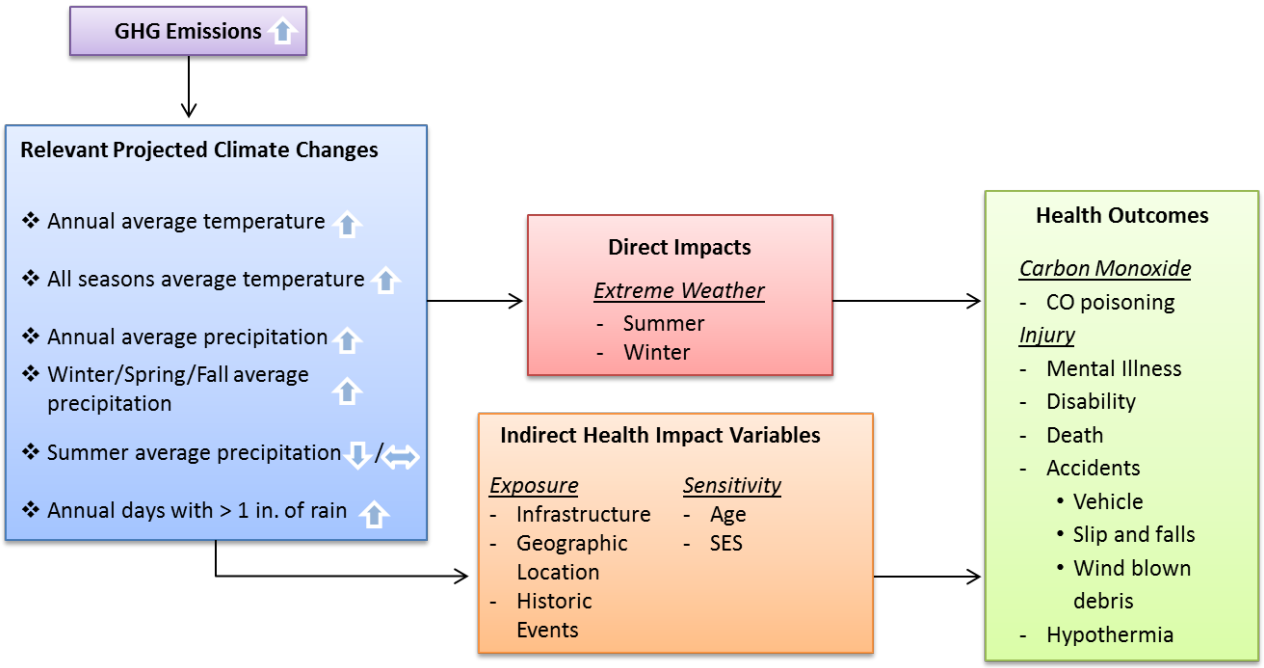


Fig. 3.6: Summer and winter extreme weather event related direct and indirect conceptual human health impact pathway based on climate changes resulting from increased Greenhouse Gas Emissions (GHG).

Winter weather events

Winter weather events include extremely low temperatures, heavy snowfall and ice storms. There is some evidence that lake-effect snow and ice storm events are related to climate change in Michigan and will continue to increase in frequency, at least short term; and some climatologists have linked the occurrence of extreme cold events to disruption in the arctic jet stream (see Figure 2.3) caused by melting polar ice (Kim et al., 2014). These weather events can also indirectly lead to health impacts through changes in the built environment. Health effects include the risk of CO poisoning and death from improperly used heaters and generators, hypothermia, and physical injuries from accidents due to snow and ice. In Michigan, almost 1,000 people are unintentionally poisoned by CO every year, and 20-23 die from CO poisoning. The main sources of exposure are faulty furnaces and hot water heaters, and improper use of gas-powered equipment such as generators and power washers (MDHHS and MSU, 2009-2012).

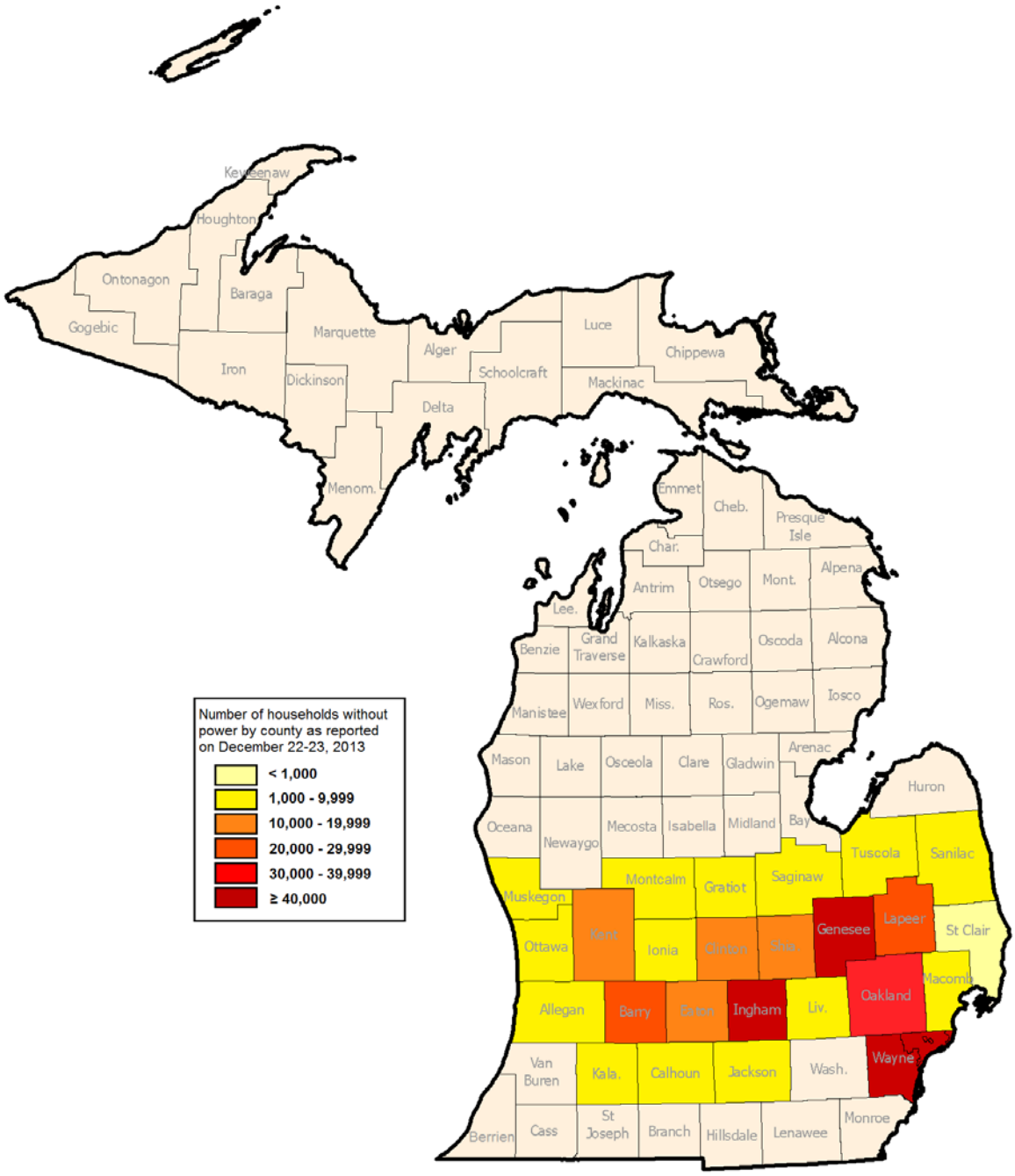


Fig. 3.7: Household power outages by county as reported in the press on December 22-23, 2013 (Mamou et al., 2014)

For example, a severe ice storm struck Michigan December 21-29, 2013. The weight of the ice toppled trees and knocked down power lines over a large area. Over 400,000 Michigan households lost power, and there were 81 reported emergency department (ED) visits related to complaints of CO poisoning, as shown in Figures 3.7 and 3.8, respectively (Mamou et al., 2014).

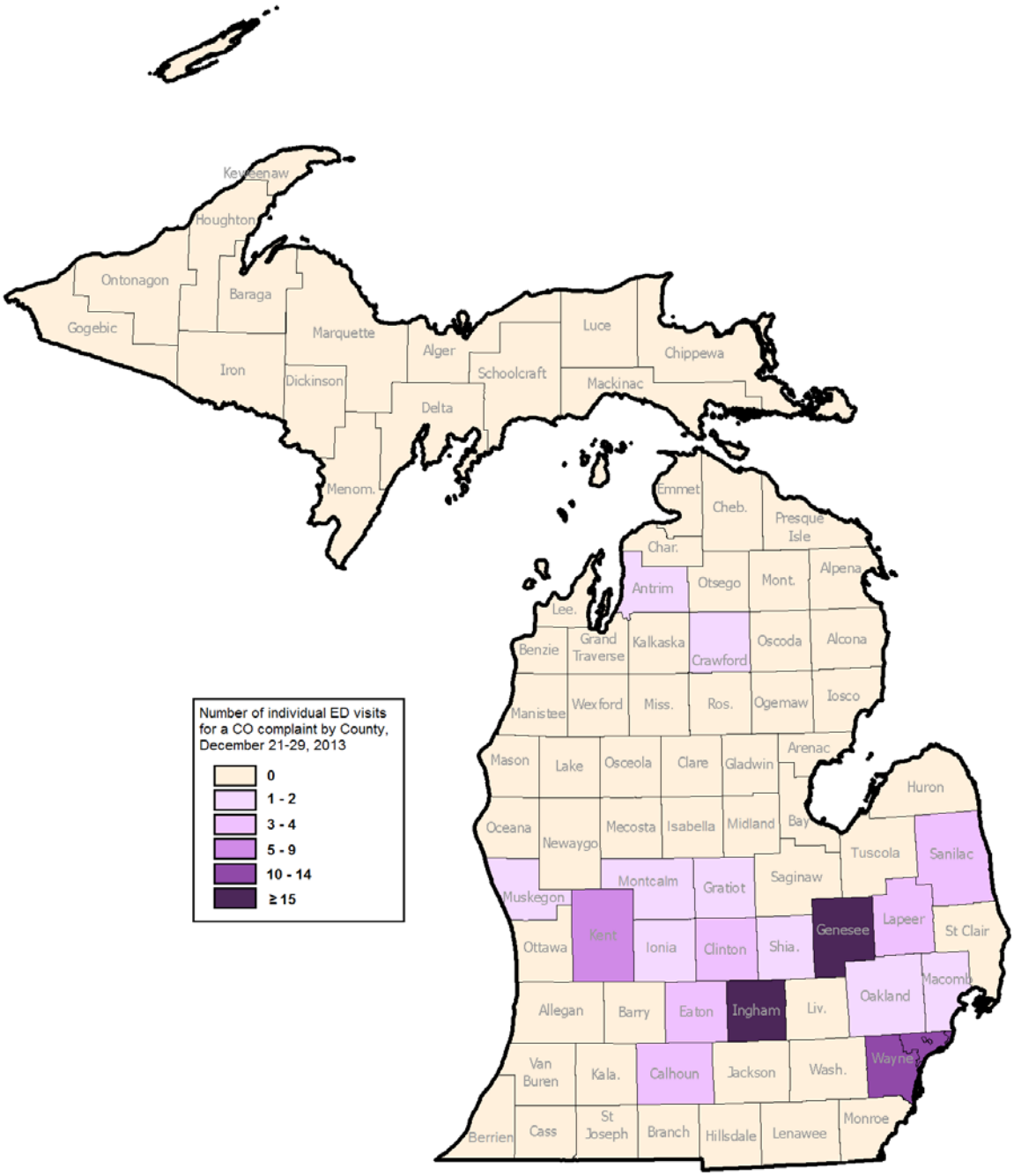


Fig. 3.8: Carbon Monoxide chief complaint emergency department visits by county of residence December 21-29, 2013 (Mamou et al., 2014)

Conclusions

Many of the conceptual pathways using changing climate as an exposure have similar human health outcomes, but the route in which these exposures cause disease, both directly and indirectly, is varied and affect many biophysical environmental variables. Heat, drought, floods and extreme weather events are ever changing and dynamic exposures that require complex assessments in order to protect vulnerable human populations and environments from negative consequences. The next section will briefly summarize surveillance systems for monitoring key health outcomes and exposures related to climate change in Michigan.

Health Outcomes Surveillance Systems

The following data sources are used to monitor key climate-sensitive health effects in Michigan. Each data source and its utility are described.

Michigan Disease Surveillance System (MDSS)

A web based disease reporting system developed for the State of Michigan as part of the CDC's National Notifiable Diseases Surveillance System (NNDSS), which provides information on the occurrence and spread of state-reportable and nationally notifiable infectious diseases and conditions. Physicians, health care providers, and laboratories are mandated to report in a timely manner and in a standard format. MDSS is the source for Michigan's official notifiable diseases statistics, and can be used to monitor data and trends on the following climate-sensitive conditions: vector borne diseases including West Nile, Dengue, *Ehrlichia*, Lyme Disease, *Rickettsia*, *Hantavirus*, *Histoplasma*, and outbreaks of a number of water-borne infectious agents including Amebiasis, *Campylobacter*, certain strains of *Escherichia coli*, *Giardia*, *Legionella*, *Salmonella*, *Shigella*, some *Staphylococcus* and *Streptococcus*, and *Vibrio*. These statistics are useful for monitoring outbreaks; however, many cases (especially gastrointestinal infections) are severely underreported. MICHAP primarily uses MDSS to track human cases of West Nile and Lyme disease. Weekly reports are available at MDHHS's Communicable Disease Information & Resources website: http://www.michigan.gov/MDHHS/0,4612,7-132-2945_5104_53072---,00.html. For a list of reportable diseases, see: http://www.michigan.gov/documents/Reportable_Disease_Chart_2005_122678_7.pdf. Official disease counts are also available at the CDC's National Disease Surveillance System (NDSS) website (http://www.cdc.gov/mmwr/distrnds.html).

Michigan Syndromic Surveillance System (MSSS)

Since 2003, the MSSS is used as a voluntary emergency department (ED) reporting system in Michigan. Designed to rapidly detect unusual outbreaks of illness resulting from either naturally occurring or intentional events that pose potential public health threats and emergencies it is a vital component of routine communicable disease surveillance for the state as well as an early-warning system for outbreaks related to bioterrorism. Currently, 88/136 (65%) of hospital EDs participate in MSSS, providing coverage for 83% of Michigan's population. Data from EDs are securely transmitted to the MDHHS in real time and currently average over 8,000 ED visits per day. Each data message consists of: each visit's date and time, and the patient's age, sex, home ZIP code, and chief complaint on intake. Chief complaints are classified into one of seven syndromic categories. Detection algorithms run every hour and an email alert is sent to State and Regional epidemiologists if a deviation is detected. MSSS epidemiologists have created new climate-related syndrome categories including: heat, cold, and CO poisoning, which are run following heat, cold, or storm events or when temperatures exceed preset thresholds to detect climate-related 'outbreaks'. MICHAP uses these climate-related syndrome

surveillance weekly reports to monitor for sentinel events and direct interventions. General information on MSSS is at: http://www.michigan.gov/MDHHS/0,1607,7-132-2945_5104_31274-107091--,00.html.

Michigan Inpatient Database (MIDB)

Created by the Michigan Health and Hospital Association, the MIDB contains discharge data on all acute-care hospitalizations among Michigan residents, including principal diagnosis and up to 45 additional diagnoses, as well as limited demographic, disposition and insurance information about the case. This database is most appropriate for long-term tracking of trends and associations and has the advantage of providing true population-based estimates. Data are available in a standard format from 1999, but the most recent information is typically about two years older than the present date. Data files are provided to MICHAP epidemiologists through an agreement with the MDHHS Division for Vital Records and Health Statistics (DVRHS) for analysis. Michigan's new public health tracking program, MI Tracking, will use MIDB to track and map hospitalization rates for asthma, CO poisoning, and heat illness starting in 2016. MICHAP is currently using MIDB to monitor hospitalization rates for asthma and heat illness, and to investigate other chronic diseases that are associated with heat and water-borne infectious diseases. Also provides a source of information on the prevalence of conditions such as diabetes that increase the risk of many climate-sensitive diseases.

Michigan Resident Death Files

Michigan Resident Death Files contain information from the death certificates of Michigan residents, including demographics, location, circumstances, and causes (underlying and 17 contributing) causes of death, and is available by request from the DVRHS or through CDC Wonder at: http://wonder.cdc.gov/mcd.html. Deaths from extreme weather events are quite rare, and there are roughly five heat-related deaths per year, so death files are not a primary source for climate-sensitive health outcome surveillance.

Michigan Behavioral Risk Factor Survey (MiBRFS)

Since 1986 the MiBRFS has been conducted annually, as a statewide telephone survey of Michigan adults aged 18 years and older through a collaborative effort between MDHHS and the Centers for Disease Control and Prevention (CDC's) national Behavioral Risk Factor Surveillance System (BRFSS). These surveys act as the only source of state-specific, population-based estimates of the prevalence of various behaviors, medical conditions, and preventive health care practices among Michigan adults. The annual Michigan surveys follow the CDC survey protocol and use the annual standardized core questionnaire, but also include about 25 state-added questions each year. Roughly 10,000 individuals participate each year; this sample when weighted produces annual prevalence estimates and 95% confidence intervals that are representative of the Michigan population. Data may be aggregated across several years to produce county or region-level estimates. MICHAP uses MiBRFS sub state estimates to assess the prevalence of asthma and of chronic diseases and conditions such as obesity, diabetes, renal, cardiovascular and chronic lung diseases that increase risk of climate-sensitive diseases. Data are available from the MDHHS Michigan Behavioral Risk Factor Surveillance System website: http://www.michigan.gov/MDHHS/0,1607,7-132-2945_5104_5279_39424---,00.html or by request from the Program Epidemiologist.

Other Data Sources

As needed, additional sources are used to provide information that does not fall within the scope of the five previously described databases. Michigan's CO Surveillance System collects death,

hospitalization, and Poison Control Center information on cases of CO poisoning in Michigan, including the circumstances of exposure (i.e., use of generator or alternate heat source). CO surveillance data is available at: http://www.michigan.gov/MDHHS/0,1607,7-132-54783_54784_54787---,00.html or by request from the Project Manager. Data from the Children's Hospital of Michigan Regional Poison Control Center are available to some MDHHS staff or can be directly requested from the Center by email or phone 1-800-222-1222. The Poison Control Center also collects information on calls regarding waterborne diseases and exposures (e.g. algal blooms), which can be helpful during outbreaks in measuring the impact of a climate event.

Exposure Surveillance Systems

The following data sources are used to monitor key climate-sensitive exposures in Michigan.

Air quality data

The federal Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for six criteria pollutants considered harmful to public health and the environment. These are monitored by the Michigan Department of Environmental Quality (DEQ) Air Quality Division (AQD) and include ozone (O_3) and particulate matter smaller than 10 and 2.5 microns in diameter (PM_{10} and $PM_{2.5}$, respectively). The AQD's Air Monitoring Unit (AMU) ensures that all data collected and reported from the 41 monitors they maintain are of high quality and meet federal requirements.

MIair is an internet tool that provides real-time air quality information via the DEQ's webpage. The www.deqmiair.org hotlink opens to the current Air Quality Index (AQI) map and displays air quality forecasts for the current and subsequent days. *MIair* also hosts *EnviroFlash*, the automated air quality forecast notification system. The AQI is a simple tool developed to communicate current air quality information to the public, using color-coded AQI values, ranging from Good to Hazardous. AQD meteorologists also provide air pollution forecasts to alert the public when air pollution levels may become elevated. "Action! Days" are declared when levels are expected to reach or exceed the Unhealthy for Sensitive Groups AQI health indicator. The DEQ also supplies Michigan air monitoring data to *AIRNow*, the EPA's nationwide air quality mapping system, available at www.epa.gov/airnow. Both of these sites can be used during climate events to monitor for hazardous respiratory exposures. Annual monitoring data summaries are available from the DEQ AQD by monitor and location, and air quality reports are available that summarize findings by county, metropolitan area, and monitor approximately one year post-data collection; these data can also be tabulated, mapped and downloaded at the EPA's *Air Data* website http://www.epa.gov/airdata/.

The U.S. Centers for Disease Control and Prevention (CDC) and U.S Environmental Protection Agency (EPA) together developed two types of air quality indicators and measures for CDC's National Environmental Public Health Tracking Network. EPA provided ozone and particulate matter (PM2.5) monitoring data from 1999-2013 to CDC, and the two agencies collaborated to develop county based measures of air quality from the data. In addition, since many areas of the country do not have air monitors, EPA developed daily estimates of air quality for Ozone and $PM_{2.5}$ from 2001-2011 using a Bayesian space-time model known as the Downscaler (DS) model. This model fuses monitoring data with results from EPA's Community Multiscale Air Quality (CMAQ) model. CDC processed these daily modeled estimates and derived county-based measures of air quality. Both monitored and modeled

data are available on the *National Environmental Public Health Tracking Network*. http://ephtracking.cdc.gov/showAirMonModData.action.

Land surface characteristics data

The National Land Cover Database (NLCD) serves as the definitive Landsat-based, 30-meter resolution, land cover database for the nation. NLCD provides spatial reference and descriptive data for land surface characteristics such as thematic class (for example, urban, agricultural, and forested land cover), percent impervious surface, and percent tree canopy cover for the years 1992, 2001 and 2011. NLCD supports a wide variety of federal, state, local, and nongovernmental applications that seek to assess ecosystem status and health, understand the spatial patterns of biodiversity, predict effects of climate change, and develop land management policy. NLCD products are created by the Multi-Resolution Land Characteristics (MRLC) Consortium, a partnership of federal agencies led by the U.S. Geological Survey. These data are used to describe physical exposure characteristics that influence climate vulnerability. NLCD 2011 is the most recent national land cover product created by the MRLC Consortium, and provides the capability to assess spatially explicit national land cover changes and trends from 2001 to 2011. MICHAP primary uses NLCD data to evaluate heat-related and respiratory vulnerability in terms of vegetation, impervious surface, and urbanicity. All NLCD data products are available for download at no charge to the public from the MRLC Web site http://www.mrlc.gov and the Michigan Geographic Data Library Catalog http://www.mcgi.state.mi.us/mgdl/ .

Tick & mosquito surveillance

Michigan State University (MSU) and MDHHS researchers have been conducting a long-term surveillance project for *Ixodes scapularis* (black-legged tick), the vector species for Lyme disease, in Michigan's western Lower and Upper Peninsulas since 2001. This study has involved looking for the presence of the black-legged tick, testing those ticks for infection with *Borrelia burgdorferi* and looking for evidence of infection in rodents and dogs in the area. These data are used to generate maps of counties determined to be either "endemic", with human cases or infected tick populations; or "at risk" due to their proximity to the counties with known tick populations. The latest maps and the underlying tick data are available to MICHAP through MDHHS's vector-borne disease program staff, with historic annual summary data available at the Emerging Diseases website http://www.michigan.gov/emergingdiseases/. Similarly, mosquito surveillance data are available by county and species. The data include test results for West Nile Virus and other arboviruses and risk maps, and are available at the Emerging Diseases website or through MDHHS's vector-borne disease program staff. Risk maps include distribution of human and animal cases as well as maps of locations of negative and positive mosquito pools submitted for testing for West Nile Virus.

Utility power outage surveillance

Information on electrical utility service areas is available from the Michigan Public Service Commission at http://www.dleg.state.mi.us/mpsc. During an outage event, most utilities post power outage maps which can be used to identify areas to monitor for CO poisonings, injuries or other effects, and to target public health messaging.

Water quality surveillance

Michigan's water quality data are mostly under the purview of the Michigan Department of Environmental Quality (DEQ) Water Resources Division (WRD). These data sources are evolving in content and availability, as is their use for exposure surveillance, either real-time or historical.

SSO/CSO and Retention Treatment Basin Discharge data

Sanitary sewer overflows (SSOs) are discharges of raw or inadequately treated sewage from municipal separate sanitary sewer systems, which are designed to carry domestic sanitary sewage only. When an SSO occurs, raw sewage may be released into basements, city streets, properties, rivers, and streams. A combined sewer is a sewer that is designed to carry both sanitary sewage and storm water runoff. A discharge from a combined sewer system, or combined sewer overflow (CSO), occurs in response to rainfall and/or snowmelt because the carrying capacity of the combined sewer system is exceeded. These discharges do not receive all treatment utilized under ordinary dry weather conditions. Retention Treatment Basin (RTB) discharges are treated discharges from facilities installed to collect and adequately treat combined sewer system overflows.

Discharge information for these events is available at the website: http://www.deq.state.mi.us/csosso/. The Discharge Information database contains information about specific discharges since June 1, 1999 for which a written report has been filed with DEQ, and can be searched by either the receiving water, county of discharge, or by the responsible entity. The Recent Discharge Events page can be searched for information on recent discharges where DEQ has not yet received a written report. Details of each reported event include: reporting entity, event type, event start and end dates/times; volume of discharge, precipitation type, amount, start and end dates /times; discharge locations, receiving water body, volume of discharge, water quality of discharge, discharge start and end dates/ times. These data could be accessed to identify locations and entities that have more frequent and larger discharges, as an indicator of vulnerability. Although required by state law, it is unclear how completely incidents of water discharges are reported.

Michigan Surface Water Information Management System (MiSWIMS)

MiSWIMS is an interactive map-based system that allows users to view information about Michigan's surface water. Users are able to view and download data and maps collected and maintained by the DEQ and DNR from surface water monitoring sites located throughout Michigan. Relevant monitoring data available by station include: coliforms, fish contaminants, waste water discharges, and septage haulers. This information could be used to identify areas of historic vulnerability to water contamination. MiSWIMS is available at: http://www.mcgi.state.mi.us/miswims/

Michigan Public Beach Information

This DEQ site contains information about Michigan inland and Great Lakes public beaches and recreational-use waterways, including beach closings, monitoring efforts and *E. coli* test results. The data in the beach monitoring systems are collected and entered by the local health department offices, and include lists of public beaches by county that are and are not monitored. Annual summary reports are available at this site: http://www.michigan.gov/deq/0,4561,7-135-3313_3686_3730---,00.html. The site also has links to **Michigan Beach Guard System** http://www.deq.state.mi.us/beach/, a public resource provided by Michigan DEQ for ongoing monitoring information on Michigan beach water quality sampling results and beach advisories and closures, and to **Beachcast** http://glin.net/beachcast/, a website and mobile application maintained by the Great Lakes Information Network for several Great Lakes states and Windsor, Ontario to provide similar real-time information about public beach advisories and closures in the Great Lakes region to potential beachgoers.

DEQ Onsite Wastewater Program

This site has information on DEQ's administrative rules for on-site water supply and sewage disposal systems. Noteworthy are Michigan 2009 and 2013 Statewide Failed Sewage System Evaluation Summary Reports which summarize data collected and submitted by local health departments on 'failed sewage systems' in their jurisdictions. This data collection project is an ongoing cooperation between DEQ and the Michigan Association of Environmental Health Administrators in support of local public health accreditation programs. These data could be used to identify locations historically vulnerable to sewage backup and contamination which could be exacerbated by precipitation events. Available at: http://www.michigan.gov/deq/0,4561,7-135-3313_51002---,00.html.

Water Quality and Pollution Control in Michigan Integrated Reports

Every two years, the DEQ WRD prepares and submits an Integrated Report to the EPA to satisfy requirements of the federal Clean Water Act. These Integrated Reports, most recently completed in 2014, describe the status of water quality in Michigan and include list of water bodies that are not attaining Michigan Water Quality Standards and require the establishment of pollutant Total Maximum Daily Loads, including pathogens and other public health indicators used to permit recreational body contact, along with maps and estimates of lengths of rivers and lakes affected. Reports are available at: http://www.michigan.gov/deq/0,4561,7-135-3313-12711--,00.html. These reports could be used to identify areas of historic vulnerability to water contamination.

Safe Drinking Water Information System (SDWIS)

The DEQ is the State's Drinking Water Agency responsible for collecting, monitoring, and reporting on public drinking water system regulatory violations to the EPA. Regulations establish maximum contaminant levels, treatment techniques, and monitoring and reporting requirements to ensure that water systems provide safe water to their customers (at EPA SDWIS site, below). Public drinking water systems are categorized as:

- *Community Water System (CWS):* A public water system that supplies water to the same population year-round.
- *Non-Transient Non-Community Water System (NTNCWS):* A public water system that regularly supplies water to at least 25 of the same people at least six months per year, but not year-round. Some examples are schools, factories, office buildings, and hospitals which have their own water systems.
- *Transient Non-Community Water System (TNCWS)*: A public water system that provides water in a place such as a gas station or campground where people do not remain for long periods of time.

Currently only CWS violations for Trihalomethanes (TTHM) and Haloacetic Acids (HAAS) are tracked in the DEQ SDWIS, which is not available to the public. However, those contaminants along with others of concern are available for viewing based on water system name, county, population served, and/or system status at the EPA's SDWIS website: http://www.epa.gov/enviro/facts/sdwis/search.html. Each CWS operating agency provides its customers with an annual report of Public Water System Violations. Those and other contaminants will be made available on SDWIS in the future along with Non-community Water Systems, as it is transitioned to an EPA cloud storage site.

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IV. Michigan's Vulnerabilities to Climate Change



"Exposure refers to the susceptibilities that exist due to climate change based on the magnitude, frequency, duration, and geographic extent of various climate related events. Sensitivity is the ability of a community to withstand the range of climate exposures and associated impacts based on physiological, socioeconomic, and infrastructure characteristics (pg.74)."

Defining Vulnerability Assessments

The Third National Climate Assessment defines vulnerability as, "a function of the character, magnitude, and rate of climate variations to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2012)." Figure 4.1 illustrates the key connections between exposure, sensitivity, and adaptive capacity that collectively determine human health vulnerability resulting from climate change.

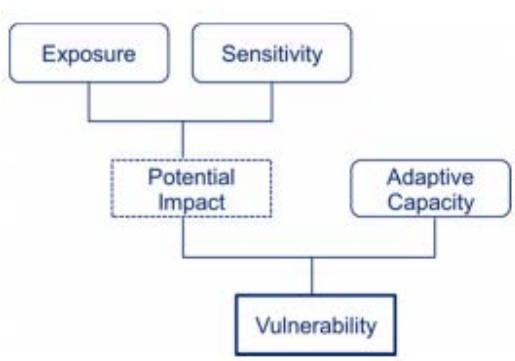


Fig. 4.1: Vulnerability Assessment Model
Source: CDC Climate and Health Program, 2014

Exposure refers to the susceptibilities that exist due to climate change based on the magnitude, frequency, duration, and geographic extent of various climate related events. The Climate and Health Profile focuses on the exposures in relation to those that are detrimental to human health. Sensitivity is the ability of a community to withstand the range of climate exposures and associated impacts based on physiological, socioeconomic, and infrastructural characteristics. The presence or absence of those factors, depending on how they are measured and perceived, can increase the susceptibility of individuals to climate exposures. Adaptive capacity then is the capacity for governments, organizations, businesses, and individuals to respond to an event in order to reduce the potential public health impact (Manangan et al., 2014)

The sections below describe the existing human health vulnerabilities in Michigan based on projected climate changes as they relate to impacts on socioeconomic characteristics, health risk factors, and the built or natural spatial environment. These characteristics influence potential health outcomes resulting from climate exposures for various geographic areas and populations.

Sensitivity

Underserved individuals with limited access to resources and care are the most vulnerable to health risks attributable to climate change. This group includes elderly persons, children, the socially isolated, certain minority populations, the impoverished, the undereducated, the underinsured, outdoor workers, those with existing illness, and those who are immunocompromised (Frumkin et al., 2008).

Age

Elderly persons are physiologically sensitive to extreme climate events and are also more likely to have pre-existing adverse health conditions. Northern Michigan and certain block groups in metropolitan Michigan contain many areas where the median age is over 55 years (See Section II). Conversely, children under the age of 5 years are also sensitive to severe climate events. Smaller body mass and naïve immune systems make children more susceptible to complications from both chronic illness and infectious disease. Spending more time outdoors also increases children's duration of exposure to disease causing factors (Balbus, 2009).

Socioeconomic Status

Over 16% of Michigan's population is below the poverty line and roughly 12% of adults have not graduated from high school. Vulnerabilities to heat stress, extreme weather events and respiratory complications are generated from inadequate shelter, confined living spaces, and limited access to sources of relief such as air conditioning or access to healthcare. The impoverished have less control over how they adapt to severe weather events and tend to live in crowded, low-quality housing, which

can exacerbate impacts from temperature and precipitation. Additionally, having less than a high school education has been associated with adverse health outcomes (Balbus, 2009).

Ethnic minorities make up approximately 24% of Michigan's population and while that alone does not account for increased vulnerability, certain groups are more exposed and/or sensitive to climate effects (Portier et al., 2010; Luber et al., 2014). For example, Native Americans located in the Upper Peninsula are sensitive to resource depletion and water contamination due to extreme heat and drought while many African American and Latino neighborhoods are typically located in high poverty and low air quality areas (Morello-Frosch et al., 2009).

Occupational Groups

Certain occupational groups may be at higher risk of climate-related health outcomes because of the elevated amount of time they spend outdoors. Those with jobs involving parks, recreation, wildlife, water quality, agriculture or construction may face prolonged periods of exposure to potentially harmful weather conditions. Additionally, individuals commuting to and from their places of employment are at elevated risks of traffic-related injury during times of extreme weather (Balbus, 2009).

Health Risk Factors

Many residents are also particularly vulnerable to the adverse effects of climate change based on certain physiologic health characteristics such as obesity (31% prevalence in Michigan) and overweight/obesity (61%). This vulnerability has continued to increase in recent years as Michigan's obesity prevalence rose 25% from 2003 to 2012 and in 2012 was tenth highest in the United States (Centers for Disease Control and Prevention, 2012). Over 15% of Michigan adults and 24% of children have been diagnosed with asthma (Trust for America's Health, 2014). Over 2 million Michigan residents have preexisting cardiovascular or pulmonary risk factors that could be exacerbated by climate change (MDHHS CVD Fact Sheet, 2013).

The demographic groups and those with chronic health conditions noted above that have an elevated vulnerability to climate-related health outcomes represent a large segment of the population. While the "sensitivity" branch of the definition of vulnerability can identify vulnerable people, the "exposure" branch can locate several vulnerable places.

Exposure

Across Michigan there are dense-to-sparsely developed urban communities, rural landscapes dominated by agriculture, and nearly untouched wilderness areas. Each of these unique areas are connected via natural waterways, man-made infrastructure, and human interaction. Climate change will impact each of these areas separately while also having the potential to generate cascading effects on human health in different areas and in unexpected ways. Those relationships are explored in more depth in chapter III: **Linking Exposures to Health Outcomes**. Described here is a set of the priority geospatial risk factors that increase the human health vulnerabilities to climate change.

Natural Environment

Vegetation

The amount of green space, along with creating an aesthetically pleasant environment, has been linked to both human health benefits and concerns. Increases in green space and tree canopy in urban environments have been shown to drastically reduce surrounding air and surface temperatures (Nowak, accessed 2015). Likewise, presence of vegetation can reduce harmful carbon emissions, $PM_{2.5}$ levels, and ozone levels (Nowak, accessed 2015). Conversely, increases in certain pollen producing plants can increase asthma hospitalizations and allergic episodes. Insects and vermin that harbor infectious disease may be drawn to areas with higher amounts of specific vegetation. Additionally, the surrounding soil can also have a role in harboring vectors that transmit disease and draining water levels during extreme precipitation events.

Water

In Michigan, there are over 36,000 miles of streams, and more than 11,000 lakes and ponds (MI Department of Environmental Quality, 2014a). For residents these water sources along with the Great Lakes represent sources of drinking water, irrigation, waste management, and recreation. However, the abundance of surface water is also a source of vulnerability from climate change in terms of flooding, water contamination, and quality. In addition to one's proximity to bodies of water, households with private wells may be at increased risks for water-borne or respiratory diseases depending on water levels (Luber, 2014).

Topography

Uplands and lowlands exist in both urban and rural settings and offer different exposures to climate change. In Michigan, of particular concern are the lowlands. The term "floodplain" pertains to the land area that will be inundated by the overflow of water resulting from a 100-year flood – an area that has a 1% chance of flooding any given year given the elevation and soil type. Approximately 6% of Michigan's land is estimated to be in the 100-year flood plain, or the Federal Emergency Management Agency's (FEMA) Special Flood Hazard Area, including about 200,000 buildings (MI Department of Environmental Quality, 2014b).

Built Environment

Urban development

Michigan is classified as having just over 6% urban development. However, the urban areas contain nearly 75% of the population (U.S. Census Bureau, 2013). This has resulted in certain areas being densely developed and often divided along social and economic lines. Urban vulnerabilities from climate change stem from urban heat island effect, lack of green space or tree canopy coverage, and lack of access to adaptive resources such as food, healthcare, or cooling centers for large populations.

Infrastructure

Michigan is ranked 8th highest in rental vacancy rates with a rate of 11.5% (U.S. Census Bureau, 2013). Those who rent their homes have less control over modifying their built environment in response to weather-related stressors and are considered more vulnerable. Of the 50 most populous counties in the United States, Wayne County ranks 48th in median household value at an estimated 118,100 dollars (U.S. Census Bureau, 2013). Wayne County also consists of high proportions of households below the poverty line and minorities. Those in households with low-median incomes may not have access to sources of relief from climate events. In addition, buildings with low value may experience climate-related damages more easily. Studies have also shown that not having access to medical care

within 1 hour of driving time constitutes as a geographic vulnerability (Hsia, 2011). Hospitals are sparsely located in Northern Michigan and rural dwelling residents may not have ready access to hospitals during severe climatic events.

Historic Events

Finally, historic weather data are informative in discovering which geographic areas of Michigan are historically burdened by specific weather events. Cumulative "extreme heat" or "heavy rain" days derived from historic NOAA Severe Storm data inform us about the frequency of events a county in Michigan has experienced. Wayne, Macomb and Oakland Counties have had 13 "extreme heat" days from 1996 to 2013 according to NOAA, at least some of which were likely associated with or enhanced by the urban heat island effect. Counties in the Upper Peninsula and along the western coast of the Lower Peninsula have the greatest frequencies of winter weather events such as blizzards, ice storms, and lake-effect snow. Knowing the frequency and geographic extent of certain storms for each county can improve a community's adaptive capacity to climate exposures just by knowing what to expect.

Priority Health Outcome Vulnerabilities

The following section explains how the sensitivities and exposures listed in table 4.1 collectively affect each of the Michigan Climate and Health Program's five priority health outcomes: heat-related illness, respiratory disease, vector-borne diseases, water-borne diseases and CO/Injury related outcomes. The sensitivities and exposure-related risk factors that contribute to increased vulnerability to specific climate events have been identified and described in further detail below.

Table 4.1: Summary of "sensitivity" and "exposure" risk factors of vulnerability for 5 priority health outcomes in Michigan.

Sensitivities						Exposures					
Risk Factor	Heat	Respiratory	Vector-borne	Water-borne	CO Poison & Injury	Risk Factor	Heat	Respiratory	Vector-borne	Water-borne	CO P & Ir
Children (< 5 Years)	x	x	x	x		Green Space	x	x	x		
Elderly (> 65 Years)	x	x	x	x	x	Impervious surface	x			x	
Living alone	x				x	Severe Storm events	x	x	x	x	
Racial minority	x	x		x	x	Soil type			x	x	
Low education	x	x		x	x	Private wells				x	
Low household income	x	x		x	x	Proximity to hospital					
Outdoor workers	x	x	x			Elevation		x	x	x	
Commuting to work					x	Ozone & PM 2.5	x	x			
Existing chronic illness	x	x				Proximity to water		x		x	
Access to heat relief	x					Rental housing	x	x		x	
						Median household value	x	x		x	

Heat-related Illness

Populations who are elderly, young, of low socioeconomic status, socially isolated or concurrently inflicted with a chronic illness may face physical and environmental barriers in order to alleviate the effects of extreme heat and are therefore considered vulnerable. Limited mobility within the elderly and socially isolated populations may inhibit them from seeking sources of relief, such as cooling stations (Kovats et al., 2008). Likewise, low income and urban dwelling residents may be unable to

afford air conditioning devices, transportation services or feel uncomfortable leaving windows open for ventilation during heat waves (Semenza et al., 1999). Combinations of these demographics may further aggravate heat vulnerability and require elevated attention as average summer air temperatures and humidity are projected to rise across Michigan (Dan Brown, GLISA, Personal Communication; Frumkin et al., 2008).

The surrounding environment also dictates susceptibility to adverse health outcomes in terms of extreme heat events. Developed cities, such as Detroit and Grand Rapids, often suffer from an "urban heat island" effect that drastically increases temperatures within metropolitan borders compared to surrounding rural areas (Frumkin et al., 2008). Impervious surfaces, such as roads and building materials that trap heat rather than reflect, a lack of green space that would normally improve air quality and mitigate heat, and excess production of greenhouse gases all contribute to the urban heat island phenomenon (Bolund et al., 1999). Occupational hazards also exist for workers who spend excess time outdoors and are exposed to elevated temperatures for extended periods of time (Frumkin et al., 2008).

Respiratory Disease

Elderly persons, children, those with low socioeconomic status, and those with existing respiratory conditions, such as COPD or asthma, may face more respiratory complications as warming air temperatures can increase ozone, pollen, and mold levels (Portier et al., 2010). The growing season in Michigan is expected to increase in length, so plants will have a longer period of time to thrive and produce not only more allergenic pollen, but also greater quantities of pollen (Shea et al., 2008). Extremely hot days are not projected to substantially increase in Michigan, so the degree of impact on the health parameters will depend on the sensitivities of the at risk populations (see section III).

Harmful molds and dusts, and pathogens such as Coccidioidomycosis can be produced from floods and cause significant respiratory problems in humans (Portier et al., 2010). These respiratory problems are often magnified by a lack of green space (also caused by droughts) so people who work or recreate outside may be at higher risks for adverse respiratory health outcomes (Luber et al., 2014). Location may also define respiratory vulnerability from flood events. For example, Detroit city sits at a low elevation near Lake Erie and is prone to flooding. Households of low monetary value or poor infrastructure may experience harmful molds after flooding events (Tollestrup et al., 2014; Swerdlow et al., 1992). Mold growth has been associated with extreme precipitation and flooding events. The intensity of flooding is determined partially by the design of the built infrastructure.

Vector-borne Disease

The projected increase in average seasonal temperatures and mean total precipitation also has implications for vector-borne disease, as mosquito, tick and vermin vectors will begin to expand their habitats. West Nile Virus and Lyme disease are just two of the communicable diseases that might increase in prevalence in Michigan as climate and habitat changes occur.

The two vector-borne diseases of most concern in Michigan are West Nile Virus (WNV) infections and Lyme disease. In general, individuals who are very young, old and/or poor are more vulnerable to these vector-borne health outcomes. Additional demographic risk factors for acquiring vector-borne diseases include spending extended amounts of time outdoors (working or recreating). Having co-morbidities that affect health (e.g., cardiovascular diseases, asthma) or immune response can sometimes exacerbate symptomatic effects as well.

In regard to spatial risk factors, historically in Michigan, a majority of WNV activity has occurred in the Detroit Metro Area and the Grand Rapids Metro Area (Ruiz et al., 2007), suggesting that certain features of urban living provided environments favorable for the *Culex* mosquitoes and WNV. Historic mosquito collection and testing in the Detroit Metro Area indicated that WNV rates were much higher than in other areas of the state (West Nile Virus briefing information, 2012). In 2013, the highest number of WNV cases occurred in southeastern Michigan, which includes the Detroit area. The WNV case rate was considerably higher for urban dwellers living in the inner suburbs, where 1940–1960 era housing dominates, vegetation cover is moderate, population density is moderate and the population is mostly white.

The vector for Lyme disease, the black-legged *Ixodes scapularis* tick, and Lyme disease were first reported in Michigan in 1985. Cases have now been reported in both the Upper and Lower Peninsula, although, most cases are still acquired out-of-state. Historically, the only endemic region in Michigan has been Menominee County in the Upper Peninsula, bordering a highly endemic region of Wisconsin. Recently, however, populations of infected black-legged ticks have been found in southwest Michigan and several counties along the Lake Michigan shoreline (Michigan Zoonotic & Vector-Borne Disease Surveillance Summary, 2013). The number of cases reported in the state is thus anticipated to continue increasing due to the expanding tick distributions and Michigan's suitable habitat.

Water-borne Disease

The elderly, children, and those with existing health concerns are also expected to experience more severe complications from water-borne parasites that could stem from climate exposures (Frumkin, 2008). Those who recreate or work around water systems are also vulnerable for water-borne disease outcomes due to prolonged exposures to potentially contaminated sources (Frumkin et al., 2008). A majority of Michigan's Native American population resides in the Upper Peninsula where mean total precipitation is projected to decrease. With heavy reliance on water quantity and quality for agriculture and drinking sources, drought and excess precipitation events could make Native Americans more susceptible to foodborne and mental illnesses through pathways discussed in section IV (Portier et al., 2010). Heavy runoff after severe rainfall can also contaminate recreational waters and increase the risk of ear, nose, and throat, respiratory or gastrointestinal illness through higher bacterial counts. Less abundant and potentially more severe waterborne diseases such as hepatitis, giardiasis, cryptosporidiosis, and toxic algal blooms pose serious health threats to vulnerable human populations.

Geographically in Michigan, areas bordering the Great Lakes coast and residents located within floodplains are more vulnerable to flooding events over time (MI Department of Environmental Quality, 2014b). Detroit, which is a low lying coastal city, is vulnerable to flooding. Detroit has a combined sewer system and is susceptible to discharges of untreated sanitary sewage into water ways when storm water accumulation is aggressive. This problem is exacerbated by impervious surfaces in Detroit, which increases both the volume and velocity of storm water runoff. Grand Rapids is also prone to seasonal flooding although the City has undertaken a complete combined sewer separation due to be completed in 2015/16. The DEQ completed a Source Water Assessment for the City of Grand Rapids water supply, which is Lake Michigan, in 2003 and found a moderately high susceptibility to contaminants such as viruses and bacteria from sewage, livestock and wildlife.

Some of this raw sewage ends up in lakes and streams, as well as underground aquifers that supply drinking water wells. There are about 1.3 million on-site wastewater treatment systems in Michigan,

most of which are septic systems for single-family homes. State officials estimate that 10 percent of those (130,000) have failed, due to a combination of system failure and heavy precipitation, and are polluting the environment. Some counties requiring septic system inspections during real estate transactions report a 20 - 25% failure rate (Alexander, 2013). According to DEQ data, Michigan's municipal wastewater treatment facilities discharged 7.8 billion gallons of raw sewage and another 21.6 billion gallons of partially treated sewage into lakes and rivers in 2011. Most of those discharges occurred in Detroit and other cities where heavy rainfall overwhelmed combined sewer systems that treat both wastewater and storm water (Alexander, 2013).

CO Poisoning/Injury

The elderly are often socially isolated which may delay assistance after physical or infrastructural damage occurs from extreme temperatures or precipitation. Additionally, those with low Socio-economic Status (SES) may not have properly functioning, or even be in possession of, CO detectors when power outages occur from infrastructure damages. In the event of power outages, CO exposure, often due to the improper use of gas generators, is responsible for many poisonings and even death. For example, a powerful ice storm in December 2013 was responsible for a massive spike in CO poisoning emergency department visits in several counties (Quiggle, Stanbury, Rosenman, 2015).

Additionally, climatic events may geospatially segregate certain populations when heavy infrastructural or flood-related damage occurs. Falling debris created from buildings or vegetation can directly contribute to weather-related mortality and injury. Indirectly, debris can alter human health via traffic accidents, power outages, and subsequent CO poisoning. These damages may result in social disruption which can exacerbate stress and mental illness in predisposed populations. Infrastructural integrity and adequate emergency response preparedness also determine how vulnerable populations are to injuries resulting from climate exposures.

Commuters may experience more traffic-related injury or death due to future projected increases in freezing-rain events from increased winter precipitation combined with temperatures warming above the point of producing snow. Areas downstream of the Great Lakes are expected to have greater amounts of winter precipitation due to the lake-effect. Finally, census data indicates the northern Michigan population tends to be older and may have lower quality of housing. Housing structure integrity in these areas could exacerbate hypothermia, CO poisoning, and other chronic health conditions that may not be addressed in a timely manner because hospital are more sparsely located in northern Michigan.

Climate exposures, vulnerability, and health outcomes

The sensitivities and exposures of vulnerability span many health outcomes and are affected by several climate factors. The vulnerabilities identified highlight populations and locations that need heightened attention when considering climate and health. They also intensify many of the causal pathway links highlighted in section IV. Through Step 1 of the BRACE Framework, MDHHS strives to reduce health disparities by servicing the vulnerable sectors of Michigan.

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V. The Burden of Climate Change and Human Health



Source: National Institute of Environmental Health Sciences, http://www.niehs.nih.gov/research/programs/geh/climatechange/health_impacts/asthma/index.cfm

"Temperatures are trending upward and are projected to continue over the long-term; the rate of change in precipitation is more difficult to project, and extreme events are very difficult to model, resulting in qualitative rather than quantitative predictions of future climate. Local vulnerability factors and population trends will likely have a larger impact on health burden than the rate of climate change in Michigan (pg. 88)."

Introduction

In chapter II: **Michigan's Current and Future Climate Conditions**, the baseline climate conditions along with future climate projections were described for the entire state. Chapter III: **Linking Climate Changes to Health Outcomes** introduced the priority climate related health outcomes along with the potential pathways by which changes in Michigan's climate may impact those specific public health outcomes. Those relationships were further explored in chapter IV: **Michigan's Vulnerabilities to Climate Change** as the geophysical, socioeconomic, and health characteristics of the state were described in terms of their capacity to alter the vulnerability of Michigan's population of being negatively impacted by climate change.

Here, the conclusions of those sections are synthesized to better inform how future climate conditions may exacerbate those existing vulnerabilities and health impacts. This high level view of climate and health in the state will be used as the framework for further analysis of how and by how much climate change may alter disease burden for citizens in Michigan.

Future Health Impacts from Climate Change

Respiratory Disease

Respiratory diseases are related to levels of atmospheric ozone, pollen, mold, and other particulates, which are influenced by air temperatures, humidity levels, precipitation/drought events, and the movement of air throughout a region. Warmer air temperatures can increase risks due to ozone, pollen, and mold levels. For Michigan, there is agreement among the projections that average temperatures will increase over the next century (see Figure 2.6). There is less agreement on the timing of the warming; although more warming is expected to occur on the coldest days versus the hottest (see Figures 2.7 and 2.8, respectively). Given that warming is associated with a longer growing season, plants will have a longer period of time to thrive and potentially produce more pollen (see Figure 2.10). Extremely hot days are not projected to substantially increase (see Figure 2.9) so the degree of impact on health will depend on the sensitivity of the populations being exposed to the heat. However, high humidity has also been shown to increase risks due to its role in low level ozone creation and mold levels. In Michigan the number of high humidity days is projected to increase during summer.

Mold levels have also been associated with extreme precipitation and flooding events, and although the degree of flooding is determined in part by the design of the infrastructure in place to manage it, extreme precipitation events are expected to stay the same or increase (see Figure 2.12). The Wisconsin Climate Change Initiative's (WICCI) downscaled climate projections for Michigan further indicate that the more intense extreme precipitation events (those producing greater than 2 inches of rain) will increase in frequency by a greater degree than those extreme events producing 1 – 2 inches. However, the projections consulted did not provide information about the seasonal timing of these events.

Lastly, the movement (or lack of movement) of air masses affects ozone levels whether the air is stagnant and ozone is able to disperse or if ozone from far away sources is moved into the region. The movement of air masses is largely determined by wind patterns that are especially difficult to simulate at the local scale. Increases in temperature and humidity would exacerbate existing air stagnation

events if the conditions occur simultaneously. In the near term, wind patterns are not likely to change significantly.

Heat-related illness

Heat-related morbidity (e.g. heat exhaustion, heat stroke, etc.) and mortality are correlated with air mass stagnation events and extreme heat events. As previously mentioned, air mass stagnation events are difficult to project at the local scale because simulated wind patterns are uncertain. However, projections do point toward increasing summertime humidity that would exacerbate air mass stagnation events if they occur. In the near term, wind patterns are not likely to change significantly, so the frequency of air mass stagnation events will either stay the same or increase (increases will occur if higher humidity levels allow an event to be characterized as an air mass stagnation event when it previously would not have crossed that threshold). Most projections indicate that days above 95^0 F will increase only a few days per year on average, but the upper simulated range of 25 more days per year could have significant health impacts (See Figure 2.8). The frequency of consecutive days above 95^0 F is projected to remain the same or increase by a few days across the state**.** Summer heat index values are projected to increase, leading to increased heat stress, but most of the changes are related to increased humidity as opposed to increased temperatures (See Figure 2.9). The Milder winters may also reduce the amount of morbidity and Mortality

CO poisoning and traumatic injuries

Carbon monoxide poisoning can occur when people improperly use household appliances, such as gas stoves, or use generators inside their home during power outages, cold spells, flood clean-up, and similar events. Although the frequency of events such as power outages and flood clean-ups is determined more by the integrity of the structures in place to carry power and prevent indoor flooding, extreme weather events create the right conditions for failure of these systems.

Extreme weather events, such as floods, ice and snow storms, and tornadoes, may also lead to traumatic injuries and deaths. In the future there may be more freezing-rain events as temperatures warm above the point of producing snow (see Table 2.8). Tornadoes are not simulated in climate models because they occur on too small of spatial scales. In general it is best to prepare for an increase of extremely hot days and more extreme precipitation events because the projections do not indicate that these events are expected to decrease (see Figures 2.8 and 2.12, respectively). Impacts related to extremely cold days may decrease since fewer days below freezing are projected for the future (see Figure 2.7).

Water-borne illness

Water-borne toxins and diseases increase during climate-related events such as algal blooms, flooding, and changes to ecosystems where new pathogens are introduced. Algal blooms increase when temperatures increase and extreme precipitation events occur. Algal bloom events are also dependent on factors such as nutrient laden agricultural run-off, so events will be localized to areas where this occurs. Flooding events can lead to well contamination, increased surface runoff, and sewage overflows that put surface and drinking water systems at risk for health concerns. Projections indicate that warming is expected, and summer warming is expected to be greatest in southern regions while winter warming is most pronounced in the north (see Figure 2.6). Precipitation projections are more uncertain. Spring mean precipitation is projected to increase in most models, although there is great variability at any given location. Summertime mean precipitation events show large increases and decreases in the models, which indicates high uncertainty (see Figure 2.11). The most intense

precipitation events are projected to stay the same or increase, but the timing of those events is uncertain (see Figure 2.12). New water-borne pathogens can come about from increasing water temperatures and humid weather conditions that foster growth. Warmer average temperatures at all times of the year coupled to more humid summers may accelerate new pathogen growth. In general, future climate conditions will be the same or more conducive to water-borne toxins.

Vector-borne disease

Vector-borne diseases and their link to climate conditions is especially complex because several climate variables are involved, and the timing of climate conditions is an important factor. The climate conditions that are favorable to West Nile Virus (WNV) and its mosquito vector are a warm winter and early spring followed by a hot, dry summer. Climate projections indicate that all seasons are warming and spring will occur earlier as the growing season expands (see Figure 2.10). Summer humidity is projected to increase, but there is uncertainty about summer precipitation projections (see Figure 2.11). Most of the projected changes align with climate conditions that are favorable to WNV.

Another complex human health concern is Lyme disease, which is impacted by warm, snowy winters followed by warm, rainy, humid springs that favor the proliferation of the tick vector *Ixodes scapularis*. Lyme disease has potential to persist later in the year if fall conditions are warm and humid. Again, projections indicate that all seasons will warm, but precipitation and humidity information is more uncertain. The projections indicate that more winter precipitation will fall as rain across the Midwest, but annual lake-effect snowfall amounts have already increased and regional modeling studies suggest a continuation of that trend in the future (see Figure 2.11). Rain versus snow for winter precipitation will be determined by the degree of warming and whether freezing thresholds are met. The Upper Peninsula is expected to warm more during the winter than the Lower Peninsula, but temperatures in the north are farther from the threshold for producing rain. In general, snow is a complex variable to model, so it is best to anticipate greater precipitation variability in Michigan's winter season (i.e., rainy and/or snowy winters). Spring precipitation is projected to increase in most of the models, but the consulted projections did not indicate whether spring or fall humidity levels will change in the future. From a temperature standpoint, climate conditions will be favorable to the increase of Lyme disease in the future. However, the complex nature of precipitation modeling and uncertainty associated with whether the right combination of climate conditions for more than one consecutive season will occur make it difficult to project whether Lyme disease will become more widespread in the future. In the near term, lake-effect snowfall amounts will likely continue to increase. Therefore Lyme disease may become more prominent in the lake-effect zones.

Regional Considerations

Detroit and Southeastern Michigan – Climate Division 10

Detroit and southeast Michigan will face many of the same changes in climate as the surrounding geographic area, but its urban to suburban setting alters and amplifies many vulnerabilities. Land use, pre-existing infrastructure design, and socioeconomic capacity are among many characteristics that will either reveal strengths or pose obstacles in adapting to climate change and associated health risks.

There are many potential impacts of climate change that cut across many sectors and jurisdictions. Southeast Michigan, Detroit in particular, is expected to face the following critical challenges in the coming decades:

- As average temperatures rise throughout the region, the probability of heat waves and hot days will grow, increasing the risk of heat-related illnesses. The number of days over 90°, 95°, and 100° F are all expected to increase through the coming century, assuming greenhouse gas emissions will continue to increase. Heat islands in urban centers that house less mobile populations are particularly vulnerable.
- As severe rainstorms become more frequent and more intense, flooding will increase the risk of sewage overflows, water contamination, and algal blooms. Many communities in southern Michigan employ combined sewer systems that transport both sewage and storm water. Extreme storms overwhelm these systems and discharge untreated sewage into waterways.
- More storm activity will also amplify the risk of damage to infrastructure, and in severe cases, may limit the effectiveness of emergency responders.
- Detroit likely will see an increase in the number of unhealthy ozone days due to climate change. The Detroit area includes many fossil fuel emission sources, and the region is projected to see an increase in the number of hot days that will increase ozone production.

Grand Rapids and Southwest Michigan – Climate Divisions 5, 6, 8

Grand Rapids and southwest Michigan have already seen impacts of climate change. The presence of major waterways through agriculturally-dominated and urban settings that have been subject to a number of land uses are a vital resource to the region, but also a consistent thread of vulnerability in communities. Existing problems of flooding, water quality, and infrastructure damage will be amplified due to climate change without appropriate adaptation measures.

Southwest Michigan and Grand Rapids are expected to face the following critical challenges in the coming decades:

- As average temperatures rise throughout the region, the probability of heat waves and hot days will grow, increasing the risk of heat-related illnesses. Heat islands in urban centers that house less mobile populations are particularly vulnerable.
- As severe rainstorms become more frequent and more intense, flooding will increase the risk of sewage overflows, water contamination, and algal blooms. Many communities in southwestern Michigan employ combined sewer systems that transport both sewage and storm water. Extreme storms overwhelm these systems and discharge untreated sewage into waterways.
- The risk of flooding, particularly along the Grand River, will be amplified by more storm activity. Without adaptation or intervention, the risk of infrastructure damage and health hazards will increase.
- Much of southwestern Michigan may see an increase in the number of poor air quality days resulting from air stagnation during an increasing number and duration of heat waves.

The Upper Peninsula and Northern Lower Michigan – Climate Divisions 1-4

Northern sections of the state have warmed faster than areas to the south and have seen dramatic increases in average winter temperatures (see Table 2.1). Changes in winter seasonality specifically may be a factor in public health impacts and emergency response. While extreme summer heat (e.g., days exceeding 95^0 F) comparable to southern Michigan is not a concern, the prevalence of air conditioning is far less in the North, and populations are less adapted to warm temperatures. The number of days exceeding 80^0 F has increased and is expected to increase throughout the next century. Even these moderately warm temperatures can increase risks in communities not accustomed to them.

The frost-free period, the number of days between the last spring freeze and the first autumn freeze, has grown longer by 5-10 days in many northern Michigan locations. By mid-century, the Upper Peninsula and northwest Lower Peninsula of Michigan will likely see a frost-free season that is 3-4 weeks longer than during the recent past. These rapid changes in seasonality could alter disease vectors and impact ecosystems in other ways that indirectly affect human health risks.

The Upper Peninsula's sparse population forces emergency responders to cover larger geographic areas than the rest of the state. As extreme precipitation continues to increase throughout the Upper Peninsula and issues currently limited to southern areas appear farther north, emergency response teams may see increased activity. On the other hand, a shorter winter season could reduce the period of the year that emergency response is challenged by snow and ice, making ground transportation safer.

East and South Central Lower Michigan- Climate Divisions 7 and 9, respectively.

These regions are predominantly agricultural but contain urban areas such as Bay City, Saginaw, Lansing and Jackson. The East Central region surrounds Saginaw Bay and encompasses the Saginaw Bay watershed which is the largest contiguous freshwater coastal wetland system in the United States. Both regions are trending upward in total precipitation and, at a 25% increase from the 1951 – 1980 period to the 1981 – 2010 period, report the largest relative increases in Fall precipitation for the entire state (see Table 2.3). This increases the potential for flooding and water contamination due to runoff from agricultural areas and septic systems.

Summary and Synthesis

In the short term, which is within the next 15-20 years, current climate patterns will generally persist. Temperatures are trending upward and are projected to continue over the long-term. The rate of change in precipitation is more difficult to project, and extreme events are very difficult to model. This necessitates qualitative rather than quantitative predictions of future climate. It is likely that local vulnerability factors and population trends will have a larger impact on health burden than the rate of climate change in Michigan.

Overall, based on the best evaluation of climate patterns and a synthesis of the best model projections by GLISA climatologists, the climate impacts on priority health conditions listed in Table 5.1 can be expected in Michigan.

Key: Table 5.1 Climate Projection with Related Health Impacts

+	Projected increase in the variable
-	Projected decrease in the variable
+/=	Projected variable increases or remains the same
-/=	Projected variable decreases or remains the same
?	Unclear or cannot project the variable
NC	No change in the projected variable

Table 5.1: Summary of Future Impacts to Priority Health Outcomes Based on Existing Vulnerabilities and Climate Change Projections

Environmental Exposures	Climate Stressors	Climate Projections (2021 – 2050) with Related Health Impacts
Respiratory Disease		
- Ozone Levels - Particulates	warm air temperatures, high humidity, air stagnation, wind patterns	+ Air temperatures, especially for days below freezing. + Summer humidity, producing more unfavorable conditions during air mass stagnation events ? Cannot project frequency of air mass stagnation events **NC** Large-scale wind patterns in the near term ? Cannot simulate local-scale winds
Conclusion: 1. Climate conditions leading to worsening ozone levels will likely stay the same or intensify. 2. Increased combustion to meet electricity demands for air conditioning during hot humid weather could lead to increased particulate levels. 3. Air toxics levels may increase during air stagnation events. Overall, projected conditions favor increased air pollution and worsening respiratory disease.		
- Pollen Levels	warm air temperatures, growing season length, date of first frost, Carbon dioxide levels	+ Air temperatures, especially for days below freezing. + Days of frost-free growing season, with day of last spring freeze up to a week earlier by 2050 + Carbon dioxide levels in atmosphere
Conclusion: 6. Climate projections favor earlier and longer growth period for plants 7. Pollen levels are expected to increase which could exacerbate respiratory diseases including allergic asthma		
- Mold Levels	extreme precipitation events, high humidity, especially in fall	+/= extreme precipitation; >2 in. events project an increased frequency by greater degree than 1-2 in. events ? Cannot project timing of these events **NC** Fall humidity levels
Conclusion: Cannot project if climate conditions favorable for mold growth will change given the importance of timing for mold, so impact on allergic diseases is uncertain.		
- Particulate Levels (dust, forest fires)	drought	- Number of consecutive dry days/year in northern Lower Peninsula -/= Number of consecutive dry days/year for remaining portions of the state
Conclusion: Drought related climate stressors on particulate levels should be minimal overall, and therefore drought's impacts on respiratory diseases are projected to be minimal.		

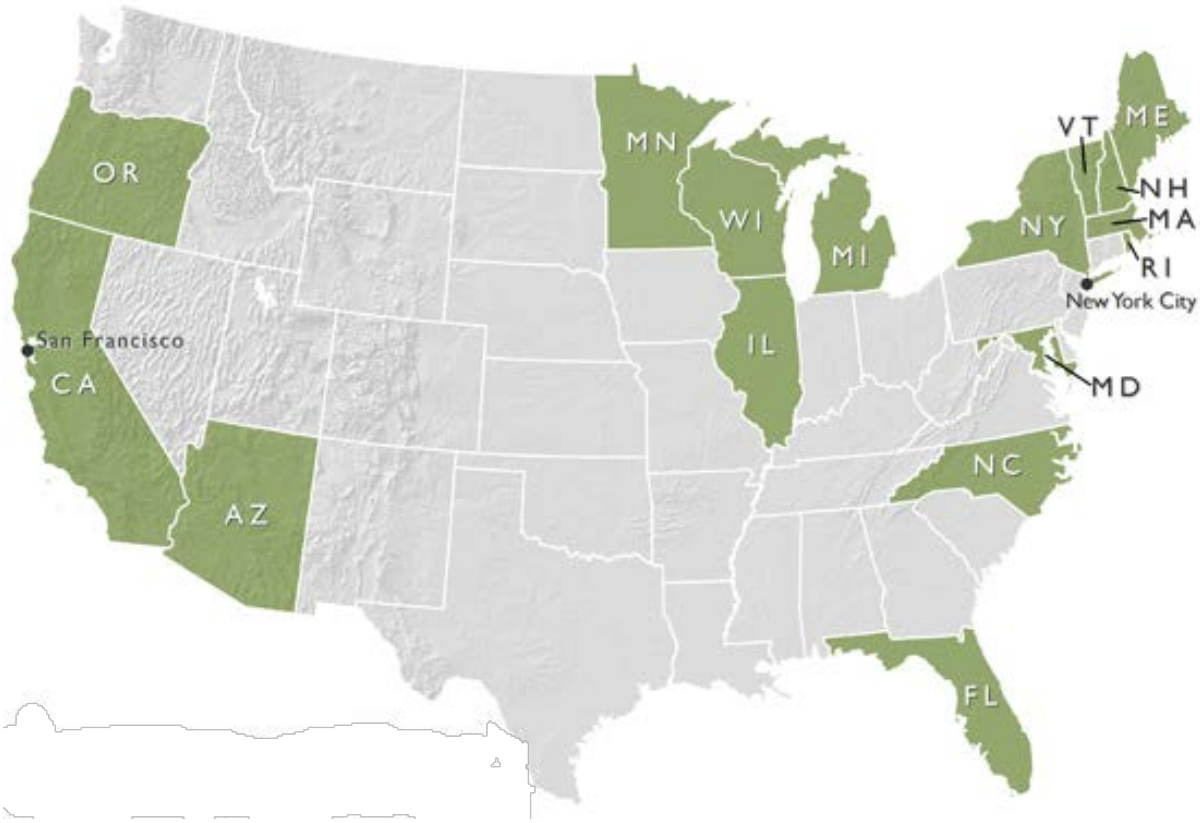
Environmental Exposures	Climate Stressors	Climate Projections (2021 – 2050) with Related Health Impacts
Heat-related Morbidity and Mortality		
- Elevated Temperatures	air stagnation	+ Summer humidity, producing more unfavorable conditions during air mass stagnation events ? Cannot project frequency of air mass stagnation events **NC** Large-scale wind patterns in the near term ? Cannot simulate local-scale winds
Conclusion: Air mass stagnation events may increase in frequency if high humidity occurs with high temperature and low winds, leading to increased heat stress-related morbidity and mortality.		
- Elevated Temperatures	extreme heat events	+ A few more (near-term) up to 25 more (long-term) days/ per year over 95^0F ? Consecutive high-heat days over 95^0F
Conclusion: Projected increasing numbers of high heat days by mid-century, which will likely have large impacts on human health, especially if there are consecutive high-heat days over 95^0F.		
Carbon Monoxide (CO) Poisonings and Traumatic Injury/Death		
- Power Outages - Trauma Risk	extreme weather events flooding, snow and ice storms, tornadoes	+ Extremely hot days and extreme precipitation events => increased stress on power grid + Winter precipitation as freezing rain rather than snow => downed power lines +/= extreme precipitation; >2 in. events project an increased frequency by greater degree than 1-2 in. events ? Cannot simulate local-scale winds
Conclusion: 1. Extreme weather events conducive to power outages are projected to increase, especially in winter, leading to increased use of generators and thus increased risk of Carbon monoxide poisoning. Power outages during hot weather increase risk for heat stress and for food and water contamination. 2. Freezing rain increases risk for ice and thus for traumatic injury, as does flooding.		
- Flood Clean-up	extreme precipitation events	+/= extreme precipitation; >2 in. events project an increased frequency by greater degree than 1-2 in. events ? Cannot project timing of these events
Conclusion: 1. Intense precipitation events are projected to stay the same or increase, which will increase flood risk in vulnerable areas. 2. Clean up utilizing power washers may increase risk of carbon monoxide poisoning.		

Environmental Exposures	Climate Stressors	Climate Projections (2021 – 2050) with Related Health Impacts
- Cold Spells	extreme cold days	- Days below freezing. ? Extreme cold events
Conclusion: Projected warming generally reduces the need for indoor heating and associated risk of CO poisoning will likely decrease.		
Water-borne Toxins and Disease		
- Algal Blooms	warm temperatures, extreme precipitation	+ Average temperatures across all seasons; greatest summer time increase for southern Michigan +/= extreme precipitation; >2 in. events project an increased frequency by greater degree than 1-2 in. events ? Cannot project timing of these events
Conclusion: In general, climate conditions will be the same or more conducive to the development of algal blooms in the future. Southern regions are most vulnerable to runoff due to intense precipitation.		
- Flooding - Sewage/Contaminants	warm temperatures, extreme precipitation	+ Average temperatures across all seasons; greatest summer time increase for southern Michigan +/= extreme precipitation; >2 in. events project an increased frequency by greater degree than 1-2 in. events ? Cannot project timing of these events
Conclusion: 1. In general, climate conditions leading to flooding will be the same or more intense in the future, with southern regions most likely to see increases. 2. Areas vulnerable to sewage/septic failures and runoff have an increased risk for water-borne diseases.		
- New Pathogens - Ecosystem Changes	warm temperatures, high humidity	+ Average temperatures across all seasons; greatest summer time increase for southern Michigan, and greatest winter time increase in northern Michigan + Summer humidity
Conclusion: Projected increases in temperature and humidity may be favorable to the emergence of new pathogens in the state.		

Environmental Exposures	Climate Stressors	Climate Projections (2021 – 2050) with Related Health Impacts
Vector-Borne Diseases		
- Mosquito vector (West Nile Virus)	warm winters, early springs, followed by hot dry summer	+ Average temperatures across all seasons; greatest summertime increase for southern Michigan; and greatest winter time increase in northern Michigan + Days above freezing, with day of last spring freeze up to a week earlier by 2050 ? Summer-time precipitation; some models predict large increases and others large decreases.
Conclusion: In general the projections point to warmer winters, earlier springs, and warmer summers, climate conditions suitable for West Nile Virus and its mosquito vector.		
- Tick vector (Lyme Disease)	warm and snowy winter followed by warm, rainy, humid spring followed by warm humid fall	+ Average temperatures across all seasons; greatest summer time increase for southern Michigan, and greatest winter time increase in northern Michigan + Winter precipitation as rain/freezing rain rather than snow except for lake-effect snow, which should increase **NC** Spring and fall humidity levels.
Conclusion: Cannot project the complex sequence of climate conditions suitable for Lyme disease and its tick vector.		

VI. Partnerships and Collaborations

CDC Climate-Ready States & Cities Initiative Grantees



"There is a growing recognition that the magnitude of health 'co-benefits,' like reducing both pollution and cardiovascular disease, could be significant, both from a public health and an economic standpoint (pg. 94)."

Introduction

The Human Health chapter of the National Climate Assessment noted, "There is a growing recognition that the magnitude of health 'co-benefits,' like reducing both pollution and cardiovascular disease, could be significant, both from a public health and an economic standpoint" (Luber et al., 2014). Moreover, while the BRACE framework requires the assessment of climate impacts on health and the public health system, the interventions to adapt to those climate impacts often reside in other sectors such as economic development, community planning, public works, and energy. Since 2010, MICHAP, through the previous Strategic Planning and Implementation grants, has established a strong network of multidisciplinary stakeholders and collaborators to comprehensively address the health impacts associated with climate change and identify the "co-benefits" of various interventions in order to fully value costs and benefits. These partnerships and collaborations are described below.

Description of Partnerships and Collaborations

MICHAP Advisory Committee

Formed in 2010 as an offshoot of the strategic planning group, these 12 experts drawn from partnerships in academia and public health practice provide feedback and consultation to MICHAP on work plans and products.

Michigan Department of Environmental Quality (DEQ)

In 2010, DEQ facilitated and participated in development of the Michigan Climate Action Plan and the MICHAP strategic plan, key roles in the formation of the Michigan Climate Coalition. They will continue to provide data and resources relevant to climate adaptation, including air and water quality data. In addition, MICHAP will look to build interagency climate planning capacity by meeting with climate related work groups.

Michigan Climate Coalition (MCC)

Created from the Michigan Climate Action Planning process, MCC is a collective open to all with an interest in climate science, energy efficiency, sustainability and related disciplines from the public and private sectors, including non-governmental organizations (NGOs), businesses, government, and educational institutions. Provides MICHAP a platform to distribute climate and health information and learn of climate related initiatives from other potential collaborators.

National Weather Service Regional Office (NWS)

Since 2010, the regional NWS has been a key partner who provided information for the Heat Response Plan and co-presented with MICHAP staff at Michigan's Homeland Security Conference and UM grand rounds. They will continue to provide expert advice, technical assistance, data, and communications channels to ensure the public is made aware of extreme heat and other climate related public health threats.

Michigan Association of Planners (MAP)

Beginning in 2010, MAP participated in the MICHAP strategic planning process, and worked to bolster outreach and education through their membership regarding the public health impacts of climate change. As the deliverables of the BRACE framework are completed, MAP will continue to provide a platform for presenting those results to community planners while also providing valuable feedback and opportunities to best relate those tools and data to partners and planning processes outside of traditional public health.

Great Lakes Integrated Sciences and Assessments Program (GLISA)

An integral partner since the development of the first strategic plan in 2010, GLISA staff has worked with MICHAP to provide expert advice and technical assistance using climate data and to identify tools and climate

models that are needed by Local Health Departments (LHDs) in order to plan for extreme weather events and other climate-related health outcomes. Specifically, they provided historic and projected climate data for each of Michigan's climate regions and are co-authors of this Climate and Health Profile Report. They will continue to be a technical and communications resource throughout the BRACE Grant for Michigan as well as the entire Midwest BRACE collaborative.

University of Michigan (U of M)

Through the previous Implementation Grant, MICHAP funded 4 summer internships for students in the U of M Masters of Public Health program. The students assisted with informing heat and health research, analysis of climate change indicators, the scoping and assessment phases of an HIA, writing reports and developing educational materials. Moving forward in the BRACE grant, students and staff will continue to be engaged in various aspects of the project from providing data and information sources to guiding MICHAP staff in best practices related to climate and health adaptation strategies and communication tools.

Michigan State University (MSU)

Previously, MSU faculty worked with MICHAP to develop an interactive model predicting deaths and hospitalizations during heat waves in Michigan cities. The model was presented to local health officials, and stakeholder feedback was incorporated into the model development. Moving forward with the BRACE framework staff and students will be sought in regards to producing climate and health communications along with how to best engage and train planning and local public health officials in adopting the BRACE process.

Local Health Departments (LHDs)

The ultimate goal for MICHAP is to engage LHDs in the BRACE process and partner with them to best utilize the data, tools, and materials as a means of intervention against the climate related health impacts identified in the CHPR, Vulnerability Assessment, and Disease Burden Projections. Through the previous Implementation Grant, health impact assessment (HIA) training was conducted that resulted in the funding of two HIAs and served as a catalyst for the inclusion of environmental health factors in many projects and plans. MICHAP will seek to follow a similar strategy for training and engagement of LHDs in the BRACE framework.

Michigan Public Health Association (MPHA)

A long standing partner, MPHA was an original participant in the strategic planning process and works with MICHAP on outreach and education to their membership regarding the public health impacts of climate change. MICHAP has presented every year at MPHA's annual public health conference and will continue to do so as the BRACE steps are completed and vital data and tools are made available.

Office of Public Health Preparedness (OPHP)

A key partner in the development and implementation of the BRACE framework at the state and local levels, OPHP is the emergency preparedness and response arm of the Michigan Department of Health and Human Services. MICHAP will look to leverage their expertise and role as the entity responsible for the protection of the health of Michigan citizens before, during and after an emergency through the integration of public health and medical preparedness initiatives. Previously, MICHAP developed the 'natural disasters' emergency response plan annex in collaboration with OPHP to address the public health emergency response to severe weather events, including extreme heat, floods, and other weather-related events. OPHP will continue to serve as a point of contact to interact and educate LHD Emergency Preparedness Coordinators. MICHAP will also seek to partner with OPHP to develop toolkits that aid in the preparation and response to climate related emergencies.

Land Information Access Association (LIAA)

MICHAP partnered with LIAA to develop a grant proposal to the American Public Health Association (APHA) and the Kresge Foundation to create a comprehensive master planning approach in multi-jurisdictional communities to reduce vulnerability and increase resilience. Through that LIAA was awarded 3 year funding from the Kresge Foundation to increase the resilience of Michigan communities. MICHAP staff is providing public health expertise, data and technical assistance to the community action teams, LHDs, and ultimately each community's master plan.

Detroit Climate Action Collaborative (DCAC)

The Detroiters for Environmental Justice (DEJ) established the DCAC to develop the City of Detroit's first climate action plan (CAP). MICHAP's Project Manager was a past chair of the Public Health Workgroup and continues to be a member of the steering team. Workgroup members are currently drafting the public health section for the CAP and are partnering to conduct a public health sector based meeting during the spring of 2015. A key component of the sector based process is to obtain important input from Detroit leaders across sectors including municipal, environmental, private business, and residential. In addition MICHAP is leading the development of a climate and health surveillance system through existing state and local public health processes and infrastructure.

Michigan Municipal League (MML)

In 2011 MICHAP Principal Investigator Lorraine Cameron joined MML's Michigan Green Communities (MGC) Challenge Steering Committee. The MGC serves as a guide for communities to measure their progress toward sustainability, encourages friendly and productive competition between Michigan communities, provides a framework for peer-to-peer benchmarking, and recognizes communities for their sustainability accomplishments. MICHAP will work with MGC to incorporate metrics developed as part of BRACE into the challenge while also providing expertise in ways that communities can achieve public health benefits through the goals and metrics they are already working towards.

West Michigan Environmental Action Council (WMEAC)

MICHAP will support WMEAC in their efforts to develop and implement a collaborative planning process for communities in the West Michigan region, particularly in the Lake Michigan Coastal area, by providing important climate change and health impact data, utilizing MICHAP's past experience in working with diverse groups of decision makers, planners, and local health officials to plan comprehensively for climate change.

Michigan Association of Local Environmental Health Administrators (MALEHA)

In partnering with this organization, whose goal is to promote and strengthen all facets of environmental health delivery systems, MICHAP will focus on understanding what the most effective and efficient methods are for developing trainings, policies and procedures that incorporate the BRACE framework into traditional local public health planning processes.

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