GROUNDWATER ASSESSMENT REPORT

Allegan County

FINAL DRAFT 09/16/24

Acknowledgments

The Allegan County Groundwater Assessment Report benefited from significant collaboration with the Allegan County Groundwater Study Workgroup, Board of Commissioners, County staff, the Michigan Department of Environment, Great Lakes, and Energy, and representatives from local governments who participated in this planning process.

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Appendix A: Allegan County Groundwater Study - Phase 1

Appendix B: Allegan County Groundwater Study - Phase 2

Appendix C: Groundwater Protection Area Delineation Approach & Modeling

Appendix D: Point Source Inventory & Contamination Risk Map Tasks

Appendix E: Review of the Top 25 Sites of Groundwater Concern

Appendix F: Non-Point Source Pollution Analysis & Risk Ranking

Appendix G: Population Projections

Appendix H: List of Files & Data Sources Provided to Allegan County

Index

Executive Summary 4

CH 1. An Introduction to Water in Allegan County 8

- 1.1 Where the Water Lives
- 1.2 Groundwater Sources
- 1.3 Groundwater Use
- 1.4 Groundwater Supply

CH 2. Groundwater Protection Area Delineation 24

- 2.1 What's a Groundwater Protection Area?
- 2.2 Why is a Groundwater Protection Area Delineation Important?
- 2.3 Groundwater Protection Area Delineation Map
- 2.4 Wellhead Protection Areas

CH 3. Areas of Concern & Water Quality Risks 34

- 3.1 Point Source Pollution
- 3.2 Non-Point Source Pollution
- 3.3 Composite Groundwater Risk Map

CH 4. Groundwater Demand & Future Use Projections 54

- 4.1 Aquifer Access
- 4.2 Historic Groundwater Use
- 4.3 Groundwater Use Today
- 4.4 Future Groundwater Demand Projections

Report Takeaways 78

Glossary of Terms 80

EXECUTIVE SUMMARY

Purpose for this Study

Nearly all water demand in Allegan County, whether from private residences or public water utilities, is supplied by groundwater. The City of Holland is the exception, as they are the only local government unit (LGU) in the County that relies on treated surface water from Lake Michigan. Groundwater in Allegan County is obtained primarily from two groundwater resources (aquifers) underlying the entire County; therefore, a resilient supply of clean water is essential for the public health and the economic vitality of the County. Although most of the population of Allegan County shares the groundwater from these two aquifers, neither the County nor LGUs have mandated oversight responsibilities for comprehensive groundwater management. In other words, except for public water supplies, these groundwater resources are largely unregulated and few controls exist to protect them from overuse, contamination, impacts from human activities in adjacent counties, or climate change.

In response to the findings of groundwater concerns in neighboring Ottawa County, Allegan County began its own research to assess the present conditions of these important resources. The first Allegan County-wide groundwater study was conducted in 2020 and revealed that the large-scale declines in groundwater levels, as observed in Ottawa County, are not yet apparent in Allegan County. **However, the study identified similar conditions in Allegan County that led to Ottawa County's groundwater predicament. This includes;**

i. Elevated chloride concentrations impacting groundwater discharge areas from the bedrock aquifer,

i. To a lesser degree, elevated nitrate concentrations impacting the shallow groundwater,

ii. The presence of numerous potential or known sites of contamination throughout the County,

iii. Hints of declining groundwater levels due to unsustainable water use trends, and

iv. A complex geology where some pockets within the aquifer system are water limited while another area a relatively short distance away in depth and/or direction may be water rich.

2019

Fall — Allegan County hosts an informational groundwater meeting to share the results of the Ottawa County Groundwater Study.

Spring — The Phase 1 Groundwater Study is initiated to assess the general health of the groundwater resource. This included a screening-level review of hydrogeology and groundwater quality in the County.

2020

Winter — The Phase 1 Study is completed and findings are presented to Allegan County and Local Units.

2021

Winter — An Ad-Hoc Groundwater Study Workgroup is established to report and make recommendations to the Board of Commissioners related to groundwater planning and management.

2022

Summer — The Phase 2 Groundwater Study is initiated to further identify sites of contamination and their potential risks to public and environmental health.

Spring — The Phase 2 Study is completed and results are presented to the Workgroup and Board of Commissioners.

2023

Summer — Efforts to conduct a Groundwater Strategic Plan kick-off.

2024

Winter — This Groundwater Assessment Report (GAR) was drafted as part of the County's Groundwater Strategic Plan process.

Allegan County has the opportunity to proactively address these issues before a groundwater crisis occurs, but they cannot do it on their own. In 2022, the Allegan County Groundwater Study Workgroup was created by the Board of Commissioners to formulate a protection strategy for tackling groundwater issues across all of Allegan County. This initiative continues to be supported by the Commissioners and grant funds are available to finance certain groundwater-related activities on a short-term basis. However, developing and implementing a County-wide groundwater strategy needs to be a partnership between the County, its LGUs, and private groundwater resource users.

The Research Process

It is the intent of this Groundwater Assessment Report (GAR) to provide the public, local leaders, and stakeholders with the knowledge and know-how to act. The GAR synthesizes conclusions from the Phase 1 and Phase 2 studies, and explores new research elements including the designation of groundwater protection areas that extend beyond the County borders, an expanded contaminant source inventory and risk area mapping, and a groundwater demand and future projections assessment. This new research seeks to fill in knowledge gaps identified by the Allegan County Groundwater Study Workgroup and data needed to form a more holistic groundwater management strategy for the future.

Next Steps:

- Workshop #1: Results of this report are shared with LGUs to raise awareness about current and potential groundwater issues and foster a discussion about groundwater questions, concerns, and solutions.
- Synthesize LGU input and develop potential groundwater strategies.
- Workshop #2: Potential initiatives and activities that could be implemented as part of an overall strategy to address groundwater issues are shared with LGUs to gather feedback, assess priorities, and build support.

GOAL: Develop and implement a County-wide groundwater strategy supported by LGUs and other groundwater stakeholders.

Report Takeaways

Key takeaways from this research are provided below, organized in no specific order of importance. They provide a short summary of important points to highlight during future strategy discussions and community conversations about the state of groundwater in Allegan County. All of the following statements are explored in greater detail within the subsequent chapters of this report and respective appendices.

- Almost all water users in Allegan County rely on groundwater from two aquifers. Groundwater is the preferred source of water supply because of its:
  - General protection from surface contaminants
  - Lower vulnerability to weather events
  - Reliability and cost-effectiveness
  - Consistent quality
  - Time tested systems comprehension
  - Jurisdictional control
- Groundwater is not equally accessible across the County because the subsurface geology is spatially complex. For example, finding groundwater, the amount that can be pumped, or the speed of flow can all change quickly over a small geographic distance.

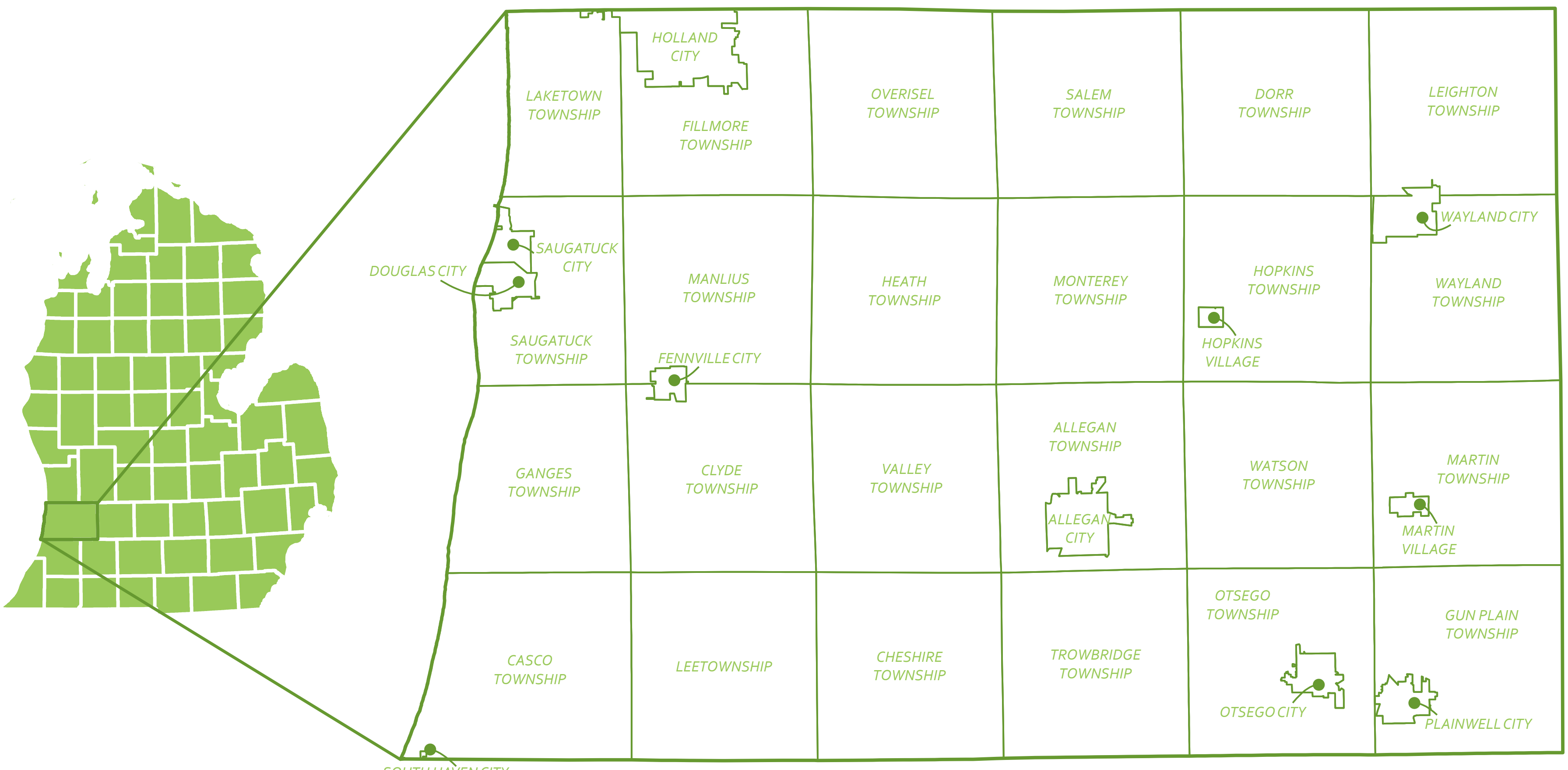
- The Groundwater Protection Area (GPA) for Allegan County is limited to the County's geographic boundaries and immediately adjacent neighboring counties. Barry, Van Burren, and Kalamazoo Counties have the largest groundwater contribution areas to Allegan County and have a greater potential impact on groundwater conditions.
- 351 sites of groundwater concern were identified and their risk to drinking water supply and surface water was assessed. The highest risk sites were generally clustered around population centers, particularly in or around the Cities of Wayland, Plainwell, Allegan, and the Village of Martin.
- In both urban and rural areas throughout the County, data showed groundwater with substances that exceed established drinking water standards related to human health or aesthetic qualities, such as taste, smell, or color. Specific issues include:
    - Significantly elevated nitrate concentrations impacting shallow groundwater
    - Elevated chloride concentrations impacting groundwater discharge areas and along major roadways
    - Significantly elevated iron concentrations throughout the groundwater system
- A composite groundwater quality risk map was developed, providing an at-a-glance resource to help identify areas that may be at higher risk for groundwater contamination. Many areas of higher risk generally coincide with areas of high groundwater use (including for public supply) and warrant continued monitoring and protection.
- Allegan County is projected to see modest overall growth over the next 30 years, and as a result, cumulative groundwater overuse doesn't appear to be an imminent threat.
- Certain areas of the County are experiencing growth more than others and will continue that trend, such as Salem, Martin, Casco, and Leighton Townships – these are the areas to prioritize long-term monitoring to protect and preserve the local groundwater resource.
- Projected growth in certain areas of the County call for long term monitoring and planning, particularly in areas with limited groundwater resources.

CHAPTER 1

INTRODUCTION

Chapter 1. An Introduction to Water in Allegan County

Allegan County is located in the southwestern region of Michigan. Situated on the scenic shores of Lake Michigan, the County shares its southern border with Van Buren and Kalamazoo Counties, Barry County to the east, and Kent and Ottawa counties to the north. Allegan County is larger in area than most Michigan counties, encompassing a total of 1,828 square miles of land and 1,006 square miles of open water bodies. Thirty-five total Local Government Units (LGUs) operate within the County borders and include nine cities, 24 townships, and two villages. The Match-E-Be-Nash-She-Wish Band of Pottawatomi Indians', a federally-recognized Indian Tribe, lands and government operations are also located within the boundaries of Allegan County. As part of the Grand Rapids metropolitan area and a bordering County to the Kalamazoo–Portage metropolitan area, many communities in Allegan County provide attractive places to live with just a short commute to nearby employment centers.



1.1 Where the Water Lives

When many people think of naturally occurring water sources, surface water bodies like lakes, rivers, and streams often come to mind. The focus of this report is on groundwater, the water that exists underground in the water-bearing layers of permeable rock and soil. This chapter provides an introduction to groundwater concepts and an overview of groundwater sources, use, and supply in Allegan County.

Surface Water

The County's location provides a distinctive setting, boasting 25 miles of Lake Michigan shoreline, making it a sought-after destination for residents and visitors alike. Allegan County is rich in surface water resources and accompanying public land, fostering many unique recreational opportunities. The major surface water systems include Lake Michigan, the Kalamazoo River, the Black River, the Rabbit River, and the Macatawa River, along with numerous connecting tributary streams and associated inland lakes.

In addition to the County's ten major rivers, there are nearly 100 lakes covering almost 8,000 acres (1.6% of the total County land area). The largest inland lake solely within Allegan County is Lake Allegan, spanning 1,587 acres, while Gun Lake is larger at 2,611 acres, it only partially lies within the County. Nineteen other inland lakes exceed 100 acres in size. Several large lakes, including Lake Allegan, serve as hydroelectric reservoirs formed by the damming of the Kalamazoo River.

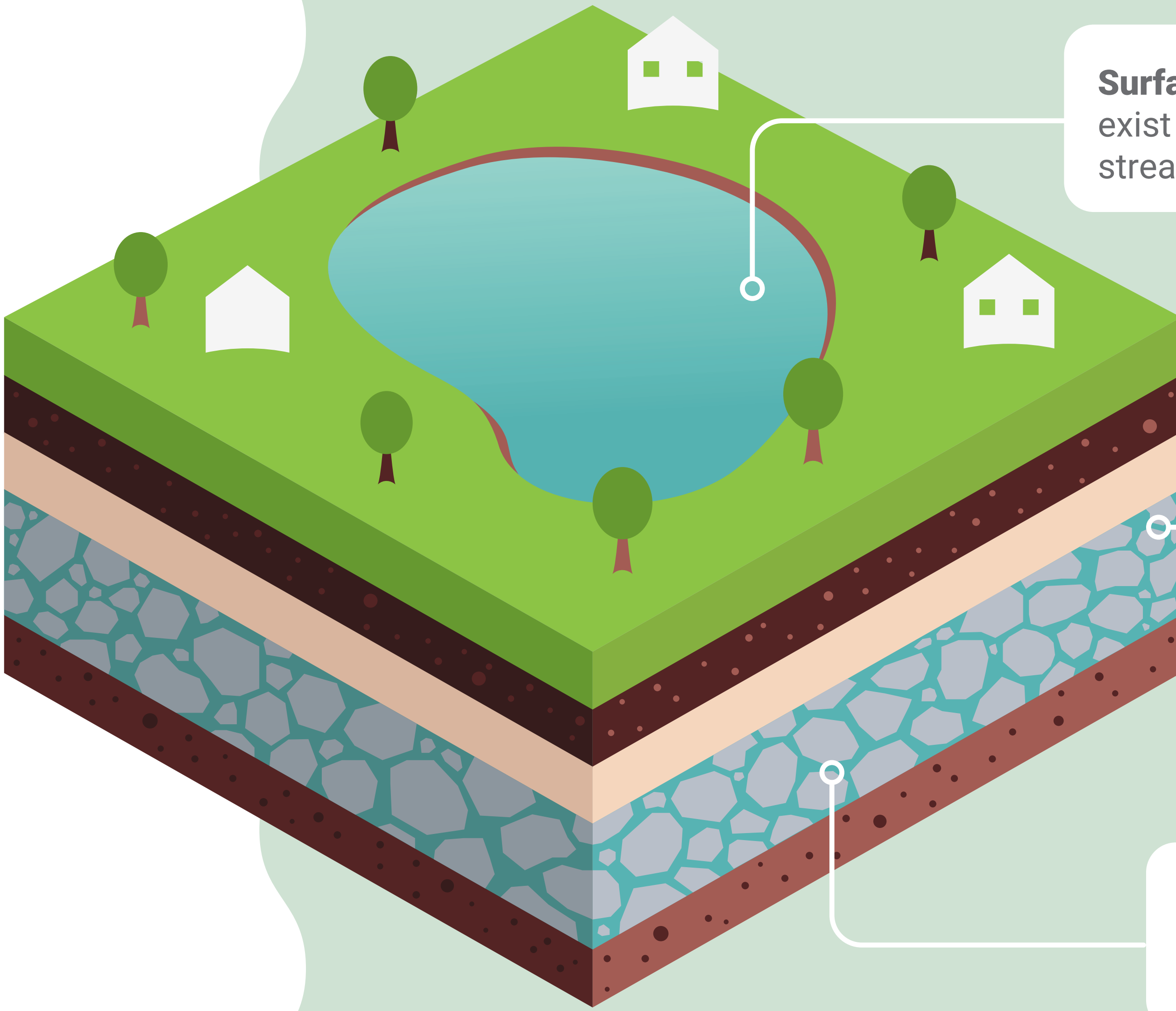
The Water Table

In Allegan County, the water table is generally high in the eastern and central portions of the County, especially in Monterey Township. Conversely, it is low in the western portions of the County and along the Kalamazoo, Rabbit, and Black Rivers. Depressions in the water table in topographic lowlands, where surface water bodies are present, signify regional discharge areas where groundwater converges to streams, rivers, and wetlands.

The water table pattern plays a critical role in groundwater management as it dictates groundwater flow direction. Groundwater moves "downhill" in the subsurface geology, from where the hydraulic head is high to where it is low. As part of this research, a groundwater protection area has been identified showing the flow of groundwater in and out of the County. This topic is further discussed in the following chapter.

Groundwater is water that exists underground in saturated zones beneath the land surface (e.g., pore spaces in sediments, fractures in rock). This research specifically studied groundwater in Allegan County.

Groundwater vs Surface Water



Surface Water: Waterbodies that exist above ground, including streams, rivers, lakes, and reservoirs.

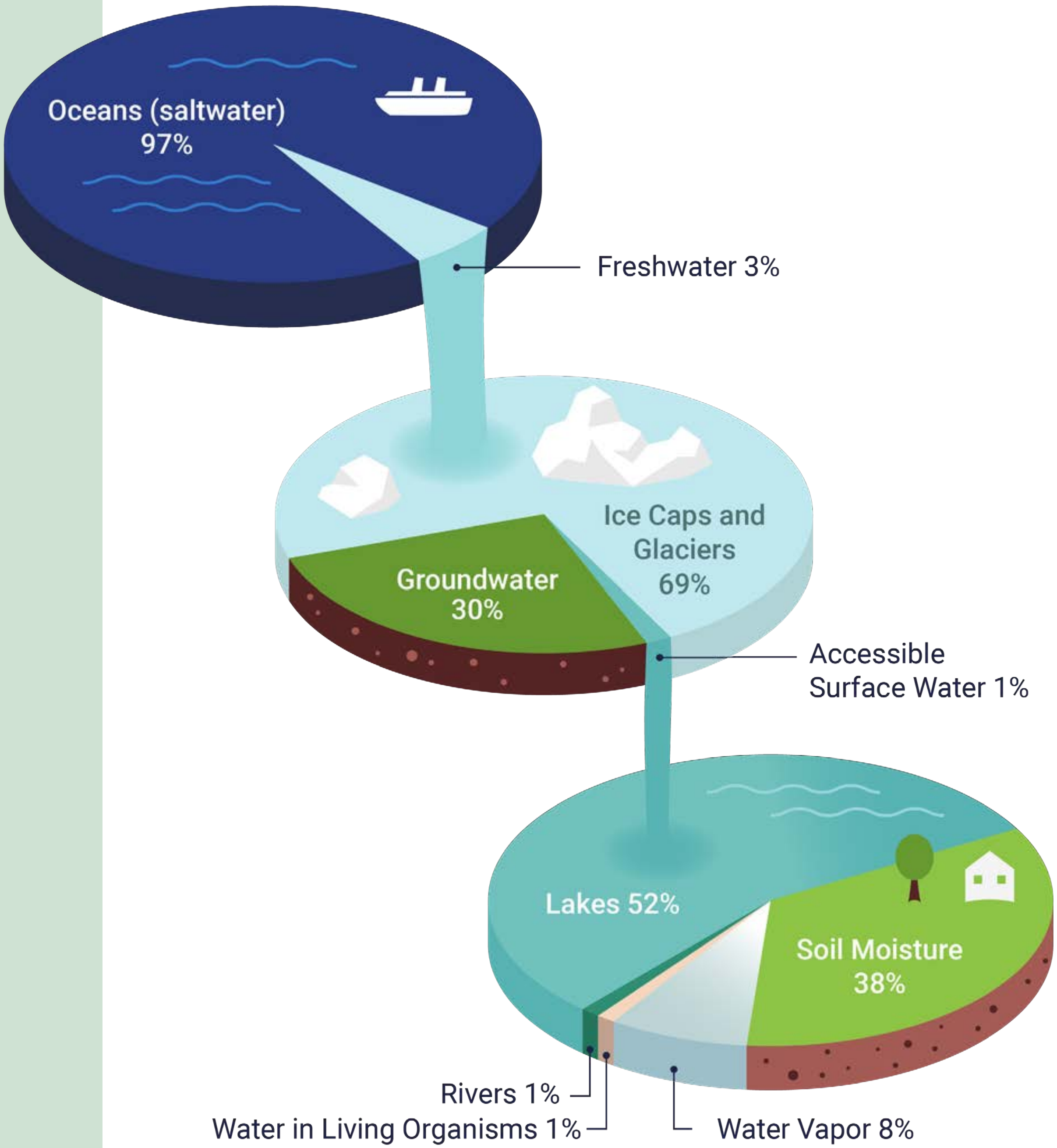
Water Table: The upper boundary of the zone of saturation, where groundwater fills the pore spaces in soil and rock.

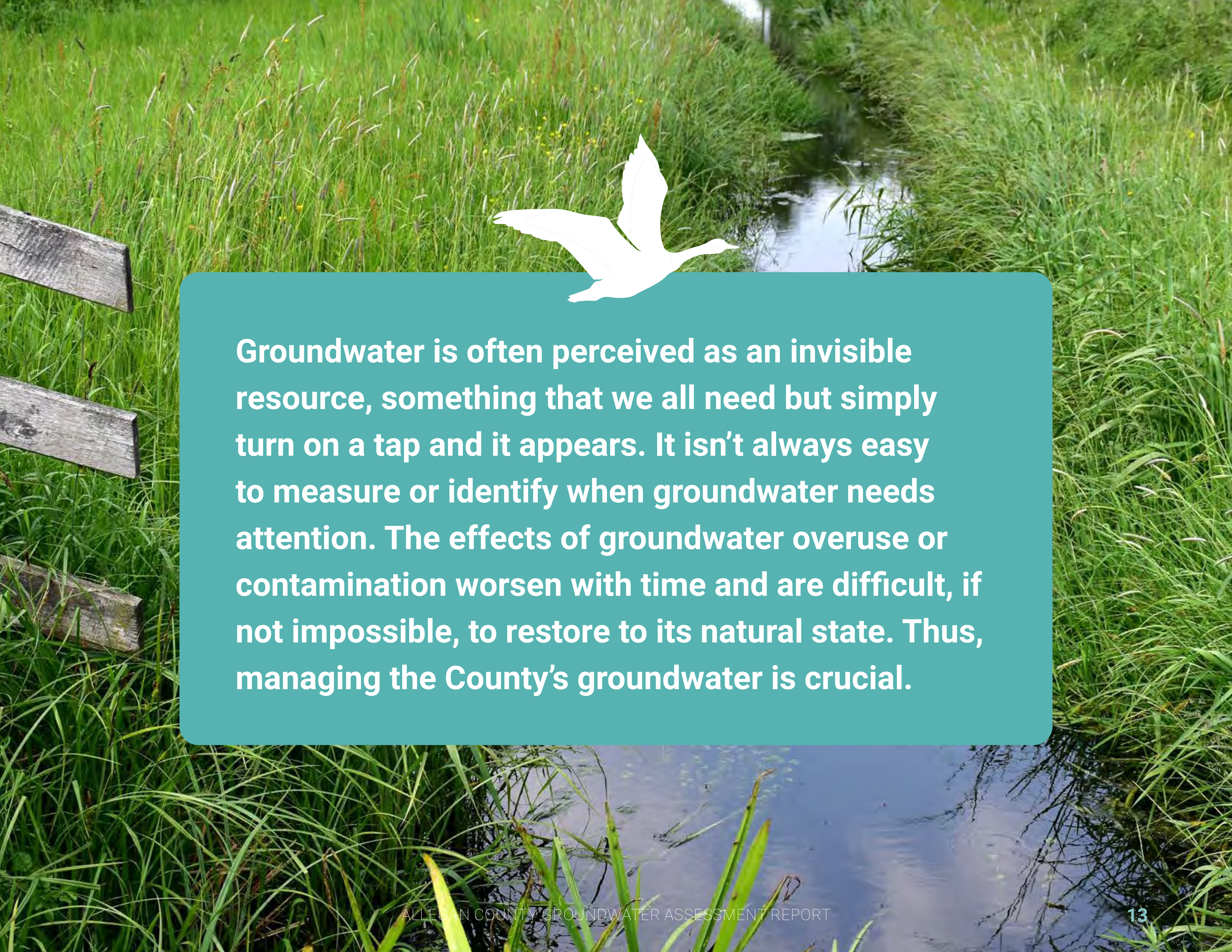
Groundwater: Water that exists underground in saturated zones beneath the land surface.

Groundwater in the Big Picture

Only about 3% of water on earth is freshwater. Of this freshwater, almost 69% of it is trapped in ice caps and glaciers. Groundwater comprises about 30% of the earth's freshwater, and is the second largest source of freshwater in the world. Other freshwater sources, like surface water, soil moisture, and water vapor, make up just 1% of the remaining freshwater on the planet.

As reported by the U.S. Geological Survey in 2015, just over a third of water used in the United States is from groundwater. Irrigation wells use the most groundwater nationally. Domestic wells, mining operations, and livestock are water user groups who rely more heavily on groundwater than surface water supplies. Groundwater is popular in Michigan because of the state's extensive aquifers and its relative accessibility. Groundwater is a source of drinking water for about half of Michigan's population. The volume of fresh groundwater in the Great Lakes basin is approximately equal to the volume of water in Lake Huron. Like most of Michigan, Allegan County sits on large groundwater reserves that are tapped for water supply.



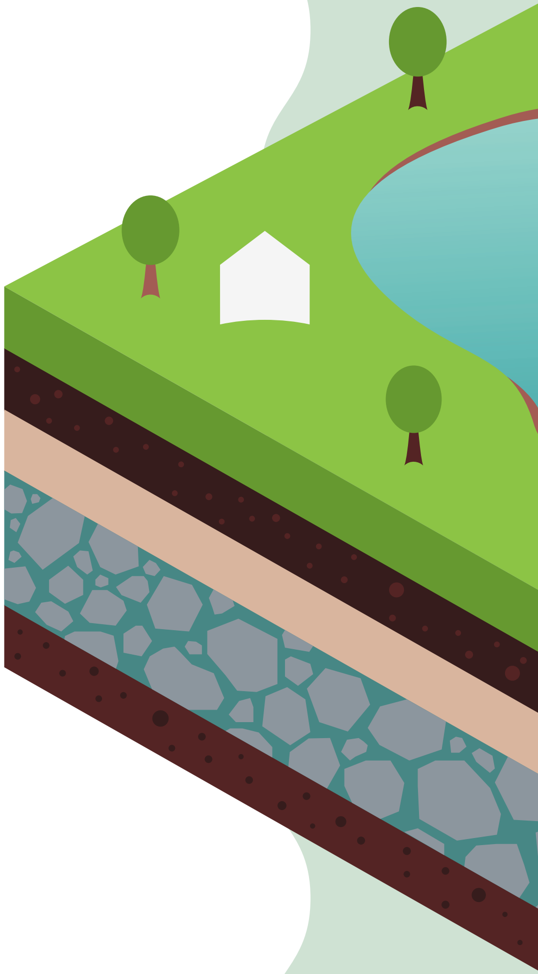


Groundwater is often perceived as an invisible resource, something that we all need but simply turn on a tap and it appears. It isn't always easy to measure or identify when groundwater needs attention. The effects of groundwater overuse or contamination worsen with time and are difficult, if not impossible, to restore to its natural state. Thus, managing the County's groundwater is crucial.

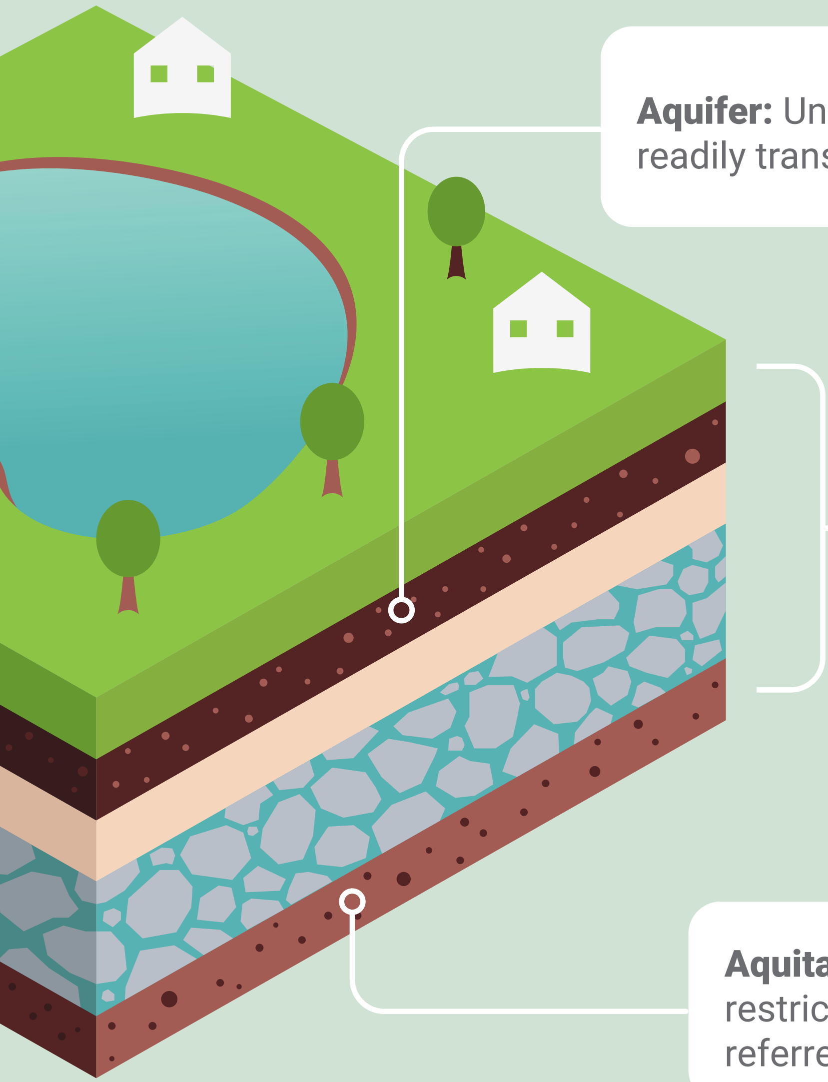
1.2 Groundwater Sources

Groundwater is readily available throughout most of the County and is the preferred source of water supply due to its consistent quality, its general protection from surface contaminants, and its lower vulnerability to weather events, resulting in a reliable and cost-effective potable water source. Despite the abundance of surface water resources in Allegan County, almost all water use for private, public, and crop irrigation comes from groundwater resources.

Groundwater in Allegan County is drawn from two main aquifers: a shallow layer of deposits formed from past epochs of glacial activity, known as the glacial aquifer, and a deeper zone of fractured bedrock, referred to as the bedrock aquifer. Both aquifer systems are remarkably different in geological composition, depth, and accessibility. Understanding and managing groundwater in Allegan County presents a significant challenge due to the complex and varied nature of the subsurface. While the bedrock aquifer exhibits relatively uniform characteristics where it is accessible, the glacial aquifer is highly diverse, both vertically and horizontally.



Groundwater Sources



Aquifer: Underground layers of water-bearing permeable rock and/or soil that readily transmits water to wells and springs.

Subsurface: Underground, sometimes referred to as the ***subsurface geology***. Like the land above, it's important to remember that the subsurface has its own terrain and depending on the underground geological formations, water moves down through the sub-surface as well as horizontally across it.

Aquitard: A geological formation or layer of rock or sediment that restricts the flow of groundwater due to its low permeability. Sometimes referred to as a ***confining layer***.

Glacial Aquifer

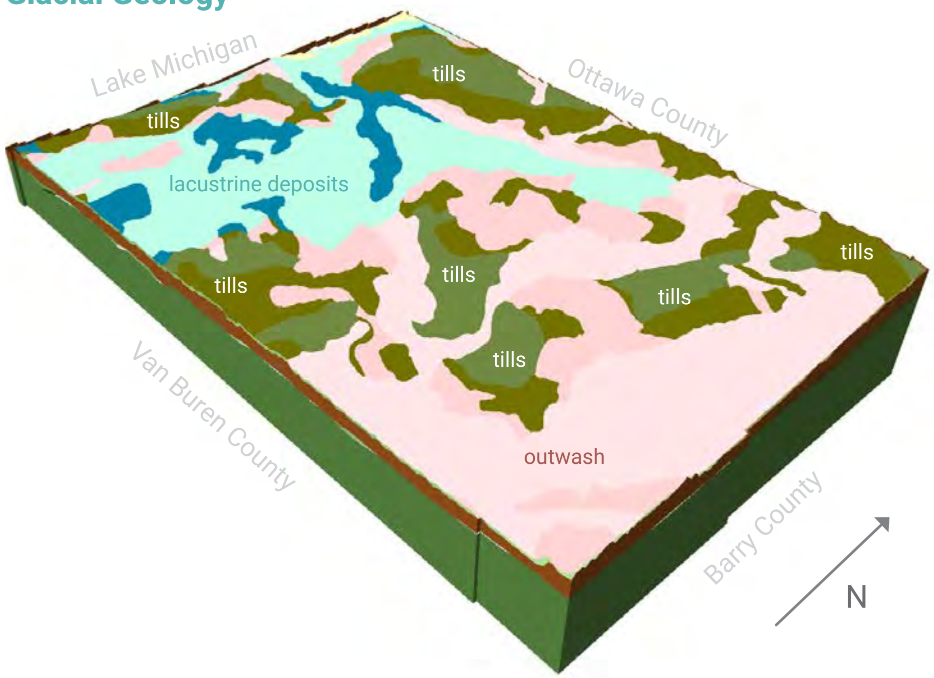
Most wells in Allegan County utilize the glacial aquifer for groundwater. The glacial drift aquifers are a complex collection of geologically related deposits or sediments with a high degree of variability. For this report, the term "glacial aquifer" will be used to refer to all glacial aquifers, regardless of their connectivity or specific geological composition.

Portions of the glacial aquifer in Allegan County are generally composed of sand, gravel, and clay that were deposited over many thousands of years during repeated glacial advances and retreats within the Michigan Basin, ending roughly 10,000 years ago. The composition of the glacial aquifer is highly variable in texture and extent. Groundwater is obtained in useable quantities only from the saturated sands and gravels (aquifers) that make up the glacial drift. Some parts of the glacial aquifer can be very permeable, allowing for water to easily move through its layers, such as coarse-grained lake sediments and the glacial outwash. Other geology containing glacial tills and fine-grained lake sediments are less permeable. The silt and clay type soils that make up the remainder of the glacial drift do not transmit groundwater, and for practical purposes, are not considered aquifers or sources of groundwater. Characterizing this variation is crucial in determining how easily water can move through the subsurface and helps in siting water wells, protecting connected streams and ecosystems, and predicting contaminant transport for pollution control. It also can explain why groundwater may be available in the glacial aquifer in one location but not another nearby.

Bedrock Aquifer

The bedrock aquifer sits below the glacial aquifer. Water in this aquifer is not easily accessible throughout Allegan County. The bedrock aquifer consists of the fractured/semi-fractured portions of the Marshall Sandstone Formation occupying the northeastern quarter of the County. This is the section of the bedrock aquifer where groundwater can be extracted, as it is composed mainly of fractured sandstone and has the capability to store and transmit useable quantities of groundwater. The aquifer thickens significantly at the northeastern part of the County, and as a result is an important groundwater resource in this region. The rest of the County is underlain by the low permeability Coldwater Shale Formation that does not yield significant quantities of groundwater and is rarely used for water supply.

Glacial Geology



Glacial Drift Aquifer

Depth: Shallow Aquifers

Location: Across all of Allegan County

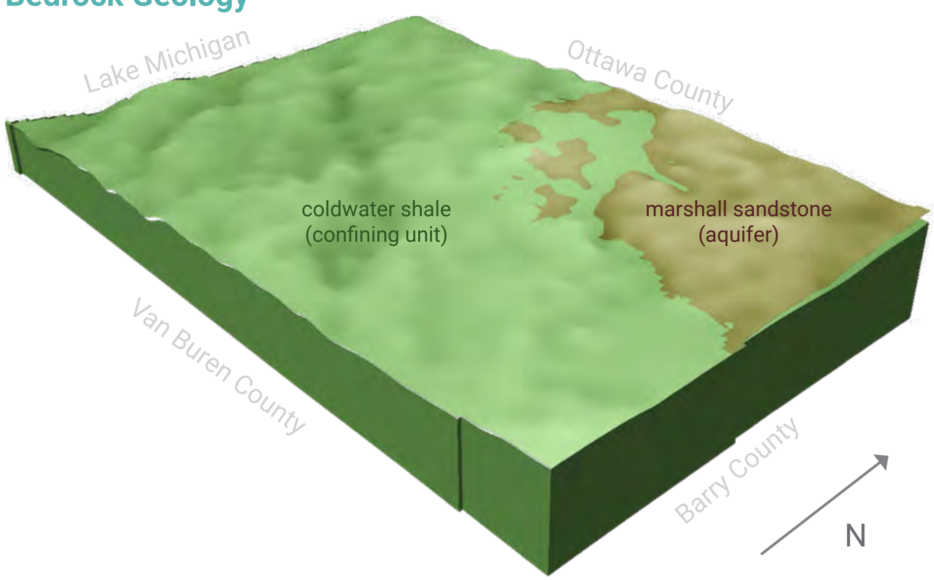
Composition: Glacial Drift Formation (sand, gravel, clay)

Use: 88% of all water wells utilize this aquifer

- Coastal dunes
- Ice-contactoutwash
- Lacustrine fine
- Lacustrine coarse
- Lakes
- Lodge till
- Proglacial outwash
- Thin drift over bedrock
- Ice-marginal till

2D maps are available on the State of Michigan's GIS Open Data Portal.
Glacial Geology Map
Bedrock Geology Map

Bedrock Geology



Bedrock Aquifer

Depth: Deep Aquifers

Location: Northeastern Allegan County

Composition: Marshall Sandstone Formation

Use: 7% of all water wells utilize this aquifer

1.3 Groundwater Use

Groundwater demand and anticipated future use will be examined in greater detail in Chapter 4 of this report. Provided here is an introduction to groundwater use and withdrawal concepts to offer context for future discussion.

Water wells are distributed across all townships, cities, and villages in the County. As of 2020, 30,328(1) wells were accounted for in Allegan County. The majority of these wells are private wells for single-family homes (91%), while about 3% are used for public water supply systems, 3% for crop irrigation, and a small number of wells are used for industrial applications (0.3%). The remaining wells in the County are categorized as other/unknown (3%) and may include unidentified wells or those used for water monitoring. Individually, each private well serving a single-family home uses less water each day than other types of wells. When a large cluster of private wells are in close proximity to each other, their cumulative groundwater withdrawal can be similar to a single high-capacity well used for irrigation or public supply.

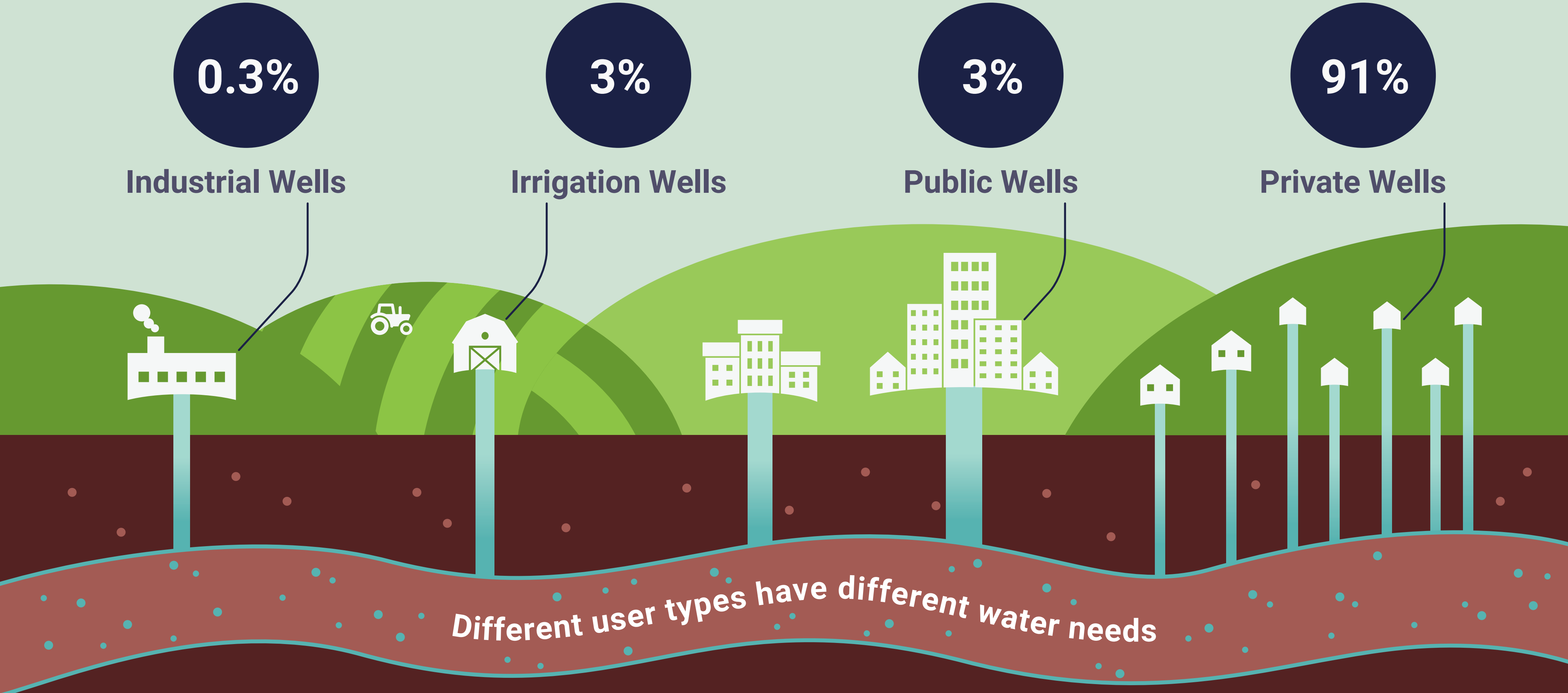
For this report, we have focused on the primary classes of water wells that make up the majority of groundwater use in the County. This includes the following:

1. Private Water Wells supply water to single-family residences and are the most numerous class of wells and widely distributed across the County.
2. Type I Water Wells
    - Municipal Type I Water Wells supply water to community water systems with greater than 25 year-round customers, are commonly referred as “city and village” wells.
    - Type I Water Wells supply water to manufactured housing communities, but fall under the same Type I classification. These systems tend to be small and compact, but because of the size of the development they serve, are considered a type of large quantity withdrawal well.
3. Irrigation Wells supply seasonal water to croplands and are not used for drinking water. They are regulated the same as industrial wells and are often categorized as both types of wells (Irrigation and Industrial) in the data records.

(1) It is known that the actual number of water wells in Michigan far exceeds the number of water well records in Wellogic. Although the percentage of missing wells in Allegan County is unknown, the number of wells reported here are underestimates. The relative number of wells (e.g., drift vs. bedrock wells, or domestic vs. irrigation) is accurate based on our analysis in other parts of the state.

NUMBER OF WATER WELLS BY USER TYPE

As of 2024, 30,328 wells were accounted for in Allegan County. The majority of these wells are used for domestic purposes (91%), with the remainder serving public supply (3%), irrigation (3%), industry (0.3%), and other/unknown sources (3%) such as undocumented or monitoring wells.



Although the majority of wells in the County are used for domestic purposes, individually, one private well for a single family home uses less water each day than one public well supplying water to a whole city.

1.4 Groundwater Supply

Understanding the variability in the subsurface geology of Allegan County provides valuable insights into how quickly water moves through the ground and how much water can be pumped. Water flow rate is often measured in gallons per minute (GPM).

- Hydraulic conductivity (K) is a key property that measures the permeability of different sediments, influencing the speed of groundwater movement.
- Transmissivity (T) builds on hydraulic conductivity by factoring in the thickness of the aquifer. This influences aquifer productivity.
- Aquifer yield, or the ability of an aquifer to produce water, is directly related to its transmissivity.

According to the estimates from the Phase 1 Allegan County Groundwater Study, aquifer yield is relatively small (less than 70 GPM) in the western-central townships of Manlius, Clyde, and Lee, as well as in large portions of Overisel, Heath, Valley, and Ganges Townships. Along most of the Lake Michigan coastline, parts of the northern and southern borders of the County, and throughout most of Watson Township, yields are expected to be somewhat large (70-500 GPM). As shown in Map 1, the eastern townships of Martin, Gunplain, Hopkins, and Otsego, as well as smaller areas in Monterey, Wayland, and Allegan townships, yields are expected to be large (500-1500 GPM).

HELPFUL DEFINITIONS

GPM: Gallons per minute. A measurement of how many gallons a pump can move per minute. It is a common unit of measurement of flow rate.

Hydraulic conductivity (K): Measures the ability of water to move through different sediments.

Transmissivity (T): The product of hydraulic conductivity (K) and aquifer thickness. Transmissivity controls aquifer productivity.

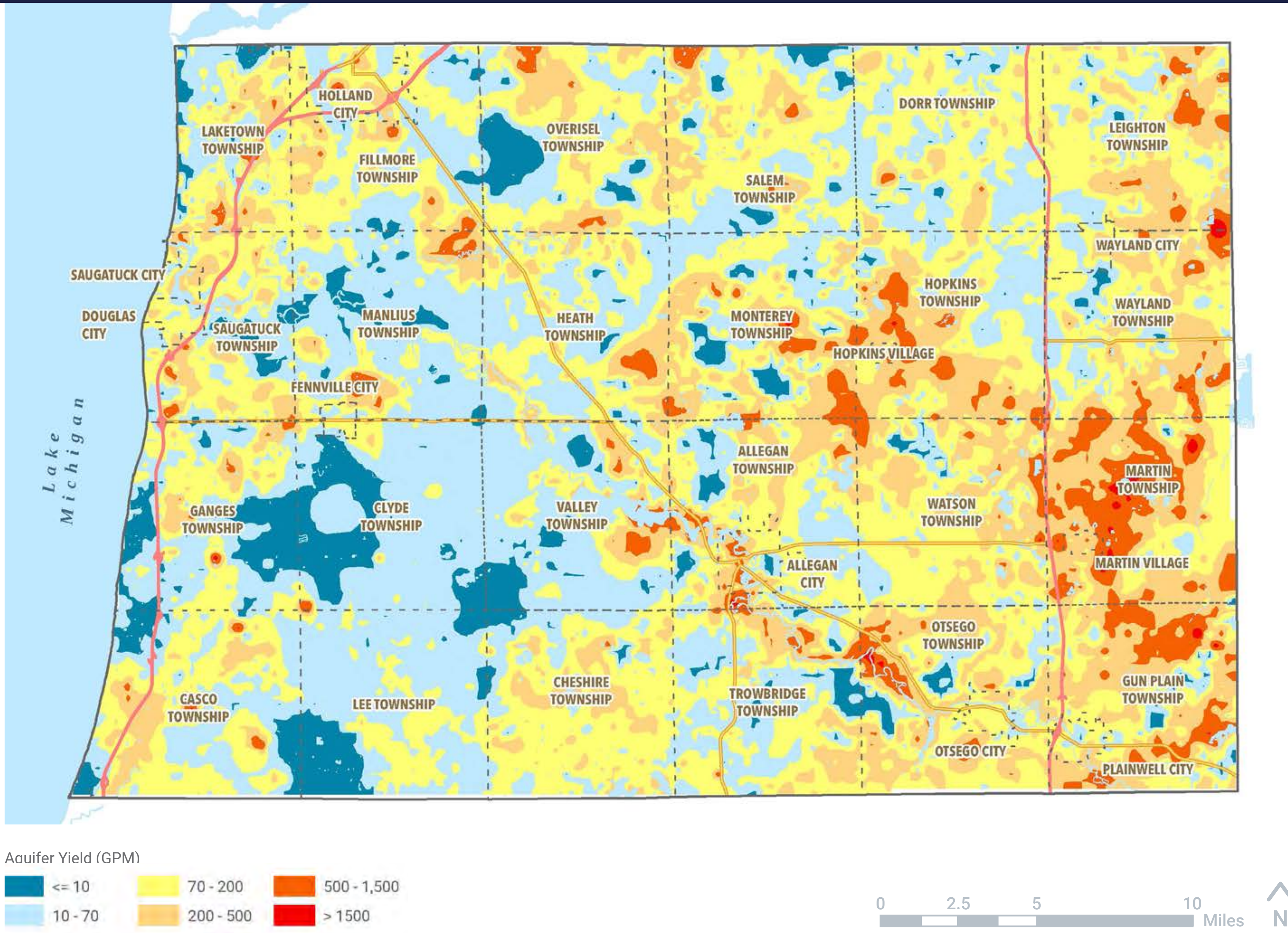
Aquifer Yield: Ability of the aquifer to produce water.

Sustainable Yield: Water withdrawals that will preserve groundwater resources over the long-term.

Recharge: Net infiltration of precipitation to the water table.

Discharge: Groundwater leaving the aquifer to surface water or wells.

MAP 1 Aquifer Yield Estimates



While aquifer yield estimates indicate how much water can be pumped, sustainable yield considers additional aquifer properties, pumping rates, well density, and long-term aquifer recharge—the net infiltration of precipitation to the water table. Sustainable yield can be difficult to measure because it is influenced by these multiple properties. Aquifer properties that help inform sustainable yield were explored in Allegan County, including well-density and long-term mean recharge.

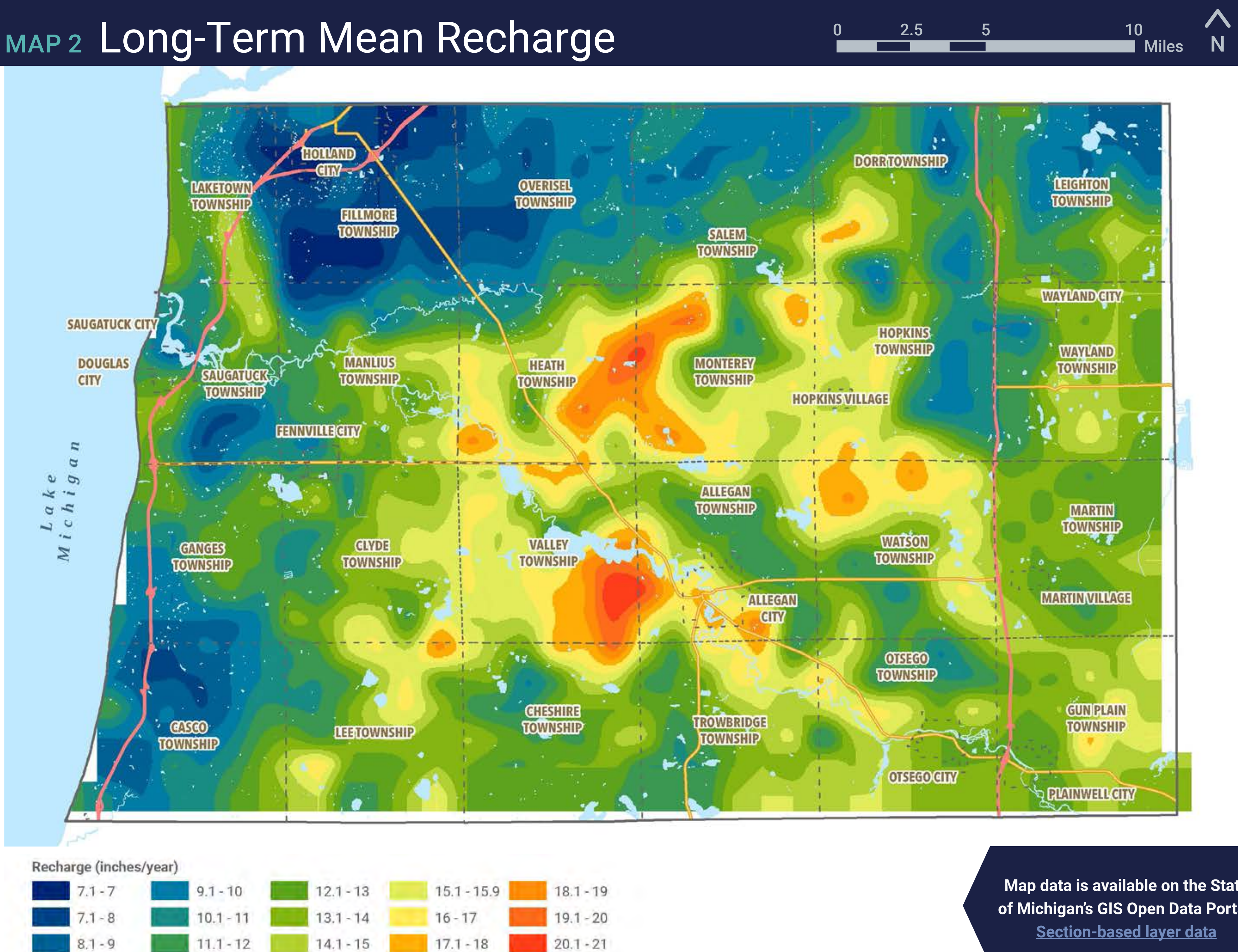
Areas with high well density were identified in central Dorr Township, north-northeast Leighton Township, western Allegan Township/Allegan City, northwest Leighton Township, and portions of Saugatuck, Ganges, Laketown, Salem, Otsego, and Gunplain Townships. It is important to remember that groundwater is not a finite resource, but it does need to be managed to be a sustainable one. Identifying these pressures (pumping rates, well density, etc.) helps inform sustainable groundwater management.

Map 2, depicting long-term mean recharge, was generated using observed stream flow hydrographs and information about land use, soil conditions, and watershed characteristics. It shows that recharge is generally highest in the central portions of the County, north and south-southeast of Lake Allegan, and along the upper and middle reaches of the Kalamazoo River. Recharge is lower in upland areas of Fillmore and Overisel Townships, portions of Casco and Ganges Townships, and to a lesser extent, in Saugatuck Township. Identifying recharge areas helps shape our understanding of sustainable groundwater management as well.

While this research doesn't calculate yield/pumping rates to determine sustainable yield, it does assess current use and projected future groundwater demand in Allegan County (Chapter 4) to assist with management, providing a baseline for monitoring groundwater resources.

The following chapters explore the need for protecting Allegan County's groundwater resources from contamination or overuse as a tool to plan for a sustainable future. An executive summary with key takeaways is provided at the beginning of this report. Research documents with more detailed results, technical data, and methodologies are included as appendices.

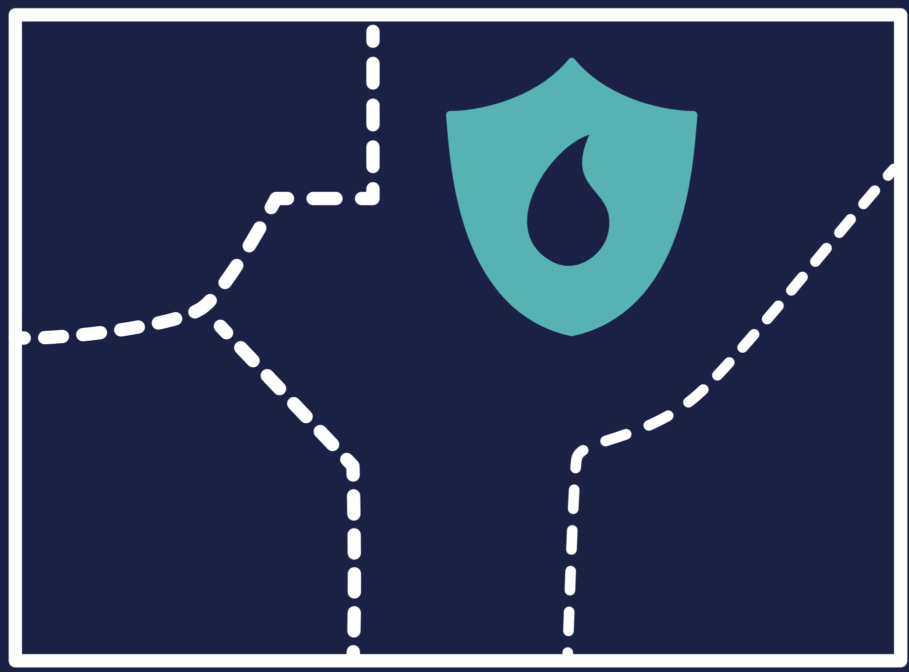
MAP 2 Long-Term Mean Recharge



Map data is available on the State of Michigan's GIS Open Data Portal.
Section-based layer data

CHAPTER 2

GROUNDWATER PROTECTION AREA DELINEATION



Chapter 2. Groundwater Protection Area Delineation

2.1 What's a Groundwater Protection Area?

A groundwater protection area is a designated zone where measures are taken to safeguard groundwater from potential contamination or overuse. The Groundwater Protection Area (GPA) for Allegan County represents the groundwater capture area of the near-surface aquifer system important for groundwater resources in the County. Like a watershed for surface water bodies such as rivers and streams, the GPA is the "groundwater-shed." These are the portions of the aquifer that lie underneath Allegan County or are outside of the County but will contribute groundwater as it naturally flows "inward" across the County border. Just beyond the GPA, groundwater flows away from the County.

By definition, the edge of the GPA coincides with a groundwater divide. As groundwater "flows downhill," the location of the groundwater divide corresponds with the point of the highest groundwater head (or highest point of the water table in an unconfined/shallow aquifer). The area of the aquifer from the groundwater divide to the point of eventual discharge, like a stream or other surface waterbody, is referred to as the source groundwater area (see Figure 2.1).

A groundwater divide can be identified by mapping groundwater flow patterns across space, which was the approach used in this research. More specifically, computer simulations of groundwater flow were developed and analyzed to identify the location of the groundwater divides in the vicinity of Allegan County, and apply this knowledge to the delineation of the GPA (see Appendix C).

HELPFUL DEFINITIONS

Groundwater Protection Area (GPA): A designated zone where monitoring measures are taken with the intent to safeguard groundwater from potential contamination or overuse.

Delineation: Mapping boundaries or extents. In the case of this report, to identify the boundaries of the GPA.

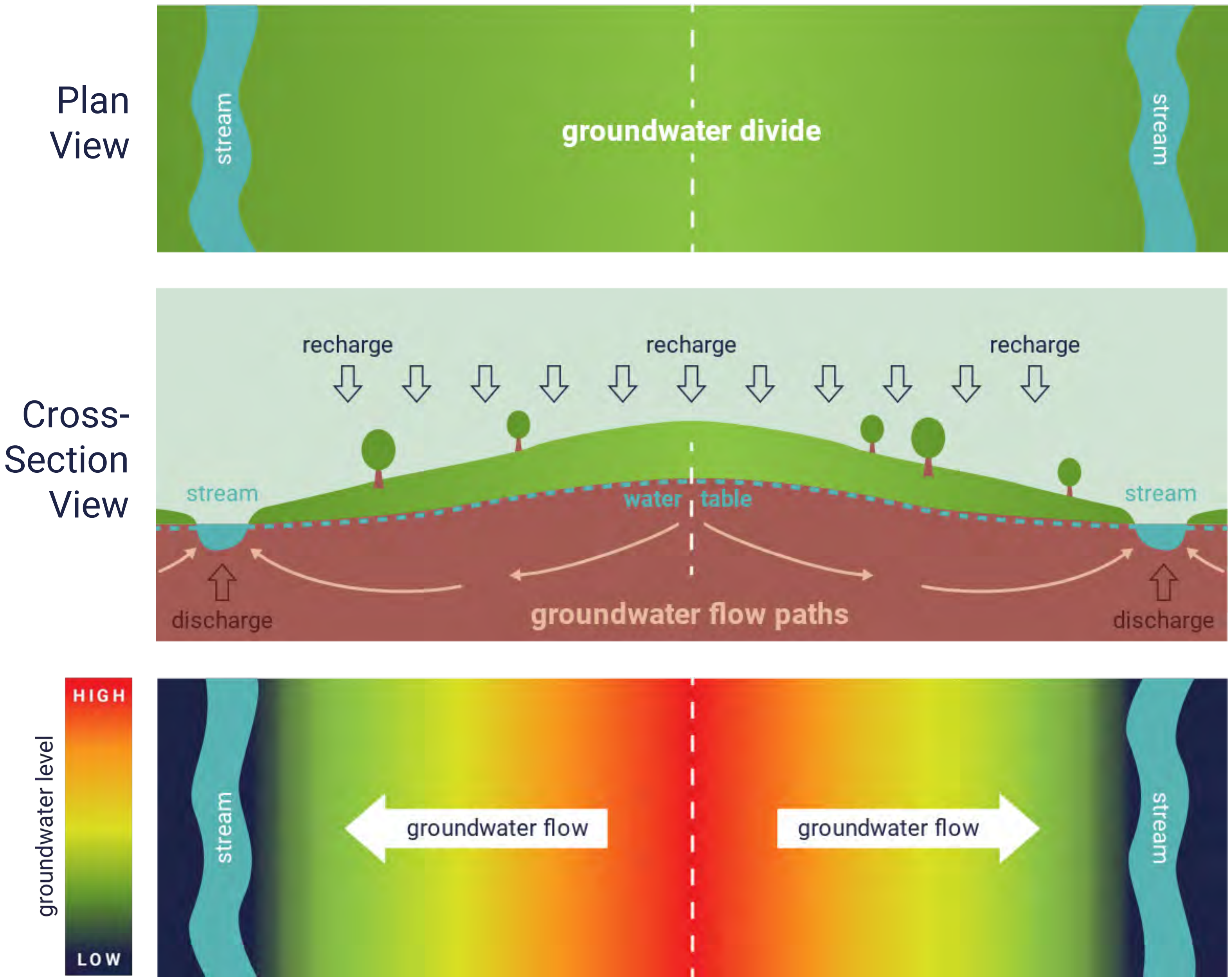
Watershed: Also known as a drainage basin, is an area of land where all the water that falls or flows across it drains into a common outlet, such as a lake, river, or stream.

Groundwater Divide: A subsurface water table boundary that separates the areas where groundwater flows in different directions.

Groundwater Head: The potential energy exerted by groundwater in relation to the height of a static water column above a reference point. It is a crucial parameter in hydrogeology for understanding groundwater flow and aquifer behavior.

Groundwater-shed: In this report, this term has been used to help describe the groundwater flow area that defines the GPA delineation.

FIGURE 2.1 Concept of a groundwater divide and source groundwater areas



2.2 Why is a Groundwater Protection Area Delineation Important?

We all need clean, accessible, and sustainable water to live and thrive. As the majority of Allegan County subsists off of groundwater, it is fair to say that this is a vital resource County residents, visitors, businesses, industries, and agricultural producers all rely upon. One foundational aspect of managing and protecting groundwater in Allegan County is to identify where the sources of water are in the subsurface. This is important because oftentimes the surface protection area may not overlap with the groundwater source area, as groundwater outside of the surface protection area today can move and be inside of it in the future. Knowledge of the spatial distribution of groundwater source areas helps to identify current and future risks and threats to the source of groundwater.

Some examples of threats to sources of groundwater include:

- Contamination due to pollution at the land surface.
- Aquifer over-mining (cumulative groundwater depletion) due to groundwater pumping.
- Reduced groundwater recharge because of climate change and land cover change from pervious to impervious surfaces (i.e. roofs, pavement, and parking lots keep precipitation from infiltrating into the aquifer and instead directly runs off to surface water or other drainage networks).
- Climate extremes that could create excess runoff to surface water bodies during periods of elevated precipitation and reduced aquifer recharge/ increased groundwater demand during periods of excessive heat or drought.

A Groundwater Protection Area (GPA) can be thought of as a "groundwater-shed" with water flowing into it from local and distant sources. As a result, groundwater occurring inside and outside Allegan County's near surface aquifers have the potential to impact water quality and quantity. These impacts are often delayed, taking years or even decades to reach Allegan County from outside its borders.

The GPA highlights the entire groundwater recharge area for Allegan County that needs to be protected, now and in the future. Without a proper delineation of the County's groundwater source areas, it is very difficult to measure if a particular development, process, or accident poses any threat to the County's water resources. The GPA delineation provides a baseline for monitoring and preventing potential impacts. It also opens doors for informed discussions on a regional scale so that Allegan County can work with neighboring municipalities to protect their shared groundwater resource.

2.3 Groundwater Protection Area Delineation Map

Overview of Approach

Groundwater flow patterns were mapped in 2021 as part of the Phase 1 Allegan County Groundwater Study. This initial assessment only included the geographic boundaries of Allegan County. Since groundwater meanders between governmental units, this current research now includes a GPA delineation that extends beyond that of Allegan County, taking a more regional approach.

This process followed a multi-scale, multi-step approach, which is presented in greater detail in Appendix A and Appendix C.

First, a regional-scale groundwater model of Allegan County and the surrounding counties was developed to capture the large-scale spatial patterns of groundwater levels, providing a "big picture" of groundwater in the area. Next, three higher-resolution submodels were developed along the County border to provide detail and more accurately delineate the groundwater divides in key areas of interest. The final step was to inspect the submodel flow patterns to delineate the local groundwater divide, and "stitch" together the overall Groundwater Protection Area for the County with the new submodel delineations.

The Submodels

Three areas outside of Allegan County were identified for the creation of groundwater protection area submodels. The contours in Figure 2.2 represent lines of equal groundwater head. Groundwater flows perpendicular to these contours. The warm colors (red, orange, yellow) represent higher groundwater head, while the cool colors (purple, blue, green) illustrate lower groundwater head.

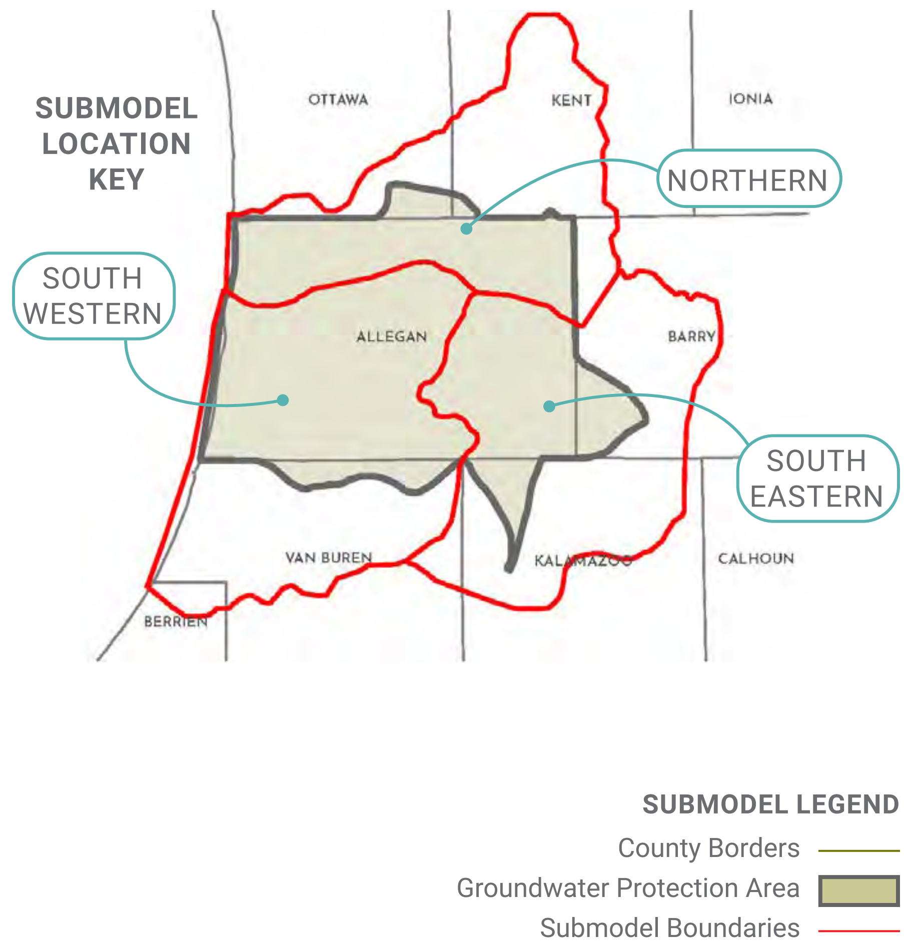
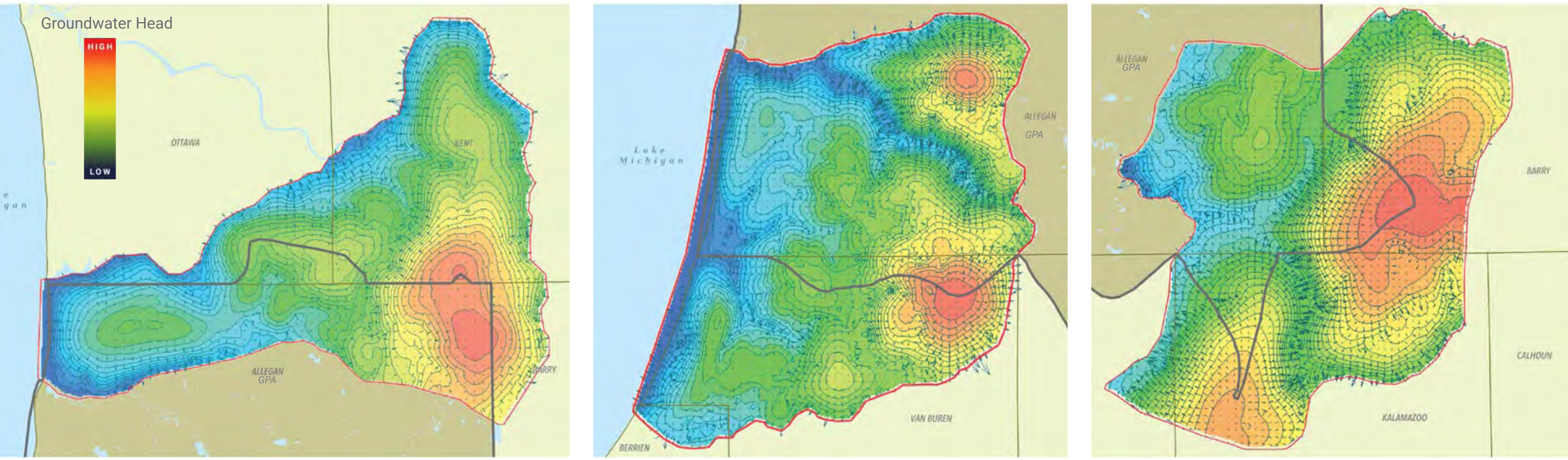


FIGURE 2.2 Groundwater Protection Area Submodels

0 3 6 12 Miles
N

NORTHERN SUBMODEL / SOUTHWESTERN SUBMODEL / SOUTHEASTERN SUBMODEL



The northern submodel (Figure 2.2, left) follows the Grand River as its northern boundary, the Thornapple River as its eastern boundary, and the Rabbit River as its southern boundary. Lake Michigan forms the western boundary. In this general area, groundwater flowing into Allegan County primarily comes from Ottawa County, with a very small section coming from Kent County. Of the three submodels, this one represents the smallest area of groundwater flow toward Allegan County.

The southwestern submodel (Figure 2.2, center) follows the Thornapple River and Gun Lake as its eastern boundary and the Rabbit River as its northern boundary. The southern boundary is situated beyond the groundwater mounds south of the County border to ensure the groundwater divide could be identified. The western boundary is formed by Lake Michigan. A notable area of groundwater flows into Allegan County from Van Buren County.

The southeastern submodel (Figure 2.2, right) follows the distribution of recharge mounds to the east and south and the boundaries of the other submodels to the west and north so that the County has seamless/complete coverage among the three submodels. A notable area of groundwater flows into Allegan County from Kalamazoo and Barry Counties.

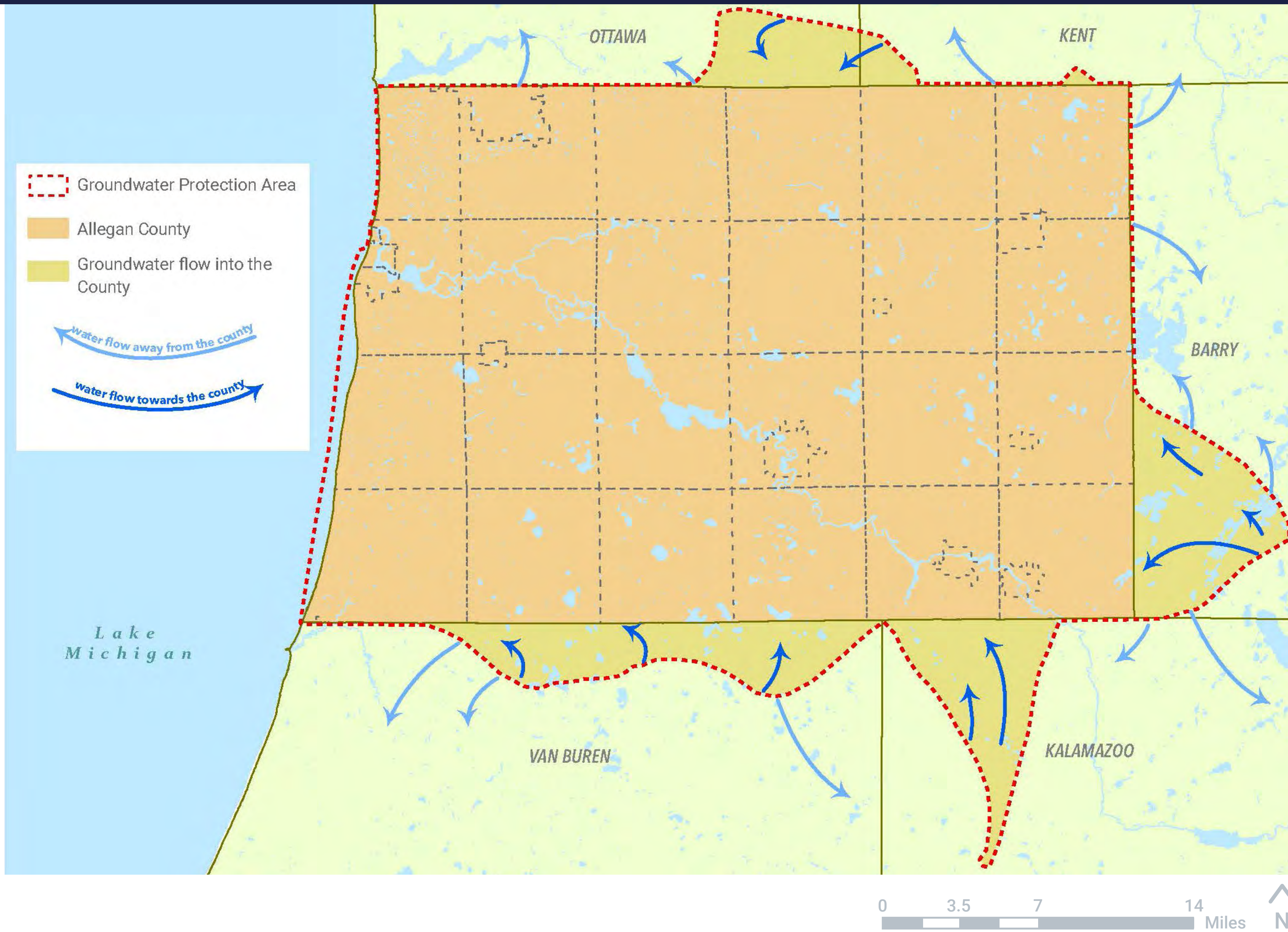
Groundwater Protection Area

Factoring in the groundwater flow results of the three submodels, a GPA Delineation for Allegan County was created. Map 3 shows the complete GPA for Allegan County. The GPA includes all of Allegan County, but also portions of Ottawa County (including Zeeland and Jamestown Townships), Kent County (Byron Township and a small portion of Gaines Township), Barry County (Orangeville and Prairieville Townships, and a small portion of Barry Township), Kalamazoo County (Cooper, Alamo, and Oshtemo Townships), and Van Buren County (Pine Grove, Bloomingdale, Columbia, and Geneva Townships).

Note that in some places groundwater is leaving the County as it flows “outward” across the boundary. In those places, the GPA boundary coincides with the County border. In some places, groundwater from outside of Allegan County is flowing toward the County but is not included in the GPA. This is because the groundwater in those areas will naturally discharge to the surface before entering the County.

Van Buren, Kalamazoo, and Barry Counties have larger groundwater flow patterns into Allegan County and have a greater potential impact on groundwater quality or overuse. On a regional scale, it will be most beneficial to coordinate with these neighboring counties on groundwater resource protection.

MAP 3 Groundwater Protection Area Delineation with Flow Annotations



2.4 Wellhead Protection Areas

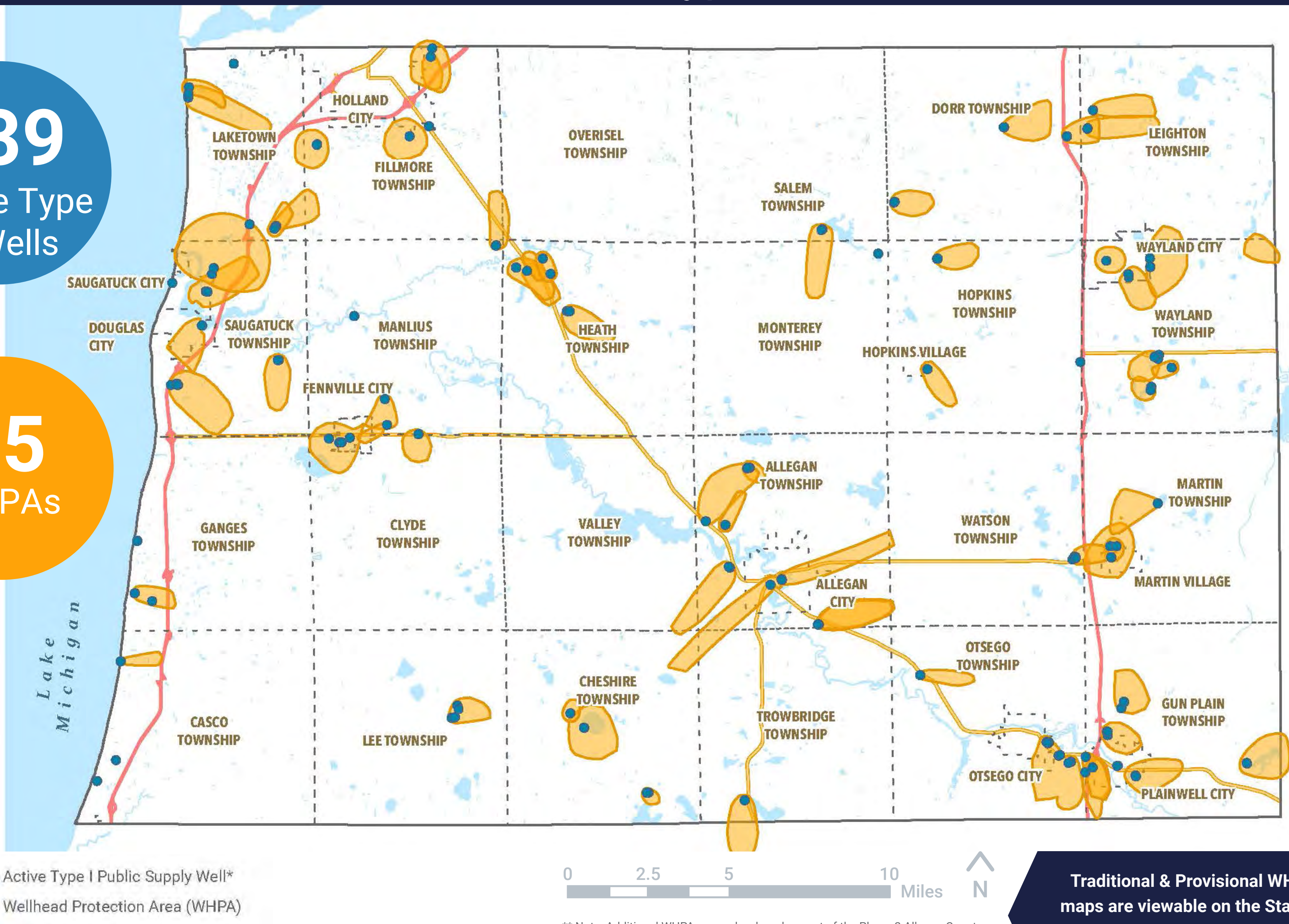
While the County-wide GPA delineation provides valuable information about potential outside groundwater influences, a wellhead protection area (WHPA) identifies protection areas on a more granular scale. Wellhead protection areas are the source water (or capture) area of the aquifer that is providing groundwater to a pumping well over a 10-year period. WHPA delineation helps local governments manage land use and human activities in the key source water areas for drinking water wells and is critical for the operation of high-capacity community water supply wells. In Michigan, an important class of such wells are Type I Wells, often referred to as public wells, which provide water to at least 25 residents or 15 living units year-round. Of the 139 active Type I Wells, 65 of them have identified wellhead protection areas (Map 4). In some instances, multiple closely-spaced wells may share a common WHPA.

Like the GPA delineation, WHPAs may extend beyond the political boundaries of the County. This can be observed along the southern and eastern boundaries of Allegan County, further reinforcing the importance of coordination with neighboring counties on groundwater resource protection.

MAP 4 Wellhead Protection Areas - Type I Wells

139 Active Type 1 Wells

65 WHPAs



* Type 1 Well provides water to at least 25 residents or 15 living units year-round.

** Note: Additional WHPAs were developed as part of the Phase 2 Allegan County Groundwater Study (Appendix B) and are not on the State of Michigan's GIS Open Data Portal.

Traditional & Provisional WHPA maps are viewable on the State of Michigan's GIS Open Data Portal and EGLE's Water Well Viewer.**

CHAPTER 3

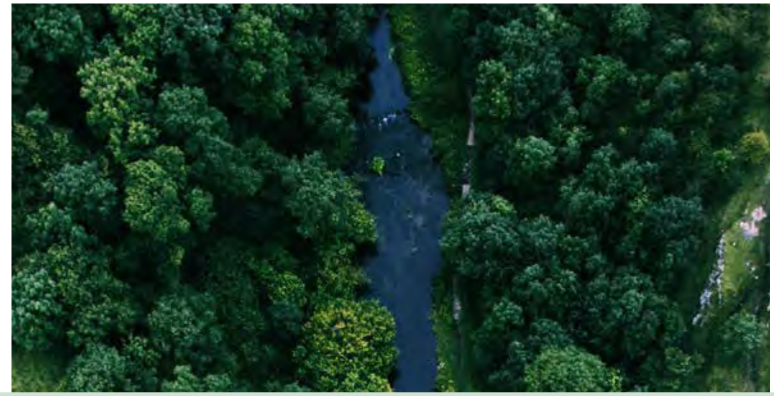
AREAS OF CONCERN & WATER QUALITY RISKS

Chapter 3. Areas of Concern & Water Quality Risks

This chapter focuses on risks to groundwater from substances that exceed established drinking water standards related to human health and aesthetic qualities, like taste, smell, or color. The containment, removal, or treatment of contaminants in groundwater is often difficult and costly. Once groundwater is polluted, remediation can take years, and millions of dollars, if at all possible. This is why characterizing and mitigating groundwater contamination is vital for ensuring safe drinking water supplies, protecting ecosystems, and sustaining economic activities reliant upon clean water.

This research builds on the previously completed Phase 2 Groundwater Study that explored sources of potential groundwater contamination in the County (Appendix B). The chapter presents an analysis of potential sources and risk areas impacted by groundwater contamination in Allegan County. By examining both point and non-point source pollution sources, the report identifies areas where contamination risk is elevated, emphasizing the importance of understanding and mitigating these risks to protect groundwater quality and public health.

More technical information, including full ranking tables, data sources, and detailed narrative about the methodology used for this research, can be found in Appendices D, E, and F.



Addressing known sources of groundwater pollution and potential risks from non-point sources will help local leaders make proactive and informed decisions aimed at preserving the integrity and safety of Allegan County's groundwater supply.

3.1 Point Source Pollution

Point source pollution originates from a single, identifiable source. It is pollution that is discharged from a specific, discrete location. Examples of point source groundwater pollution include:

- Leaking underground storage tanks (LUSTs)
- Landfills and waste handlers
- Accidental spills
- Improper disposal at industrial/commercial sites
- Legacy disposal at industrial/military sites

HELPFUL DEFINITIONS

Point Source Pollution: Pollution that originates from a single, identifiable source.

Off-Site Groundwater Risk Analysis: Estimation of risk to "downstream" groundwater receptors based on plume migration pathways and aquifer vulnerability (sensitivity to surface pollution).

On-Site Groundwater Risk Analysis: Review of site history, documentation of substances present, pathways for groundwater contamination, and soil & groundwater quality data.

Sites of Groundwater Concern Identification

Contamination risk from sites with point source pollution were assessed by combining the results from the Phase 2 Allegan County Groundwater Study with risk classifications made by Michigan's Department of Environment, Great Lakes, and Energy (EGLE) engineers and scientists. The risk classifications assigned by EGLE are based on site-specific criteria related to human and environmental health risk.

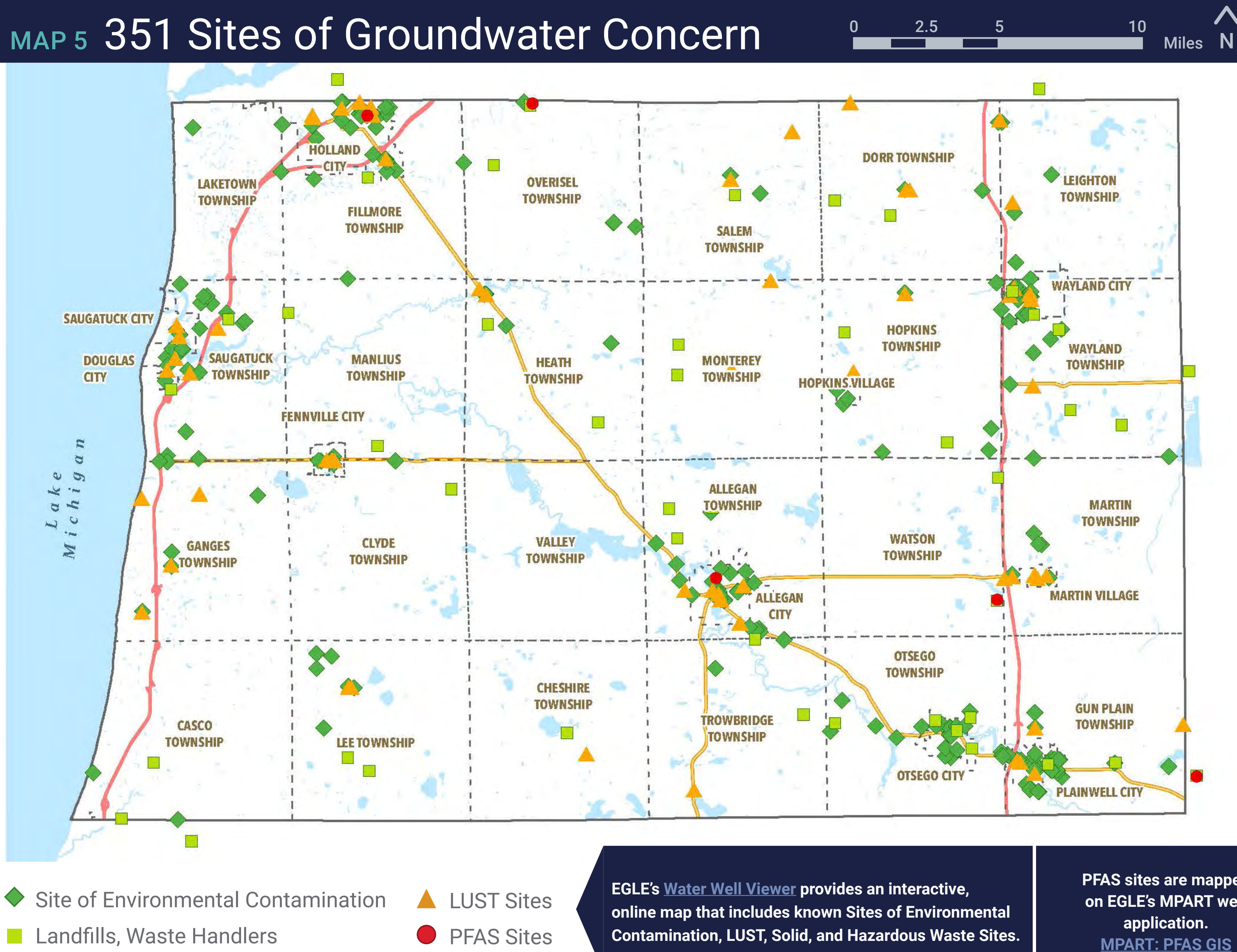
351 sites of groundwater concern identified in, or just beyond, Allegan County, were studied:

- 237 Sites of Environmental Concern
- 46 Historical or operational landfills or waste handlers
- 63 Active leaking underground storage tank (LUST) sites
- 5 emerging PFAS (Per-and polyfluoroalkyl substances) sites

All 351 sites of groundwater concern were reviewed for their history, documentation of substances present, pathways for groundwater contamination, and soil/groundwater quality data. This provided information to better assess the human and environmental health aspects of the site contamination, e.g., the type/concentration of groundwater pollutants, and how they relate to public health or drinking water standards.

These on-site risks were combined with past research that examined the off-site risk for plume migration pathways. This type of site-specific analysis paints a clearer picture of the overall risk a site of concern poses to groundwater, including downstream sources such as water wells and surface water.

MAP 5 351 Sites of Groundwater Concern



EGLE's Water Well Viewer provides an interactive, online map that includes known Sites of Environmental Contamination, LUST, Solid, and Hazardous Waste Sites.

PFAS sites are mapped on EGLE's MPART web application. MPART: PFAS GIS

To complete the contamination source inventory, data was obtained and analyzed from the recently available Remedial Information Data Exchange (RIDE) system created and maintained by EGLE. The RIDE system is a web portal that organizes and makes available site-specific information, metadata, and documentation for many of the sites of environmental concern identified by the of State of Michigan in past decades. This includes 285 of Allegan's 351 sites of groundwater concern.

Sites of Groundwater Concern Risk Ranking

The previous Phase 2 study (Appendix B) focused on the off-site risk potential of the 351 sites. This was completed through spatial modeling (simulation) of groundwater flow under the sites of concern to determine potential groundwater impact areas. The sites of concern and the areas they impacted were overlaid with maps of critical groundwater receptors (drinking water wells, non-drinking water wells, and surface water bodies) and aquifer vulnerability to surface pollution. This allowed each location to be ranked in order of potential off-site impacts.

For this study, the RIDE system was utilized to assess the on-site risk based on the data/information and established criteria from the State of Michigan for risk. For the sites available on RIDE, a RIDE Risk classification was obtained. This identifies the current risk of the site as it relates to human and environmental health exposures through several pathways. The classifications are based on site characteristics, how the data was collected, established public health standards, and/or site-specific criteria.

For the purposes of this study, RIDE Risk classifications for the following categories were extracted:

- Drinking Water Ingestion,
- Groundwater-Surface Water Interface,
- and Sensitive Environmental Receptors

The final step for updating the sites of groundwater concern Risk Ranking was to develop metrics for the RIDE Risk classifications so that they could be combined with the Phase 2 risk scores. Multipliers were assigned to the Phase 2 Risk scores to scale them up or down to more accurately increase or decrease risk, respectively. The total composite score was used to generate a new, more informed ranking list. These results are illustrated in Map 6. A full list of the Point Source Contamination Risk Scores can be found in Appendix D.

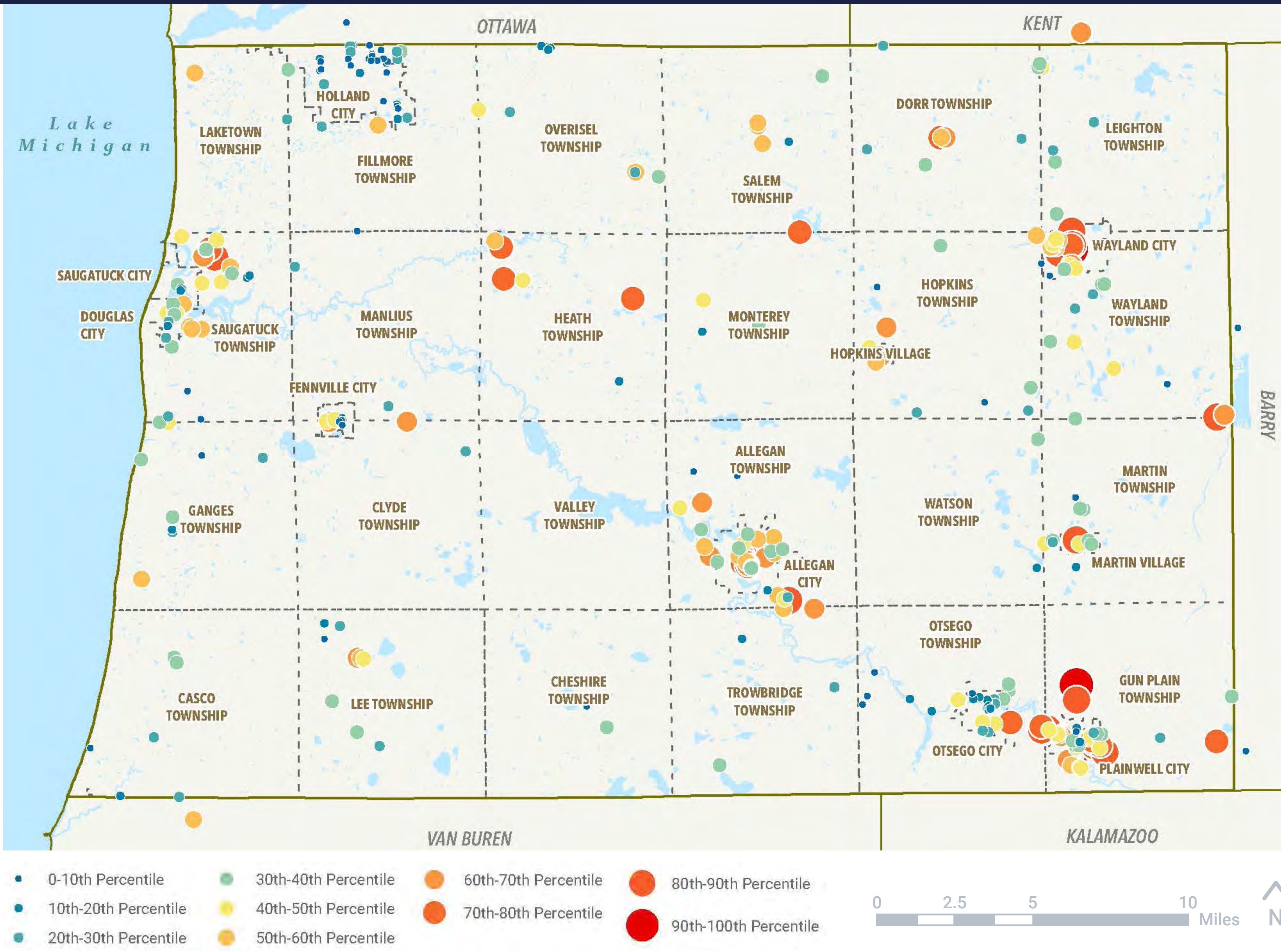
HELPFUL DEFINITIONS

EGLE: Michigan Department of Environment, Great Lakes, and Energy.

RIDE: Remedial Information Data Exchange system created and maintained by EGLE. This web portal has information about many of the sites of environmental concern identified by the of State of Michigan in past decades.

Critical Groundwater Receptors: Groundwater discharge points that have to be protected, like drinking water wells, irrigation wells, surface water bodies, or other water dependent ecosystems.

MAP 6 Risk Ranking of the 351 Sites of Groundwater Concern



Priority Sites: Top 30 Sites of Groundwater Concern

Beyond the risk ranking for the 351 sites of groundwater concern, an additional analysis of the top 30 ranking sites was completed. A separate report was created detailing this information and can be found in Appendix E. These top 30 ranking sites were deemed priority sites, as they have the greatest potential risk to the groundwater resource. Twenty-five of the 30 sites included information/documentation available in the RIDE system.

Information investigated for each of the priority sites included:

- Site ID, site name, local government unit (LGU), original dataset, and substances of concern;
- Relevant drinking water standards and human health perspectives;
- EGLE RIDE reviewer risk classifications based on Part 201 risk-based criteria;
- Summary of previous Baseline Environmental Assessments (BEA) and other documentation, e.g., Phase I and Phase II Environmental Site Assessments (ESAs);
- Concentrations/exceedances of hazardous substances / contaminants;
- Comments regarding water well and surface water risk from the Phase 2 Allegan County Groundwater Study, and;
- Recommendations for off-site groundwater sampling at water wells.

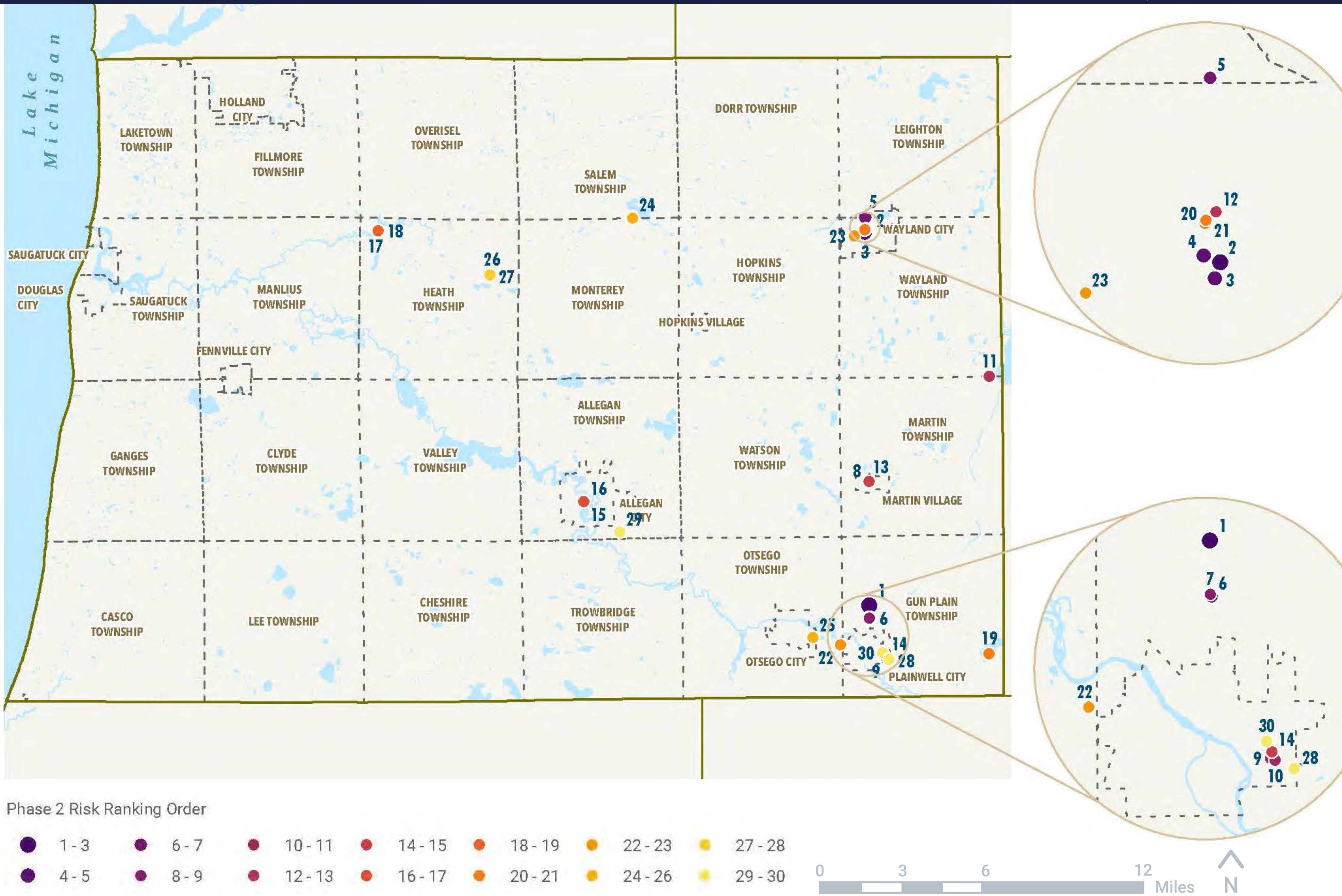
The highest priority sites tend to cluster around the population centers of Allegan County, as depicted in Map 7. The geographic area with highest number of priority sites are in Gunplain Township/City of Plainwell (seven total). The cities of Wayland and Allegan have six and five priority sites in or near their borders, respectively. Allegan Township and Heath Township (Hamilton area) both contain three sites within their borders. The Village of Martin has two priority sites, and Wayland Township near Shelbyville, Saugatuck Township, Dorr Township, and Otsego Township each have one site within their borders.

HELPFUL DEFINITIONS

Priority Site: One of the Top 30 sites of groundwater concern (sometimes referred to as "highest priority sites").

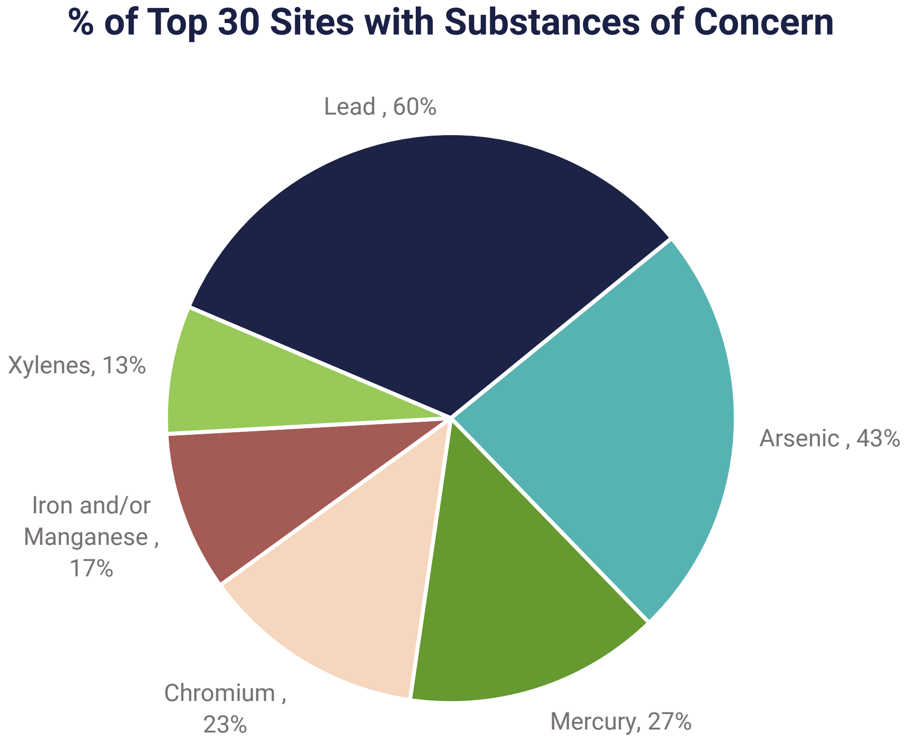
Recognized Environmental Conditions (RECs): The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing, past, or material threat of a release into structures on the property or into the ground, groundwater, or surface water of the property.

MAP 7 Highest Priority Sites of Groundwater Concern (Top 30)



Common site histories that contribute to recognized environmental conditions (RECs) at these priority sites include: former operations involving the automotive industry, particularly automotive service repair and gasoline filling stations; presence (historical or current) of underground storage tanks storing heating fuel oil, diesel oil, or gasoline; and improperly disposed of industrial waste and debris containing metals and synthetic chemicals.

Substances of concern were found across multiple priority sites and include lead, arsenic, mercury, chromium, iron and/or manganese, and xylenes.



Other substances of concern identified at one of the 30 priority sites include: vinyl chloride, benzene, dichloromethane (DCM), ethylbenzene, tetrachloroethylene (PCE), trichloroethylene (TCE), 2-methylnapthalene, cadmium, nitrate, benzo(b) fluoranthene, benzo(a)pyrene), benzo(ghi)perylene and Indeno(123-cd)pyrene.

TABLE 1 Summary information of the highest priority sites (Top 30) of groundwater concern in Allegan County

RISK RANKING	SITE ADDRESS	LOCAL GOV. UNIT	TYPE/DATASET*	SUBSTANCE(S) OF CONCERN
1	687 North 10th Street	Gunplain Twp.	Site of Env. Concern (Part 201)	Iron, Manganese
2	203 South Main Street	City of Wayland	Site of Env. Concern (Part 201)	Dichloromethane (DCM), Lead
3	Wayland Self Serve	City of Wayland	LUST (Part 213)	Unknown; gasoline products likely
4	114 Pine Street	City of Wayland	Site of Env. Concern (Part 201)	Lead, Arsenic
5	585 10th St. Plainwell	Gunplain Twp.	Site of Env. Concern (Part 201)	Lead, Cadmium, Chromium, Ethylbenzene, xylenes, and 2-methylnapthalene
6	3603 N. Main Street	Leighton Twp.	Site of Env. Concern (Part 201)	Lead, Xylene, 2-methylnapthalene, ethylbenzene
7	712 East Bridge Street	City of Plainwell	Site of Env. Concern (Part 201)	Lead, Xylene, Benzene
8	798 E. Bridge Street (Formerly 760 E. Bridge)	City of Plainwell	Site of Env. Concern (Part 201)	Lead, Mercury, Arsenic, Chromium
9	1258, 1260 Lincoln Road & Village EMH Pk	Allegan Twp.	Site of Env. Concern (Part 201)	Nitrate and benzopyrene
10	150 North Main Street	City of Wayland	Site of Env. Concern (Part 201)	Lead, Arsenic, Mercury, Tetrachloroethylene (PCE), Trichloroethylene (TCE)
11	101 124th Avenue	Wayland Twp.	Site of Env. Concern (Part 201)	Lead
12	236 Hubbard Street	City of Allegan	Site of Env. Concern (Part 201)	Arsenic, vinyl chloride, Lead, Benzo(b)fluoranthene
13	1218 M-89 Highway	Allegan Twp.	Site of Env. Concern (Part 201)	Lead, Iron, Manganese, Chromium, Arsenic
14	637 West Sycamore Street, Wayland	City of Wayland	Site of Env. Concern (Part 201)	Iron, Arsenic
15	Ridderman Card -OP	Gunplain Twp.	LUST (Part 213)	Unknown

* Michigan's Natural Resources and Environmental Protection Act has two sections: Part 201 – Environmental Remediation and Part 213 – Leaking Underground Storage Tanks (LUST)

TABLE 1 Continued

RISK RANKING	SITE ADDRESS	LOCAL GOV. UNIT	TYPE/DATASET*	SUBSTANCE(S) OF CONCERN
16	Martin (LUST Site)	Village of Martin	LUST (Part 213)	Unknown
17	6494 Clearbrook Drive & 6402 and 6500 13	Saugatuck Twp.	Site of Env. Concern (Part 201)	Lead
18	558, 520, and 512 Water Street	City of Allegan	Site of Env. Concern (Part 201)	Lead, Mercury, Arsenic, Chromium, Cadmium
19	1185 M-89 Highway	Allegan Twp.	Site of Env. Concern (Part 201)	Benzo(ghi)perylene and Indeno(123-cd)pyrene
20	1227 M-89, Plainwell MI 49080	Otsego Twp.	Site of Env. Concern (Part 201)	Lead, Iron, Manganese, Chromium, Arsenic
21	East 1/2 of SE 1/4 Section 29	Gunplain Twp.	Site of Env. Concern (Part 201)	Arsenic, mercury, Polycyclic aromatic hydrocarbons (benzo(a)pyrene)
22	Friendly 66 (Martin Pacific Pride)	Village of Martin	LUST (Part 213)	Unknown; gasoline products likely
23	Angle Steel Div (Kewaunee Scientific)	City of Plainwell	Site of Env. Concern (Part 201)	Lead
24	101 Brady Street, Allegan	City of Allegan	Site of Env. Concern (Part 201)	Lead, Mercury, Arsenic, Cadmium, Chromium
25	111 Hubbard Street	City of Allegan	Site of Env. Concern (Part 201)	Lead, Chromium
26	243 Hubbard Street, Allegan	City of Allegan	Site of Env. Concern (Part 201)	Arsenic, Lead
27	4634 4671 East Washington Street & 3501	Heath Twp.	Site of Env. Concern (Part 201)	Mercury, Arsenic
28	Hamilton Farm Bureau Cooperative	Heath Twp.	LUST (Part 213)	Unknown
29	1840 142nd Avenue	Dorr Twp.	Site of Env. Concern (Part 201)	Lead, Mercury, Arsenic
30	3506 M-40	Heath Twp.	Site of Env. Concern (Part 201)	Mercury, Benzene, Ethylbenzene, Xylenes

* Michigan's Natural Resources and Environmental Protection Act has two sections: Part 201 – Environmental Remediation and Part 213 – Leaking Underground Storage Tanks (LUST)

3.2 Non-Point Source Pollution

Non-point source pollution (NPS) refers to pollution that originates from many scattered sources rather than from a single, identifiable point. Non-point source pollution can impair groundwater quality due to distributed or large-scale processes that may be natural or man-made. In the context of water pollution originating from human activity, common non-point sources include runoff from agricultural fields, road deicing, sedimentation from construction sites, and seepage from septic systems. Non-point source pollutants can also be naturally occurring. For example, underground minerals or metals like iron or arsenic may cause non-point source pollution in groundwater.

Non-Point Source Pollution Identification

Because non-point source pollution comes from multiple sources, it is challenging to identify and control, making it a significant environmental concern. Analysis of non-point source pollution for this report was completed by analyzing water quality samples from the WaterChem statewide database. WaterChem stores the results from analyses completed at the Drinking Water Analysis Laboratory established by the Michigan Safe Drinking Water Act. Analytical data from the geocoded database spanning from 1983-2013 was used to improve our understanding of groundwater quality and non-point source pollution in Allegan County.

The following chemical constituents of groundwater were analyzed: nitrate, chloride, sodium, iron, lead, arsenic, and manganese. Point-based maps showing elevated concentrations of these non-point source pollutants in Allegan County were created to visualize the distribution of these pollutants across the County.

Non-Point Source Pollution Risk Ranking

A risk ranking of the elevated non-point source pollutants in Allegan County was created to assess potential impacts to local government groundwater supply. The relative risk to NPS pollution is higher if the water quality index is higher, and vice versa. This risk ranking was divided into two categories, Primary and Secondary NPS Pollution.

A “Primary NPS Pollution Index” was calculated by summing the water quality index for the contaminants known to adversely impact human health: nitrate, lead, and arsenic. These primary pollutants have been identified as those in the available dataset with a Maximum Contaminant Level (MLC) or Action Level indicated).

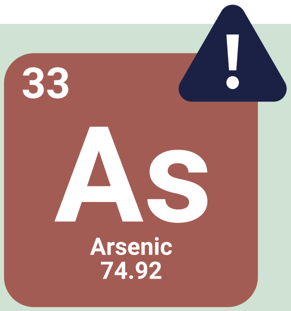
A similar “Secondary NPS Pollution Index” was computed for chemicals with non-mandatory water quality standards for chloride and iron. These secondary pollutants typically influence things like color, taste, and odor but don’t have known human health risks associated with consumption.

Primary NPS Pollution Enforceable Limit:

- Nitrate (+10 mg/L)
- Lead (+0.015 mg/L)
- Arsenic (+0.010 mg/L)

Secondary NPS Pollution Guideline Limit:

- Chloride: 250 mg/L
- Iron: 0.3 mg/L



Cheshire Township ranks highest in terms of Primary NPS Pollution Risk due to high arsenic concentrations, followed by Overisel Township, the City of Holland, Martin Township, and Hopkins Township. The townships of Watson, Fillmore, and Dorr also have notable ranking Primary NPS Pollution Risk.

(see Map 8)

Watson Township ranks highest in terms of secondary water quality severity index due to high iron concentrations followed by Lee and Ganges Townships, the City of Holland (relatively high iron and chloride concentrations), Clyde Township, and Otsego Township (high iron concentrations). The townships of Valley, Gunplain, Saugatuck, and Martin also have high ranking secondary water quality severity indexes.

(see Map 9)

HELPFUL DEFINITIONS

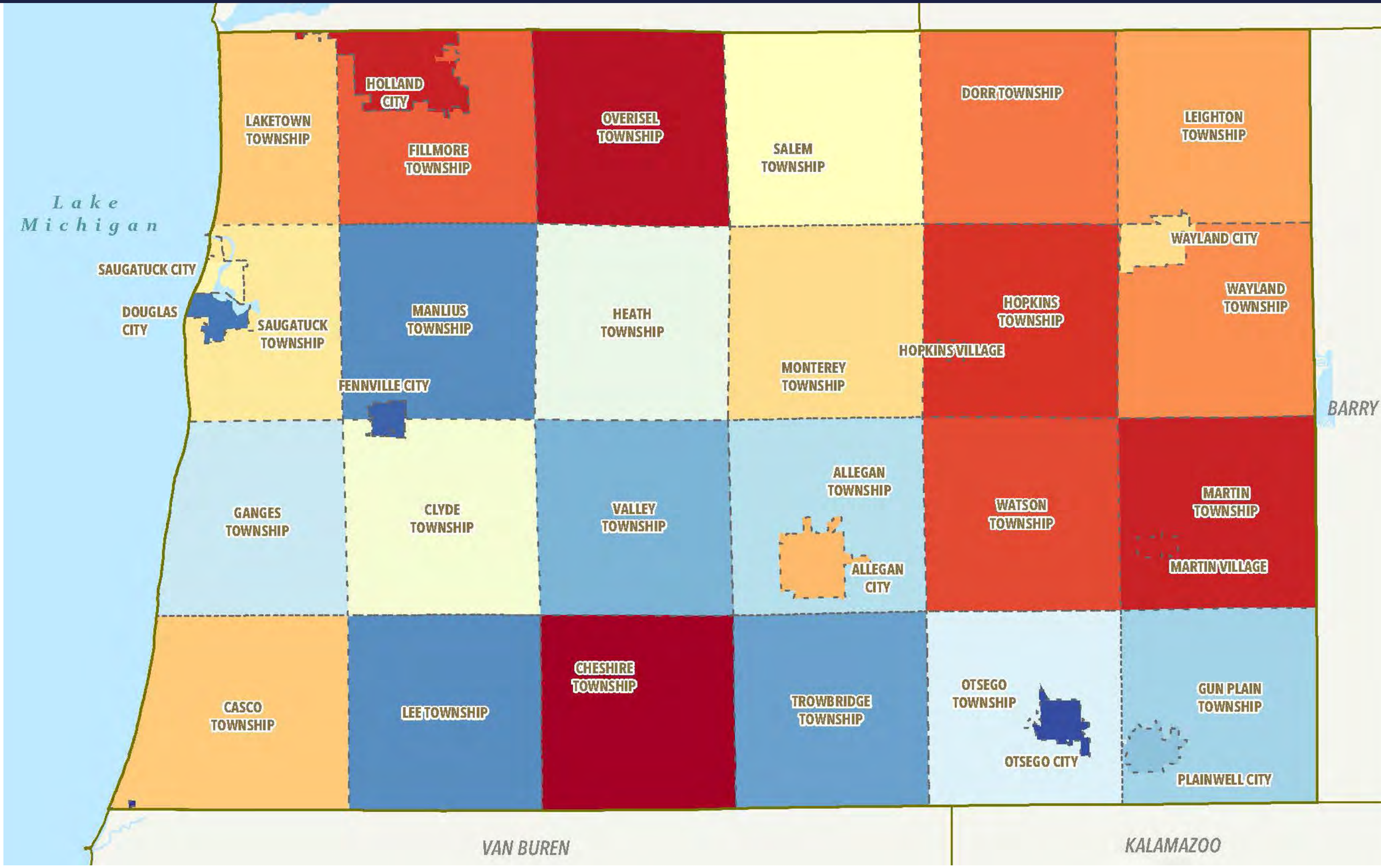
Non-Point Source Pollution (NPS): Pollution that originates from many scattered sources rather than from a single, identifiable point.

WaterChem: Statewide database of water quality samples collected by the Drinking Water Analysis Laboratory.

Primary NPS Pollutant: Non-Point Source contaminants known to adversely impact human health.

Secondary NPS Pollutant: Non-Point Source contaminants with non-mandatory water quality standards, typically only influencing things like color, taste, and odor.

MAP 8 Risk Ranking of Primary Non-Point Source Pollution (Pollution Index of Nitrate, Lead, and Arsenic*) by Local Government Unit



Pollution Risk Index: Sum of 50th and 75th percentiles normalized by substance specific MCL (nitrate, arsenic, lead)

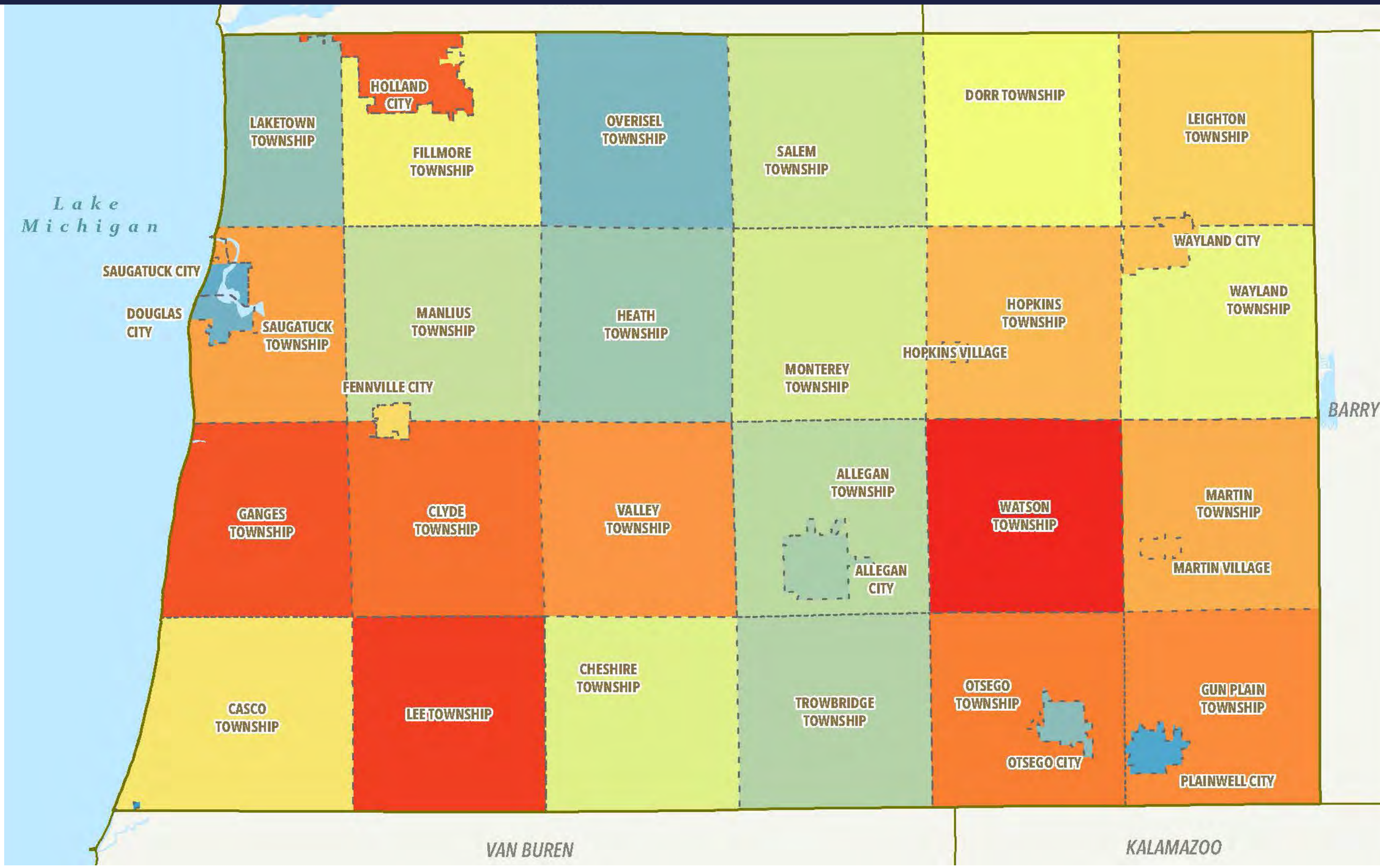
* See Appendix F

0, 0.1, 0.18, 0.19, 0.2, 0.21, 0.28, 0.33, 0.35, 0.41, 0.48, 0.5, 0.52, 0.54, 0.6, 0.63, 0.7, 0.83, 0.91, 1, 1.04, 1.05, 1.07, 1.13, 1.2, 1.21, 1.25, 1.3, 2.57

N

0 2.5 5 10 Miles

MAP 9 Risk Ranking of Secondary Non-Point Source Pollution (Pollution Index of Chloride and Iron*) by Local Government Unit



Pollution Risk Index: Sum of 50th and 75th percentiles normalized by substance specific SMCL (chloride and iron)

* See Appendix F

0	0.58	1.19	1.46	1.84	2.08	2.71	3.57	4.28	5.22	6.46
0.29	1.04	1.2	1.48	1.92	2.31	3.31	3.61	4.76	5.86	6.9
0.47	1.13	1.28	1.56	2.05	2.52	3.33	4.09	4.77	6.09	8.18

N

0 2.5 5 10 Miles

3.3 Composite Groundwater Risk Map

A composite groundwater risk map of Allegan County showing the areas of highest groundwater quality concern has been created as an easy to interpret reference.

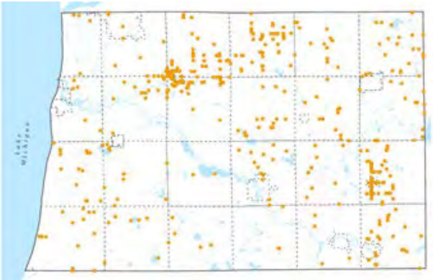
Map 10 overlays the 351 sites of groundwater concern and all the non-point source pollutants elevated above the primary MCLs or secondary drinking water levels as outlined on page 46 of this report. Additionally, the Centers for Disease Control's Social Vulnerability Index (SVI) has been included as an underlying basemap to provide context for human risk factors. This index identifies a level of vulnerability based on four themes, including socioeconomic status, household composition, race/ethnicity/language, and housing/transportation.

Being able to see all the ranked water quality risk elements with the underlying SVI not only illustrates the critical risk areas within the County, it also gives a greater perspective for communities where groundwater quality impacts could be most harmful.

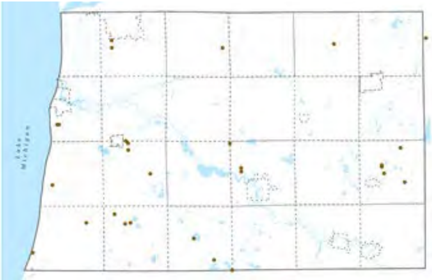
SVI maps are viewable on the CDC/ATSDR interactive web platform and can be viewed by County or Census Tract.
[Social Vulnerability Index (SVI) Maps]

Ranked 351 Sites of Groundwater Concern

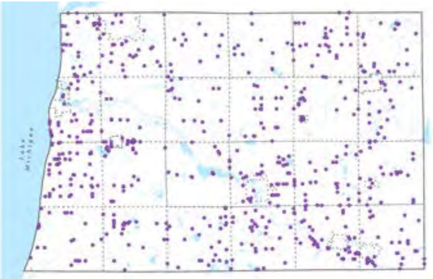
Elevated NPS Chloride Concentrations



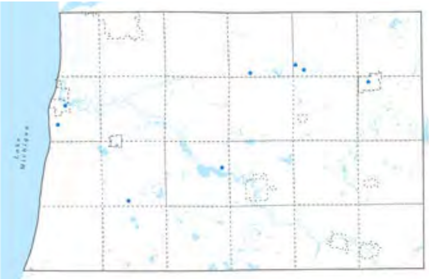
Elevated NPS Nitrate Concentrations



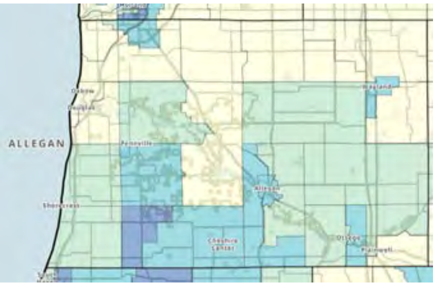
Elevated NPS Arsenic Concentrations



Elevated NPS Iron Concentrations



Elevated NPS Lead Concentrations



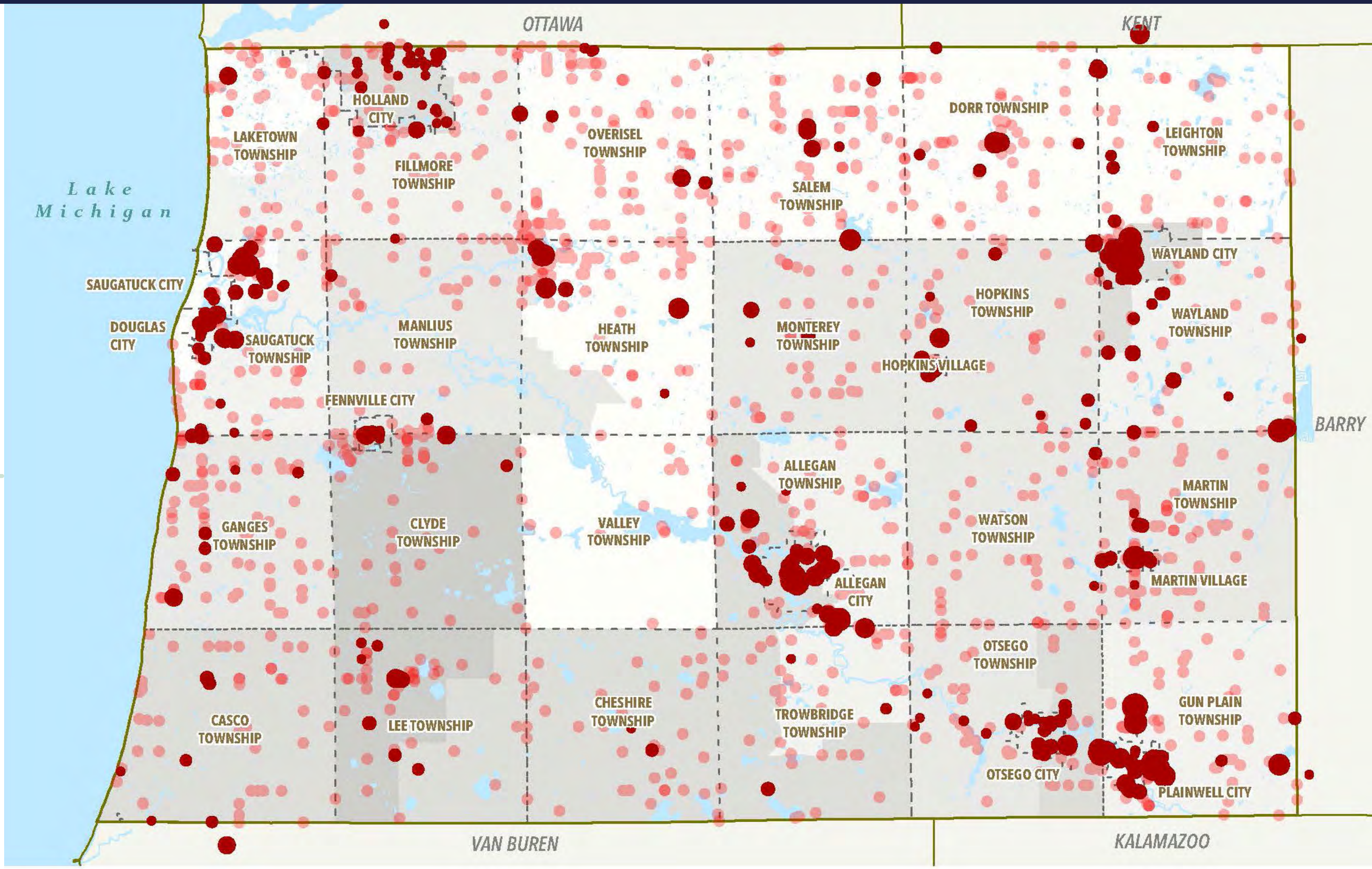
CDC Social Vulnerability Index (SVI)

- Low
- Low-Medium
- Medium-High
- High

SVI Legend

MAP 10 Composite Groundwater Risk

0 2.5 5 10 Miles N



Point Source Contamination Risk Ranking

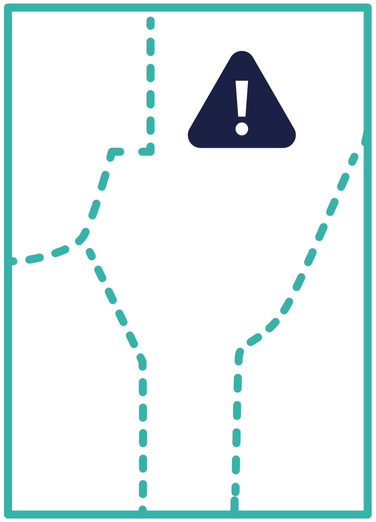
- 0 - 5th Percentile
- 95th - 100th Percentile

CDC Social Vulnerability Index (By Census Tracts)

- Low Social Vulnerability
- High Social Vulnerability

Nonpoint Source Pollution (Higher Concentrations)

- Iron (Concentration higher than 2 mg/L)
- Chloride (Concentration higher than 250 mg/L)
- Nitrate (Concentration higher than 10 mg/L)
- Arsenic (Concentration higher than 0.010 mg/L)
- Lead (Concentration higher than 0.015 mg/L)



Areas of Concern

This composite groundwater quality risk map provides an at-a-glance resource to help identify areas that may be at higher risk for groundwater contamination. Water quality risk does not necessarily mean the water is contaminated today but it does identify potentially vulnerable areas so proper groundwater planning can take place.

Overall contamination risk is primarily focused in the population centers in or around many cities and villages within Allegan County (e.g., City of Wayland, Plainwell, Holland, Village of Martin). This is not surprising, given that industry and public drinking water supplies are concentrated in these areas. Public water supplies are regularly tested and have rigorous state reporting requirements to protect public health, welfare, and safety. It is worth noting that areas of higher risk generally coincide with areas of high groundwater use (including for public supply) and warrant continued monitoring and protection.

Contamination risk from non-point source pollution is also notable, particularly in rural areas of the Townships across Allegan County (e.g., Ganges, Salem, Dorr, Overisel, and Martin Townships). In both urban and rural areas throughout the County, data showed groundwater with substances that exceed established drinking water standards. Specific issues include:

- Significantly elevated nitrate concentrations impacting shallow groundwater
- Elevated chloride concentrations impacting groundwater discharge areas and along major roadways
- Significantly elevated iron concentrations throughout the groundwater system

Once groundwater becomes polluted, it is difficult (if at all possible) and very expensive to clean up. This leaves some communities more susceptible to negative socioeconomic impacts from groundwater contamination. Many of the areas discussed with higher ranking sites of groundwater concern have moderate social vulnerabilities. For example, Martin Township and Village have moderate social vulnerabilities, a high potential risk for primary and secondary NPS contamination (pollutants known to adversely impact human health and taste/smell/color), and several high-ranking sites of groundwater concern. Additionally, Lee and Clyde Townships have a high social vulnerability, rank high in secondary NPS pollutants contamination risk, and include several lower ranking sites of groundwater concern. This is important to recognize, as many of these populations rely on private wells and may be ill-equipped to complete regular water testing or have funds to remediate/find access to alternate water sources in the case of an incident.

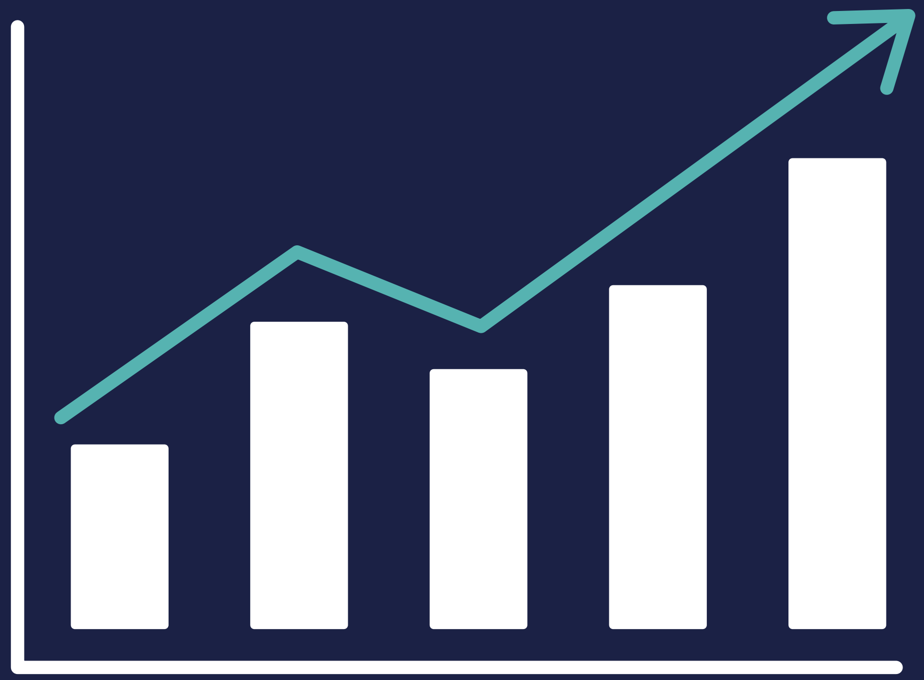
Importance of Water Quality Testing

Given the prevalence of water quality risk across the County, routine testing and monitoring is recommended. This is an important step in preventative care of the groundwater resource and allows for swift action when a problem is manageable.

As previously mentioned, public water suppliers test quarterly and private wells (old or new) are typically only tested before they are put into use. Although taking steps to prevent issues before they arise is the best method for protecting groundwater, it is important to note that (depending on the result) a “bad” water quality test can be efficiently treated in a variety of ways. This includes well treatment such as chlorinating for bacteria, adding an at-home carbon filter or reverse osmosis (RO) system, changing the well location or depth, or using multi-source water use at home, like bottled water for drinking and well water for bathing/washing.

CHAPTER 4

GROUNDWATER DEMAND & FUTURE PROJECTIONS



Chapter 4. Groundwater Demand & Future Projections

4.1 Aquifer Refresher

In Allegan County, groundwater is the only viable source of drinking water for nearly all private and public water supplies. Groundwater is available from two primary aquifers; 1) a shallow glacial drift system that overlies the entire County, and 2) a deeper bedrock formation that lies beneath the glacial drift system and is only available in the northeast part of the County. All groundwater obtained for water supply in the County is withdrawn from these two geologic features, so a shared knowledge of the current and future use of these vital resources is important in maintaining long-term groundwater access.

The glacial aquifer is highly variable in extent and texture, and both factors play an important role in the amount of water that can be withdrawn from any particular location. While this is the primary aquifer utilized by most wells in the County, there are certain areas where groundwater cannot be withdrawn in useful quantities from the glacial drift due to the absence of sandy soils, or because the glacial drift is too thin to support sustainable groundwater withdrawal.

The bedrock aquifer is accessible and thickens in the northeast part of the County and, as a result, is an important groundwater resource in this region. Much of the bedrock that is present in the interior of the County (closer to the Kalamazoo River) has limited usefulness as a viable water resource due to its spotty occurrence and relatively thin nature. Due to its very poor permeability in the south, northwest, and central parts of the County, the bedrock is not productive across much of the County and is rarely used for water supply.

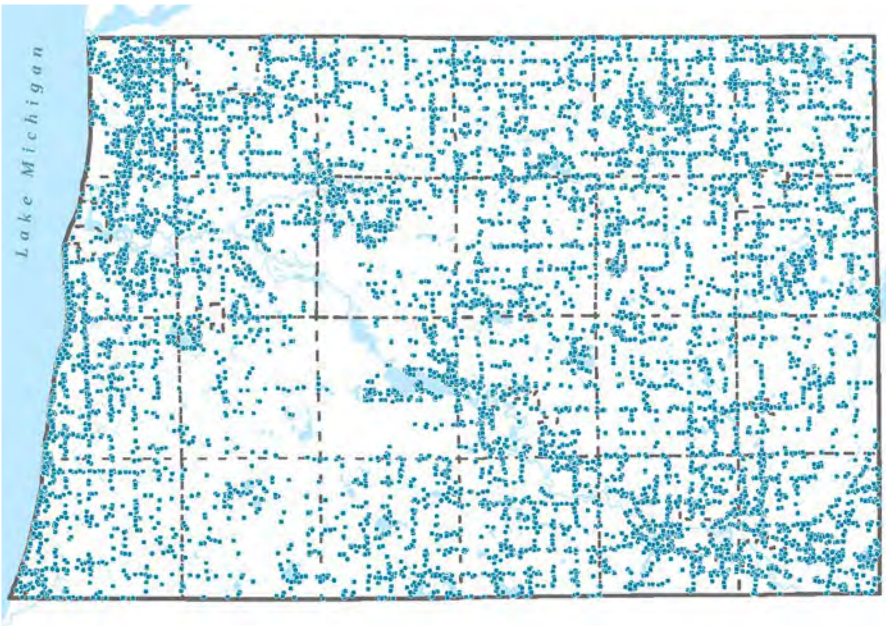
4.2 Historic Groundwater Use

Groundwater use in Allegan County has experienced a significant increase in the last two decades. The number of reported wells has grown from roughly 12,000 wells in the year 2000 to about 27,000 wells by 2020, indicating a substantial rise in demand for the County's groundwater resources . The increase in groundwater use is evident across all townships in the County, with the most significant increases observed in the outer townships along the County's periphery, notably in Casco, Overisel, Salem, Dorr, Leighton, and Martin Townships. Some of these areas, especially near population centers like Plainwell and Allegan, have increased pressure on groundwater use due to the combination of dense residential wells and nearby high-capacity public water supply wells. Holland is the exception, as the city's source supply is surface water instead of groundwater.

[1] These figures are relative since wells installed earlier than 2000 are continuously being added to the statewide well log database.

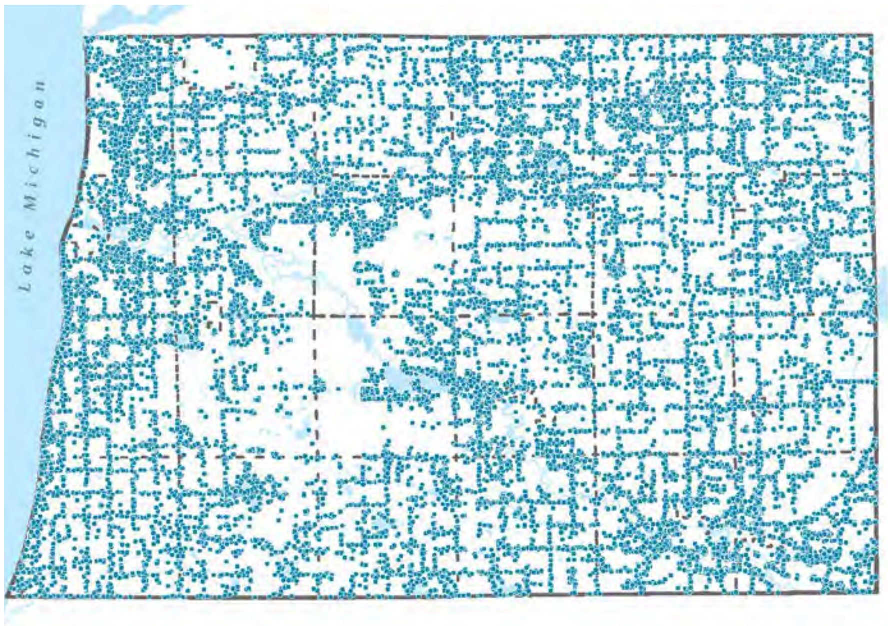
Water Well Network Growth

Up to 2000



Number of Wells: **11,510**

Up to 2020



Number of Wells: **26,700**

Historic well record data can be found on EGLE's statewide groundwater database, Wellogic.

EGLE's Water Well Viewer displays all current Wellogic wells in an interactive map.

0 2.5 5 10 Miles
N

4.3 Groundwater Use Today

This report focuses on the primary classes of water wells that make up the majority of groundwater use in the County. Water wells are generally classed as either Type I water wells, Type II water wells, private water wells, or irrigation wells. An additional class of water well includes the industrial well. These wells are relatively uncommon and are used for non-drinking water applications, however, the number of wells in this class is very small when compared to the demands from the primary classes of wells.

In terms of substantial withdrawals, water wells were classed from most to least significant as follows;

*

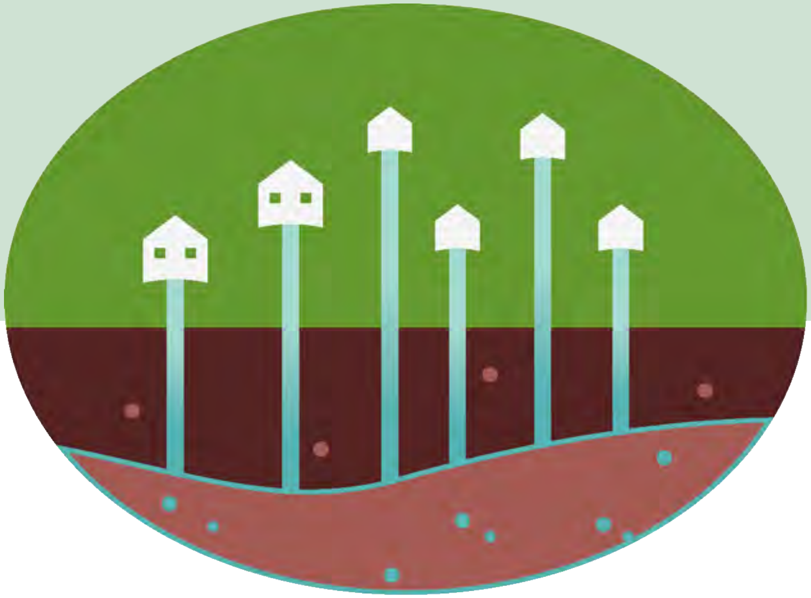
- **Private water wells** are the most numerous, are widely distributed throughout the County, and supply water to single family residences.
- **Type II water wells** usage is very small compared to the other well classes, as their water demands tend to be seasonal or lesser in hours for places of employment, schools, day care centers, hotels, restaurants, campgrounds, churches, or highway rest stops.

Type I Wells

- **Municipal type I water wells** supply water to community water systems with greater than 25 year-round customers. These are commonly referred as "city and village" wells or public wells.
- **Type I water wells that supply water to manufactured housing communities** are water systems that tend to be small and compact but fall under the Type I classification and are, therefore, considered large-quantity withdrawal wells.
- **Irrigation wells** supply seasonal water to croplands. These wells are not used for drinking water. Irrigation wells are regulated the same as industrial wells and are often categorized as both in the data records. Detailed information regarding individual daily or monthly withdrawals of irrigation wells are not publicly available, and so are more difficult to quantify. This is discussed in the subsequent section.

* For this research, type II wells were included in the analysis of private wells, as type II water well usage is very small compared to the other above well classes.

All classes of water wells can be found installed within either the glacial aquifer or within the Marshall Formation of the bedrock aquifer.



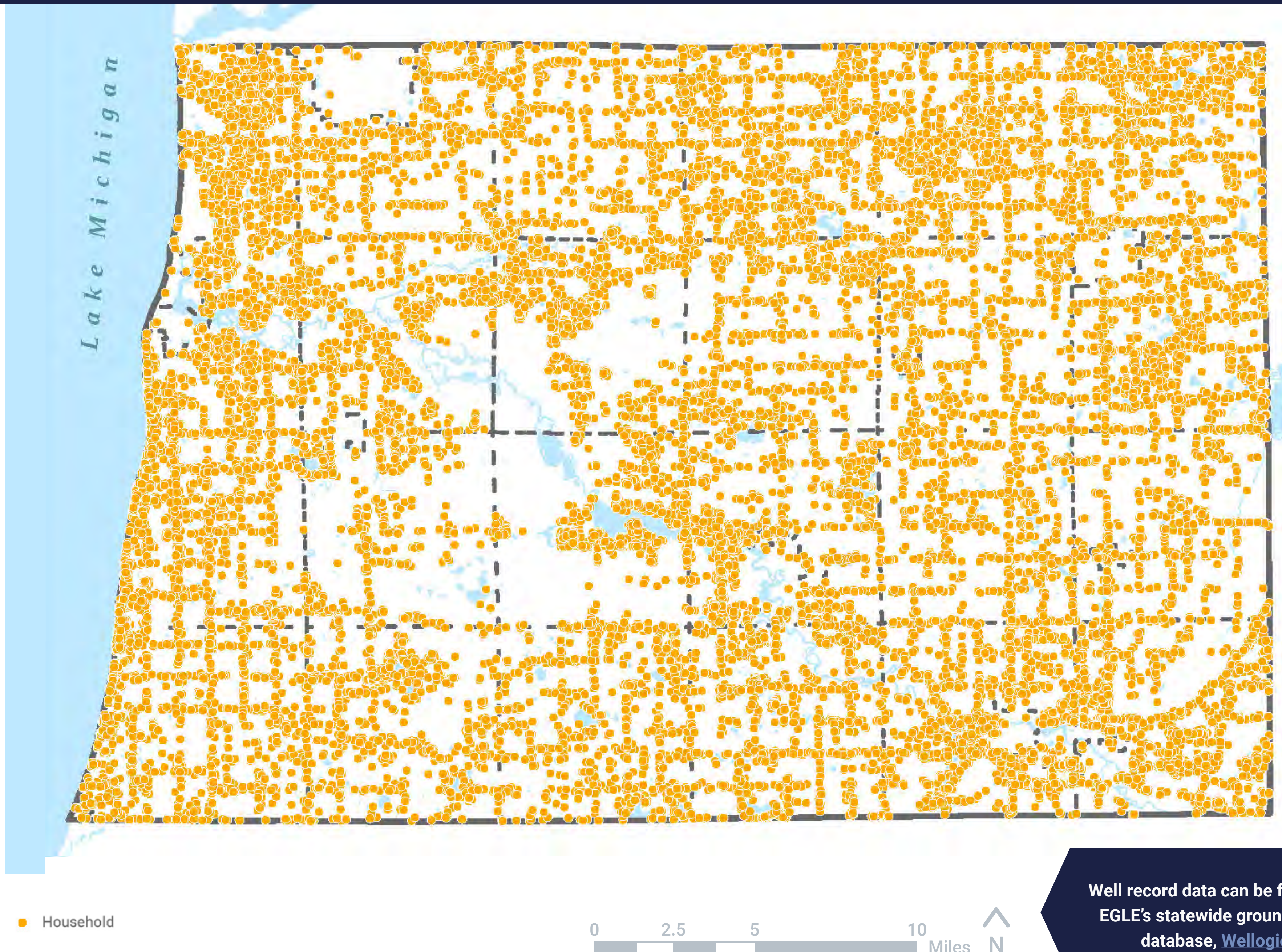
Private Water Wells

The largest number of wells by class in Allegan County are the private water wells. Cumulatively, private wells comprise the bulk of groundwater withdrawals in the County. Private water wells are distributed somewhat uniformly. Private water wells are distributed somewhat uniformly. Individually, they do not have a negative bulk effect on aquifer capacity except potentially, when they are concentrated in a small area. As of the date of this report, there are over 27,500 registered private water wells in the County which constitute the fastest-growing segment of water well-type construction.

Groundwater withdrawals from private water wells are rarely, if ever reported, but a basic average daily demand can be reasonably calculated using the industry standard method of assuming 100 gallons per day per capita, with an average household population of 2.5 persons. This method is typically used to estimate water demands and associated infrastructure for large water supply systems. For the purpose of demand calculations in this report, the average daily withdrawal from each private well is, therefore, 250 gallons per day. Indeed, some households may use more or less, but the bulk average conforms to the Ten States Standard for calculating average day demands.

Map 12 shows the present distribution of private wells across Allegan County. An examination of Map 12 shows large areas in the central part of the County that are devoid of private wells due in part to “unbuildable” parcels (state lands) and/or areas where the glacial drift aquifer is inadequate to support a household water supply system.

MAP 12 Distribution of Private Wells



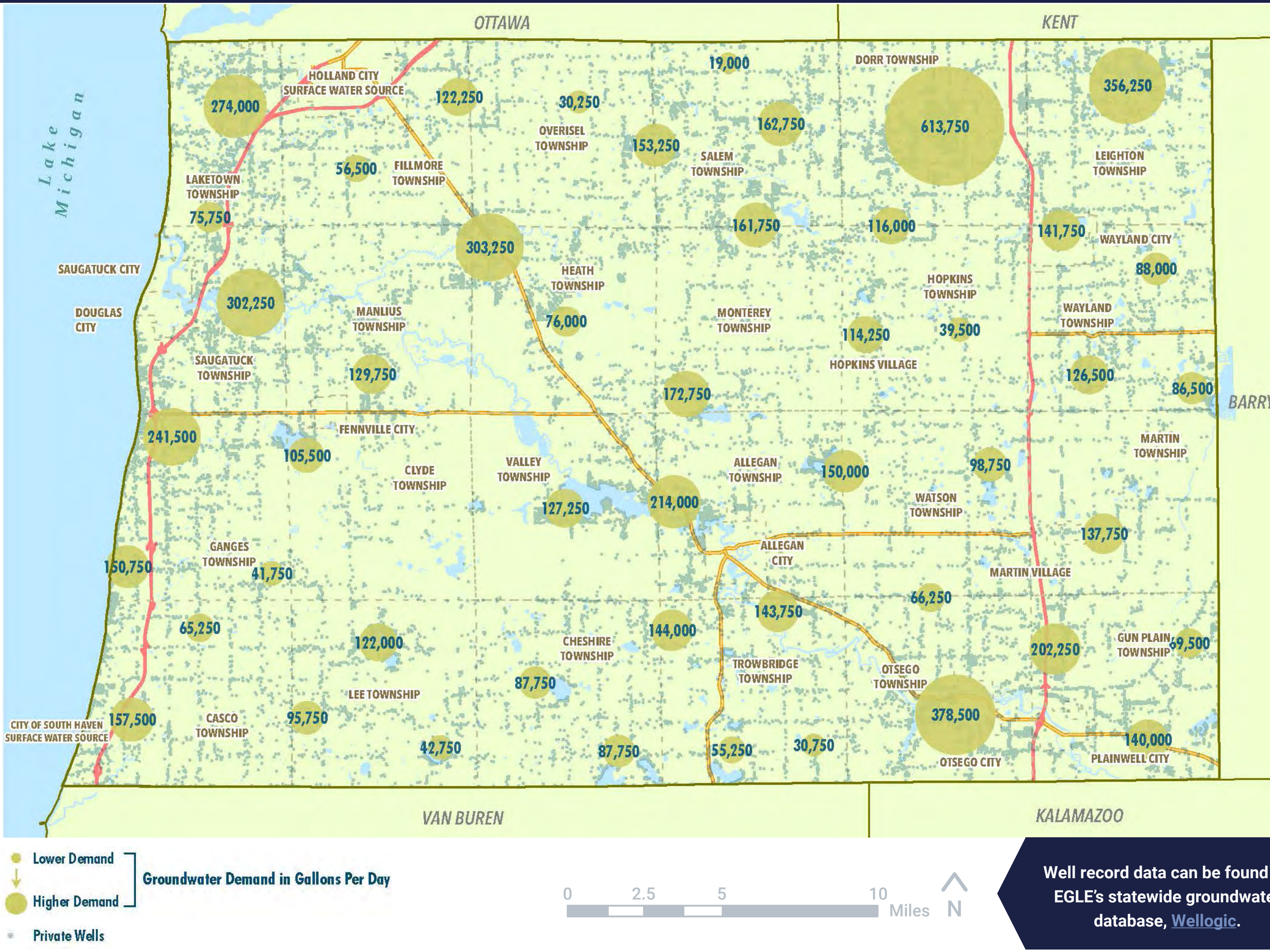
Well record data can be found on EGLE's statewide groundwater database, Wellogic.

Because private water wells are distributed across the County, it is more relevant to the goals of this study to examine where private wells are concentrated and have the potential to negatively impact aquifer storage. These areas are intended to be the focus for future groundwater monitoring.

To examine aquifer demand pressure from private wells, a spatial analysis technique was used whereby individual private well data points were aggregated into larger circles based on their spatial proximity. Each resulting circle is sized relative to the number of private wells within the aggregation. Using the standard multiplier of 250 gallons per day, overall, the resultant map displays areas of concentrated groundwater demand due to private wells. These maps help in understanding the spatial distribution and density of private wells, making it easier to visually identify demand pressure.

Examination of Map 13 shows the majority of private wells clustering near the larger cities, villages, and along the Lake Michigan shoreline. The largest density of private wells are located in the areas of Dorr, Plainwell/Otsego, Allegan, and around Green Lake in Leighton Township.

MAP 13 Groundwater Demand of Private Wells



Well record data can be found on EGLE's statewide groundwater database, Wellogic.

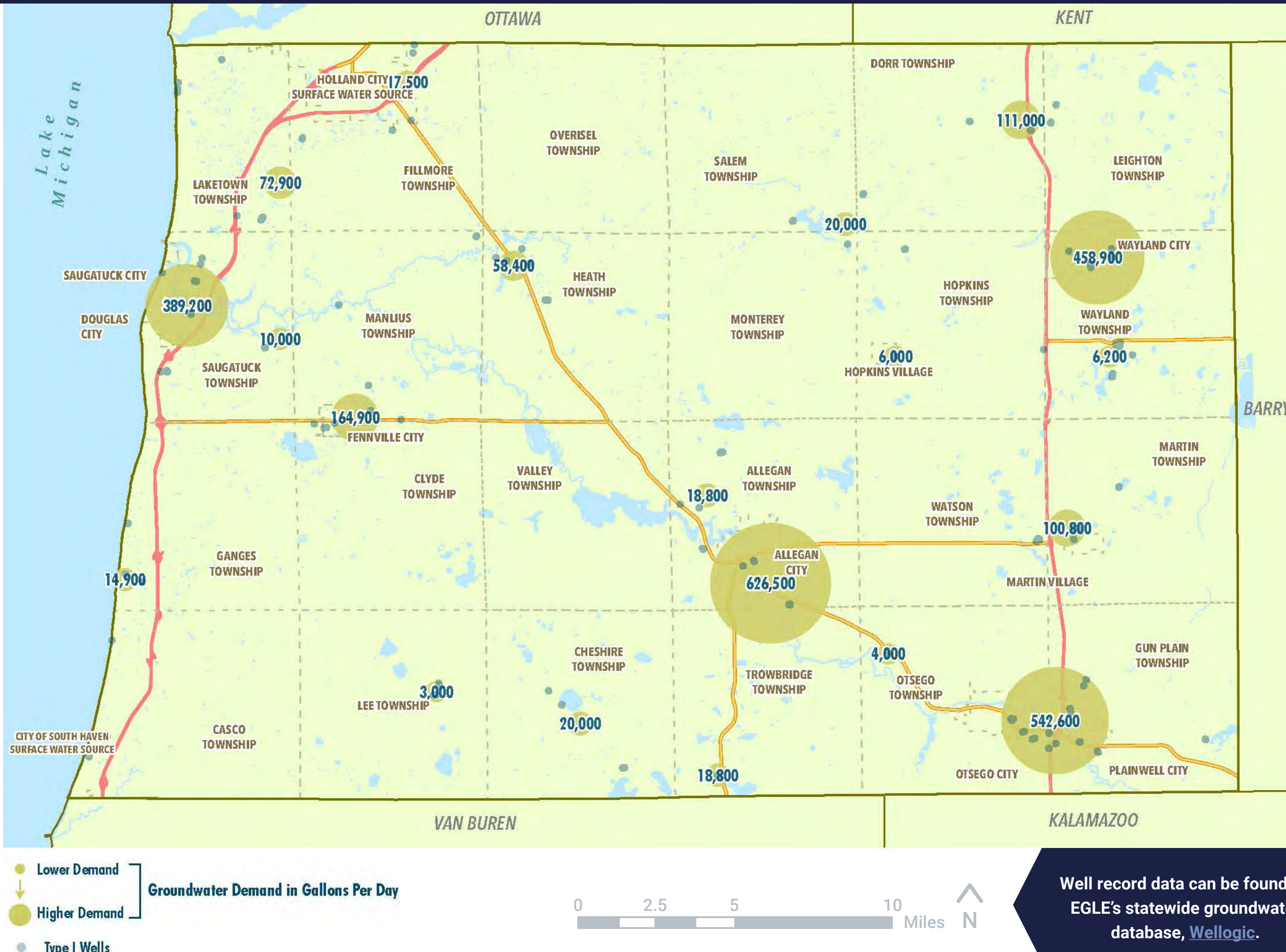
Type I Community and Manufactured Housing Community Water Wells

The second largest number of wells by class are the Type I community water supply wells. Type I water wells are distributed somewhat uniformly, with the largest withdrawals occurring at cities and villages with the larger populations. Manufactured housing communities (MHCs) tend to be small and don't have the same water use characteristics as larger community water systems, for example, MHC systems typically do not supply water for lawn irrigation, businesses and fire suppression. Singularly, these systems do not have a significant negative effect on the local aquifer capacity, however, this class of water wells have regulated withdrawal restrictions based on the residing drainage basin and its available capacity. As of the date of this report, there are over 182 Type I water wells that supply water to about 50 water supply systems.

Groundwater withdrawals from Type I water wells were calculated using the standard method of assuming 100 gallons per day per capita, which was multiplied by the population served in each case. For all Type I water supplies, redundant wells are required. In some instances, Type I water supplies will have multiple wells in various locations, therefore, for the purpose of this report we used a single point centered at each Type I water supply and assigned the average day withdrawal to that location.

Map 14 shows the locations of Type I wells across the County and the groundwater demand distribution from each of the pumping centers.

MAP 14 Location and Demand Distribution of Type I Water Wells



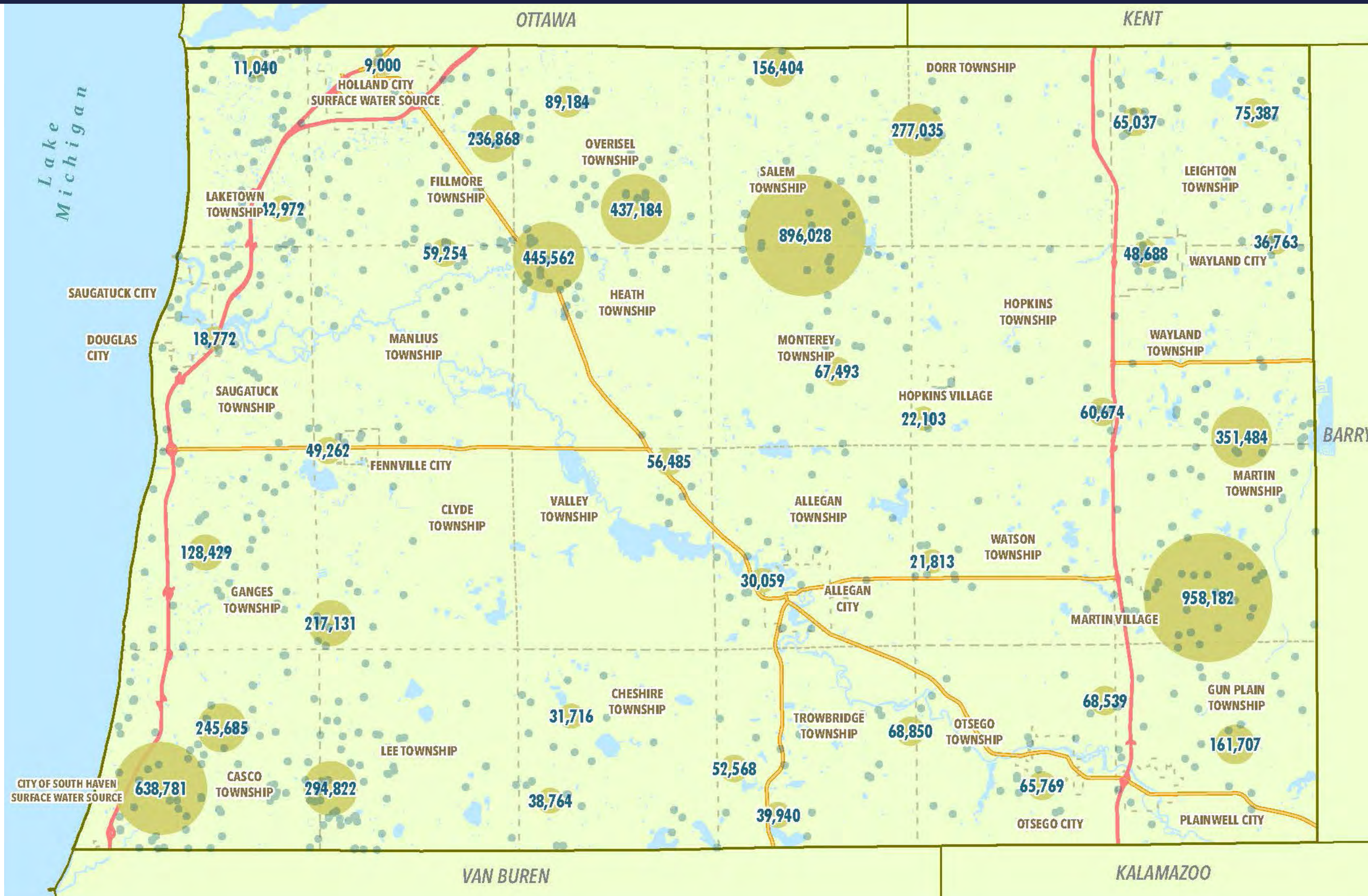
Well record data can be found on EGLE's statewide groundwater database, Wellogic.

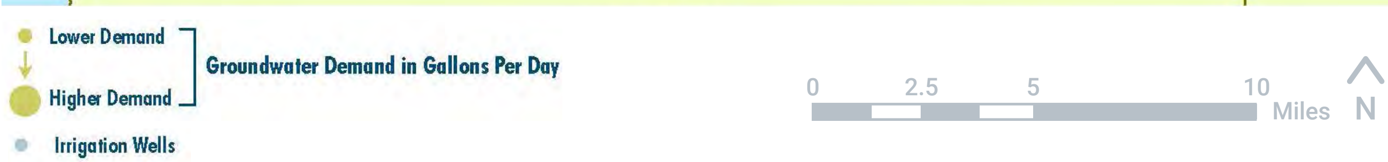
Irrigation Water Wells

The third class of water wells is the irrigation well. This particular class of well is operated seasonally, on average for about four months in a typical year, and is dependent on weather conditions. Irrigation wells are distributed somewhat across the County but tend to be clustered in the southwest and north-northwest areas of the County where glacial drift aquifers are conducive to larger withdrawals. In other regions of the east half of the County, irrigation wells are widely spaced and located in “glacial outwash” areas where the glacial drift is conducive to larger withdrawals. The individual withdrawals from irrigation wells are the most difficult to determine since daily and monthly withdrawals are not reported - only aggregate annual withdrawals from each township are publicly available. Irrigation well operators report total groundwater withdrawals on an annual basis. Annual withdrawal records from all irrigation wells are combined for each township, and the total aggregate withdrawal is reported as the “total irrigation water well withdrawal per township per year”. As of the date of this report, there are over 772 irrigation water wells in the County. Some of these wells may be unreported abandonments, while others may be replacement wells, and still others may have been classified incorrectly (such as industrial wells or test wells).

Individual irrigation well withdrawals were calculated by taking the ten-year annual withdrawal average for each township and dividing the average annual withdrawals by the number of wells in each respective township. The resulting average annual withdrawal per well was divided by 365 days to provide an average daily withdrawal per well specific to each township. Map 15 shows the locations of irrigation wells throughout the County and the associated groundwater demand distribution.

MAP 15 Location and Demand Distribution of Irrigation Water Wells





Well record data can be found on EGLE's statewide groundwater database, Wellogic.

Existing Cumulative Demand

Cumulatively, the overall groundwater demands from all well classes is shown in Map 16. The overall County-wide demand on groundwater is estimated to be about 16.5 million gallons per day.

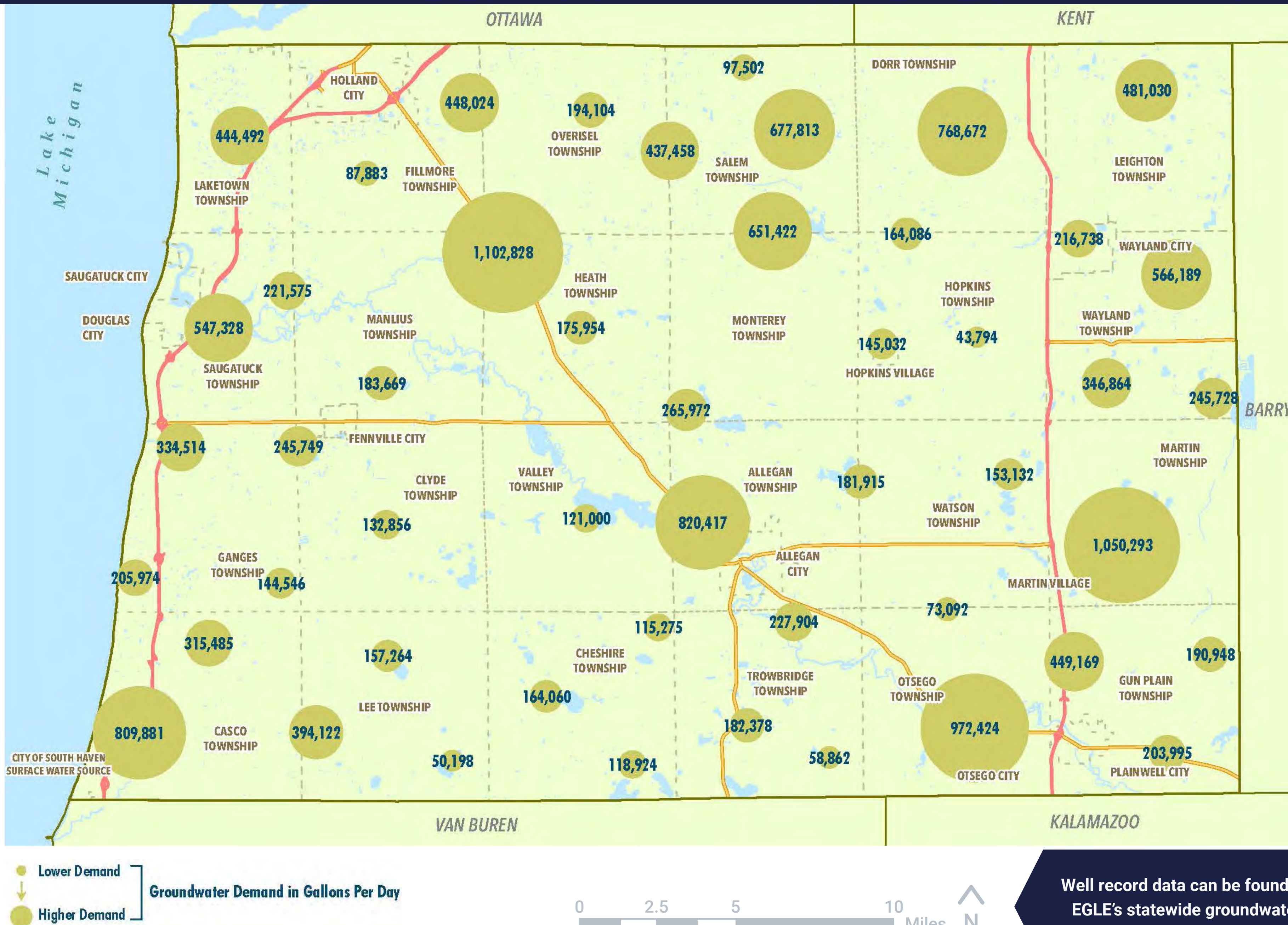
Examination of Map 16 shows the greatest groundwater demands are generally around the population centers (Plainwell, Otsego, Hamilton and Allegan) and in Salem, Dorr, Leighton, Martin and Casco townships.

County-wide demand

16.5

million GPD

MAP 16 Cumulative Demand of Private, Type I, and Irrigation Wells



Well record data can be found on EGLE's statewide groundwater database, Wellogic.

4.4 Future Groundwater Demand Projections

The primary basis for projecting groundwater use in Allegan County is related to the need for better information on aquifer recharge and withdrawals, especially in regions where groundwater pressures already exist or may be anticipated to grow. In this report, we present a basic understanding of the current state of groundwater withdrawals in Allegan County, but we also need to project future demands and relate them back to the state of supply. This has multiple considerations, including the potential impacts of climate, land use/cover, and demographic shifts that may change withdrawal rates.

While the potential impacts of climate and land use/cover are difficult to predict, the changes in population have a direct relationship to changes in water consumption. This section, therefore, focuses on projected trends in population. The results of this analysis highlight areas where groundwater withdrawals are highest, and where groundwater withdrawals could be expected to increase over time. This will provide the basis for setting up monitoring locations where groundwater elevations can be observed and recorded for long periods into the future.

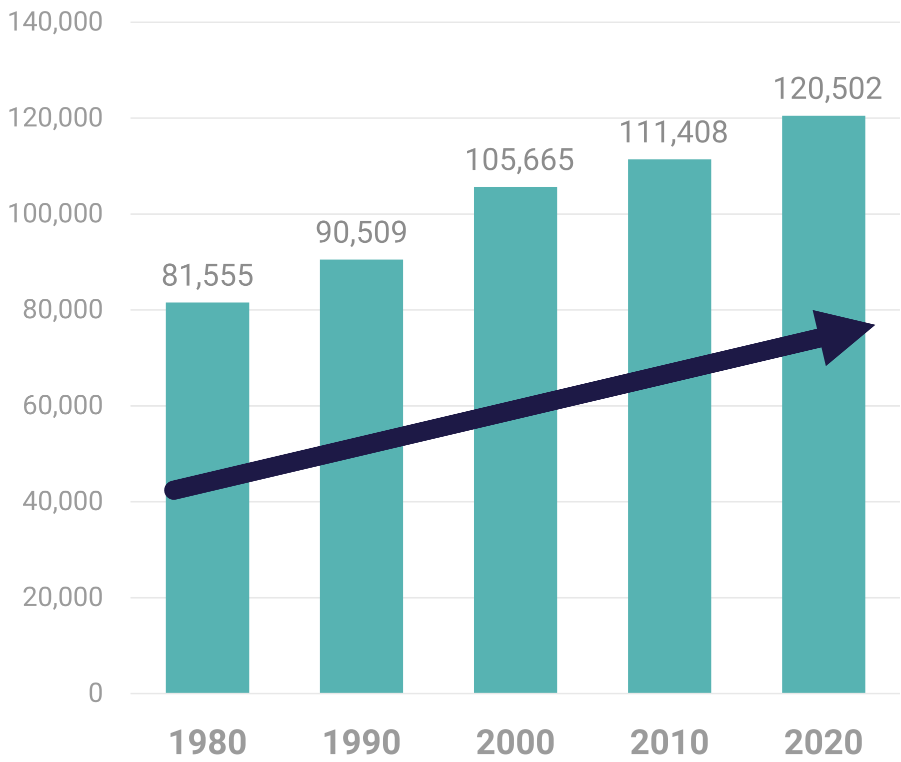
Population Trends

Population growth will be accompanied by growth in demand for water, therefore understanding projected population trends is a key indicator for projected groundwater use in Allegan County.

Today, the United States has an aging population and falling birth rates. While overall population growth has not declined yet, the Population Reference Bureau recognized that national population decline is expected over the next 20 years as deaths likely begin to outnumber births. Michigan is ahead of this national trend and has experienced a loss in population or stagnation of growth for nearly 20 years. Per analysis from the Michigan Center for Data and Analytics, Michigan's population declined from 2000 to 2010 and was one of the slowest-growing states in the country from 2010 to 2020.

While population trends in the last several years have shown more modest gains in the state overall, a migration in population from the traditionally denser east coast to the west side of Michigan can be observed. From 2010 to 2020, Allegan County was the fifth fastest-growing county (+8.2%) in the state and outpaced the national growth rate. Overall, growth within the County has been steady since 1980, with increases in population by nearly 10,000 every ten years.

Figure 4.1. Allegan County Population Growth since 1980



Population growth in Allegan County has been forecasted at ten-year intervals through the year 2050 using statistical averaging techniques. These methodologies are designed to offer a broad overview of future growth trends. For the purpose of this report, three methods were used to determine changes in population over time: the arithmetical increase method, the growth rate method, and the constant proportion method. Appendix G provides detail on each method and includes the resulting population projection tables.

Since all three methods forecasted similar trends in population patterns, they were averaged to provide one conclusion. Allegan County is projected to see modest overall growth in the next 30 years. The predicted population between 2020 and 2050 will increase by about 13,694 or roughly 14,000 people (see Table 4, Appendix G). Most Local Government Units (LGUs) in Allegan County are anticipated to see some population growth, while others in the County are expected to decrease. The larger growth areas appear to be in the areas of Allegan, Dorr, Fennville, Heath, Leighton, Manlius, Monterey, Otsego, Overisel, Salem, Saugatuck, and Wayland Townships, and the Cities of Fennville and Douglas. These townships represent the northeast part of the County where the bedrock is an important source of groundwater, and along a diagonal trend from the southeast corner of the County at Plainwell to the northwest along the M-89 and M-40 corridors, and in Manlius Township along M-89.

Translating Population Growth into Projected Groundwater Demand

The change in groundwater demand can be related directly to the change in population using the same basic average daily demand of assuming 100 gallons per day per capita. Therefore, for the purpose of predicting future groundwater demands, each unit increase in population will add a unit increase of 100 gallons per day. Consequently, taking the 30-year predicted population growth of 14,000 people, this will amount to an additional water demand of about 1,400,000 gallons per day. Since our current county-wide daily water demand is about 16,500,000 gallons per day, the predicted additional water demand by 2050 could reach 18,000,000 gallons per day.*

Change in GW Demand (2020-2050) =

Projected Population Change x 100 GPD/capita

Total Projected GW Demand (2050) =

Projected Change in Demand + Present Demand

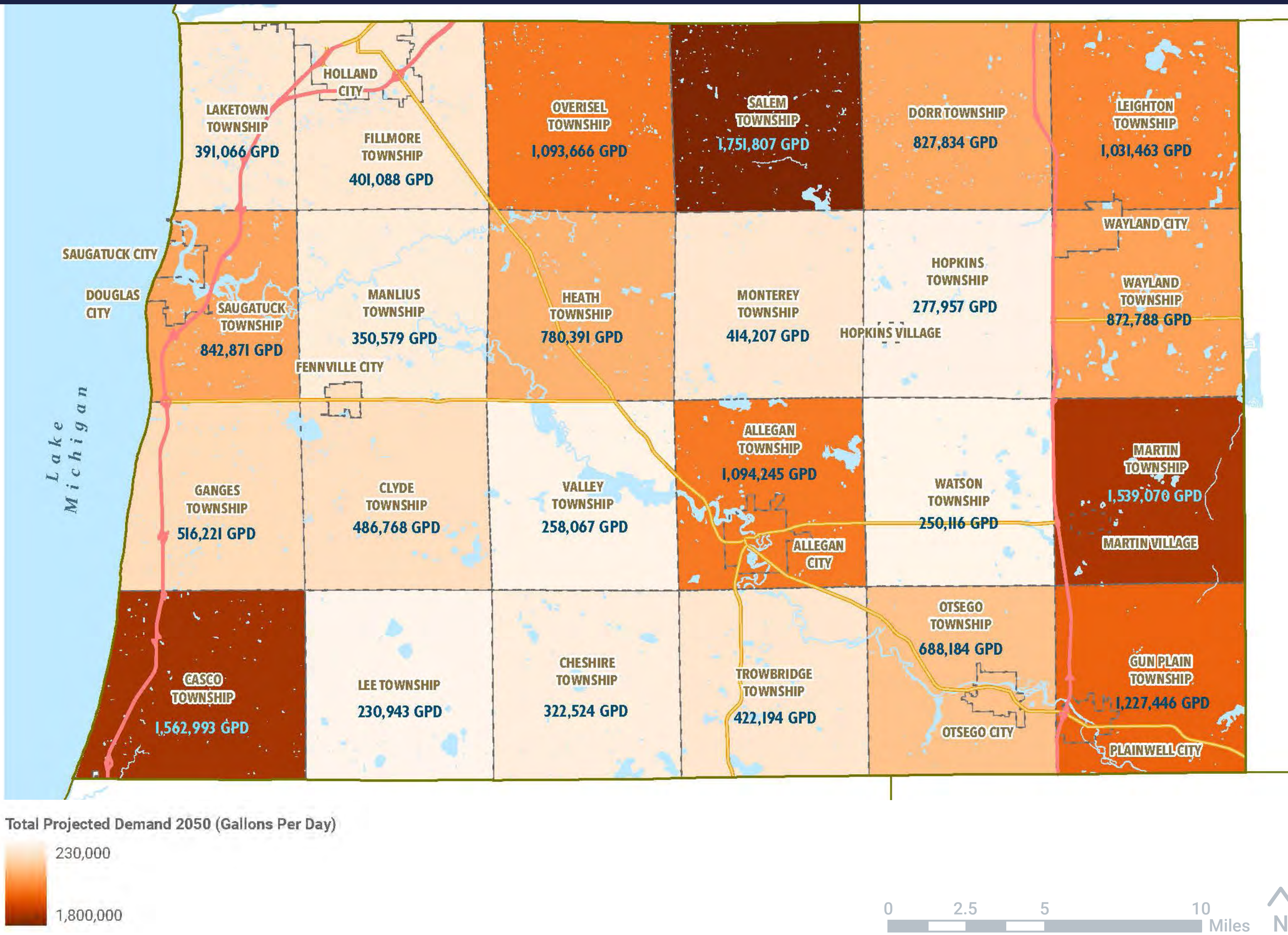
Projected Groundwater Demand

For all of Allegan County (2050)

Existing Population	120, 498 People
Existing Demand	16,480,210 GPD
Projected Population Change (2020-2050)	+13,694 People
Projected Additional Demand (2020-2050)	+1,369,389 GPD
TOTAL PROJECTED DEMAND (2050)	**17,849,598 GPD**

* Figures provided in this chapter of current or future groundwater use are not meant to be exact predictions but do illustrate the magnitude of anticipated use based on available data and standard methodologies.

MAP 17 Projected Groundwater Demand by Local Government Unit 2050



Map 17 and Table 2 illustrate the projected groundwater demand by LGU. This adds the projected change in demand for each Township to the present-day demand, providing a depiction of the total projected groundwater demand for 2050. Because irrigation well data is only available on a per Township basis, growth figures needed to match this unit to be added to the existing demand. Note that the demand for cities and villages is included in their respective/adjacent Townships. The highest projected groundwater use areas are along the County's perimeter, specifically along its northeastern boundary and in the southwestern corner. Salem, Martin, and Casco Townships are projected to have the highest overall groundwater demand over the next 30 years, with Leighton Township seeing the highest increase from present-day use.

Table 2. Projected Groundwater Demand by Local Government Unit 2050

Local Government Unit*	Population in 2020	Projected Population Change from 2020-2050	Existing Demand for Private + Type I + Irrigation Wells (GPD)	Projected Additional Demand in 2050 (GPD)	Total Projected Demand in 2050 (GPD)
Allegan Township	4,689	+518	1,042,478	51,768	1,094,245
Casco Township	2,796	-5	1,563,483	-490	1,562,993
Cheshire Township	2,211	+45	318,031	4,493	322,524
Clyde Township	2,060	+43	482,463	4,305	486,768
Dorr Township	7,922	+1,042	723,608	104,226	827,834
Fillmore Township	2,778	+93	391,800	9,288	401,088
Ganges Township	2,574	+124	503,851	12,370	516,221
Gun Plain Township	6,148	+394	1,188,021	39,426	1,227,446
Heath Township	3,937	+656	714,788	65,603	780,391

Hopkins Township	2,760	+158	262,158	15,799	277,957
Laketown Township	5,928	+468	344,262	46,804	391,066
Lee Township	3,805	-32	234,094	-3,151	230,943
Leighton Township	7,001	+2,873	744,166	287,297	1,031,463
Manlius Township	3,312	+467	303,864	46,715	350,579
Martin Township	2,723	+197	1,519,356	19,714	1,539,070
Monterey Township	2,436	+283	385,907	28,300	414,207
Otsego Township	5,903	+780	610,191	77,993	688,184
Overisel Township	3,133	+400	1,053,648	40,018	1,093,666
Salem Township	5,156	+1,271	1,624,733	127,074	1,751,807
Saugatuck Township	3,443	+802	762,674	80,197	842,871
Trowbridge Township	2,530	+100	412,168	10,026	422,194
Valley Township	2,221	+303	227,800	30,267	258,067
Watson Township	2,176	+138	236,331	13,785	250,116
Wayland Township	3,573	+425	830,336	42,452	872,788

* Note that the demand for cities and villages is included in their respective/adjacent Townships.

Projected Groundwater Demand and Groundwater Availability

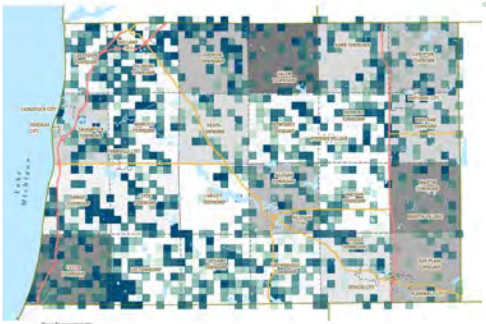
Areas in the County predicted to grow have been identified. With this growth, increased demand for groundwater results. The increased demand for groundwater may consequently occur in areas with limited groundwater resources. Basic groundwater productivity can be shown by mapping the general transmissivity over the domain of the County. Values for transmissivity were calculated directly from the Wellogic database[2]. Instead of mapping all transmissivity values, the scale was limited to areas with low transmissivity, relative to that aquifer. These low transmissivity values were mapped and overlaid with the County's projected future groundwater demands, providing a clearer picture of places with limited groundwater resources and their respective anticipated water usage in 2050. The resulting Map 18 displays this overlay, in addition to smaller reference maps showing locations of low transmissivity for the bedrock aquifer (red) and glacial aquifer (blue).

The areas in red illustrate low bedrock aquifer transmissivity, mainly along the northern areas of the County. This is not surprising since the aquifer in this region can be scattered and thin. Salem and Overisel Townships lie along this geography and are both expected to experience growth. A caveat to this method of calculating transmissivity, particularly for bedrock aquifers: transmissivity values are affected by aquifer thickness. If a particular well only penetrated a short depth into the bedrock aquifer's Marshall Formation, the resulting transmissivity value will be lower than a similar well penetrated through its full thickness, assuming the hydraulic conductivity was held fairly constant. Therefore, the northeast areas of the bedrock aquifer showing low transmissivity may have been derived from shallower bedrock wells that didn't penetrate the entire thickness of the Marshall Formation. A similar case can be made for the glacial drift aquifers.

The areas in blue in Map 18 show low glacial drift aquifer transmissivity mainly along the west and southwest – again this is not surprising since these areas are dominated by lacustrine sands and silts which tend to have low to moderate well yields which limit groundwater production. Casco, Lee, Manlius, and Filmore Townships lie within these areas and are all expected to experience growth.

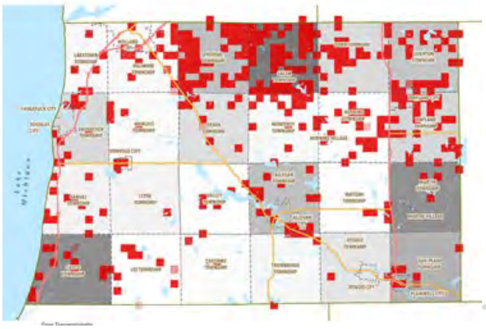
Glacial Aquifer:

Low Transmissivity



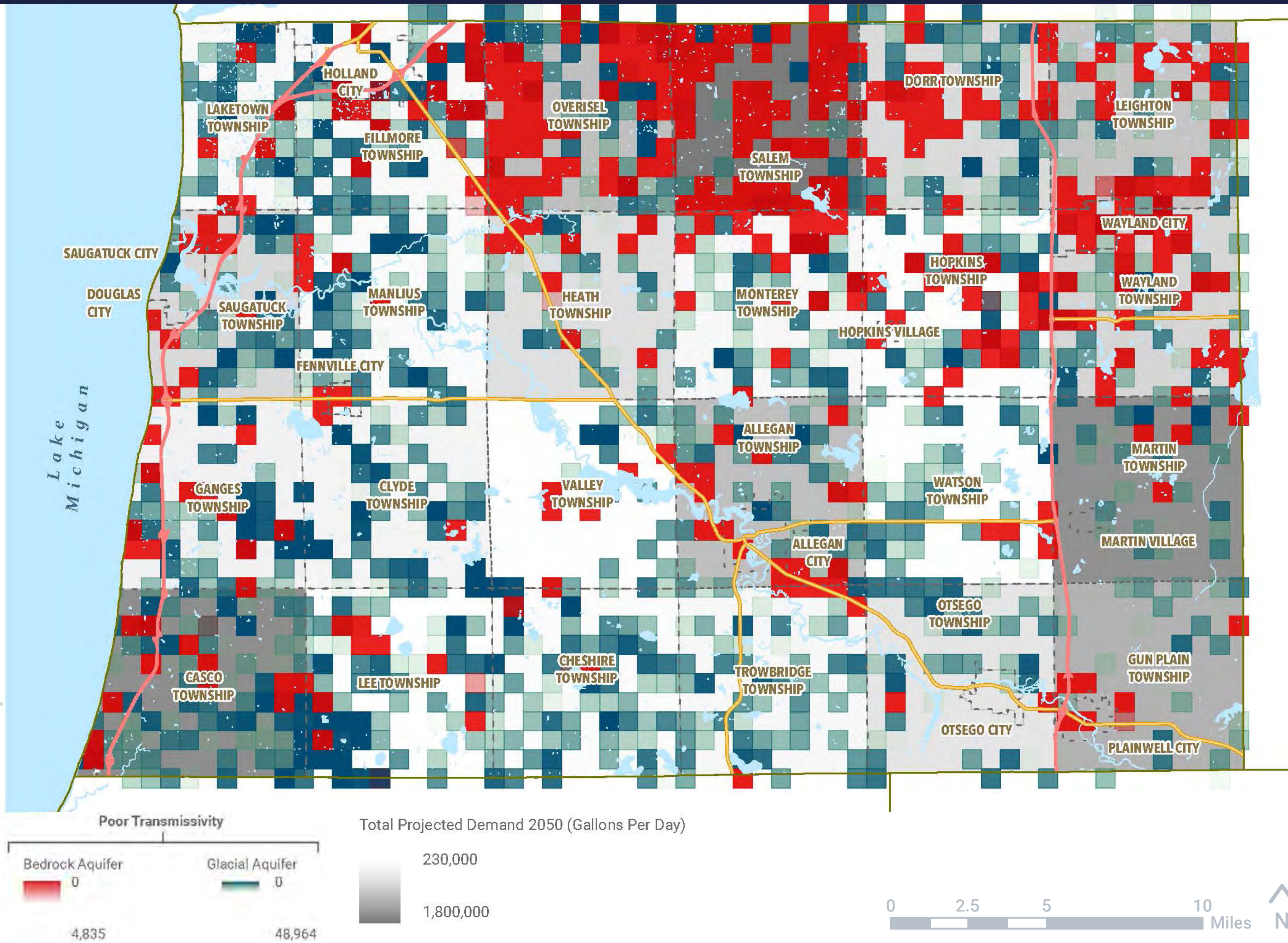
Bedrock Aquifer:

Low Transmissivity



[2]Wellogic contains a unique estimated value of transmissivity for each well record. Transmissivity is estimated using estimated hydraulic conductivity values for each lithology reported in the Wellogic database. The Glacial Landsystem map was used to further refine estimates of transmissivity, but in all cases these values are estimates based on visual classification of soils by various well drilling contractors.

Areas of Low Transmissivity and Projected Groundwater Demand by LGU 2050



Projected Groundwater Demand Findings

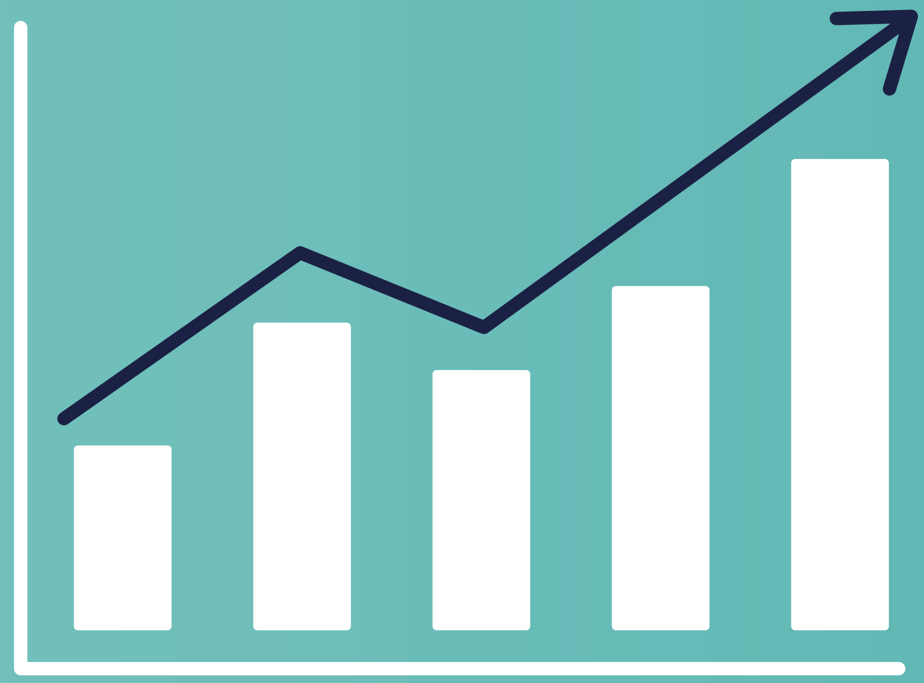
Allegan County is projected to see modest overall growth, primarily around its cities and villages and northeastern townships. The greatest growth areas are projected;

- In the northeast corner of the County (over the bedrock aquifer).
- Along the communities that lie along the M-89 corridor.
- Fennville area and northwest toward Saugatuck, Hamilton, and Filmore.
- Leighton Township's increase in water use could be higher than any other Township (+287,297 GPD).

Based on projected population growth and anticipated groundwater demand, cumulative groundwater overuse doesn't appear to be an imminent threat.

Cumulative groundwater use isn't a concern but expansion of wells into new areas is less predictable. No depletion of groundwater resources has been observed to date. This is largely due to the nature of the data available, which presently can only reveal large trends in groundwater levels. As the County moves forward with targeted groundwater monitoring, long term trends in groundwater levels (either depletion or amelioration) will be apparent and based on precise long term monitoring data. Monitoring will be an important tool to more clearly observe groundwater use trends and identify future capacity issues.

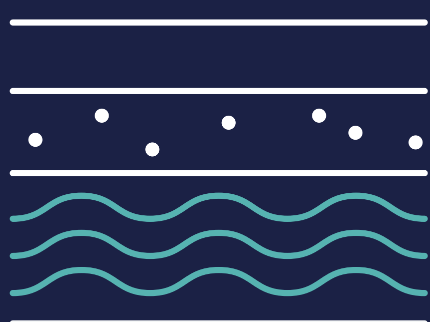
Changes in groundwater elevation due to over-use can only be evaluated with long-term groundwater elevation monitoring. Recognizing the projected areas of highest groundwater demand coupled with the general knowledge of areas with limited groundwater resources (low transmissivity) can help inform sensible locations for monitoring wells.



Report Takeaways

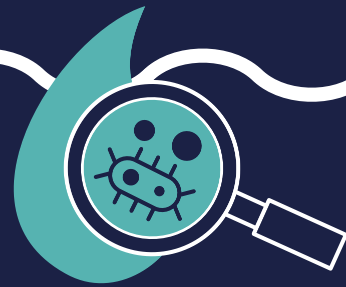
CH 1. An Introduction to Water in Allegan County

- Almost all water users in Allegan County rely on groundwater from two aquifers. Groundwater is the preferred source of water supply because of its:
  - General protection from surface contaminants
  - Lower vulnerability to weather events
  - Reliability and cost-effectiveness
  - Consistent quality
  - Time tested systems comprehension
  - Jurisdictional control
- Groundwater is not equally accessible across the County because the subsurface geology is spatially complex. For example, finding groundwater, the amount that can be pumped, or the speed of flow can all change quickly over a small geographic distance.



CH 2. Groundwater Protection Area Delineation

- The Groundwater Protection Area (GPA) for Allegan County is limited to the County's geographic boundaries and immediately adjacent neighboring counties.
- Barry, Van Burren, and Kalamazoo Counties have the largest groundwater contribution areas to Allegan County and have a greater potential impact on groundwater conditions.

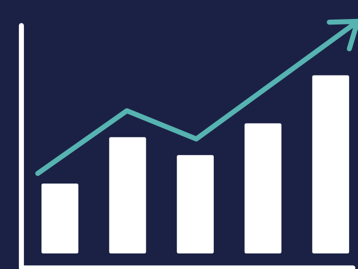


CH 3. Areas of Concern & Water Quality Risks

- 351 sites of groundwater concern were identified and their risk to drinking water supply and surface water was assessed. The highest risk sites were generally clustered around population centers, particularly in or around the Cities of Wayland, Plainwell, Allegan, and the Village of Martin.
- In both urban and rural areas throughout the County, data showed groundwater with substances that exceed established drinking water standards related to human health or aesthetic qualities, such as taste, smell, or color. Specific issues include:
  - Significantly elevated nitrate concentrations impacting shallow groundwater
  - Elevated chloride concentrations impacting groundwater discharge areas and along major roadways
  - Significantly elevated iron concentrations throughout the groundwater system
- A composite groundwater quality risk map was developed, providing an at-a-glance resource to help identify areas that may be at higher risk for groundwater contamination. Many areas of higher risk generally coincide with areas of high groundwater use (including for public supply) and warrant continued monitoring and protection.

CH 4. Groundwater Demand & Future Use Projections

- Allegan County is projected to see modest overall growth over the next 30 years, and as a result, cumulative groundwater overuse doesn't appear to be an imminent threat.
- Certain areas of the County are experiencing growth more than others and will continue that trend, such as Salem, Martin, Casco, and Leighton Townships – these are the areas to prioritize long-term monitoring to protect and preserve the local groundwater resource.
- Projected growth in certain areas of the County warrant long term monitoring and planning, particularly in areas with limited groundwater resources.



Glossary of Terms

- **Amelioration of Groundwater:** Positive trends in groundwater conditions.
- **Aquifer Yield:** Ability of the aquifer to produce water.
- **Aquifer:** Underground layers of water-bearing permeable rock and/or soil that readily transmits water to wells and springs.
- **Aquitard:** A geological formation or layer of rock or sediment that restricts the flow of groundwater due to its low permeability. Sometimes referred to as a confining layer.
- **Bedrock Aquifer:** A bedrock aquifer is a body of permeable and/or fractured rock that is saturated and can conduct groundwater to yield water to wells and/or springs. Also, please note if a body of rock is saturated but not permeable, it is not considered an aquifer.
- **Confining Layer:** See aquitard.
- **Critical Groundwater Receptors:** Groundwater discharge points that have to be protected, like drinking water wells, irrigation wells, surface water bodies, or other water dependent ecosystems.
- **Delineation:** Mapping boundaries or extents. In the case of this report, to identify the boundaries of the GPA.
- **Depletion of Groundwater:** Decline in groundwater levels or resources.

- **Discharge:** Groundwater leaving the aquifer to surface water or wells.
- **EGLE:** Michigan Department of Environment, Great Lakes, and Energy.
- **Glacial Drift Aquifer:** Glacial drift is a name for all sediment (clay, silt, sand, gravel, boulders) transported by glaciers and deposited directly by or from the ice.
- **GPM:** Gallons per minute. A measurement of how many gallons a pump can move per minute. It is a common unit of measurement of flow rate.
- **Groundwater Divide:** A subsurface water table boundary that separates the areas where the groundwater flows in different directions.
- **Groundwater Head:** The potential energy exerted by groundwater in relation to the height of a static water column above a reference point. It is a crucial parameter in hydrogeology for understanding groundwater flow and aquifer behavior.
- **Groundwater:** Water that exists underground in saturated zones beneath the land surface (e.g., pore spaces in sediments, fractures in rock).
- **Groundwater Protection Area (GPA):** A designated zone where monitoring measures are taken with the intent to safeguard groundwater from potential contamination or overuse.
- **Groundwater-shed:** In this report, this term has been used to help describe the groundwater flow area that defines the GPA delineation.
- **Hydraulic conductivity (K):** Measures the ability of water to move through different sediments.
- **Irrigation Wells:** Wells that supply seasonal water to croplands and are not used for drinking water. They are regulated the same as industrial wells and are often categorized as both types of wells (Irrigation and Industrial) in the data records.
- **Manufactured Housing Community Type I Water Wells:** Wells that tend to be small and compact, but because of the size of the development they serve, are considered a type of large quantity withdrawal wells.
- **Municipal Type I Water Wells:** Municipal Type I Water Wells supply water to community water systems with greater than 25 year-round customers, are commonly referred as “city and village” wells.
- **Non-Point Source Pollution (NPS):** Pollution that originates from many scattered sources rather than from a single, identifiable point.
- **Off-Site Groundwater Risk Analysis:** Estimation of risk to “downstream” groundwater receptors based on plume migration pathways and aquifer vulnerability (sensitivity to surface pollution).

- **On-Site Groundwater Risk Analysis:** Review of site history, documentation of substances present, pathways for groundwater contamination, and soil & groundwater quality data.
- **Point Source Pollution:** Pollution that originates from a single, identifiable source.
- **Primary NPS Pollutant:** Non-Point Source contaminants known to adversely impact human health.
- **Priority Site:** One of the Top 30 sites of groundwater concern (sometimes referred to as "highest priority sites").
- **Private Water Wells:** Wells that supply water to single-family residences and are the most numerous class of wells and widely distributed across the County.
- **Recharge:** Net infiltration of precipitation to the water table.
- **Recognized Environmental Conditions (RECs):** The presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing, past, or material threat of a release into structures on the property or into the ground, groundwater, or surface water of the property.
- **RIDE:** Remedial Information Data Exchange system created and maintained by EGLE. This web portal has information about many of the sites of environmental concern identified by the of State of Michigan in past decades.
- **Secondary NPS Pollutant:** Non-Point Source contaminants with non-mandatory water quality standards, typically only influencing things like color, taste, and odor.
- **Social Vulnerability Index (SVI):** This index identifies a level of vulnerability based on four themes, including socioeconomic status, household composition, race/ethnicity/language, and housing/transportation.
- **Subsurface:** Underground, sometimes referred to as the subsurface geology. Like the land above, it's important to remember that the subsurface has its own terrain and depending on the underground geological formations, water moves down through the sub-surface as well as horizontally across it.
- **Surface Water:** Waterbodies that exist above ground, including streams, rivers, lakes, and reservoirs.
- **Sustainable Yield:** Water withdrawals that will preserve groundwater resources over the long-term.

- **Transmissivity (T):** The product of hydraulic conductivity (K) and aquifer thickness. Transmissivity controls aquifer productivity.
- **Water Table:** The upper boundary of the zone of saturation, where groundwater fills the pore spaces in soil and rock.
- **WaterChem:** Statewide database of water quality samples collected by the Drinking Water Analysis Laboratory.
- **Watershed:** Also known as a drainage basin, is an area of land where all the water that falls or flows across it drains into a common outlet, such as a lake, river, or stream.
- **Wellhead Protection Areas (WHPA):** The source water (or capture) area of the aquifer that is providing groundwater to a pumping well over a 10-year period.

APPENDIX A

Allegan County Groundwater Study - Phase 1

Understanding the Big Picture
"Story" of Allegan County's Groundwater
With a Focus on Management Implications

HYDROSIMULATICS INC
https://www.magnet4water.com

ALLEGAN COUNTY GROUNDWATER STUDY

Phase 1 – Understanding the Big Picture

"Story" of Allegan County's Groundwater

With a Focus on Management Implications

March 22, 2021

Report No.: HSA2021001

Development, Population Growth, and Increased Water Use

Allegan County is undergoing a period of growth and development that started decades ago and has continued in recent years. Increased agricultural activities and above-average population growth (with respect to statewide and nationwide averages - see Figure 1) has resulted in water use increases across the county. To effectively protect and manage the long-term sustainability of the county's water resources, a holistic understanding of the county's "water system" is needed.

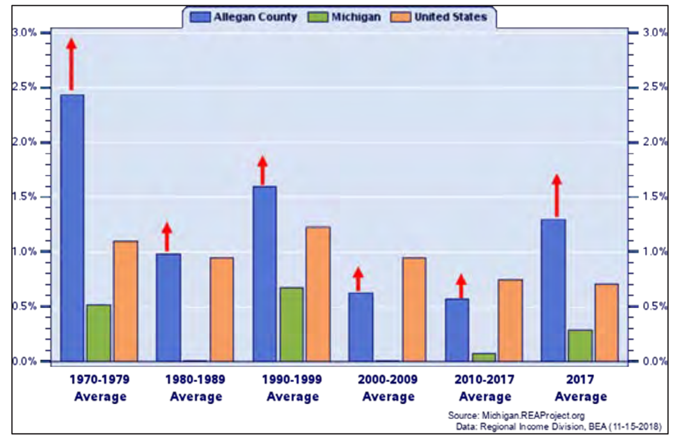


Figure 1: Average population growth by decade in Allegan County, State of Michigan, and the United States. In some decades, the growth rate in Allegan County was significantly higher than the statewide and/or nationwide averages. The above-average population growth in Allegan county, coupled with increased agricultural activities, has increased groundwater use in the county.

Source of Water: Groundwater

Presently (and historically), almost all the water supply in Allegan County is from groundwater, used for: households / private drinking water; year-round public water supply (Type I wells); transient and non-transient community water supply (Type II wells); irrigation, and industry (including power generation). Holistic management of the county's groundwater resources is especially important, considering that the subsurface is 'invisible' (or often deemed mysterious) and actions and events impacting groundwater (quantity and quality) are delayed and cumulative in nature.

Groundwater in Allegan County is pumped from two aquifers: a shallow "glacial" aquifer, and a deep "bedrock" aquifer. The glacial aquifer consists of unconsolidated sediments left behind from multiple episodes of glacial advance and retreat. The glacial aquifer exists throughout the county, ranging in thickness from 25ft to 470ft. The bedrock aquifer consists of the fractured / semi-fractured portions of the Marshall Sandstone Formation occupying the northeastern portion of the county. The rest of the county is underlain by the low permeability Coldwater Shale Formation (see Figure 2). The Marshall

Formation generally pinches out along its western subcrop extent, increasing in thickness in the east-northeast direction. See slides 11-13 in the main report for complete details.

Water wells are found throughout all townships, cities and villages in Allegan County. A vast majority of the water wells in Allegan County are completed in the glacial aquifer: as of August 2020, 88% of the wells in the *Wellogic* water well database were confirmed as “glacial wells” (13354 out of 15114 total wells). Only 1095 (or 7%) of the wells were confirmed as “bedrock wells”. The remaining wells lack sufficient information to make a distinction.

Most wells in Allegan county are used for domestic water supply; as of August 2020, 86% of the wells in *Wellogic* were classified as “household wells” (13050 out of 15144 total wells) – see Figure 3. Roughly 6% (896 wells) were classified as public supply wells); 3.4% (521) as irrigation wells; and 0.3% (42) as industrial wells. See slide 60 in the main report for complete details.

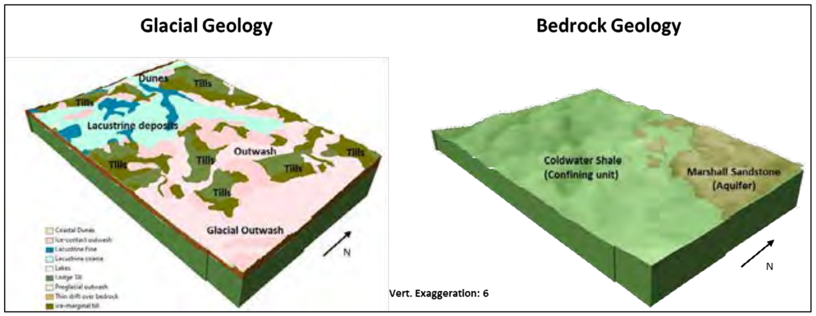


Figure 2: 3D depiction of the large-scale glacial geology (shallow) and bedrock geology (deep). Most water wells in the county are screened in the glacial aquifer, which is extremely heterogeneous, both vertically and horizontally. Wells completed in the bedrock are generally limited to the central and northeast portion of the county where the Marshall Sandstone Formation (aquifer or marginal aquifer) subcrops.

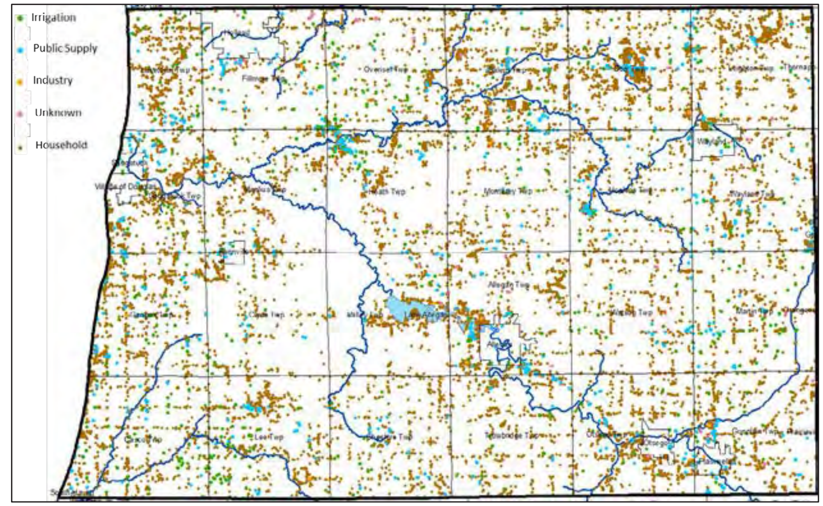


Figure 3: Water wells in Allegan County as of August 2020, by water sector: irrigation, public supply, industry, household, or unknown. Most wells in Allegan County are used for domestic water supply. When many household wells are operating in close proximity, the cumulative impacts of pumping can mirror high-capacity wells used for irrigation, public supply, and/or industry.

Increased Groundwater Use

Spatial and temporal analysis of *Wellogic* well records indicates significant increases in groundwater use in past decades, especially the last two (1999-2009, and 2010-2020). Up to 2000, six hundred and thirty-one wells were reported. By 2020, nearly 9000 more wells were added, and by August 2020, a total of 15144 wells were reported to the Wellogic system (see Figure 4)[1]. See slides 55-56 in the main report.

Groundwater use has increased in virtually all townships of the county, but most significantly in the “outer” townships along the periphery of the county, particularly in Ganges, Casco, Lee, Salem, and Dorr townships (see Figure 5). Not surprisingly, some of these water use “hot-spots” occur in sections inside / near population centers (because many residential wells plus high-capacity public supply and/or industrial wells), e.g., Plainwell and Allegan. Holland is a notable exception, as the city uses surface water. See slides 61-65 in the main report for complete details.

[1] It is known that the actual number of water wells in Michigan far exceeds the number of water well records in *Wellogic* - perhaps as much as 67% of the total number of wells are missing on a statewide scale. Although the percentage of missing wells in Allegan County is unknown, the number of wells reported here are underestimates. The relative number of wells (e.g., drift vs. bedrock wells, or domestic vs. irrigation) is accurate based on our analysis in other parts of the state.

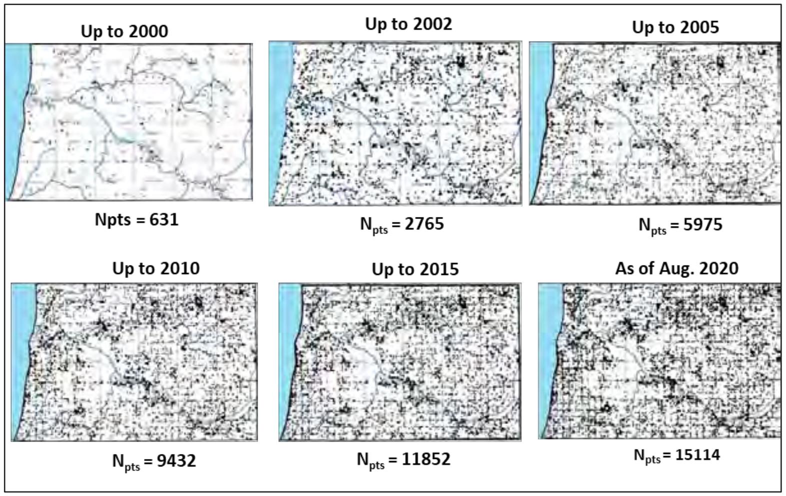


Figure 4: Water well network growth over the past two decades. There has been steady and significant growth in the water well network throughout virtually all parts of the county (west-central Allegan County is a notable exception). This natural, unmanaged growth is beginning to stress the groundwater system, both in terms of water quality, but also water quantity (water levels). Future development will benefit from coordinated management between local and county levels of governance, and from information gathered / visualized / analyzed in this study.

Figure 5: Screening-level estimate of annual groundwater use, by township, for present day (as of August 2020). Each township includes a name label, and the number representing the estimated annual water use in millions of gallons per year (MGY). The townships estimated to be using the most groundwater are: Dorr Twp. (765 million gallons per year, or MGY), Lee Twp. (685 MGY), Ganges Twp. (673 MGY), Salem Township (669 MGY), and Casco Twp. (657 MGY). Note that these values are screening-level or "ballpark" estimates.

3D Heterogeneity of the Subsurface

One major challenge to understand / manage groundwater is the heterogeneity of the subsurface environment in which it occurs. Although the bedrock aquifer (Marshall Sandstone Formation) is relatively homogenous (similar geology across space)[2], the glacial aquifer is extremely heterogeneous, both vertically and horizontally (see Figure 6). Some parts of the glacial aquifer are very permeable (e.g., areas consisting of glacial outwash and coarse-grained lake sediments), while other parts are less permeable (e.g. where glacial tills and fine-grained lake sediments are found). See slide 12 and slides 14-28 in the main report for 3D visualizations and 2D cross-sections of borehole lithologies.

[2] The bedrock aquifer along the Marshall-Coldwater Shale interface is fairly complex, "islands" of the Marshall Sandstone Formation surrounded by confining materials and vice versa shown in Figure 2. The islands are most likely the result of erosion of the Marshall Sandstone Formation along its thin margins.

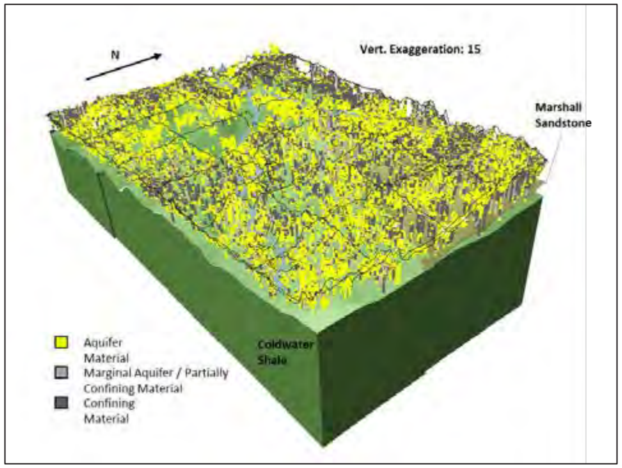


Figure 6: 3D depiction of categorized water well borehole lithologies across the county. These data are extremely valuable – they are free (previously collected) and available "everywhere" with excellent spatial density. Interactive 3D visualizations from different perspectives and 2D cross-sections can be used to estimate aquifer and aquitard extents (both horizontally and vertically) without performing modeling/simulation.

3D Geological Model

A 3D model of the glacial aquifer heterogeneity was created using an advanced geostatistical approach (transition probability) based on more than 10,000 wells in the *Wellogic* dataset. In the resulting 3D model, each cell is assigned as one of the four following material types: aquifer material [AQ], marginal aquifer material [MAQ], partially confining material [PCM], and confining material [CM].

The model shows (see Figure 7): in some areas, there are relatively extensive/continuous shallow fine-grain tills (CM and PCM) underlain by coarser-grained materials (AQ and MAQ), or aquifer "pockets"; in the northeast, many wells pierce through the less permeable clays/silts (CM) to withdraw water from the Marshall Sandstone aquifer (AQ / MAQ); in other areas, more permeable materials (AQ, MAQ) are typically found near the surface; and in the low land areas, extensive, continuous lacustrine deposits are found where it is common to have continuous shallow sand deposits (AQ /MAQ) underlain by clays/silts (CM / PCM). In short, there are no "perfectly stratified" geologic layers as described in many standard text books. See slides 30-34 in the main report for representative cross-sections of the 3D geology model.

The ability to characterize such heterogeneity is extremely useful, in terms of water resources development and well siting (i.e., determining where to drill and at what depth), protection of strongly connected streams and groundwater-dependent ecosystems, and prediction of contaminant transport needed for pollution control. But the complexity / important heterogeneity cannot be exhaustively presented in a written report. Rather, the 3D model is best used in a dynamic Decision-Support System

(DSS) that allows users zoom in anywhere, at any depth, to find out the likely geological materials (graphically, descriptively, and interactively).

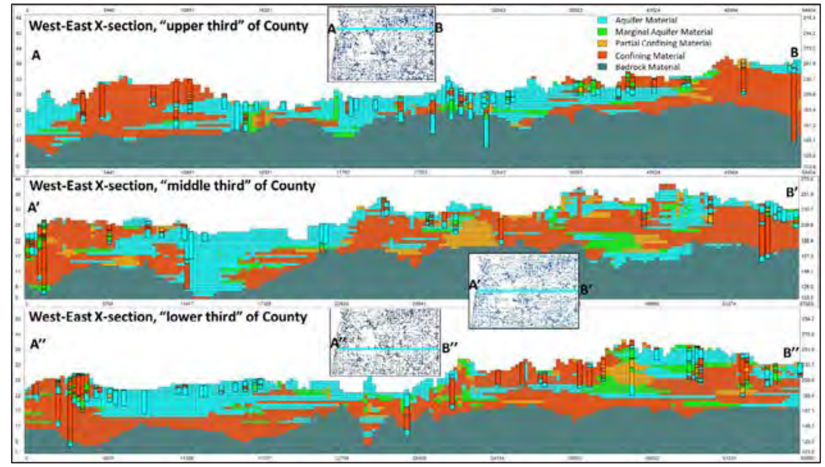


Figure 7: Cross-sections from the 3D geological model, with categorized boreholes. Red cells / borehole intervals represent confining materials; orange is partially confining material; green is marginal aquifer material; and blue is aquifer material. The bedrock is shown as a continuous grey bottom surface. Note that the glacial aquifer is complex and heterogeneous – both aquifer and non-aquifer (confining) material exhibits strong spatial persistence, but there are no "perfect layers".

Hydraulic Conductivity and Transmissivity

An understanding of the geologic spatial variability can yield insights to spatial changes in hydraulic properties of the subsurface (i.e., how fast water moves, how much water can be pumped, etc.). Hydraulic conductivity (K) quantifies how permeable different sediments are – it is a fundamental property of geologic materials that controls how fast groundwater moves, when combined with knowledge of the water table or head gradients.

In Allegan County, zones of high K in the glacial aquifer are found in the north (Overisel and Salem Twps., parts of Hopkins Twp.), northeast(Dorr and Leighton Twps.), east (Wayland and Martin Twps.), and southeast (Ostego and Gunplain Twps., and parts of Trowbridge Twp.) – see Figure 8. Zones of low permeability are found in the southwestern portions (i.e., parts of Casco and Lee Twp., parts of Ganges and Clyde Twps.) and western portions (parts of Saugatuck, Manlius, and Valley Twps.) of the county. See slide 38 in the main report for more details.

The product of K and aquifer thickness, called transmissivity (T), controls aquifer productivity (or how transmissive the aquifer is over the entire aquifer thickness). Transmissivity of the glacial deposits is generally highest in the central and eastern portions of the county where glacial outwash is found.

Transmissivity is lower in areas where fine-grained tills are mixed with coarse-grain sediments (e.g., northwest and west-central Allegan County).

In the bedrock aquifer, T is generally higher in the east-northeastern portions of the county (Wayland, Leighton, and Hopkins Twps.), and in parts of Watson and Martin Twps. (see Figure 9). Transmissivity decreases along a southeast-northwest gradient, with relatively low values found in Salem, Monterey and Overisel Townships. At the regional scale, the bedrock aquifer in Allegan county represents an area of low or very low transmissivity that extends north-northwest into Ottawa County. Transmissivity increases significantly towards the southeast. See slides 39 and 40 in the main report for more details.

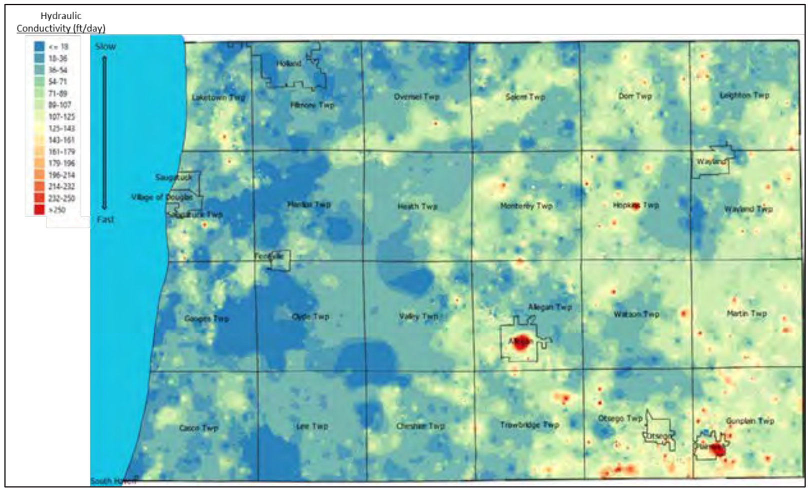


Figure 8: Vertically averaged hydraulic conductivity of the glacial deposits. Zones of high K in the glacial aquifer are found in the north, northeast, east, and southeast. Zones of low permeability are found in the southwestern and western portions of the county.

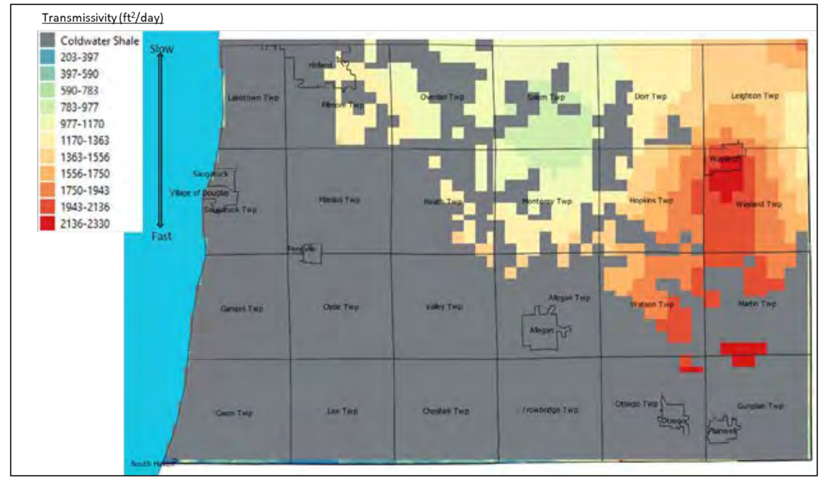


Figure 9: Transmissivity of the Marshall bedrock aquifer. Relative to values seen elsewhere in the state, the Marshall bedrock transmissivity is low because of its small thickness (recall that it generally pinches out along its western subcrop extent) and low permeability. Within the county, bedrock transmissivity is generally higher in the east-northeastern portions of the county and in parts of Watson and Martin Twps. Transmissivity decreases along a southeast-northwest gradient, with relatively low values found in Salem, Monterey an Overisel Townships.

Aquifer Yield

Transmissivity can be directly related to the yield of the aquifer (ability to produce water). For this study, an estimate of aquifer yield was made by calculating the pumping rate that would be required to lower the hydraulic head at the well to 50% of the available drawdown over 3 months, given an estimate of local transmissivity and a known mathematical relationship between drawdown, pumping, and aquifer properties (Jacob-Cooper Approximation).

Under this definition, aquifer yield is small (<70 gallons per minute, or GPM) in the western-central Townships of Manlius, Clyde, and Lee, and also in large portions of Overisel, Heath, Valley, and Ganges Townships (see Figure 10). Yield is expected to be somewhat large (70-500 GPM) along most of the Lake Michigan coastline (Laketown, Saugatuck, Casco Twps.), along parts of the northern border of the county (Salem, Dorr, Leighton Twps.) and the southern border (Cheshire and Trowbridge Twps.), and throughout most of Watson Township. Yields are expected to be large (500-1500 GPM) in the eastern Townships of Martin, Gunplain, Hopkins, and Otsego) and in smaller, fragmented areas of Monterey, Hopkins and Allegan Townships. Areas where yield is expected to be very large (>1500 GPM) are very small and limited to a few locations. See slides 51-53 in the main report for more details.

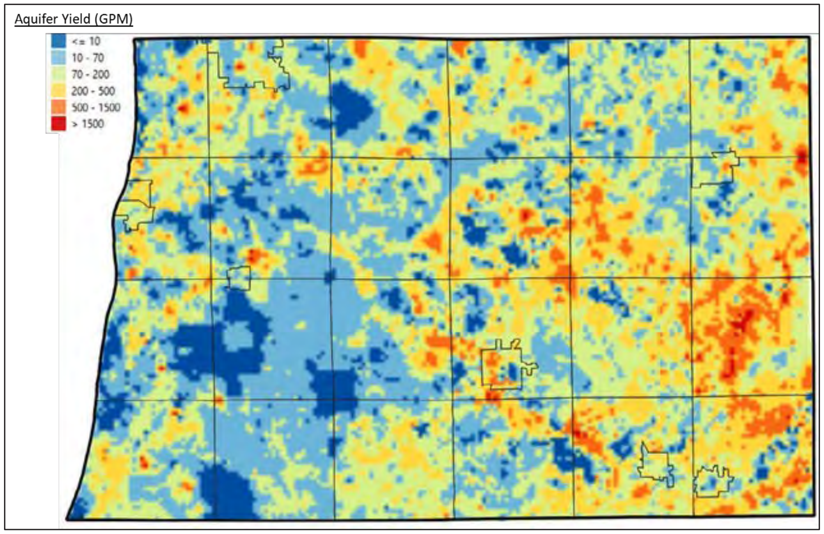


Figure 10: Screening-level estimate of aquifer yield in the glacial aquifer, or the pumping rate that would be required to lower the hydraulic head at the well to 50% of the available drawdown over 3 months, under the given set of assumptions. In this analysis, we assume a well efficiency of 70%. We also assumed purely 2D flow to wells screened across the entire saturated thickness, but in reality, the well is screened across a portion of the saturated thickness, and there is significant vertical flow with associated head loss. Therefore, the *actual* yield encountered in the field is expected to be less than that reported here.

Sustainable Yield and Recharge

The estimated aquifer yield is not the same as the "sustainable yield" or pumping that will preserve groundwater resources over the long-term. Sustainable yield depends on not only aquifer properties and pumping rates, but also well density and the long-term aquifer recharge (net infiltration of precipitation to the water table). It is therefore more meaningful for a defined area and over a sufficiently long-time period. For example, when pumping in an area consistently exceeds recharge (annual pumping exceeds annual recharge), the yield is *not* sustainable, and groundwater levels decline (so-called "groundwater mining").

In Allegan County, several "hot-spots" can be identified in terms of well density: central Dorr Twp.; north-northeast Leighton Twp.; western Allegan Twp. / Allegan City; northwest Leighton Twp.; and portions of Saugatuck, Ganges, Laketown, Salem, Otsego and Gunplain Townships (see slide 58 in the main report).

A map of long-term mean recharge was generated following empirical methods involving observed stream flow hydrographs and information related to land use, soil conditions, and watershed characteristics. Recharge is generally largest in the central portions of the county, north and south-southeast of Lake

Allegan, and along the upper and middle reaches of the Kalamazoo River (see Figure 11). Recharge is generally low in the upland areas of Fillmore and Overisel Townships and in the portions of Casco and Ganges Townships (and Saugatuck Twp., to lesser degree). See slide 41 in the main report.

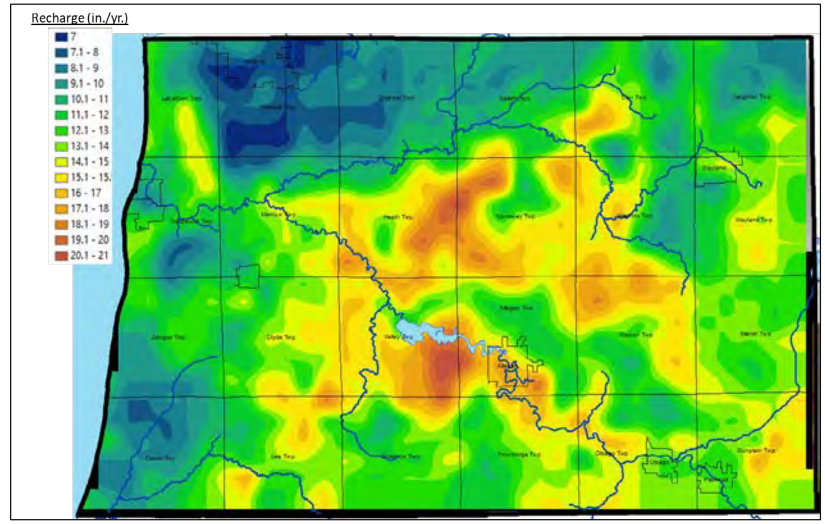


Figure 11: Estimates of long-term mean recharge rate across the county. Recharge is generally largest in the central portions of the county, north and south-southeast of Lake Allegan, and along the upper and middle reaches of the Kalamazoo River. Recharge is generally low in the upland areas of Fillmore and Overisel Townships and in the portions of Casco and Ganges Townships (and Saugatuck Twp., to lesser degree).

Temporal Water Level Trends

Long term sustainability can be best evaluated with long-term monitoring wells, but data from them is not available in the county and is prohibitively expensive to collect on a county-wide scale. However, Static Water Level (SWL) data from domestic wells in an area can be used to provide a screening-level evaluation of temporal water level trends.

Although normally data is collected at a "point" over time at a particular well, SWL data (collected at the time of installation of a water well) analyzed over a sufficiently large area often includes representative dates (i.e., the area includes wells drilled in different decades). If the temporal decline is significantly larger than SWL spatial variability and measurement "noise", a trend can be identified (see Figure 12 for an example). But when the area is too large, the temporal decline can be hidden by spatial variability and noise. In other words, there is a tradeoff between space and time in the SWL temporal analysis.

In general, there does not appear to be large-scale declines (e.g., township-wide) that are observed in neighboring Ottawa County, or at least the average decline is not significantly larger than the spatial variability. There are hints of systematic decline, especially at finer scales (e.g., section scales), but these must be confirmed with long-term monitoring and local surveys (e.g. in parts of Dorr Twp., northern Saugatuck / southern Lake town Twps., and parts of Allegan Twp.). Even at the section-scale, spatial variability is still significant and can “overshadow” potential temporal trends. See slides 66-82 in the main report.

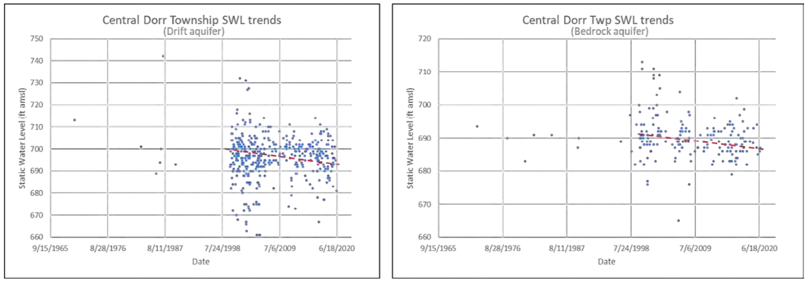


Figure 12: Example of SWL trend analysis that suggests a systematic decline across multiple sections in Dorr Township, for both the glacial aquifer (“drift”) and bedrock aquifer. Note the data “gap” prior to 2000. The Wellogic system was initiated around 2000, and although an effort has been made to include wells constructed prior to 2000, there are many older (pre-2000) wells missing from the database. There may also be post-2000 wells missing from the database, albeit a much smaller amount than pre-2000. If more historical data are / become available, the SWL analysis may become more meaningful.

Flow Patterns in the Glacial and Bedrock Aquifers

The water table pattern plays a critical role in groundwater management; it dictates groundwater flow direction (groundwater moves “downhill”, from where head is high to where it is low). Combined with hydraulic conductivity, it controls groundwater velocity.

The water table is generally high in the eastern and central portions of the county (especially Monterey Twp.), and low in the western portions and along the Kalamazoo, Rabbit, and Black Rivers (see Figure 13). The water table depression in topographic lowlands where surface water bodies are found is typical of regional discharge areas where groundwater is converging to streams, rivers, wetlands, etc. See slides 42-47 in the main report for more details.

Water levels in the bedrock aquifer are highest in the northeast corner of the county (Leighton Twp.) and along the interface with the Coldwater Shale in Monterey Twp. (see Figure 14). Groundwater in the bedrock aquifer primarily discharges toward the surface (through the glacial aquifer) to the Little Rabbit River and the Rabbit River. Regionally, the bedrock aquifer is recharged to the east in Barry County (see the “mound” in the Figure 14); however, the regional gradient inside Allegan County is small, meaning the bedrock aquifer flow system in the county is localized (i.e. there is relatively little flux of groundwater from the regional recharge mound).

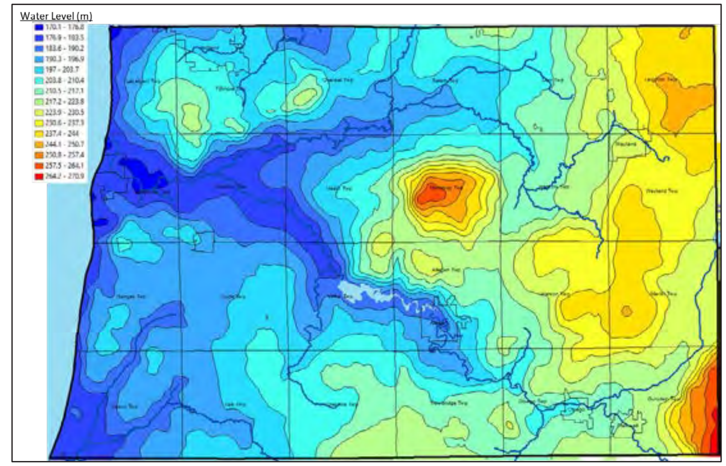


Figure 13: Long-term mean water table pattern in the glacial aquifer. The water table is generally high in the eastern and central portions of the county (especially Monterey Twp.), and low in the western portions and along the Kalamazoo, Rabbit, and Black Rivers.

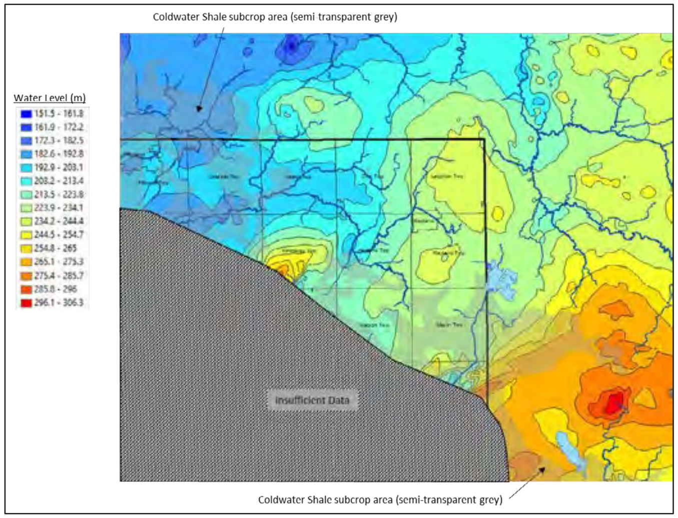


Figure 14: Long-term mean groundwater levels in the bedrock aquifer. Water levels in the bedrock are highest in the northwest corner of the county (Leighton Twp.) and along the interface with the Coldwater Shale in Monterey Twp. (see Figure 14). Groundwater in the bedrock primarily discharges toward the surface (through the glacial aquifer) to the Little Rabbit River and the Rabbit River.

Depth to Water Table

The map of the water table can be combined with high-resolution Digital Elevation Model of the land surface to derive a countywide map of depth to water (DTW). The DTW plays an important role in groundwater management. For example, we need to know DTW when designing a water well, for evaluating of risk of basement flooding, or for assessing aquifer vulnerability.

In Allegan County, the depth to water table is expected to be large (>15m) along the Lake Michigan coastline and in highland areas in central, south-central, and eastern portions of the county (see Figure 15). The depth to water table is small along streams and rivers and in the low-lying, flat areas of western / southwestern Allegan county. See slide 48 in the main report for more details.

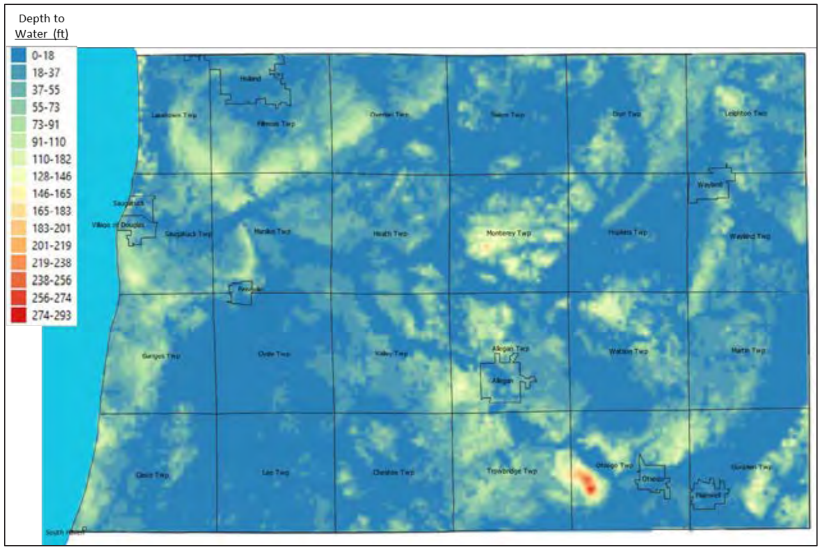


Figure 15: Countywide depth-to-water (DTW) map. The DTW plays an important role in groundwater management. For example, we need to know DTW when designing a water well, for evaluating the risk of basement flooding, or for assessing aquifer vulnerability.

Discharge Areas in the Glacial Aquifer

The water table, along with other data (e.g., hydraulic conductivity), can be used to define aquifer discharge areas and recharge areas that play a critical role in aquifer management.

Although natural recharge into the shallow unconsolidated aquifer occurs in a distributed manner everywhere, not all areas are equally important. In some areas, usually at lower elevations, groundwater moves upwards and discharges to streams, lakes, and wetlands, and rainwater recharge percolating to the water table gets “immediately” discharged. These are called discharge areas. Streams, lakes, and wetlands in discharge areas often have a significant groundwater component and are habitats for groundwater-dependent ecosystems (see Figure 16).

In Allegan County, groundwater discharges primarily to the major surface water bodies (e.g. the Rabbit, Kalamazoo, and Black Rivers) and along their corridors (see Figure 17). Groundwater discharges directly to Lake Michigan along parts of the coastline (e.g., Laketown Twp., Ganges Twp.). Groundwater is also clearly converging towards and discharging into upstream tributaries of the Rabbit, Kalamazoo, and Black River. See slide 50 of the main report.

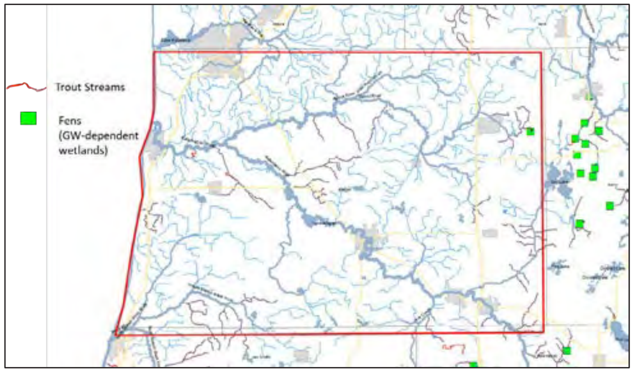


Figure 16: Streams, including known trout streams (red stream segments), and fens in/near Allegan County. Fens are globally rare groundwater-dependent wetlands that harbor a disproportionate amount of biodiversity. The fens just east of the Allegan-Barry County line receive groundwater from recharge areas in both Allegan County and Barry County; therefore, proper management may require coordination between the counties.

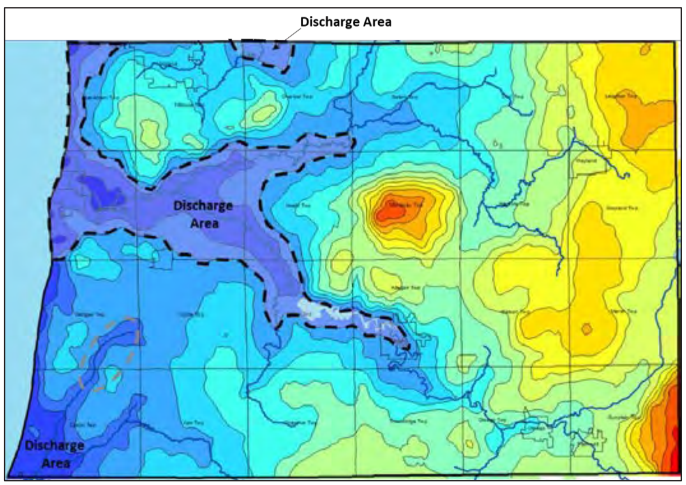


Figure 17: Map of primary groundwater discharge areas in Allegan County. Streams, lakes, and wetlands in discharge areas often have a significant groundwater component and are habitats for groundwater-dependent ecosystems.

Recharge Areas for the Glacial Aquifer

In other areas, the groundwater flow pattern is such that the flow direction points downward (this usually occurs at higher elevations); recharging water moves deep and travels regionally, feeding the entire aquifer or having a more regional impact. These areas are called recharge areas. The location of recharge areas has implications on land use planning (e.g., development in recharge areas disproportionately impacts aquifer sustainability) and on waste disposal activities (e.g., spills in recharge areas have significantly more impact than in discharge areas). Groundwater monitoring in recharge areas is critically important.

At a countywide scale, the major groundwater recharge areas are situated along the eastern townships (Leighton, Wayland, Martin, and Gunplain) and in the central portion of the county (primarily Monterey Twp.) – see Figure 18. The former area may have recharge areas extending into Kalamazoo, Barry, and/or Kent County, which would require trans-county coordination. There are also minor local recharge areas in the northwest (Fillmore Twp., and Overisel Twp. to a lesser degree), and the south-central portion of the county (Cheshire and Trowbridge Townships). See slide 49 in the main report.

Recharge Areas for the Bedrock Aquifer

Recharge areas for the bedrock aquifer can be more difficult to identify. Often, they can be traced out to areas far away the area of interest (e.g., at an outcrop). For Allegan County, the bedrock aquifer is clearly recharged "locally" or directly from above. Local mounding of groundwater levels in the bedrock aquifer are found in the northwest corner of the county (Leighton Twp.) and along the interface with the Coldwater Shale in Monterey Twp. (mimicking the pattern seen in the glacial aquifer). These areas are local recharge areas for the bedrock aquifer. See Slides 54 and 55 in the main report.

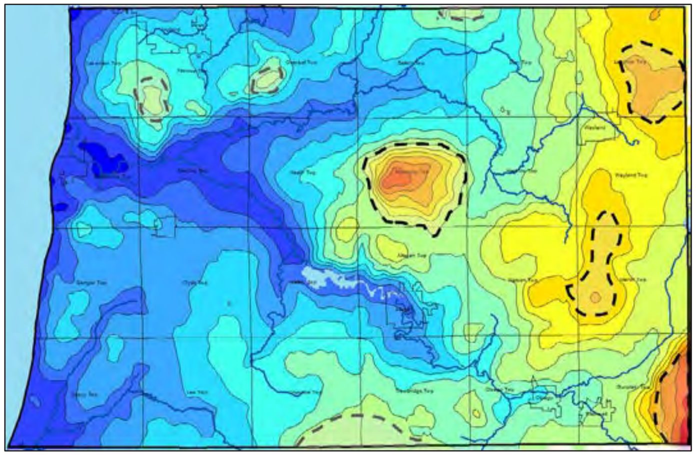


Figure 18: Map of primary groundwater recharge areas of the glacial aquifer. Recharging water moves deep and travels regionally, feeding the entire aquifer. Therefore, the location of recharge areas has implications on land use planning (e.g., development in recharge areas disproportionately impacts aquifer sustainability) and on waste disposal activities (e.g., spills in recharges areas have significantly more impact than in discharge areas). Groundwater monitoring in recharge areas is critically important.

Known & Potential Sites of Contamination

There are a significant number of sites (78) of environmental concern where environmental damage is suspected, possible, or confirmed based on available information (see Figure 19). See slide 120 in the main report for more details.

There are two known PFAS (Perfluoroalkyl and polyfluoroalkyl substances) sites in Allegan County: the 636 40th Street East site in Holland, and the Watson Township Dump in Watson Township. PFAS are of particular concern because of their durability in the environment (they are sometimes referred to as "forever chemicals") and the relatively low concentrations in water supply required to have adverse impacts.

There are 168 confirmed leaky underground storage tanks (LUSTs), 61 which are "open" (a release has occurred from and corrective actions have not been completed to meet the appropriate land use criteria). There are an additional 165 locations with at least one underground storage tanks (USTs) that is not closed in place or removed. See slides 121 and 122 in the main report.

Also of significance are 38 historical landfills and 3 waste handler facilities (which may pose a risk to groundwater contamination from leachate of waste products stored on site), as well as 94 oil / gas wells (which may provide a vertical conduit for flow of deeper, highly mineralized groundwater to the near-surface environment). See slides 123-124 in the main report.

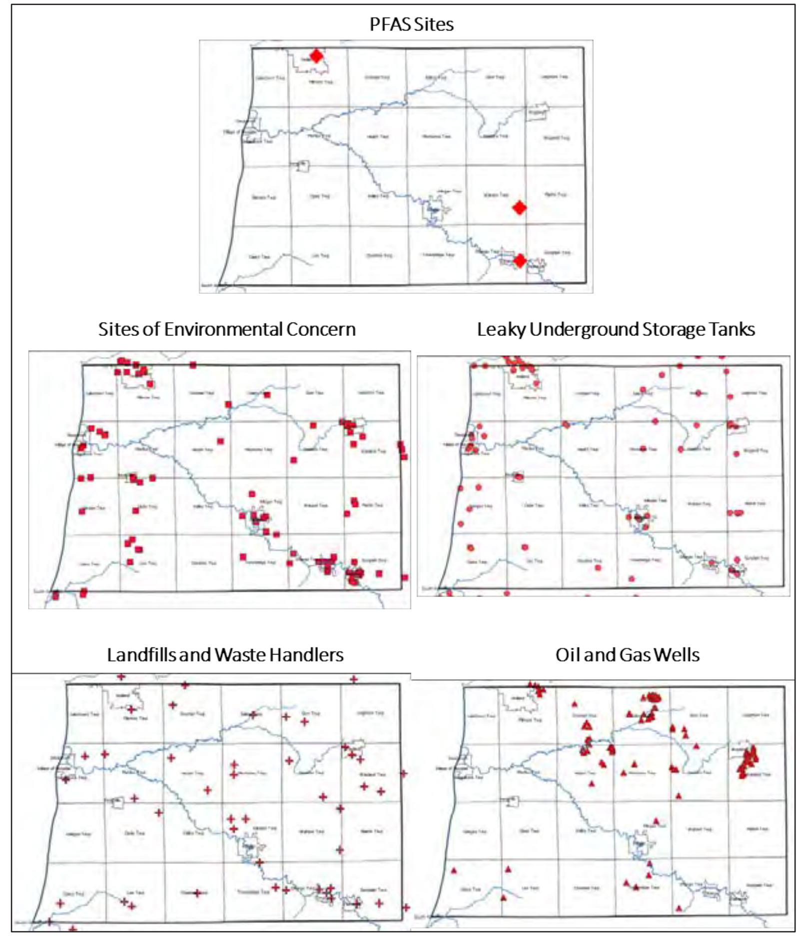


Figure 19: Maps of potential or known sources of groundwater contamination, including confirmed PFAS sites. Monitoring the large number of sites in Allegan County is very expensive, so prioritization is critical. It becomes very important to understand where the contamination goes if there is a spill, and if there are any potentially vulnerable groundwater receptors in its path. On the other hand, if contamination is detected at a monitoring well (or domestic drinking water well), we need to know where the contamination is coming from, and which potential site of concern was most likely responsible.

Contaminant Particle Tracking

The hydraulic conductivity and water table maps created for this study can be combined to map groundwater speed and directions. The information obtained can then be used to track the movement of groundwater "particles" forward and backward along the water table surface. Forward tracking is best used to answer: if a spill occurs, where does it go (see Figure 20), and how long will it take? Backward tracking is best used to determine: if a contaminant is found in a monitoring well, where did it come from (Figure 21), and how long ago was it released?

This technique is best utilized in an interactive DSS so that it can be applied dynamically in an unknown future scenario at a local site in the county.

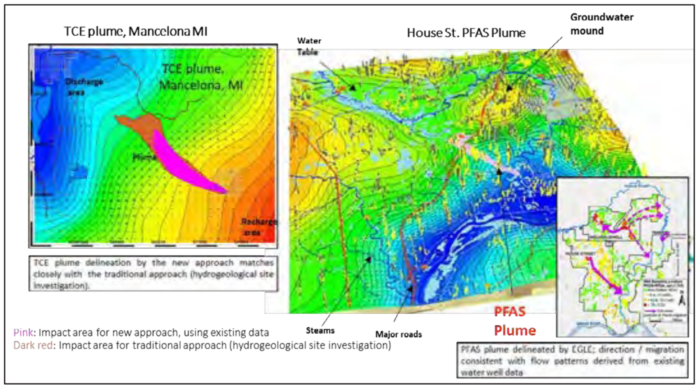


Figure 20: Examples of forward contaminant particle tracking: (left) comparison of the TCE plume in Mancelona, MI, where the red polygon is the plume delineated from traditional hydrogeological field investigation, and the pink is the envelope of simulated particle path lines; (right) House St. PFAS plume (pink polygon) and the simulated water table. Forward tracking is best used to answer: if a spill occurs, where does it go, and how long will it take?

Wellhead Protection Area

Backward particle tracking can also be used to delineate capture zones of groundwater receptors, e.g., a water well. Understanding the capture zone for a well is critically important for protecting the water supply. The area that is providing water to a pumping well is called the wellhead protection area (WHPA). See Figure 21 for an example.

Given the large number of wells and the fact that new wells are constantly added, the backward particle tracking technique for delineating a WHPA is best utilized in a DSS so that the county can dynamically delineate the capture zones for any wells, including new wells.

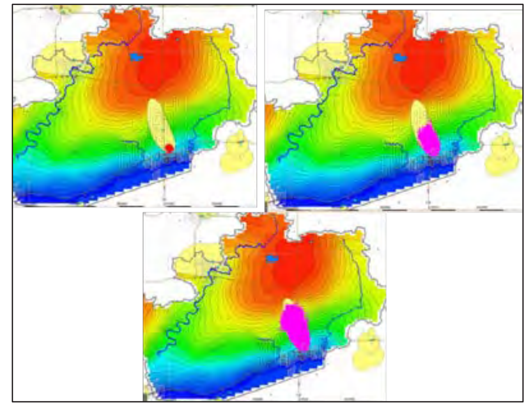


Figure 21: Example of reverse particle tracking in for wellhead protection area (WHPA) delineation. The different graphics show the pathlines at different elapsed times (starting at time≈0 in the top-left). The simulated pathlines match well with the wellhead protection area delineated with traditional hydrogeological field investigations. Backward tracking is best used to determine: if a contaminant is found in a monitoring well, where does it come from (Figure 21), and how long ago was it released?

Nonpoint Source pollution – Nitrate

Groundwater contamination in the county is not limited to point sources. Nonpoint sources of pollution are significant in Allegan.

Nitrate contamination is a significant issue in the shallow aquifer predominantly due to agricultural activities (runoff from fertilizer), but also possibly from leaking septic tanks/sewage. Approximately 4% of the groundwater quality samples from the *WaterChem* database (or 524 of 14383 total samples) are above the Maximum Contaminant Level (MCL) of 10 mg/L – a legally enforceable standard set by the United States Environmental Protection Agency (EPA). Samples with concentrations above the MCL are found throughout the county. Townships with notable visual "clusters" of samples above the MCL include: Overisel, Salem, Heath, Martin, Gunplain, and Manlius (especially along its northern and northwestern township border) – see Figure 22. Almost 10% of the samples are above 5 mg/L, which can be considered more than twice the expected "natural" nitrate concentration in groundwater (about 2 mg/L or less). See slides 86-91 in the main report.

Nitrate concentrations in drinking water above the MCL is known to cause adverse impacts on human health, specifically the risk of methemoglobinemia – a condition in which blood lacks the ability to carry sufficient oxygen to body cells. Infants below the age of one have the highest risk of developing methemoglobinemia. And although the MCL was set at 10 mg/L based on acute (short-term) health effects, research into possible chronic health effects of consuming water with nitrates at elevated concentrations is on-going.

Elevated nitrate concentrations in groundwater that discharges to surface water bodies can also lead to eutrophication, or the growth of algae that feed on nutrients, resulting in unsightly scum on the water surface, thereby decreasing the recreational value of the water body.

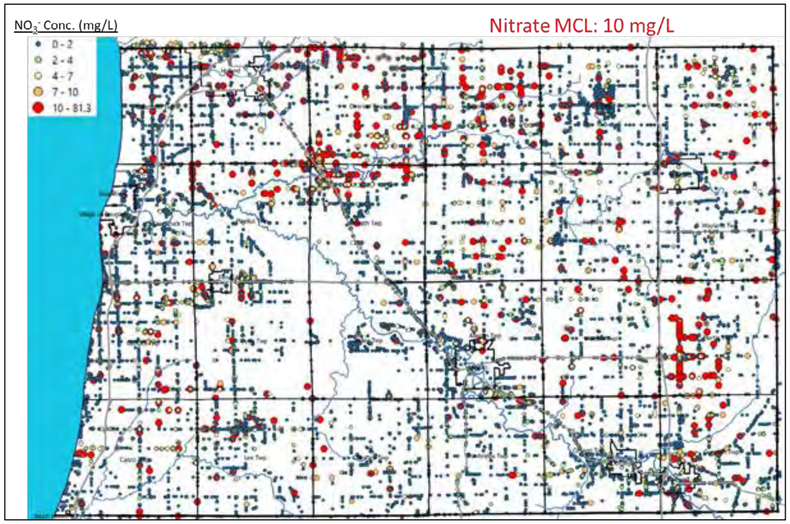


Figure 22: Point nitrate concentration data across the county; from the *WaterChem* database. Approximately 4% of the groundwater quality samples from the *WaterChem* database (or 524 of 14383 total samples) are above the Maximum Contaminant Level (MCL) of 10 mg/L. Nitrate concentrations in drinking water above the MCL is known to cause adverse impacts on human health, specifically the risk of methemoglobinemia.

Nonpoint Source Pollution – Salinity

Nitrate contamination tends to impact the shallow glacial aquifers, since the primary source (agricultural fertilizers) is at the land surface. Another significant nonpoint source contamination is a natural process from below. Michigan's fresh groundwater sits on a pool of brine, slowly inching toward the surface to significantly impact groundwater quality in discharge areas where groundwater is predominantly moving upwards. This phenomenon was well documented in neighboring Ottawa County and is suspected to be impacting Allegan County's groundwater resources (albeit to a lesser degree).

Typically, most shallow aquifers in this part of the country have natural chloride concentrations of less than 15 mg/L. In Allegan County, 4242 of the 22741 chloride samples (8%) from the *WaterChem* database are clearly elevated (>100 mg/L). Approximately 2% of the samples are significantly elevated above the Secondary Maximum Contaminant Level (SMCL) of 250 mg/L set by the US Environmental Protection Agency (EPA). Samples with concentrations above the SMCL are found throughout the county, although most townships have significantly fewer elevated samples relative to samples with low/natural concentrations. Fillmore Twp., Overisel Twp. – and to a lesser degree, Laketown, Salem, Lee Townships –

have notable visual "clusters" of samples above the SMCL (see Figure 23). Most elevated or significantly elevated samples occur next to or close to a stream or river (where groundwater is discharging to the surface). See slides 92-96 in the main report.

SMCLs are non-mandatory guidelines to assist public water systems in managing their drinking water for aesthetic considerations (e.g., taste, color, odor). Contaminants are not considered to present a risk to human health at the SMCL. But there are risks to applying groundwater with elevated chloride concentrations (>100 mg/L) as irrigation water to agricultural crops. It is well documented that crops can be damaged or destroyed by chloride-laden water applied to them.

Note that the "signal" from the natural brine upwelling process is likely mixed with the signals from other possible sources of chloride, including: application of halite ("road salt") for roadway deicing; septic tank effluent; and livestock excretion or fertilizer application (but expected concentrations are typically below 30 mg/L).

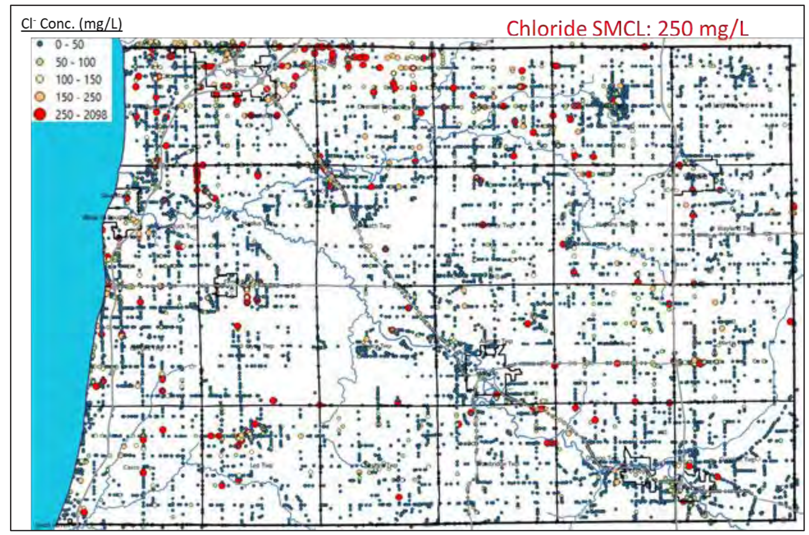


Figure 23: Point chloride concentration data across the county; from the *WaterChem* database. Chloride concentrations at or above the Secondary MCL are not considered to present a risk to human health. However, there are risks to applying groundwater with elevated chloride concentrations (>100 mg/L) as irrigation water to agricultural crops.

Nonpoint Source Pollution – Other Chemicals

Concentration data for a few other water quality parameters were available from the *WaterChem* database, namely: sodium; iron; manganese, lead, and arsenic.

There were relatively few data points for sodium and there is no established SMCL, but the relationship between aesthetic quality ("saltiness") of sodium is similar to that of chloride. Most of the samples that are available have low concentrations (<150mg/L). Approximately 1.4% of the sodium data are above 250mg/L. See slides 97-99 in the main report.

Iron and manganese are considered secondary standards and have SMCLs of 0.3 mg/L and 0.05 mg/L, respectively. Both are commonly found in rock-forming minerals and have concentrations in groundwater controlled by the distribution of compounds and minerals and the environmental geochemistry. The SMCL is a guideline for the minimum level for color and/or staining and metallic taste. It is not uncommon for these SMCLs to be exceeded, especially in deeper aquifers. In Allegan County, this is indeed the case. Approximately 36% and 34% of the samples for iron and manganese, respectively, exceed the SMCL. Iron concentration varies dramatically over very short distances (see Figure 24). There is insufficient data for manganese to capture local-scale variability. See slides 100-103 and 114-115 in the main report.

Both lead and arsenic are primary (legally enforceable) standards based on known impacts to human health. Lead has a MCL of zero; if concentrations exceed the action level of 0.015 mg/L in 10% of samples (e.g., from customer taps sampled), the water supply system must undertake a number of additional actions to reduce concentrations. Approximately 1.1% of the lead samples from *WaterChem* are above the lead action level. Arsenic has a MCL of 0.010 mg/L. Samples with concentrations above the MCL (about 6.7% of the total number of samples) are found in a few isolated across the county. Townships with at least one sample above the arsenic MCL include: Fillmore, Overisel, Dorr, Saugatuck, Clyde, Allegan, Martin, Casco, Lee, and Cheshire. See slides 104-108 and 109-113 in the main report.

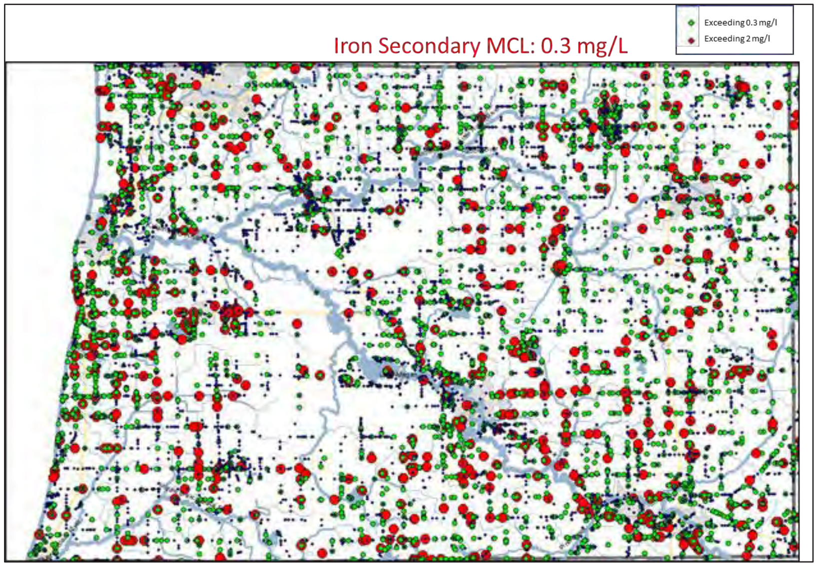


Figure 24: Point iron concentration data across the county; from the *WaterChem* database. Iron is commonly found in rock-forming mineral. The iron secondary MCL is a guideline for the minimum level for color and/or staining and metallic taste. It is not uncommon for iron SMCLs to be exceeded, especially in deeper aquifers. Concentrations exceeding the iron SMCL are common in Allegan County.

Recommendation for Future Work – An Interactive Decision Support System

A traditional report can only go this far; no matter how many graphics are included in this summary and in the main report, we cannot exhaust all possibilities. As we have touched on throughout this summary, the best way to use the data, maps, and visualizations presented in this study is to develop a unified groundwater information system for Allegan County.

An interactive, web-based decision support system can be used to guide water resources planning and permitting processes within agencies of Allegan County, the Townships, and others. This final product is unique in the sense that it empowers the county for years to come, making it possible for the county itself to evaluate scenarios and weigh different management options.

This decision support system (DSS) will enable resource managers and planners to zoom into any location in the county to:

- Visualize the complex 3D geology of the subsurface, including the borehole lithologies and the results from the 3D transition probability geology model;
- Map groundwater level distributions, flow directions and patterns in both the shallow glacial aquifer and, where applicable, the deeper bedrock aquifer;

- Map the cone of depression (water level decline due to pumping) for existing or new wells under different scenarios, and evaluate the impacts on surrounding land parcels;
- Assess vulnerability of a proposed development to insufficient water supply by mapping / analyzing sustainable yield;
- Map environmental receptors and their contributing source water areas / capture zones / "groundwater-sheds" for pumping wells and groundwater-fed streams and wetlands, which is critical for holistic management of aquifer protection, wellhead protection and ecosystem protection;
- Map land use, nonpoint source contamination, and contamination sites, and interactively and dynamically access site information / attributes like address, chemical type (for a contamination site);
- Delineate potential impact areas of emerging contaminants (e.g., PFAS), or trace back from known sites of contamination to identify potential sources;
- Map aquifer recharge areas and discharge areas to assess aquifer vulnerability (or sensitivity) to surface contamination or saline upwelling, respectively;
- Design long-term monitoring well networks for sampling water quantity (levels, fluxes) and water quality, especially in stressed areas identified in this Phase 1 study; and
- Create 2D and 3D integrated overlays of raw, derived, and simulated data layers.

The integrated system will enable the informed participation of citizens and improve interactions between local government, their constituents, researchers, and consultants, bringing the following benefits to the stakeholders:

- *Resource managers and planners* will be able to evaluate the effectiveness and impact of their management plans to improve policy-making decisions. They can visually evaluate the impact of potential threats, land use, contamination, and withdrawals. They can become more effective in identifying/prioritizing areas for monitoring, development, conservation, or protection. They can also be more effective in engaging the general public and informing high-level decision makers about the implications of a proposed development and the transport of contamination on sensitive receptors (e.g., drinking water wells, residential areas, groundwater dependent ecosystems).

- *Communities and stakeholders* will be able to visualize the invisible subsurface and better understand the impact of proposed management measures in a vivid and interactive way. They can also visualize the potential impact of their own activities on the groundwater environment. Thus, they are motivated and empowered to engage in the intricate process of community-based ecosystem and water/land use management, planning, and protection.

- *Consultants* will be able to design more focused, cost effective analysis and monitoring networks to protect county's water resources and environment (ecosystems, recharge areas, etc.). They also will have an effective mechanism to communicate a solution, a design, or strategy to their clients.

- *Policymakers* can make more informed decisions with regard to setting and enforcing laws and regulations for water resources management and to use interactive tools to improve public relations and to evaluate future land use management plans related to zoning and new developments.

A DSS allows the county to use the results "dynamically". The seamless integration of modeling results, data from disparate sources, management analyses, and interactive visual communication will make it possible for resource managers and planners to focus on high level issues and to quickly and iteratively refine management strategies and policies.

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APPENDIX B

Allegan County Groundwater Study - Phase 2

Screening-Level Modeling, Risk Analysis, and Ranking

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***Addendum*:**

ALLEGAN COUNTY GROUNDWATER STUDY – PHASE 2:

Screening-Level Modeling, Risk Analysis, and Ranking

By: Zachary K. Curtis

Hydrosimulatics INC.

Submitted:

June 12, 2023

Report No.: HSA2023002

Contents

Motivation....4
Objective and Scope....4
Updated Risk Ranking Results....5
Recommended Next Steps....29

List of Figures

Figure 1: Histogram distribution of total scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites)....................6
Figure 2: Histogram distribution of drinking water scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites)....................7
Figure 3: Histogram distribution of non-drinking water scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites)....................8
Figure 4: Histogram distribution of surface water scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites)....................9
Figure 5: Histogram distribution of aquifer vulnerability scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites)....................10
Figure 6: Map of total risk ranking scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites). 11
Figure 7: Map of total risk ranking scores for sites in the northeast quadrant of the county. 12
Figure 8: Map of total risk ranking scores for sites in the southeast quadrant of the county. 13
Figure 9: Map of total risk ranking scores for sites in the southwest quadrant of the county....................14
Figure 10: Map of total risk ranking scores for sites in the northwest quadrant of the county. 15
Figure 11: Map of drinking water scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites). 16
Figure 12: Map of non-drinking water scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites)....................17
Figure 13: Map of surface water scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites). 18
Figure 14: Map of aquifer vulnerability scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites)....................19

List of Tables

Table 1: Total scores and “subscores” (drinking water scores, non-drinking water scores, etc.) for all 351 sites analyzed in this study (including the additional 62 Open LUST sites, which are labeled in red font). The are ordered in terms of total score (highest to lowest) . …………………………….. 20

Motivation

The Phase 2 study represents the first critical step for Allegan County toward managing its large number of point-sources (sites) of groundwater concern. The integration of numerous spatial datasets and groundwater modeling capabilities enabled characterizing in a relatively short time the potential for groundwater transport and risk to critical groundwater receptors. This information can be used to guide the next steps of management and investigation, which may involve incorporating human and environmental health perspectives and updating the risk ranking/priority lists, as well as refining the groundwater modeling as more data become available and management priorities evolve.

The sites of groundwater concern investigated in the Phase 2 analysis included: 237 Sites of Environmental Contamination (Part 201) downloaded August 2022 from the Environmental Mapper web application[1] maintained by the Department of Environment, Great Lakes, and Energy (EGLE); 46 historical or operational landfills or waste handlers (Part 105, Part 111) downloaded August 2022 from the Michigan Geographic Information System (GIS) data portal[2]; and five Per- and polyfluoroalkyl substances (PFAS) sites downloaded August 2022 from the EGLE's MPART PFAS Geographic Information System[3]. Additionally, six "Open" (Active) LUST sites from the Environmental Mapper application were included in the analysis. Accounting for some duplication (i.e., a handful of sites are included in multiple datasets downloaded for this study), the total number of unique sites analyzed for the study was 289.

Objective and Scope

The purpose of this Addendum is to document the additional analysis completed by Hydrosimulatics to include the remaining 62 Open LUST sites in the countywide risk ranking portfolio. The same methodology and process applied to the original 289 sites of groundwater concern was used on the remaining LUST sites – see the Phase 2 final report "ALLEGAN COUNTY GROUNDWATER STUDY – PHASE 2: Screening-Level Modeling, Risk Analysis, and Ranking" submitted by Hydrosimulatics on March 14, 2023.

In particular, Hydrosimulatics performed the following tasks:

1. Delineate potential impact areas of the remaining LUST sites. This involved flow pattern delineation and forward "particle tracking" from source locations of assumed travel times of 2yr, 10yr, and 20yr.
2. Perform integrated overlay analysis of all remaining LUST sites. This involved "scoring" each site based on the proximity of the LUST site and its impact areas to critical groundwater receptors, including drinking water wells, non-drinking water wells, and surface water. This also involved assigning a "vulnerability" score to each site based on the aquifer vulnerability underlying the site (see Task 3 in the original Phase 2 study).

[1] 1 Accessible at: https://www.mcgi.state.mi.us/environmentalmapper/#
[2] Accessible at: https://gis-michigan.opendata.arcgis.com/
[3] Accessible at: https://egle.maps.arcgis.com/apps/webappviewer/index.html?id=bdec7880220d4ccf943aea13eba102db

3. Update the risk ranking lists to include the remaining Open LUST sites, including the overall risk ranking, the drinking water ranking, the non-drinking water ranking, and the surface water ranking.
4. Document the results from particle tracking (plan-view maps of impact areas) and update the supplemental document: "Screening-level Modeling – Estimated Impact Areas of Site of Groundwater Concern". This also involved creating GIS shapefiles of the updated portfolio of sites of groundwater concern that includes all Open LUST sites in Allegan County. The GIS shape files have been packaged into one file, so that if they are accessed by the public, the sites are easily found.

Updated Risk Ranking Results

Table 1 lists the total score and "subscores" (drinking water score, non-drinking water score, etc.) for each of the 351 sites analyzed in this study (including the additional 62 Open LUST sites, which are labeled in red font). They are ordered in terms of total score (highest to lowest).

Figure 1 shows a histogram of the total risk ranking scores. The average, minimum, and maximum total score assigned was 25.7, 0, and 71.1, respectively. The top 25 sites (in terms of highest score or highest risk) have scores of ≥40, and the top 50 sites have scores of ≥43.7. There are 58 sites that have a total score of ≤10 (very low risk). There is one site with a total score of zero (no risk).

Figure 2, Figure 3, Figure 4, and Figure 5 show the histograms for drinking water scores, non-drinking water scores, surface water scores, and aquifer vulnerability scores, respectively.

The average, minimum, and maximum drinking water score assigned was 41.0, 0, and 100, respectively. There are 48 sites with a drinking water score of ≥80, 14 sites with a drinking water score of ≥90 or higher, and three sites with a score of 100. There are 126 sites with a drinking water score of ≤20, and 52 sites that have a drinking water score of zero (no drinking water risk).

The average, minimum, and maximum non-drinking water score assigned was 15.3, 0, and 90, respectively. There are 7 sites with a non-drinking water score of ≥80. There are 264 sites with a non-drinking water score of ≤20, and 169 sites that have a non-drinking water score of zero (no non-drinking water risk).

The average, minimum, and maximum surface water score assigned was 41.2, 0, and 100, respectively. There are 23 sites with a surface water score of ≥80, 11 sites with a score of ≥90, and 1 site with a score of 100. There are 111 sites with a surface water score of ≤20, and 42 sites that have a non-drinking water score of zero (no surface water risk).

The average, minimum, and maximum aquifer vulnerability score assigned was 0.7 (0.68), 0.2, and 1.0, respectively. There are 142 sites with a surface water score of ≥0.8, 93 sites with a score of ≥0.9, and 32 sites with a score of 1.0. There are 25 sites with a surface water score of ≤0.3, and 4 sites that have an aquifer vulnerability score of 0.2.

Figure 6 presents a countywide map of the sites symbolized based on total score. Figure 7, Figure 8, Figure 9, and Figure 10 show the sites again symbolized based on total score for the northeast, southeast, southwest, and northwest quadrants of the county, respectively. Notable "visual hotspots" or clusters of sites with high or moderately high total risk scores include: in and around Wayland, in the northeast portion of the county; in and around Plainwell, in the southeastern corner of the county; in Allegan and southeast of the city; in the northern third of Hopkins Township, and north-northeast of Saugatuck.

Figure 11 shows a map of the sites symbolized based on drinking water score. Figure 12, Figure 13, Figure 14 show a map of the sites symbolized based on non-drinking water score, surface water score, and aquifer vulnerability score, respectively.

Hotspots of sites with high or moderately high drinking water scores largely reflect the spatial pattern seen in the total risk scores; notable areas include: in and around Wayland, in the northeast portion of the county; in and around Plainwell, in the southeastern corner of the county; in Allegan and around the city; and in and around Saugatuck and the Village of Douglas.

Notable "visual hotspots" or clusters of sites with high or moderately high non-drinking water scores include: in Wayland, in the northeast portion of the county; north of Plainwell and Otsego, in the southeastern corner of the county; in the northern third of Hopkins Township, in the western half of Ganges township, and north-northeast of Saugatuck and south of the Village of Douglas.

Notable "visual hotspots" or clusters of sites with high or moderately high surface water scores are not surprisingly focused along the Kalamazoo River in Plainwell, Otsego, Allegan, and along the Rabbit River (and its tributaries) in Wayland, Hopkins Township, Salem Township and Heath Township.

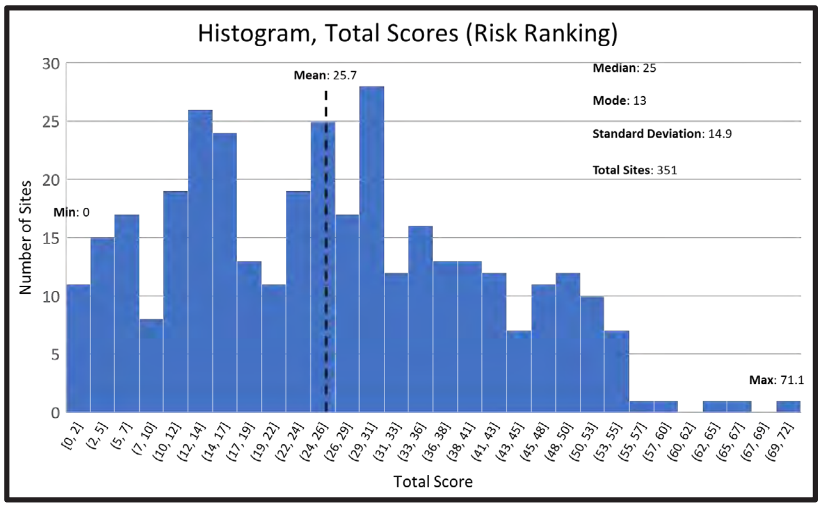


Figure 1: Histogram distribution of total scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites).

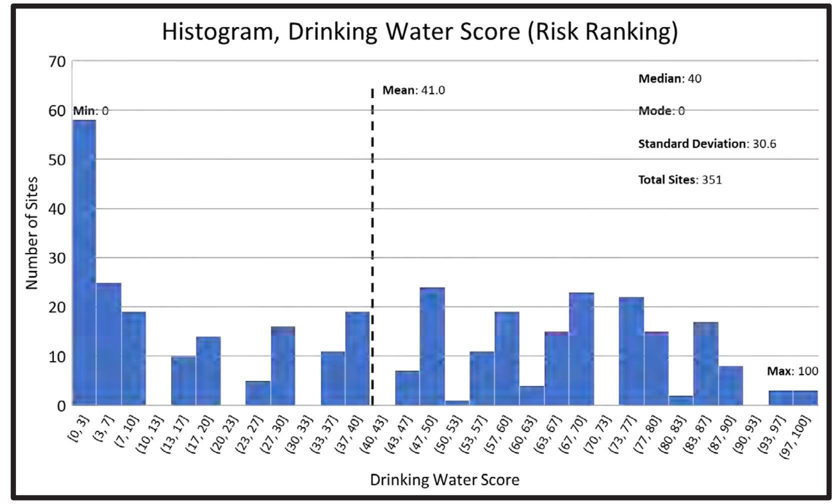


Figure 2: Histogram distribution of drinking water scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites).

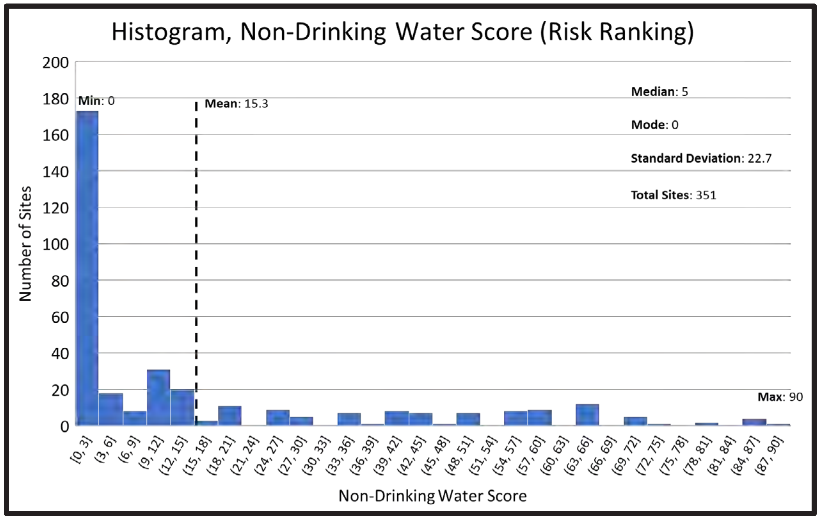


Figure 3: Histogram distribution of non-drinking water scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites).

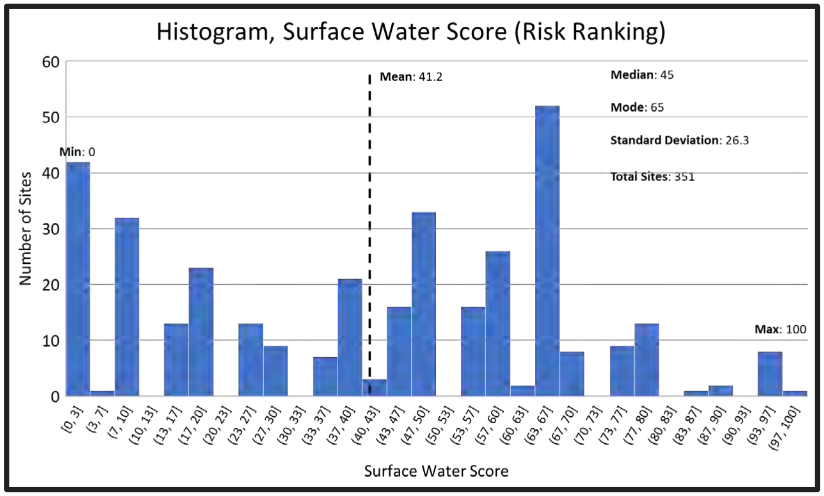


Figure 4: Histogram distribution of surface water scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites).

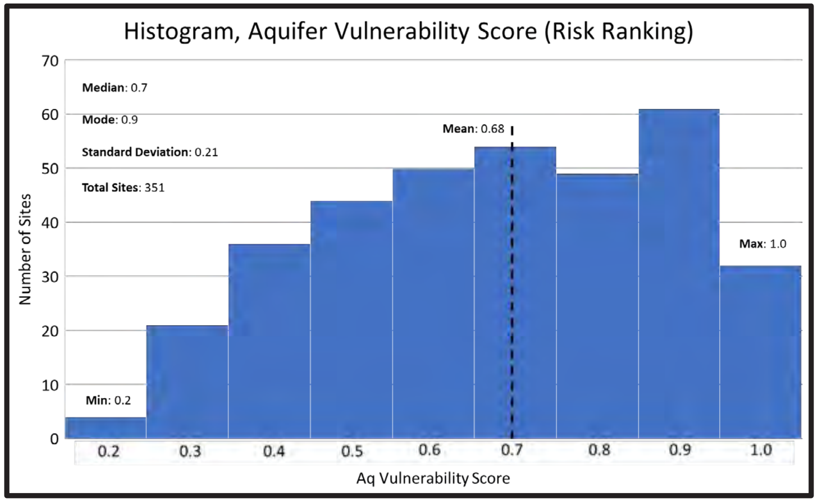


Figure 5: Histogram distribution of aquifer vulnerability scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites).

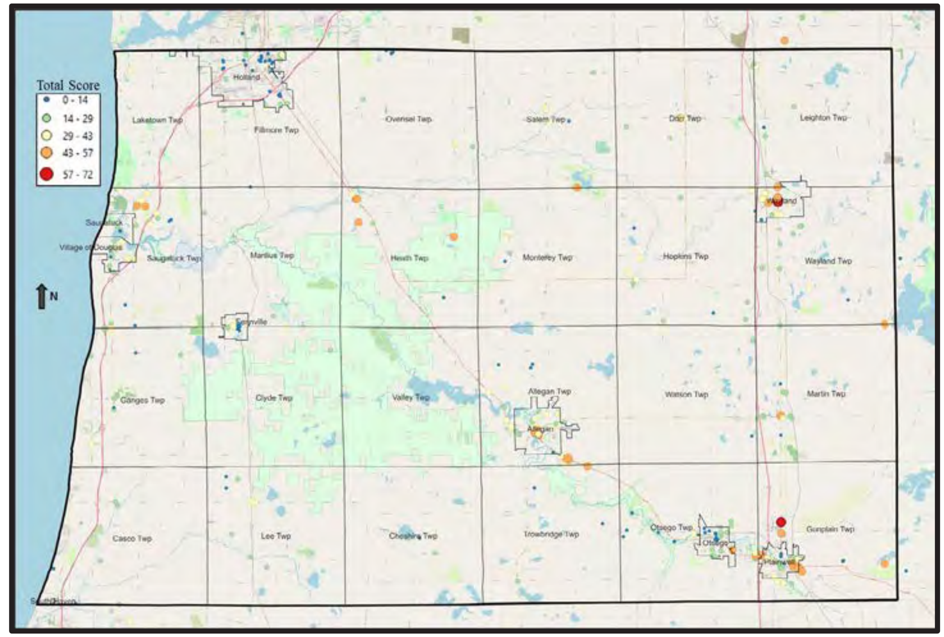


Figure 6: Map of total risk ranking scores for all 351 sites of groundwater concern analyzed in this study (including the additional 62 Open LUST sites).

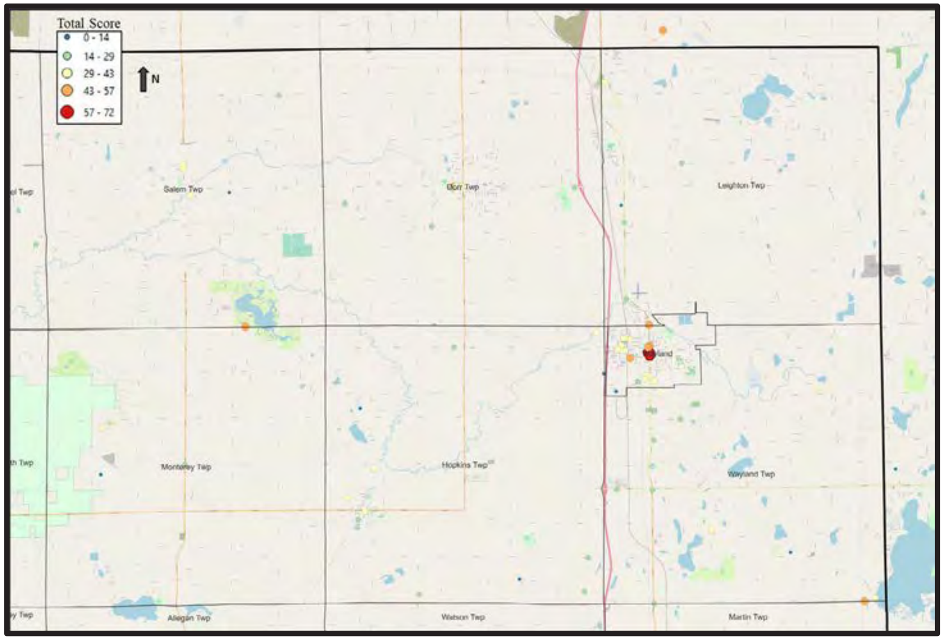


Figure 7: Map of total risk ranking scores for sites in the northeast quadrant of the county.

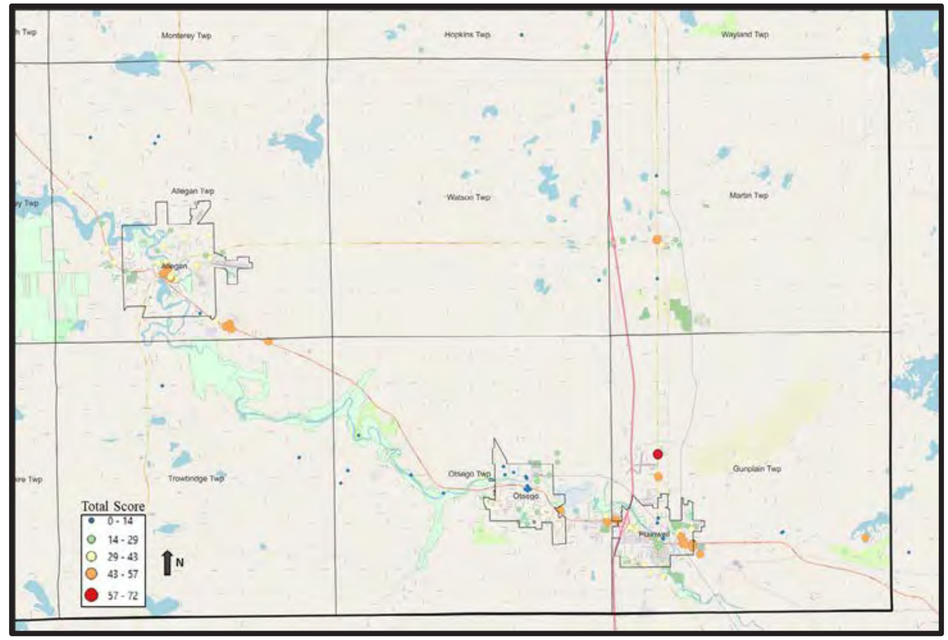


Figure 8: Map of total risk ranking scores for sites in the southeast quadrant of the county.

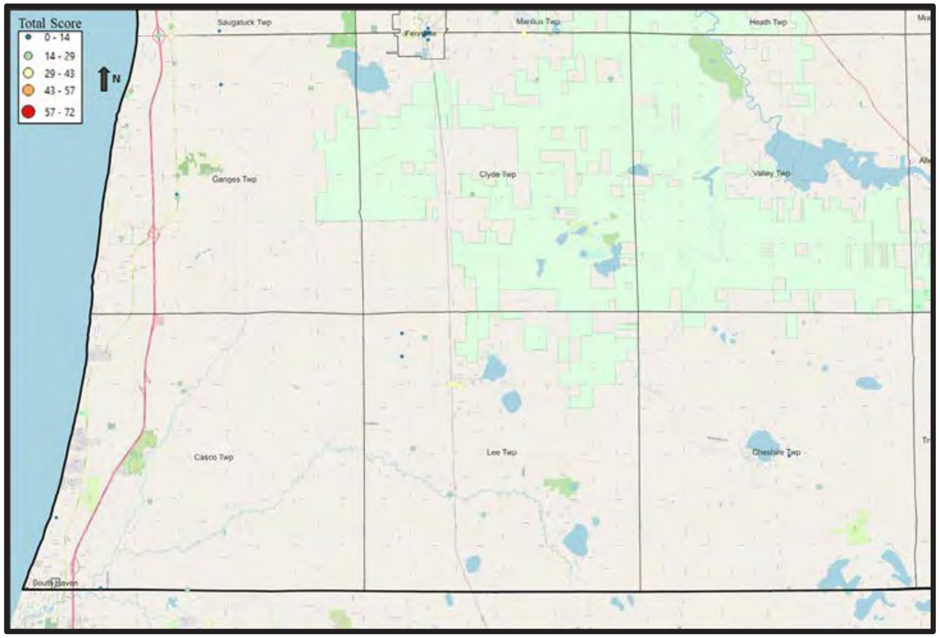


Figure 9: Map of total risk ranking scores for sites in the southwest quadrant of the county.

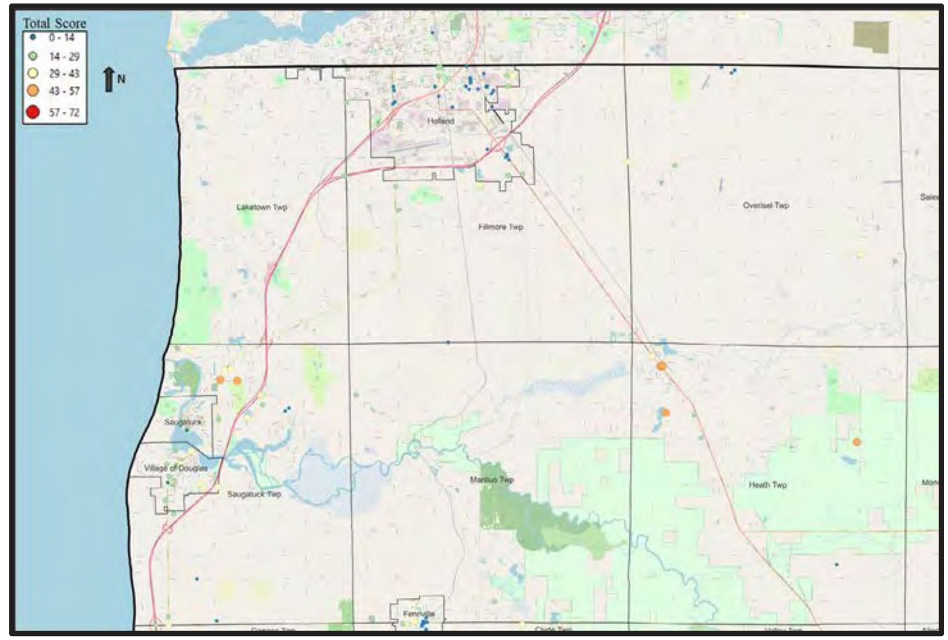


Figure 10: Map of total risk ranking scores for sites in the northwest quadrant of the county.

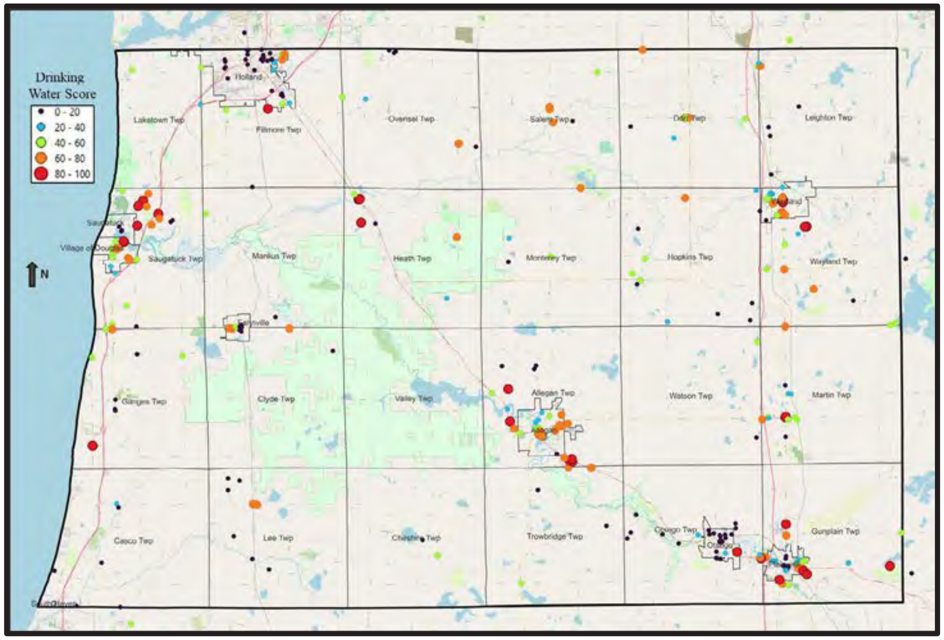


Figure 11: Map of drinking water scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites).

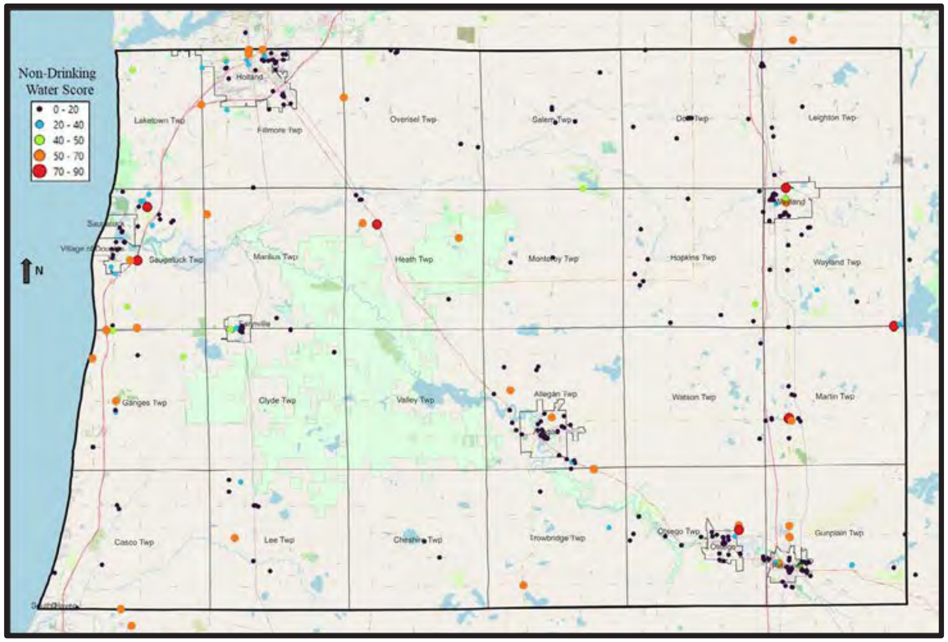


Figure 12: Map of non-drinking water scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites).

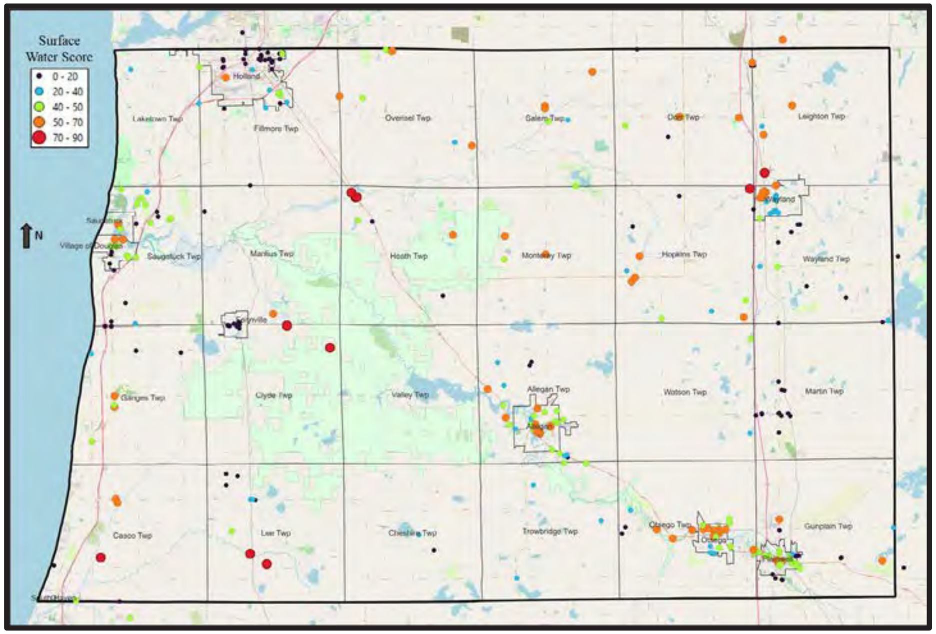


Figure 13: Map of surface water scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites).

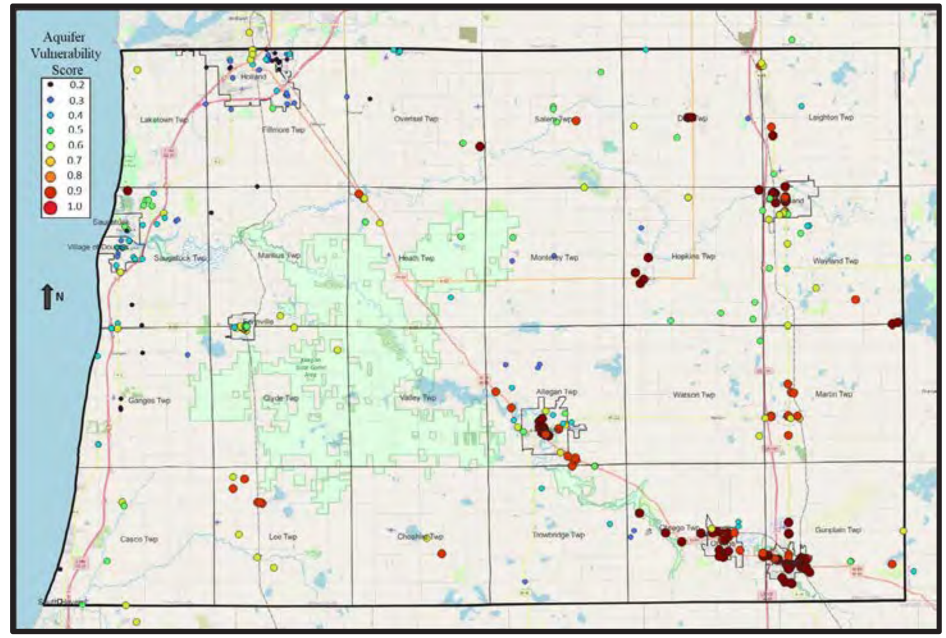


Figure 14: Map of aquifer vulnerability scores for all 351 sites analyzed in this study (including the additional 62 Open LUST sites).

Table 1: Total scores and "subscores" (drinking water scores, non-drinking water scores, etc.) for all 351 sites analyzed in this study (including the additional 62 Open LUST sites, which are labeled in red font). They are ordered in terms of total score (highest to lowest).

SiteID	Site Name	DW score	NDW Score	SW score	AQVul Score	Total Score
3000356	687 North 10th Street	90	60	75	0.9	71.7
3000306	203 South Main Street	85	70	40	0.9	65.15
00015681	Wayland Self Serve (LUST Site)	90	65	30	0.9	64.05
3000277	114 Pine Street	85	70	40	0.8	58.8
3000325	3603 N. Main Street	40	90	75	0.9	57.3
3000211	585 10th St. Plainwell	80	55	20	0.9	54.85
00011505	Ridderman Card -OP (LUST Site)	80	55	20	0.9	54.85
00015678	Martin (LUST Site)	85	85	0	0.8	54.4
3000360	712 East Bridge Street	75	15	60	1	54
3000367	798 E. Bridge Street Fmrly 760 E. Bridge	75	15	60	1	54
3000268	101 124th Avenue	60	85	20	0.9	53.95
3000265	150 North Main Street	75	45	40	0.9	53.9
00017433	Friendly 66 (Martin Pacific Pride) (LUST Site)	83	80	0	0.8	52.4
3000014	Angle Steel Div (Kewaunee Scientific)	70	17	60	1	52.1
3000421	243 Hubbard Street, Allegan	80	0	60	1	52
3000310	236 Hubbard Street	80	0	60	1	52
3000426	4634 4671 East Washington Street & 3501	85	15	95	0.7	51.9
00006437	Hamilton Farm Bureau Cooperative (LUST Site)	85	15	95	0.7	51.9
3000016	Section 25 Gun Plain Township	90	0	75	0.8	51
00042709	Former Wayland Motors Sales (LUST Site)	80	48	37	0.8	50.92
3000299	159 N. Main Street	80	45	40	0.8	50.8
3000283	1218 M-89 Highway	85	0	60	0.9	50.25
3000436	637 West Sycamore Street, Wayland	75	30	40	0.9	49.85
00015356	Sandy Pines Retail Center (LUST site)	80	45	60	0.7	49.45
Site 123	Otsego Township SLF	95	0	55	0.8	49
3000151	Boyce, Lelia Public Administrato	70	65	80	0.6	48.7
3000152	Boyce, Lelia Public Admins 1	70	65	80	0.6	48.7
3000285	124 Locust Street	85	0	50	0.9	48.25
3000004	Allegan Metal Finishing	90	30	25	0.8	48.2
3000073	Conrail-Plainwell	60	45	45	0.9	48.15
3000416	1175 M-89, Plainwell, MI 49080	80	0	60	0.9	48
3000281	1185 M-89 Highway	80	0	60	0.9	48

3000407	1227 M-89, Plainwell MI 49080	80	0	60	0.9	48
3000439	6494 Clearbrook Drive & 6402 and 6500 13	75	75	60	0.6	48
Site 1990	Heath Twp Landfill	90	60	50	0.6	47.8
3000384	East 1/2 of SE 1/4 Section 29	85	0	45	0.9	47.25
3000324	3506 M-40	85	15	95	0.6	47.2
3000424	4645 4670 Washington Street & 4621 135th	85	15	95	0.6	47.2
3000270	105-113 Brady Street	68	0	65	1	47
3000423	101 Brady Street, Allegan	68	0	65	1	47
3000272	111 Hubbard Street	68	0	65	1	47
3000302	1840 142nd Avenue	65	0	70	1	46.5
3000379	954 E. Bridge St. & 121 Locust St.	75	7	50	0.9	45.64
3000378	954 East Bridge Street	75	7	50	0.9	45.64
3000271	110 Water Street (portion of)	65	0	65	1	45.5
3000288	1258, 1260 Lincoln Road & Village EMH Pk	100	5	20	0.8	45.2
3000287	1255 Lincoln Road	85	20	30	0.8	44.8
3000333	406 Water Street	62	0	65	1	44
00008231	Mr Steven K Angle (LUST Site)	62	0	65	1	44
Site 762	Pease Avenue Pictures (site and WHPAs in Ottawa County)	60	65	70	0.6	43.7
3000282	1187 Lincoln Road (Trowbridge Twp)	70	70	50	0.6	43.6
3000239	North Pointe Plaza	95	20	55	0.6	43.1
3000340	558, 520, and 512 Water Street	60	0	65	1	43
3000029	Res Wells Lincoln Rd	65	70	50	0.6	42.1
00039997	Landman Sales Inc (LUST Site)	60	25	40	0.9	41.75
00009400	Wesco #9 (LUST site)	30	55	50	1	41.5
3000018	MDOT Fennville	70	0	85	0.7	41.5
3000350	6530 Sanctuary Way	90	25	50	0.6	41.5
00019008	Fifelski Service Station (LUST site)	65	0	60	0.9	41.25
3000319	324 Eastern Avenue	70	0	65	0.8	41
3000318	320 Eastern Avenue	70	0	65	0.8	41
3000382	A portion of Parcels 03440-030-008-00 &	60	0	70	0.9	41
3000201	310 Water Street	62	0	65	0.9	40.9
Site 95	Allegan Township Dump	95	60	40	0.5	40.75
3000261	Allegan (554) Street	28	55	50	1	40.5
3000267	100 Monroe Street	55	0	65	1	40.5
50005597	City of Allegan (LUST site)	68	0	65	0.8	40.2
00042506	Philly LLC (LUST site)	80	15	45	0.7	40.15
3000037	Jersey Street Plainwell	85	7	0	0.9	40.14

MID-006-016-190	Allegan Metal Finishing	75	0	50	0.8	40
3000036	International Harvester	100	20	60	0.5	40
50002085	Glenn Country Store (LUST Site)	100	20	60	0.5	40
Site 333	Geneva Twp Dump (in Van Buren County)	55	55	45	0.7	39.8
3000320	326 Water Street	65	0	65	0.8	39
00034666	S P Industries (LUST Site)	50	0	70	1	39
3000370	848, 856, & 858 S. Main Street	75	10	30	0.8	38.4
3000294	1307 Lincoln Road	65	10	50	0.8	38.4
3000039	136th & 12th	40	0	100	0.9	38
00042483	Former Hamilton Vet Clinic (LUST site)	50	0	90	0.8	38
3000200	300 Water St.	62	0	65	0.8	37.8
3000241	Lincoln (1600) Road, LLC	90	15	65	0.5	37.75
00007390	Allegan Fire Department (LUST Site)	55	0	50	1	37.5
00002804	Burnips Shell Station (LUST site)	75	7	68	0.6	37.36
3000172	Blue Star & M-89	70	50	10	0.7	37
00010223	Al's Total (LUST Site)	80	0	25	0.8	37
3000335	4302 30th Street	75	7	65	0.6	36.76
3000438	6784-6874 Wiley Road, Douglas	60	85	45	0.5	36.75
3000244	Superior St (1112) W., Wayland	60	15	80	0.6	36.7
3000383	Applewood Estates, Lots 3 & 4	75	40	10	0.7	36.65
00006446	Branch Maintenance Garage (LUST Site)	65	55	57	0.5	35.9
00017349	Wayland Shell (LUST Site)	60	10	80	0.6	35.8
00000605	Speedway #3578 (LUST site)	60	10	80	0.6	35.8
3000396	Wiley Road (Vacant Land (V/L))	65	50	60	0.5	35.75
3000349	641 W. Elm Street	40	10	75	0.9	35.7
3000346	623 W. Allegan Street	30	45	50	0.9	35.65
3000249	700 Grand Street, Allegan	70	0	55	0.7	35.5
3000052	Bloomfield Res Well	75	5	0	0.9	35.1
00016911	Pullman Marathon (former) (LUST Site)	75	0	25	0.8	35
00004529	Dorr Standard Service (LUST site)	50	0	62	0.9	34.9
3000264	1134 West Superior Street	55	12	80	0.6	34.66
Site 125	Salem Township Dump	75	0	60	0.6	34.5
3000410	4612 66th Street, Holland MI 49423	45	50	40	0.7	34.25
3000392	Swing Bridge (50,60,70,80,90) Ln & Kewat	85	0	65	0.5	34.25
3000393	Union Street & Blue Star Highway	85	0	65	0.5	34.25
3000007	Exit 41 LF	85	10	10	0.7	33.85
3000390	Singapore Dunes 320-Acres Vacant Parcel	50	0	55	0.9	33.5

3000237	Wayland Recycling, Inc.	40	0	77	0.9	33.4
00040697	Wayland Recycling Inc (LUST Site)	40	0	77	0.9	33.4
3000344	609 & 611 N. Eastern Avenue	65	15	55	0.6	33.2
Site 131	Bruce Girke; J & J Tires	35	40	75	0.6	32.7
3000369	844 S. Main Street	70	10	30	0.7	32.6
3000358	700 North Main Street	60	60	43	0.5	32.6
3000163	Pullman Road at 109th Avenue	70	0	20	0.8	32
MID-980-588-495	Bush Oil Company	45	0	80	0.7	31.75
Site 130	Wayland Township Dump	70	25	10	0.7	31.75
MID-092-947-928	Drug & Laboratory Disposal, Inc.	35	17	45	1	31.6
Site108	Fillmore Twp dump	85	0	30	0.6	31.5
3000351	6541 Blue Star Hwy Vacant Hooten Inn Pro	60	25	45	0.6	31.5
3000362	736 West Elm Street	40	0	65	0.9	31
3000331	400 Broad Street	35	15	45	1	31
3000002	A 1 Disposal Corp Plainwell	35	15	45	1	31
3000260	106th (1754) Avenue	40	0	65	0.9	31
3000301	1754 106th Avenue	40	0	65	0.9	31
10593	Rockwell International Corporation (PFAS site)	30	20	60	0.9	30.9
3000303	1846 Lincoln Road	45	0	63	0.8	30.6
3000011	Hughes Engraving	50	15	20	0.9	30.55
3000391	Southwest 1/4 of Sec 28, T2N, R13W City	35	0	65	1	30.5
3000427	665 Allegan Street, Plainwell	30	35	50	0.8	30.4
00034193	Kalamazoo Lk Sewer & Water Auth (LUST Site)	70	25	45	0.5	30.25
3000336	4346 48th Street	50	60	65	0.4	30.2
00039100	Saugatuck Campground (LUST Site)	75	35	30	0.5	30
3000371	858 S. Main Street (behind)	65	0	35	0.7	29.75
3000202	Neo-Tech/IST Warehouse	53	7	20	0.9	29.74
50002327	Metropolitan Title Office (LUST Site)	80	0	48	0.5	29.6
3000337	4651 & 4655 South Division Street	70	5	20	0.7	29.55
3000313	2811 24th Street	50	0	35	0.9	29.5
00004515	Fennville Shell Mart (LUST Site)	60	40	0	0.7	29.4
Site 129	Wayland City Dump	75	10	25	0.6	29.3
12250	Admiral Petroleum #174 (LUST site)	30	30	50	0.8	29.2
00001111	Martin Public School (LUST Site)	50	55	0	0.7	29.05
3000381	960 Productions Court	80	0	45	0.5	29

3000284	1227 M-89 Hwy Home Depot - Plainwell	40	0	65	0.8	29
3000257	Texaco Gas Station (Douglas)	80	0	45	0.5	29
3000432	3784 140th Avenue, Hamilton, MI 49418	70	5	35	0.6	28.9
3000431	3776 140th Avenue, Hamilton, MI 49419	70	5	35	0.6	28.9
3000343	5 Mill District Road	35	0	65	0.9	28.75
00002991	Martin Marathon (LUST Site)	75	2	10	0.7	28.67
00039406	Lake Park Trailer Resort (LUST Site)	55	65	25	0.5	28.5
00017374	Allegan Service Center (LUST Site)	70	0	55	0.5	28.5
3000286	124th Ave (M-89) & I-196 (US-31) Highway	60	50	50	0.4	28
00017345	Bradley Express Stop #335 (LUST site)	65	5	55	0.5	28
3000403	946 Industrial Parkway, Plainwell, MI 49	50	5	20	0.9	27.85
3000321	3292 Lincoln Road	20	80	20	0.7	27.8
3000345	610 South Platt Street	35	0	50	1	27.5
3000347	637 West Main Street	75	45	10	0.5	27.5
3000222	58th Street and 106th Ave Dump	5	70	55	0.7	27.45
3000207	Allegan, City of SW1/4 S28 2N13W	35	0	65	0.8	27
3000323	3387 Eagle Drive	40	0	55	0.8	27
00015971	Plainwell Clark (LUST Site)	30	0	60	1	27
00008110	Gless Service (LUST Site)	30	0	60	1	27
3000250	2870 116th Avenue, Allegan	70	0	47	0.5	26.9
00005611	Ben Knoper & Sons Roofing Co Inc (LUST site)	25	10	80	0.7	26.85
00034657	New Salem Grocery Inc (LUST site)	45	0	65	0.6	26.5
3000443	155 10th Street, Plainwell	40	15	20	0.9	26.05
3000440	931 Industrial Parkway, Plainwell	35	7	40	0.9	25.64
3000305	1 Glass Street	30	15	40	0.9	25.55
3000420	119 West Bridge Street, Plainwell	25	0	65	1	25.5
3000322	3295 Blue Star Highway	90	0	15	0.5	25.5
3000405	946 Industrial Parkway	50	5	20	0.8	25.2
3000441	216 Saint Peters Drive, Douglas	55	10	65	0.4	25.2
00035825	Merson Trading Post (LUST Site)	55	60	35	0.4	25.2
3000387	Part of S1/2, N1/2, NE1/4, S7, T3N, R11W	50	0	38	0.7	25.1
3000063	Acorn St Industrial Park	30	7	40	1	25.1
3000298	14 Ferry Street	60	10	43	0.5	25.1

3000286	124th Ave (M-89) & I-196 (US-31) Highway	55	55	15	0.5	25
00018439	Stop Shop and Roll (LUST Site)	60	0	65	0.4	25
00001551	Carter Automotive (LUST Site)	25	0	80	0.7	24.75
3000338	4652 Division Avenue	50	3	20	0.8	24.72
3000348	640 River Street	30	5	65	0.7	24.55
3000126	Midway Packing Company	50	0	35	0.7	24.5
Site 126	Spring Water CampGround	45	0	55	0.6	24.5
3000253	Hilliards General Store	65	0	7	0.7	24.15
3000437	999 124th Avenue, Shelbyville	65	0	7	0.7	24.15
00016276	Fred J Holbrook (LUST site)	65	0	7	0.7	24.15
3000295	1322-1326 142nd Avenue	55	0	65	0.4	24
3000316	309 Clark Street	20	0	75	0.9	24
17354	Pioneer Market (LUST site)	55	0	10	0.8	24
3000315	294 W. Center Street	75	0	45	0.4	24
Site 120	Menasha Corporation	0	85	55	0.5	23.75
3000329	3717 Division Avenue	15	0	95	0.6	23.5
50001810	Douglas Amoco 28876 (LUST Site)	75	0	42	0.4	23.4
Site 96	Bloks Refuse Service SLF	40	35	10	0.7	23.35
3000430	211 North Main Street, Plainwell, MI 490	20	0	65	1	23
3000292	1291 Lincoln Road	50	0	40	0.6	23
3000230	315 Fulton Street	20	0	70	0.9	23
3000355	6797 118th Avenue	10	60	80	0.3	22.9
Site 135	Castleton-Maple Grove Dump	5	10	95	0.7	22.85
00017434	Wykstra Oil Co., Inc. (LUST Site)	45	20	0	0.8	22.8
Site 91	Sunrise Sanitary Landfill	83	0	10	0.5	22.75
Site 92	Exit 41 SLF	70	15	15	0.5	22.75
3000278	1150 129th Avenue	50	15	25	0.6	22.7
3000290	1267 126th Avenue	5	50	60	0.6	22.5
0009832	Doster Country Store (LUST site)	50	0	25	0.7	22.5
3000153	Geib Oil Company (00015972)	50	10	0	0.8	22.4
3000215	MGP Otsego - MGU	0	35	70	0.8	22.4
3000212	Plainwell Paper Mill	20	0	65	0.9	22
3000422	140 East Bridge Street, Plainwell, MI 49	20	0	60	1	22
3000023	Pilgrim Farms Pickle Plant	15	0	70	1	21.5
3000031	Sunrise LF	85	0	0	0.5	21.25
3000332	4066 & 4070 Division Street Wayland	10	5	75	0.9	20.85
3000406	977 118th Avenue, Martin MI 49070	40	20	0	0.8	20.8
3000259	Menasha Corp Landfill	0	65	55	0.5	20.75

3000021	Millies Industrial Painting	60	30	45	0.3	20.7
3000398	Transcendia	50	15	0	0.7	20.65
3000231	977 118th Avenue	40	18	0	0.8	20.32
3000414	Lalli Brothers Express LTD LSE	40	60	25	0.4	20.2
Site 107	Fennville City dump	10	5	75	0.7	19.55
3000009	Goodale Facility Wayland	50	0	10	0.7	19.5
Site 117	Lee Twp Dump	0	0	95	0.7	19
3000413	Paul Platschorre Residence	30	0	50	0.6	19
Site 98	Casco Townhip Dump	0	0	95	0.6	19
3000314	2948 Blue Star Highway	40	40	15	0.5	19
3000327	360 Water Street	20	0	65	0.6	19
00015972	Geib Oil Co (LUST site)	40	10	0	0.8	18.4
00004105	Peter J. Parbel Iii (LUST site)	65	0	10	0.5	18.25
3000022	Parker Hannifin Corporation	20	0	40	1	18
Site 100	Clyde Manlius & Ganges Trash	0	0	90	0.7	18
3000245	Amsink Property	10	35	65	0.3	17.65
3000312	2438 Blue Star Highway	50	20	10	0.5	17.5
00018858	Fleming Brothers Oil Co (LUST Site)	5	0	80	0.6	17.5
3000219	Baseline Road Pesticide Barn	10	65	0	0.7	17.15
Site 97	Brown Brothers Landfill	50	65	15	0.3	16.35
Site 124	Overisel TWP Dump	35	10	50	0.3	16.15
3000330	394 South 16th Street	15	5	40	0.9	16.1
3000434	864 Productions Place, Holland	60	0	20	0.4	16
Site 105	Dorr Township Dump	40	0	20	0.6	16
3000304	1895 M-40 Highway	40	15	30	0.4	15.8
3000019	Menasha Corp	0	10	65	0.9	15.7
70000514	Lincoln Avenue Area Groundwater	0	65	10	0.7	15.65
3000442	788 Lincoln Avenue, Holland	0	65	10	0.7	15.65
00019273	The Voss Boys (LUST Site)	0	65	10	0.7	15.65
3000334	4277 1/2 Blue Star Highway	50	30	10	0.4	15.6
3000297	143rd Avenue Leighton Township	10	0	65	0.5	15.5
3000269	1035 E. 40th Street	75	0	20	0.3	15.25
3000400	Dutch Developers, LLC	50	10	20	0.4	15.2
3000300	160 South Washington Road	10	10	40	0.9	15.2
3000293	1300 & 1400 S. Washington Avenue	0	0	75	0.4	15
3000307	2180 62nd Street	45	50	0	0.4	15
3000032	Village of Douglas Contamination	60	0	15	0.4	15
3000309	236 Culver Street	20	0	45	0.6	15
3000251	Lower Scott Lake Containment Site	5	40	15	0.8	14.6
Site 1992	Balfoort Demolition Site (spelling ??)	10	0	55	0.7	14.5
3000374	868 132nd Street	35	0	20	0.6	14.5

3000291	1269 124th Avenue	5	0	65	0.6	14.5
Site 122	Otsego City LF	0	5	65	0.9	14.35
00010682	Rieth-riley Construction Co Inc (LUST site)	10	20	25	0.8	13.8
Site 90	Gun Plain Township & Plainwell City Landfill	30	25	0	0.6	13.5
3000057	Gun Plain Township Landfill	30	25	0	0.6	13.5
Site 127	Trowbridge Township Dump	5	40	30	0.5	13.25
Site 1793	Deyoung Landfill (PFAS site)	0	0	65	0.5	13
3000248	Smith Estate 2 and Tank Battery	15	0	35	0.8	13
3000429	201 Bannister Street, Plainwell, MI 4908	0	0	65	1	13
3000389	RR Spur Btwn N. Anderson & Kalamazoo Riv	0	0	65	0.9	13
3000311	241 & 243 North Farmer Street	0	0	65	0.9	13
3000433	132 Helen Avenue, Otsego, MI 49078	0	0	65	0.9	13
3000279	115 E. Allegan Street	0	0	65	0.7	13
3000275	113 North Farmer Street	0	0	65	0.7	13
3000401	Ostego, LLC	0	0	65	0.8	13
3000328	363 West River Street	0	0	65	0.9	13
3000262	Rock-Tenn Otsego Mill	0	0	65	0.9	13
3000428	519 19th Street, Otsego, MI 49078	0	0	65	0.9	13
3000417	2063 Covault Ln at Kalamazoo River	0	0	65	0.9	13
00042503	Kalico Kitchen Ltd (LUST Site)	55	0	10	0.4	13
00005116	Otsego (LUST site), 134 E ALLEGAN ST	2	10	50	0.7	12.8
50002605	Culver St Site (LUST Site)	17	0	50	0.3	12.55
3000053	Res Well Ottogan	5	0	55	0.5	12.25
Site 101	Deyoung Refuse Removal	0	0	60	0.5	12
3000256	Otsego Area Study	0	0	60	0.8	12
Site 121	Monterey Twonship Dump	5	0	55	0.4	12
00013325	Watervliet Marathon LLC (LUST Site)	0	0	60	0.9	12
00004932	R & H Petroleum Inc (LUST Site)	0	0	60	0.9	12
Site 1993	William Kelly Disposal Area	3	5	50	0.6	11.8
50002096	Healthiatry Center (LUST site)	5	50	15	0.5	11.75
00041959	Elinor Amsink and Jerry Amsink (LUST Site)	10	0	50	0.3	11.5
3000221	Saugatuck Township Contamination	0	10	50	0.4	11.2
3000081	Gleason Road Res Well	0	10	50	0.4	11.2
00009932	Gra-bell Truck Line Inc (LUST Site)	0	0	55	0.4	11
Site 128	Watson Martin Twp Landfill	15	3	25	0.7	10.88

00005451	Philip Mac Vean (LUST Site)	15	20	0	0.8	10.8
3000317	3130 110th Avenue	10	0	40	0.5	10.5
3000233	48th Street (345) E.	0	20	40	0.4	10.4
3000361	720 N. Main Street	1	0	50	0.8	10.4
Site 111	Un-named (Marsh Sand and Gravel property)	30	5	10	0.5	10.25
3000385	Lincoln (4392) Rd and M-40 (1724) Hwy	0	0	50	0.4	10
3000373	860 & 904 Interchange Rd & 1737 M-40	0	0	50	0.3	10
Site 115	Jack Norton Hauling Service	15	0	20	0.8	10
3000419	607 North Main Street, Plainwell	0	0	50	0.8	10
Site 118	Mead Paperboard(Type III SLF)	0	0	50	0.7	10
3000425	1107 Reno Drive & 1107 132nd Avenue, Way	0	0	50	0.7	10
3000198	Ebert Farm	10	60	25	0.2	9.6
3000240	M-40 Highway (1750), Holland	0	0	45	0.4	9
Site 94	Allegan County Landfill (Dobbins Landfill)	5	0	40	0.4	9
3000418	3404 12th Street, Wayland	10	10	20	0.6	8.8
00002753	Former Cook Auto (LUST site)	5	40	15	0.4	8.8
3000412	180 E. 40th Street, Holland MI 49423	10	25	0	0.7	8.75
3000220	Lynx Golf Course	0	0	40	0.9	8
00004067	Rai Phillips 66 Inc (LUST Site)	0	65	10	0.3	7.85
3000352	6673 126th Avenue	50	45	0	0.2	7.7
Site 99	Cheshire Township Disposal	5	0	25	0.7	6.75
Site 112	Hopkins Township Dump	5	0	25	0.6	6.5
3000012	Huitt and Sons	10	10	15	0.4	6.2
3000359	701 East 64th Street	0	0	30	0.5	6
Site 642	Misak Landfill (#08000011) / Yankee Springs Twp Dump (#08000022)	20	0	0	0.6	6
3000263	353 East 1st Street	7	15	10	0.5	6
00013332	Petro & Pantry II (LUST Site)	7	10	10	0.6	5.9
3000308	220 East Main Street	5	10	10	0.6	5.3
3000289	125 East Main Street	5	10	10	0.6	5.3
50002237	Former Fennville Filling Station (LUST Site)	5	10	10	0.6	5.3
00007401	Fennville Feed (LUST Site)	5	10	10	0.6	5.3
00009675	City of Holland School District (LUST Site)	15	0	15	0.3	5.25
3000274	1130 Lincoln Avenue	5	25	0	0.5	5
Site 1991	Hopkins Twp Landfill 22nd Street	15	0	10	0.4	5
3000026	Pullman East Oil Field	5	0	15	0.8	5

3000364	74th Street South Haven MI	10	0	17	0.3	4.9
3000375	875 Brooks Avenue	0	40	0	0.4	4.8
Site 88	A1 Disposal LF	3	0	20	0.4	4.6
3000376	905 Brooks Avenue	0	38	0	0.4	4.56
3000380	955 Brooks Avenue	0	35	0	0.4	4.2
3000377	942 Brooks Avenue	0	35	0	0.4	4.2
3000003	A 1 Disposal LF	0	0	20	0.4	4
3000363	741 Waverly Court, Holland	25	0	0	0.3	3.75
3000372	859 East 48th Street	25	0	0	0.3	3.75
00018914	The Little Store (LUST Site)	10	0	10	0.3	3.5
3000280	115 E. Fennville Street	5	5	0	0.8	3.2
3000411	5593 136th Avenue, Fillmore Township, MI	15	10	0	0.3	3.15
3000365	760 E. 40th Street	30	0	0	0.2	3
3000273	1128 58th Street	0	0	15	0.7	3
00016422	American Aerosols (LUST site)	20	0	0	0.3	3
3000402	City of Fennville	5	5	0	0.7	2.8
3000357	694 East 40th Street	17	0	0	0.3	2.55
3000242	Birds Eye Foods--AST Release	5	3	0	0.7	2.38
MID-006-411-953	BASF Corporation	0	10	0	0.7	2.1
3000408	694 East 40th Street, Holland MI 49423	20	0	0	0.2	2
3000339	471 East 40th Street	0	0	10	0.5	2
3000399	1162 Washington Avenue, Holland, MI 4942	0	0	10	0.3	2
Site 113	Huitt & Son	5	5	0	0.4	1.6
3000055	Res Wells 10th St	3	0	0	0.8	1.2
3000243	Washington Ave (1111, 1147), Holland	0	0	5	0.3	1
3000258	40th (636) Street, East	5	0	0	0.3	0.75
Site 178	KavCo SLF (KAV Company)	2	0	0	0.5	0.5
3000341	588 E. 40th Street	0	0	0	0.4	0

Recommended Next Steps

As previously emphasized, this "foundational" study represents the first critical step for the county toward managing its large number of point-sources (sites) of groundwater concern. The integration of numerous spatial datasets and groundwater modeling capabilities enabled characterizing in a relatively short time the potential for groundwater transport and risk to critical groundwater receptors. This information can be used to guide the next steps of management and investigation, which may involve incorporating human and environmental health perspectives and updating the risk ranking/priority lists, as well as refining the groundwater modeling as more data become available and management priorities evolve (see **Error! Reference source not found.**).

Hydrosimulatics INC. recommends the following next steps, building on the efforts of this current study:

- ~~First: screening-level modeling at additional/remaining sites of groundwater concern. The modeling and mapping approaches used in this study can be applied to other potential sources of groundwater pollution that were not part of the scope of work for this study. Approximately 60 Open LUSTs remain uninvestigated, and there were over 160 Underground Storage Tanks (USTs) identified at the time of the Phase 1 study. There are also dozens of oil and gas wells that, if leaky or fractured, may provide a vertical conduit for flow of deeper, highly mineralized groundwater to the near-surface environment.~~

  ~~After these sites are analyzed, the *risk ranking list should be updated* to reflect the additional sites in the countywide portfolio. As additional work, Hydrosimulatics INC. is willing to complete the modeling and integrated analysis of additional sites, as well as make updates to the overall risk ranking list.~~ COMPLETED AS DETAILED IN THIS ADDENDUM.

- Second: screening-level investigation of the contamination sources. A next important step is to determine nature of the sources at the sites of highest priority (or all sites where information is available), e.g., the type of substance or chemical(s) that are present, the timing and nature of the contamination event (e.g., continuous / "instantaneous" releases, current vs. historical, accidental spill vs. intentional discharge to the event, etc.), and the "strength" or severity of the contamination (i.e., how it was released at the property and the expected/observed concentrations in groundwater at the site). After determining the nature of contamination, it is possible to establish the risk to human health based on toxicology and risk exposure analysis (e.g., observed/expected concentrations vs. established health standards, consumption vs. skin exposure, acute vs. chronic exposure, etc.).

  A "source risk rating" can be applied to all sites investigated and *a new weighted average can be developed to generate a new overall risk ranking list*. As additional work, Hydrosimulatics INC. is willing to work with the county to compile existing information related to the nature of the contamination sources, and to update the risk ranking list as needed.

- Third: data collection and focused modeling at high-priority sites (for the updated risk ranking lists). In some cases, data/information related to the nature of the contamination may not be available, or additional information is needed to determine the source risk rating. Collecting groundwater quality data on- and off-site may be necessary to assess the environmental conditions and develop a mitigation strategy. Also useful are physical groundwater data (water levels and borehole lithologies) from precise groundwater monitoring wells that can be used to better constrain a calibrated model compared to regional SWL data used for calibration[4].

[4] Recall that the regional models developed for this study are calibrated to Wellogic data, which is suitable for regional calibration, but are too "noisy" (uncertain) to be use for detailed site-scale calibration and transport modeling.

The calibrated models developed for this study can be improved or extended as more data/information is collected and the need to address limiting assumptions of the screening-level models becomes important. Additional information that can be incorporated into existing groundwater models include: geologic data (borehole lithologies) that be used improve the conceptual model at the site (e.g., the 3D subsurface structure or small-scale heterogeneities at the site); operational pumping rates, especially for large-capacity public supply wells[5]; groundwater level data that can help refine model parameters such that model outputs better match observed data (this is particularly relevant for site-scale models); and groundwater chemistry (water quality) data for mapping the real 3D extent of the plume. The calibrated/refined site-scale models can then be applied to "full" fate and transport modeling, i.e., simulating chemical concentrations as a function of space and time, accounting for source properties/dynamics and the biogeochemical properties of the substance of interest (e.g., PFAS). A full, 3D transport model can be used to design and optimize a remediation process such as extraction wells or trenches for a pump-and-treatment operation.

A further aspect of focused modeling at high-risk sites is model sensitivity analysis. This technique can be used to evaluate the impact of uncertainty of model parameters on predicted outcomes (e.g., water levels and flow patterns, plume path and direction). Groundwater properties such as hydraulic conductivity, porosity, and recharge can vary significantly across space, and a number of combinations of plausible parameter values may satisfy model calibration to observed data. The idea with sensitivity analysis is to change the model input parameters within the likely ranges of values (based on the geological/environmental setting) and evaluate the variability of the model in response to changes to input parameters. This gives managers a sense of the possible outcomes based on the information available.

Finally, the modeling approaches used in this study can be applied to delineate impact areas beyond the 20yr. horizon (e.g., 30 or 40 years of assumed travel time) to help facilitate even longer-term planning. This may also help evaluate the present-day impact of legacy contamination events (e.g., spills that occurred more than 20 years ago).

As additional work, Hydrosimulatics INC. is willing to perform focused modeling at high-priority sites and assist the county with creating a data collection plan at these sites.

- Fourth, cleanup and remediation. Based on the holistic understanding of hydrogeology and human health risk, some sites may require "immediate" action to mitigate or eliminate the groundwater contamination. In these cases, the first step is to establish liability (who will pay for cleanup?) and a process for oversight (e.g., working with the State of Michigan or US Environmental Protection Agency to secure funding and the necessary technical expertise). As previously stated, Hydrosimulatics can perform focused modeling at high-priority sites to assist in the design and optimization of site-specific remediation systems.

[5] Pumping was not represented in the calibrated regional models, although drawdown from pumping may have localized impacts on the regional flow patterns, which can be important for "active" capture of nearby groundwater plumes.

APPENDIX C

Allegan County Groundwater Protection Area Delineation Approach & Modeling

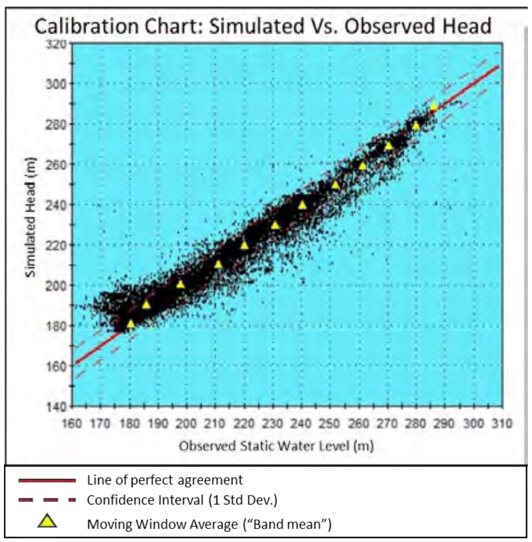
Regional Model

Calibration Parameters:

K Multiplier	0.55
R Multiplier	1.05
Land Leakance	1 day^{-1}

Calibration Performance (Statistical Indicators):

Number of Points	15,784
Root-mean-square error	7.30m
Mean Error	-0.98m
Nash-Sutcliffe Coefficient	0.934



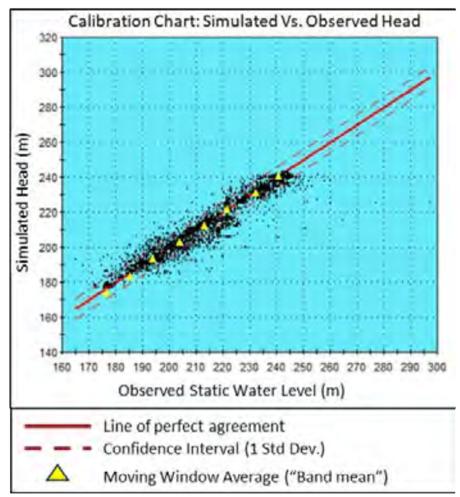
Northern Submodel

Calibration Parameters:

K Multiplier	0.55
R Multiplier	1.15
Land Leakance	1 day^{-1}

Calibration Performance:

Number of Points	1868
Root-mean-square error	5.88m
Mean Error	0.28m
Nash-Sutcliffe Coefficient	0.885



Southwestern Submodel

Calibration Parameters:

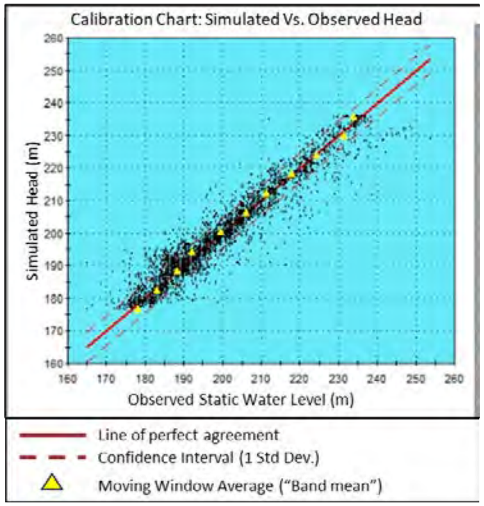
K Multiplier 0.55

R Multiplier 1.15

Land Leakance 1 day^{-1}

Calibration Performance:

Number of Points	3361
RMS error	4.44m
Mean Error	-0.57m
Nash-Sutcliffe Coef.	0.909



Southeastern Submodel

Calibration Parameters:

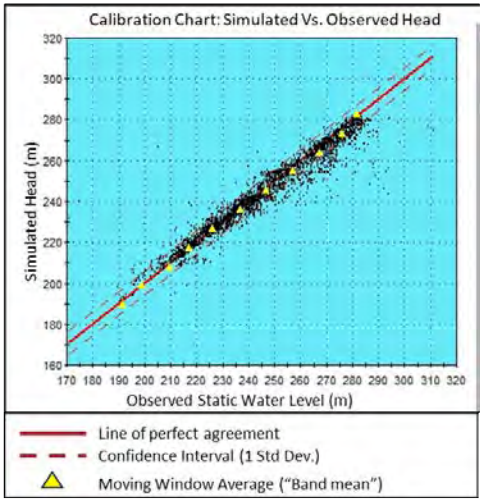
K Multiplier 0.4

R Multiplier 1.5

Land Leakance 1 day^{-1}

Calibration Performance:

Number of Points	3357
RMS error	5.54m
Mean Error	0.88m
Nash-Sutcliffe Coef.	0.936



WRITEUP OF GROUNDWATER PROTECTION AREA DELINEATION

The Groundwater Protection Area (GPA) for Allegan County represents the groundwater capture area of the near-surface aquifer system important for groundwater resources in Allegan County. The GPA is the "groundwater-shed" or the portions of the aquifer that lie underneath Allegan County, or are outside of the County but will contribute groundwater as it naturally flows "inward", across the County border. Just beyond the GPA, groundwater flows away from the County.

By definition, the edge of the GPA coincides with a groundwater divide. As groundwater "flows downhill", the location of the groundwater divide corresponds with the point of highest groundwater head (or highest point of water table in an unconfined/surficial aquifer). The area of the aquifer from the groundwater divide to the point of eventual discharge (typically a stream or other surface water body) is referred to as the source groundwater area (see Figure 1 below)

A groundwater divide can be identified by mapping groundwater flow patterns across space, which was the approach used in this project. More specifically, computer simulations of groundwater flow were developed and analyzed to identify the location of the groundwater divides in the vicinity of Allegan County, and apply this knowledge to the delineation of the Groundwater Protection Area.

Overview of Approach

The process followed a multi-scale, multi-step approach.

First, a large-scale (regional-scale) groundwater model of Allegan County and the surrounding counties was developed to capture the spatial patterns of groundwater levels, especially the distribution of "mounds" (where groundwater levels are highest relative to surrounding levels) and "valleys" (discharge areas along the corridors of streams and rivers). The model was calibrated[1] to Static Water Levels from the *Wellogic* water well database. Sensitivity analysis[2] was performed and revealed that the spatial patterns of mounds and valleys is robust (relatively insensitive to small/reasonable changes in model parameters) at this scale.

Next, three submodels were developed in the vicinity of the County borders to more accurately delineate the groundwater divides in those areas (namely, along the northern boundary, along the eastern/southeastern boundary, and along the south/southwestern boundary). The shape/extent of the submodels was based on the distribution of mounds and valleys from the calibrated regional groundwater model; each submodel included all of the relevant groundwater mounds in its vicinity, and its boundary should (to the extent possible) coincide with major streams or rivers that act as "hydraulic barriers" (i.e., groundwater patterns on one side have little impact on the other side) – see more below in Model Results. Boundary conditions (water level information) along the submodel boundaries were passed down from the regional calibrated model. Each of the submodels were independently calibrated, again using SWL data from *Wellogic*.

The final step was to inspect the submodel flow patterns to identify (delineate) the local groundwater divide, and "stitch" together the overall Groundwater Protection Area for the County from the submodel delineations.

Model Setup & Calibration

The regional groundwater model and all submodels were process-based models. Process-based modeling involves solving the governing equations of groundwater flow for the set of aquifer conditions (aquifer geometry and aquifer properties) specific to each site. The spatial framework data used as input to the models include: land topography; bedrock top; hydraulic conductivity (aquifer permeability); and natural recharge (infiltrated rain water). The source of water (recharge) was balanced by drainage of groundwater to the surface (e.g., baseflow to streams and other surface seeps).

The model consisted of two conceptual layers: the first (top-most) layer represented the entire thickness of the glacial deposits (the "glacial aquifer") and the 2nd (bottom-most) layer represented the shallow, fractured portion of the bedrock (in some places referred to as the "bedrock aquifer"). Most of Allegan County overlies the Coldwater Shale formation, which is relatively impermeable. The northeastern portion of the County overlies the more permeable Marshall Sandstone formation, which is utilized for water supply (albeit to a lesser degree than the glacial aquifer). The fractured portion of the aquifer was assumed to be 75ft.

The top surface of the models (layer 1 top) was the spatially variable land surface, represented by preprocessed Digital Elevation Models (DEMs). Ten-meter resolution DEM data was available for Allegan County from the USGS National Elevation Dataset (NED).

The bottom boundary of the glacial layer (layer 1 bottom and layer 2 top) was represented with a spatially variable surface representing the top of the bedrock unit underlying the unconsolidated sediments. A 500m data layer created for the State of Michigan was used for process-based modeling.

The ease with which groundwater flows through the subsurface (hydraulic conductivity, or K) was represented with spatially variable 2D data-layers available for the State of Michigan, for both the glacial and bedrock aquifers. The data layer for the glacial aquifer was generated by interpolating estimates of K from records in the Wellogic database, public water supply and U.S. Geological Society aquifer-tests, and aquifer properties reported in literature. The bedrock layer was generated from interpretation of aquifer pumping tested completed by the State of Michigan of US Geological Survey (completed in prior study).

Infiltration of precipitation to the water table (groundwater recharge) was represented with a spatially variable 2D recharge input to the top-most cells in the groundwater model. For this project, a recharge raster layer was available (1609 m resolution) was available, generated following empirical methods

[1] Model calibration refers to the process of fine-tuning model input parameters or model representations within plausible ranges such that the simulated outputs (groundwater levels) best match the observed groundwater levels.
[2] Sensitivity analysis involves adjusting modeling inputs/representations from the calibrated values to other plausible (but less likely) values and evaluating the impact on the simulated outputs. This is common in groundwater modeling, as aquifer properties can vary significantly and are difficult to determine with a high degree of certainty.

presented in Holtschlag (1997) involving observed stream flow hydrographs and information related to land use, soil conditions, and watershed characteristics. Recharge only applies to layer 1 (the glacial aquifer).

In instances where the groundwater head exceeds the land surface elevation, groundwater can leave the aquifer as a sink of water (i.e., groundwater is lost as surface seepage). This approach automatically captures the exchange of groundwater to surface water bodies as part of the robust solution process, as the surface water stages (elevations) are embedded in the high-resolution DEM datasets available on the MAGNET server.

Treatment of water bodies as explicit features (internal boundary conditions) was also experimented with as part of the model sensitivity analysis. More specifically, streams, rivers, and lakes were represented as two-way head dependent flux boundaries, meaning they can function as sources or sinks of water to the aquifer depending on the head gradient between the aquifer and surface water body. However, this involves estimating more model parameters and longer simulation times, and the spatial distribution of groundwater mounds and valleys were, for all practical purposes, insensitive to which treatment of surface water bodies was used; therefore, the "DEM-based" approach was utilized in the final regional model and submodel (as opposed to using explicit surface water features in the model).

The following assumptions are utilized in the development of all process-based flow models:

- The flow field is steady and represents the long-term mean flow patterns. This assumption is commonly applied at regional and subregional scales for applications such as recharge and discharge area delineation, as large-scale spatial patterns dominate over temporal variabilities at this scale.
- Vertical variabilities in aquifer layers can be ignored (i.e., groundwater flow is assumed to be two-dimensional within aquifers, and water can exchange vertically between the glacial and bedrock aquifer). Again, this is a common treatment in regional or subregional flow analysis, where the horizontal scale of flow is much larger than the vertical scale (i.e., variability in horizontal direction is much larger than that in the vertical direction).
- Groundwater pumping can be ignored, as it does not have a significant impact on regional or subregional groundwater flow patterns (i.e., it does not change the large-scale spatial patterns of the mounds and valleys used for GPA delineation).

Calibration of each model was done by adjusting a "multiplier" to the input hydraulic conductivity and aquifer recharge layers. In other words, all values in the spatially-variable layer were multiplied by a number less than or greater than 1 to systematically "shift" the values up or down but preserve the overall spatial patterns of relatively high or low values. The land surface leakance (a parameter controlling the degree of surface seepage in areas where groundwater levels exceed land elevations or surface water stages) was adjusted as part of the calibration process. The regional model and all submodel utilized a calibrated leakance of 1 day^{-1}.

All model setup, calibration, visualization and analysis were completed using the MAGNET4Water[3] groundwater modeling platform developed and maintained by Hydrosimulatics INC.

[3]Accessible at: https://magnet4water.net/magnet

Model Results

The model flow results (water levels, or head, and velocity vectors) and calibration results (model comparison to data and final model parameters) for the regional model are shown in Figure 2. The flow results and calibration results for the Northern, Southwestern, and Southeastern Models are shown in Figure 3, 4, and 5, respectively.

Table 1 presents the final calibrated multipliers for the hydraulic conductivity (K) layers and recharge layers (R) for each of the models. Calibration results (model performance evaluations) are presented in Table 2, including the following statistical indicators:

- Numb. Pts. – number of calibration targets (Static Water Levels for comparison to observed heads);
- Root-mean-square error – measure of "spread" of the data about the central tendency of the data (the Static Water Level "cloud");
- Mean error – measure of systematic bias of the model relative to the data (e.g., consistent overestimation or underestimation of the model relative to the data); and
- Nash-Sutcliffe Coefficient – an indicator of the goodness-of-fit between the model and Static Water Levels (a value of 1 is a perfect fit; values closer to 1 (e.g., >0.8) are considered a good fit).

The calibration of both the regional model and submodels is considered acceptable (or quite reasonable), given the small mean error of the models (i.e., the models, generally speaking, are not significantly over-estimating or underestimating water levels across space) and the Nash-Sutcliffe Coefficients above 0.9 for all models. The root-mean-square (RMS) errors are somewhat large (note the "spread" in the data cloud in each of the calibration charts); however, this is not suprising, as the SWL data used for calibration are "noisy" (involve large uncertainties) and the model does not capture temporal variabilities or subscale heterogeneities (which also contributes to some of the "spreading" of the calibration data). Nonetheless, the RMS errors are significantly smaller than the overall variability in head/water levels, meaning the models are able to capture the overall spatial structure of the flow system. (Although SWL data may not be very meaningful for analysis in "isolation" (i.e., for a single well) they have proven to be effective when analyzed statistically or through an aggregated spatial analysis, and the excellent spatial coverage and density of the SWL data make them uniquely suited to for this groundwater modeling exercise.)

The calibrated flow results also help to validate final model configurations, as they match well with hydrologic intuition. In the regional model, the distribution of groundwater discharge areas (where groundwater head/levels are lowest) coincides with the surface water network of the major streams/rivers and Lake Michigan (see Figure 6). The groundwater mounds or recharge areas (where groundwater head/levels are highest) are in the highland areas in between the major streams and rivers.

The northern submodel (Figure 3) follows the Grand River as its northern boundary, the Thornapple River as its eastern boundary, and the Rabbit River as its southern boundary. Lake Michigan forms the western boundary. Again, the distribution of recharge areas is consistent with topographic highs, and the discharge areas are situated along stream and river corridors.

The southwestern submodel (Figure 4) follows the Thornapple River and Gun Lake as its eastern boundary and the Rabbit River as its northern boundary. The southern boundary is situated beyond the groundwater mounds south of the County border to ensure the groundwater divide could be identified. The western boundary is formed by Lake Michigan.

The southeastern submodel (Figure 5) follows the distribution of recharge mounds to the east and south (ensuring the boundary goes beyond these mounds) and the boundaries of the other submodels to the west and north (such that the county has seamless/complete coverage among the three submodels).

Groundwater Protection Area

Figure 6 shows the groundwater protection area boundary identified from each model. Recall that groundwater flow is perpendicular to head contours; this principle was applied in the delineation of the GPA extending from the groundwater divide.

Figure 7 shows the final Groundwater Protection Area for Allegan County, "sticked together" from the submodel delineations.

Of course, the GPA includes all of Allegan County, but also portions of Ottawa County (including Zeeland Twp. and Jamestown Twp.) Kent County (Byron Twp. and a small portion of Gaines Twp.), Barry County (Orangeville Twp., Prairieville Twp., and a small portion of Barry Twp.), Kalamazoo County (Cooper Twp., Alamo Twp., and Oshtemo Twp.), and Van Buren County (Pine Grove Twp., Bloomingdale Twp., Columbia Twp., and Geneva Twp.).

Note that, in some places, groundwater is leaving the county as it flows "outward", across the boundary; in those places, the GPA boundary coincides with the County border. Also note that in some places, groundwater from outside of the county is flowing towards the county, but is not included in the GPA. This is because the groundwater is those areas will naturally discharge to the surface before entering the County.

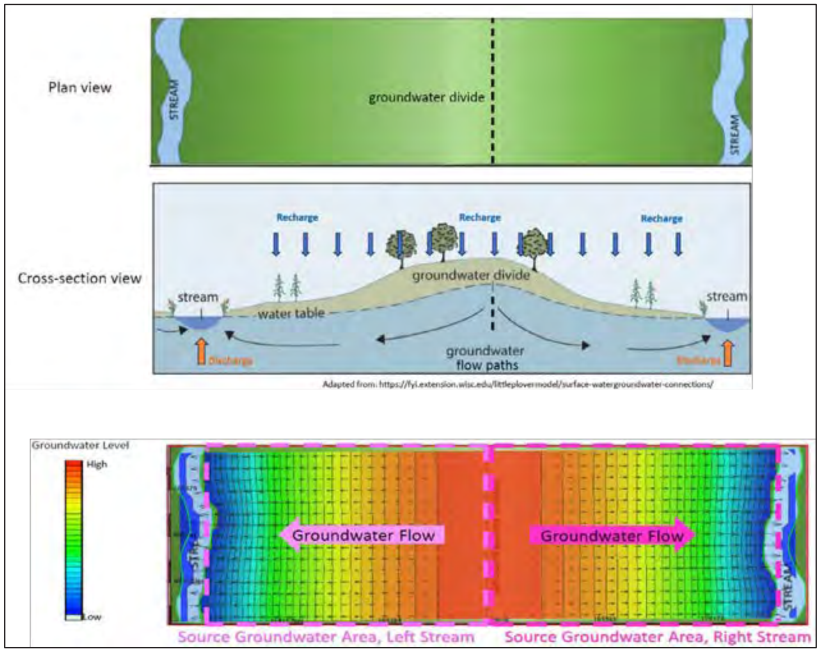


Figure 1: Concept of a groundwater divide and source groundwater areas.

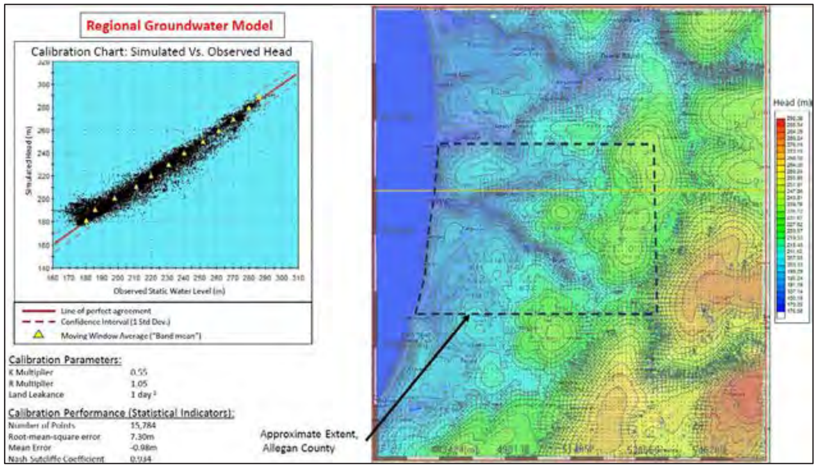


Figure 2: Regional Groundwater Model Results and Calibration.

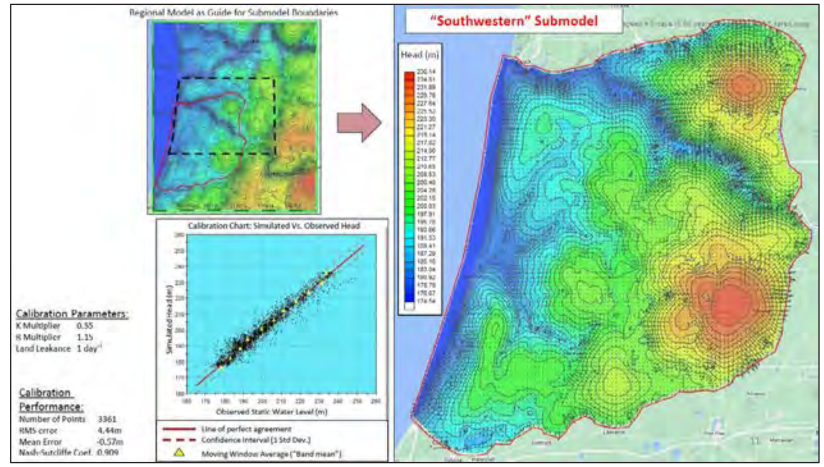


Figure 4: "Southwestern" Submodel Results – Flow Patterns, Calibrated Parameters, and Calibration Performance.

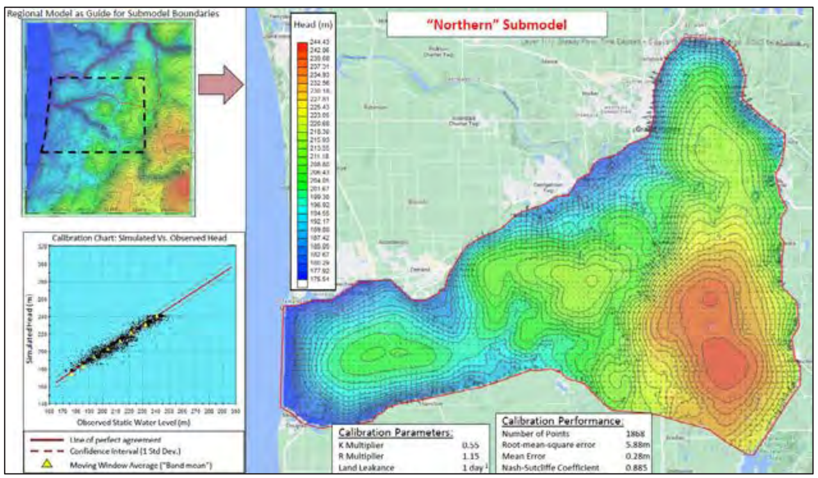


Figure 3: "Northern" Submodel Results – Flow Patterns, Calibrated Parameters, and Calibration Performance.

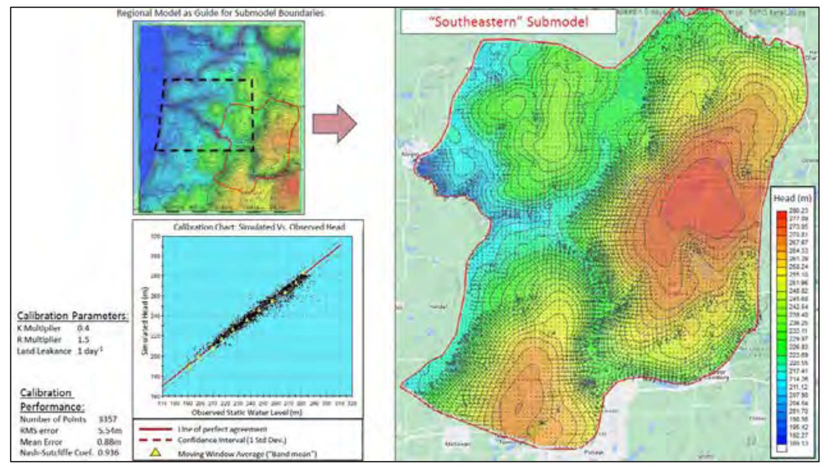


Figure 5: "Northwestern" Submodel Results– Flow Patterns, Calibrated Parameters, and Calibration Performance.

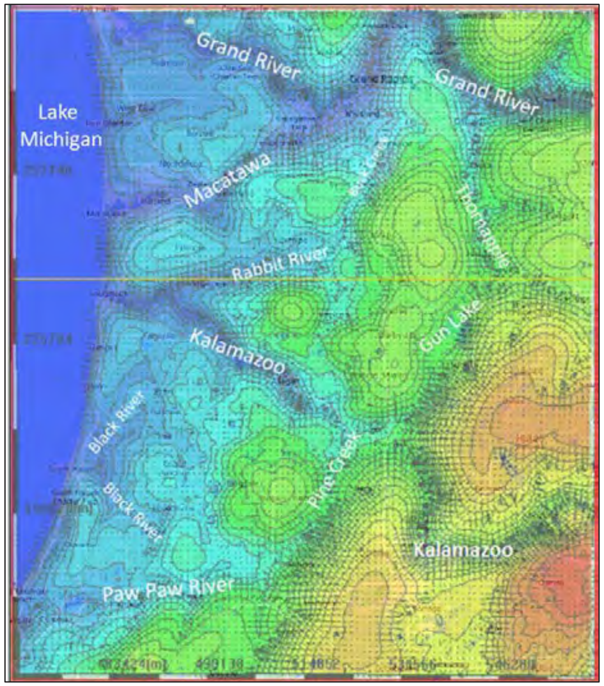


Figure 6: Calibrated Regional Flow Model Results, with Annotations of Major Surface Water Bodies.

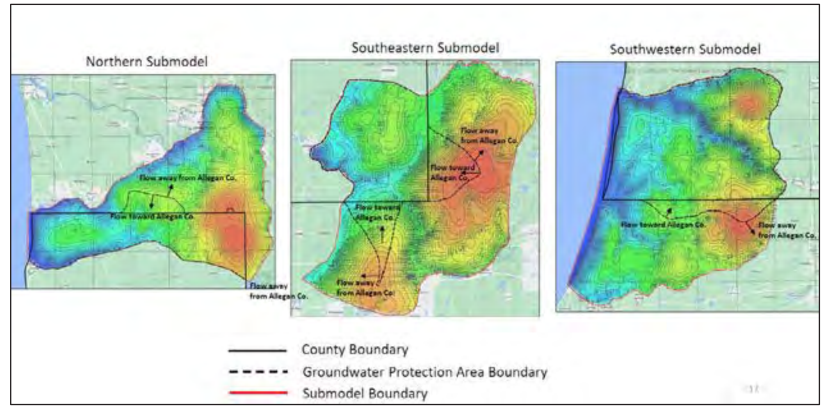


Figure 7: Groundwater Protection Area Boundary from Each Submodel Result.

Table 1: Final Calibrated Multipliers for Hydraulic Conductivity (K) and Recharge (R) Layers in Each Model.

Model	K Multiplier	R Multiple
Regional	0.55	1.05
Northern Sub	0.55	1.05
Southwestern Sub	0.55	1.15
Southeastern Sub	0.4	1.5

Table 2: Calibration Performance for Regional Model and Submodels.

Model	Numb. Pts	RMS-Error	Mean Error	Nash-Sutcliffe Coefficient
Regional	15784	7.3	-0.98	0.934
Northern Sub	1868	5.88	0.28	0.885
Southwestern Sub	3361	4.44	-0.57	0.909
Southeastern Sub	3357	5.54	0.88	0.936

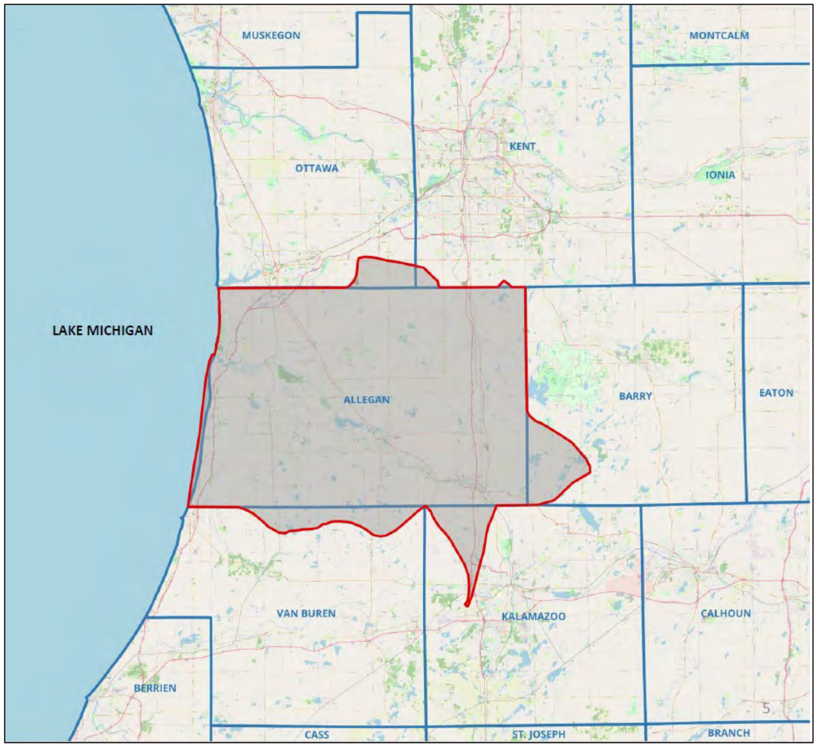


Figure 8: Groundwater Protection Area for Allegan County.

Figure 9: Zoom-in of Groundwater Protection Area for Allegan County, with Annotations.

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APPENDIX D

Point Source Inventory & Contamination Risk Map Tasks

Writeup of Source Inventory and Contamination Risk Map Tasks

Allegan Strategic Groundwater Strategic Plan Development Project

Contamination risk due to point source (PS) pollution was assessed by combining the results from the Phase 2 Allegan County Groundwater Study with risk classifications made by EGLE[1] engineers and scientists based on site-specific criteria related to human and environmental health risk. The point sources are 351 sites of groundwater concern identified in (or just beyond) Allegan County, including:

- 237 Sites of Environmental Contamination (Part 201) downloaded from the Environmental Mapper[2] web application maintained by the Department of Environment, Great Lakes, and Energy (EGLE);
- 46 historical or operational landfills or waste handlers (Part 105, Part 111) downloaded from the Michigan Geographic Information System (GIS) data portal[3];
- 63 "Open" (Active) LUST sites from the Environmental Mapper application; and
- 5 Per- and polyfluoroalkyl substances (PFAS) sites downloaded August 2022 from the EGLE's MPART PFAS Geographic Information System[4]

The Phase 2 study was essentially an "off-site risk potential" analysis of the sites completed through spatial modeling (simulation) of groundwater flow systems underlying the sites, and subsequent flow tracing (particle tracking) downstream from sites to delineate potential groundwater impact areas, at travel times of 2yr, 10yr, and 20 years. Sites and their impacts areas were overlaid with maps of critical groundwater receptors, i.e., drinking water wells (including wellhead protection or source water areas of community supply wells), non-drinking water wells, and surface water bodies (streams/rivers, lakes, and wetlands) – and aquifer vulnerability (or sensitivity) to surface pollution.

The integrated mapping product was used to develop "risk scores" to each site based on its proximity (and that of its impact areas) to groundwater receptors and the aquifer vulnerability at the site. A risk score (0-100, with 100 being largest risk, zero being no risk) was assigned for drinking water, non-drinking water (e.g., industry or irrigation), and surface water, and then a total (or overall) risk score was computed as a weighted average of the category-based risk scores. The sites were then ranked based on risk scores to generate a priority list for additional follow-up.

See complete detailed in the project report "ALLEGAN COUNTY GROUNDWATER STUDY – PHASE 2: Screening-Level Modeling, Risk Analysis, and Ranking" available on the Allegan County Water Study website: Water Study | Allegan County, MI.

The Phase 2 did not investigate the *human and environmental health* aspects of the point sources (site contamination), e.g., the type of substance or chemical compound involved, the strength and duration of the release at the site, concentrations found in groundwater at the site and how they relate to public health / drinking water standards, etc. This type of "on-site" analysis, when combined with the risk prioritization based on system hydrogeology (off-site risk potential), paints a complete picture of the overall risk a contamination site poses to groundwater (including downstream receptors such as water wells and surface water). Therefore, a contamination site source inventory of available on-site information, documentation, analyses, assessments, etc. was completed as part of this current project.

To complete the contamination source inventory, we took advantage of the recently available Remedial Information Data Exchange (RIDE) system[1] created and maintained by EGLE[5]. The RIDE system is a web portal (application) that organizes and makes available site-specific information/metadata and documentation for many of the sites of environmental concern identified by the of State of Michigan in past decades. This includes 285 of Allegan's 351 sites of groundwater concern.

For the sites available on RIDE, a RIDE Risk classification was extracted, which identifies (as determined by the thorough review by a EGLE engineer or scientist) the current risk of the site as it relates to on-site or near-site human and environmental health exposures through several pathways, including drinking water ingestion, inhalation, skin exposure, and groundwater-surface water / ecosystem interfaces. The classifications are based on site characteristics (plot- or property-scale), data collected on-site (e.g., soil and groundwater quality samples), and established public health standards and/or site-specific criteria. For example, a RIDE Risk classification of " Risk Controlled - Final" may be assigned to a site if, after review of the available information, no further action is required,

[1] EGLE=Michigan's Department of Environment, Great Lakes, and Energy
[2] Accessible at: https://www.mcgi.state.mi.us/environmentalmapper/#
[3] Accessible at: https://gis-michigan.opendata.arcgis.com/
[4] https://egle.maps.arcgis.com/apps/webappviewer/index.html?id=bdec7880220d4ccf943aea13eba102db

[5] Accessible at: https://www.michigan.gov/egle/maps-data/ride

or at the opposite extreme, a classification of "Risks Present and Immediate" will be assigned if there is clear evidence a criterion is exceeded or immediately threatened.

For the purposes of this study, RIDE Risk classifications for the following categories were extracted: Drinking Water Ingestion, Groundwater-Surface Water Interface, and Sensitive Environmental Receptors.

The next step was to develop metrics for the RIDE Risk classifications so that they could be combined with the Phase 2 risk scores. The idea was to assign "multipliers" to the Phase 2 Risk scores to scale them up or down (increased or decreased risk, respectively) based on the "new" information from the RIDE system.

For example, a multiplier of <1 was assigned to sites with "Risk Controlled – Final" or "Risk Controlled – Interim", while a multiplier of >1 was used for sites with "Risk Present in the Long Term" and similar (or riskier) classifications. If there were insufficient data for a RIDE Risk classification to be assigned, or if the Site was not available in the RIDE System ("N/A"), a multiplier of 1.0 was assigned, as no additional information was available to justify modifying the Phase Risk score up nor down. Based on this rationale, a set of multipliers for each category (Drinking Water Ingestion, Groundwater-Surface Water Interface, and Sensitive Environmental Receptors) were developed (see Tables below). Then, the multipliers were applied, site-by-site, to the Phase 2 risk scores to create new "composite" risk scores (i.e., scores based on both Phase 2 and RIDE information) for drinking water and surface water, and total risk score (weighted average):

$$Composite\ Risk\ Score\ = w_{DW}DW_c + w_{NDW}NDW + w_{SW}SW_c$$

where $DW_c = \text{composite drinking water risk score} =$ $\text{(RIDE Drinking Water Multiplier)} * \text{(Phase 2 Drinking Water risk sore)}$

$\text{NDW} = \text{Phase 2 Nondrinking Water risk score}$

$SW_c = \text{composite drining water risk score} =$ $[\text{(RIDE Surface Water Multiplier)} * \text{(RIDE Env. Recptor Multipler)}]/2 *$ $\text{(Phase 2 Drinking Water risk sore)}$

$w_{DW} = weight\ of\ drinking\ water\ risk\ score = 0.5$ (weight assigned in Phase 2 Study)

$w_{NDW} = weight\ of\ drinking\ water\ risk\ score = 0.3$ (weight assigned in Phase 2 Study)

$w_{SW} = weight\ of\ drinking\ water\ risk\ score = 0.2$ (weight assigned in Phase 2 Study)

The total composite score was used to generate a new ranking (priority) list, and a change-in-rank relative to Phase 2 ranking was computed. The results are shown in map-based form below.

Multiplier Assigned	RIDE Drinking Water Ingestion Risk Classification
1.0	**N/A or Inadequate Data to Assign Risk**
0.25	**Risk Controlled Final** - There is no groundwater contamination that exceeds drinking water criteria, groundwater contamination is not in an aquifer, or there are not current groundwater uses for drinking water or other uses that may have a long-term effect on human health, safety or welfare, and potential future uses are reliably restricted.
0.5	**Risk Controlled Interim** - There is no groundwater contamination that exceeds drinking water criteria, groundwater contamination is not in an aquifer, or there are not current groundwater uses for drinking water or other uses that may have a long-term effect on human health, safety or welfare.
1.15	**Risk Present and Require Action in the Long Term** - Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the know extent of the contaminants of concern. Or Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from the known extent of the contaminates of concern.
1.25	**Risk Present and Requires Action in the Short Term** - Groundwater contamination exceeds drinking water criteria and public or private potable water supply wells, producing from a different interval of the aquifer, are located within the known extent of contaminants of concern. *OR,* A non-potable water supply well exceeds criteria or is immediately threatened, e.g., irrigation wells, non-contact cooling water, stab wells for filling pools or other outside uses, etc.
1.35	**Risk Present and Requires Action in the Short Term** - Groundwater contamination exceeds drinking water criteria and a public or private water supply well that is producing from the contaminated aquifer, is located within two years groundwater travel time from the known extent of contaminants of concern.
1.5	**Risks Present and Immediate** - A public or private potable water supply well, or public water supply line exceeds drinking water criteria or is immediately threatened. A potable water supply is "immediately threatened" if contaminants are documented in the drinking water but below drinking water criteria (or) no contaminants have yet been documented in the drinking water but contamination of the potable water supply is expected at any time due to the proximity of the well or surface water intake to groundwater or surface water contaminated above drinking water criteria.

Multiplier Assigned	RIDE Groundwater-Surface Water Interface (GSI)
1.0	**N/A or Inadequate Data to Assign Risk**
0.25	**Risk Controlled Final** - There is no groundwater contamination that exceeds drinking water criteria, groundwater contamination is not in an aquifer, or there are not current groundwater uses for drinking water or other uses that may have a long-term effect on human health, safety or welfare, and potential future uses are reliably restricted.
0.5	**Risk Controlled Interim** - There is no groundwater contamination that exceeds drinking water criteria, groundwater contamination is not in an aquifer, or there are not current groundwater uses for drinking water or other uses that may have a long-term effect on human health, safety or welfare.
1.1	**Risk Present and Require Action in the Long Term** - The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years
1.25	**Risk Present and Requires Action in the Short Term** - Groundwater contamination exceeds drinking water criteria and a public or private water supply well that is producing from the contaminated aquifer, is located within two years groundwater travel time from the known extent of contaminants of concern.
1.5	**Risks Present and Immediate** - Contaminated groundwater is discharging to a surface water body above the Water Quality Standards – Final Acute Values (FAV) or resulting in visible NAPL file or sheen present on surface water

Multiplier Assigned	RIDE Sensitive Environmental Receptor
1.0	**N/A or Inadequate Data to Assign Risk**
0.25	**Risk Controlled Final** - No sensitive habitat or resources exist on or near the site or facility
0.5	**Risk Controlled Interim** - No sensitive habitat or resources exist on or near the site or facility
1.1	**Risk Present and Require Action in the Long Term** - The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.)
1.25	**Risk Present and Requires Action in the Short Term** - The leading edge of the groundwater contaminant plume is located within two years groundwater travel time distance of a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.)
1.5	**Risks Present and Immediate** - A sensitive habitat of sensitive resource (e.g., sport fish, economically important species, threatened or endangered species, wetland, etc.) may be exposed to contaminated media or measurable or observable harm may occur

APPENDIX E

Review of the Top 25 Sites of Groundwater Concern

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Phone: (517) 580-8215
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Inventory and Review of the Top 25 Sites of Groundwater Concern

Completed as part of the project:

Allegan County Groundwater Strategic Plan

Contaminant Source Inventory Subtask

of the

Groundwater Assessment Report

Completed by

Zachary Curtis, Ph.D.

Hydrosimulatics INC.

Last Modified: June 14, 2024

OVERVIEW

One of the key tasks of the project "Allegan County Groundwater Strategic Plan" was the inventory and analysis of the contamination risk due to sites of groundwater concern previously identified in the Phase II Allegan County Groundwater Study. A priority map/list was developed based on analysis of "off-site" plume migration analysis (Phase II study) and "on-site" environmental assessments and risk-based criteria used by engineers and scientists at Michigan's Department of Environment Great Lakes and Energy (EGLE).

At Allegan's County's request, a thorough analysis and summary of the existing documentation was completed for each of the highest priority sites, or more specifically, the top 25 sites in terms of risk to groundwater resources. The documentation was accessed from EGLE Remedial Information Remedial Information Data Exchange (RIDE) system[1].

The specific information detailed for each of the highest priority sites includes:

- Site ID, Site Name, Local Government Unit (LGU), original dataset, and substances of concern
- Relevant drinking water standards and human health perspectives
- EGLE RIDE reviewer risk classifications based on Part 201 risk-based criteria
- Summary of previous Baseline Environmental Assessments (BEA) and other documentation, e.g., Phase 1 and Phase 2 Environmental Site Assessments (ESAs)
- Concentrations/exceedances of hazardous substances/contaminants
- Comments regarding water well and surface water risk from the Phase 2 Allegan County Groundwater Study
- Recommendations for off-site groundwater sampling at water wells

Of the original top 25 sites, 4 did not have information/documentation available. Therefore, the list was expanded to the top 30 sites (which included 25 sites with information available in the RIDE system).

Please note that this document represents a synthesis or summary of existing information. No new information or professional opinions are presented. In many cases, the original information presented in a BEA or ESA is paraphrased or reworded to be more concise.

Information that is presented that pertains to relevant drinking water standards and human health perspectives is pulled from online resources made available by the US Environmental Protection Agency[2].

[1] Accessible at: https://www.michigan.gov/egle/maps-data/ride

[2] Accessible at: https://www.epa.gov/sdwa

CONTENTS

OVERVIEW **2**

CONTENTS **3**

PRIORITY RANK #1 .... **17**

Site Name: 687 North 10th Street 17
Site ID: 03000356 17
Local Unit of Government: Gunplain Twp. 17
Dataset: Site of Environmental Concern (EGLE PART 201) 17
Substances of concern: Iron, Manganese 17
Relevant Drinking Water Standards 17
Iron Secondary Drinking Water Standard *17*
Manganese Secondary Drinking Water Standard *17*
Human Health Perspectives 17
Iron *17*
Manganese *17*
RIDE Classifications 17
Ride Risk Category *17*
Drinking water ingestion category *18*
Groundwater – Surface Water Interface *18*
Sensitive Environmental Receptors *18*
RIDE Reviewer Comments: 18
Baseline Environmental Assessment (BEA) 18
Phase 2 Groundwater Study Comments 19
Recommended Off-Site Groundwater Data Collection (Target Wells) 19

PRIORITY RANK #2 .... **21**

Site Name: 203 South Main Street 21
Site ID: 03000306 21
Local Unit of Government: City of Wayland 21
Dataset: Site of Environmental Concern (EGLE PART 201) 21
Substances of concern: Methylene chloride or Dichloromethane (DCM), Lead 21
Relevant Drinking Water Standards 21
Methylene chloride Maximum Contaminant Level Goal (MCLG) *21*
Lead Maximum Contaminant Level Goal (MCLG) *21*
Lead Action Level: *21*
Human Health Perspectives 21
Methylene chloride *21*
Lead *21*
RIDE Classification 22
Ride Risk Category *22*
Drinking water ingestion category *22*
Groundwater – Surface Water Interface *22*
Sensitive Environmental Receptors *22*
RIDE Reviewer Comments: 22
Baseline Environmental Assessment (BEA) 22

Phase 2 Groundwater Study Comments 23
Recommended Off-Site Groundwater Data Collection (Target Wells) 24

PRIORITY RANK #3 .... **26**

Site Name: Wayland Self Serve 26
Site ID: 00015681 26
Local Unit of Government: City of Wayland 26
Dataset: Leaky Underground Storage Tanks (Part 213) 26
Substances of concern: unknown 26
Phase 2 Groundwater Study Comments 26
Recommended Off-Site Groundwater Data Collection (Target Wells) 26

PRIORITY RANK #4 .... **28**

Site Name: 114 Pine Street 28
Site ID: 3000277 28
Local Unit of Government: City of Wayland 28
Dataset: Site of Environmental Concern (EGLE PART 201) 28
Substances of concern: Lead, Arsenic 28
Relevant Drinking Water Standards 28
Lead Maximum Contaminant Level Goal (MCLG) *28*
Lead Action Level: *28*
Arsenic Maximum Contaminant Level (MCL) *28*
Human Health Perspectives 28
Lead *28*
Arsenic *28*
RIDE Classification: 29
Ride Risk Category *29*
Drinking water ingestion category *29*
Groundwater – Surface Water Interface *29*
Sensitive Environmental Receptors *29*
RIDE Reviewer Comments 29
Baseline Environmental Assessment (BEA) 29
Phase 2 Groundwater Study Comments 30
Recommended Off-Site Groundwater Data Collection (Target Wells) 30

PRIORITY RANK #5 .... **32**

Site Name: 585 10th St. Plainwell 32
Site ID: 3000211 32
Local Unit of Government: Gunplain Township 32
Dataset: Site of Environmental Concern (EGLE PART 201) 32
Substances of concern: Lead, Cadmium, Chromium, Ethylbenzene, xylenes, and 2-methylnapthalene 32
Relevant Drinking Water Standards 32
Lead Maximum Contaminant Level Goal (MCLG) *32*
Lead Action Level: *32*
Cadmium Maximum Contaminant Level (MCL) *32*
Chromium Maximum Contaminant Level (MCL) *32*
Ethylbenzene Maximum Contaminant Level Goal (MCL) *32*
Xylenes Maximum Contaminant Level Goal (MCL) *32*
2-methylnapthalene *32*

HUMAN HEALTH PERSPECTIVES ... 32
Lead ... *32*
Cadmium ... *33*
Chromium ... *33*
Ethylbenzene ... *33*
Xylenes ... *33*
2-methylnapthalene ... *33*
RIDE CLASSIFICATIONS: ... 33
Ride Risk Category ... *33*
Drinking water ingestion category ... *33*
Groundwater – Surface Water Interface ... *34*
Sensitive Environmental Receptors ... *34*
RIDE REVIEWER COMMENTS: ... 34
BASELINE ENVIRONMENTAL ASSESSMENT (BEA) ... 34
PHASE 2 GROUNDWATER STUDY COMMENTS: ... 35
RECOMMENDED OFF-SITE GROUNDWATER DATA COLLECTION (TARGET WELLS) ... 35
PRIORITY RANK #6 ... 37
SITE NAME: 3603 N. MAIN STREET ... 37
SITE ID: 03000325 ... 37
LOCAL UNIT OF GOVERNMENT: LEIGHTON TWP ... 37
DATASET: SITE OF ENVIRONMENTAL CONCERN (EGLE PART 201) ... 37
RELEVANT DRINKING WATER STANDARDS ... 37
Lead Maximum Contaminant Level Goal (MCLG) ... *37*
Lead Action Level: ... *37*
Ethylbenzene Maximum Contaminant Level (MCL) ... *37*
Xylenes Maximum Contaminant Level (MCL) ... *37*
2-methylnapthalene Maximum Contaminant Level (MCL) ... *37*
HUMAN HEALTH PERSPECTIVES ... 37
Lead ... *37*
Ethylbenzene ... *38*
Xylenes ... *38*
2-methylnapthalene ... *38*
RIDE CLASSIFICATION: ... 38
Ride Risk Category ... *38*
Drinking water ingestion category ... *38*
Groundwater – Surface Water Interface ... *38*
Sensitive Environmental Receptors ... *39*
RIDE REVIEWER COMMENTS ... 39
BASELINE ENVIRONMENTAL ASSESSMENT (BEA) ... 39
PHASE 2 GROUNDWATER STUDY COMMENTS: ... 40
RECOMMENDED OFF-SITE GROUNDWATER DATA COLLECTION (TARGET WELLS) ... 40
PRIORITY RANK #7 ... 43
SITE NAME: 712 EAST BRIDGE STREET ... 43
SITE ID: 03000360 ... 43
LOCAL UNIT OF GOVERNMENT: CITY OF PLAINWELL ... 43
DATASET: SITE OF ENVIRONMENTAL CONCERN (EGLE PART 201) ... 43
SUBSTANCES OF CONCERN: LEAD, XYLENE, BENZENE, VANADIUM ... 43

RELEVANT DRINKING WATER STANDARDS ... 43
Lead Maximum Contaminant Level Goal (MCL) ... *43*
Lead Action Level: ... *43*
Xylene Maximum Contaminant Level (MCL) ... *43*
Benzene Maximum Contaminant Level (MCL) ... *43*
Vanadium ... *43*
HUMAN HEALTH PERSPECTIVES ... 43
Lead ... *43*
Xylenes ... *44*
Benzene ... *44*
Vanadium ... *44*
RIDE CLASSIFICATION: ... 44
Ride Risk Category ... *44*
Drinking water ingestion category ... *44*
Groundwater-Surface Water Interface (GSI) ... *44*
Sensitive Environmental Receptors ... *45*
RIDE REVIEWER COMMENTS: ... 45
BASELINE ENVIRONMENTAL ASSESSMENT (BEA) ... 45
PHASE 2 GROUNDWATER STUDY COMMENTS ... 46
RECOMMENDED OFF-SITE GROUNDWATER DATA COLLECTION (TARGET WELLS) ... 46
PRIORITY RANK #8 ... 48
SITE NAME: 798 E. BRIDGE STREET FMRLY 760 E. BRIDGE ... 48
SITE ID: 03000367 ... 48
LOCAL UNIT OF GOVERNMENT: CITY OF PLAINWELL ... 48
DATASET: SITE OF ENVIRONMENTAL CONCERN (EGLE PART 201) ... 48
SUBSTANCES OF CONCERN: LEAD, MERCURY, ARSENIC, CHROMIUM ... 48
RELEVANT DRINKING WATER STANDARDS ... 48
Lead Maximum Contaminant Level Goal (MCLG) ... *48*
Lead Action Level: ... *48*
Mercury Maximum Contaminant Level (MCL) ... *48*
Arsenic Maximum Contaminant Level (MCL) ... *48*
Chromium Maximum Contaminant Level (MCL) ... *48*
HUMAN HEALTH PERSPECTIVES ... 48
Lead ... *48*
Mercury ... *48*
Arsenic ... *49*
Chromium ... *49*
RIDE CLASSIFICATIONS: ... 49
Ride Risk Category ... *49*
Drinking water ingestion category ... *49*
Groundwater – Surface Water Interface ... *49*
Sensitive Environmental Receptors ... *49*
RIDE REVIEWER COMMENTS: ... 49
BASELINE ENVIRONMENTAL ASSESSMENT (BEA) ... 50
PHASE 2 GROUNDWATER STUDY COMMENTS ... 50
RECOMMENDED OFF-SITE GROUNDWATER DATA COLLECTION (TARGET WELLS) ... 50
PRIORITY RANK #9 ... 52

Site ID: 03000288 52
Site Name: 1258, 1260 Lincoln Road & Village EMH Pk 52
Local Unit of Government: Allegan Twp. 52
Dataset: Site of Environmental Concern (EGLE PART 201) 52
Substances of concern: Nitrate and benzo(a)pyrene 52
Relevant Drinking Water Standards 52
Nitrate Maximum Contaminant Level (MCL) 52
Benzo(a)pyrene Maximum Contaminant Level Goal (MCLG) 52
Human Health Perspectives 52
Nitrate 52
Benzo(a)pyrene: 52
RIDE Classification: 52
Ride Risk Category 52
Drinking water ingestion category 53
Groundwater-Surface Water Interface (GSI) 53
Sensitive Environmental Receptors 53
RIDE Reviewer Comments: 53
Baseline Environmental Assessment (BEA) 53
Phase 2 Groundwater Study Comments 54
Recommended Off-Site Groundwater Data Collection (Target Wells) 54

PRIORITY RANK #10 57

Site Name: 150 North Main Street 57
Site ID: 03000265 57
Local Unit of Government: City of Wayland 57
Dataset: Site of Environmental Concern (EGLE PART 201) 57
Substances of concern: Lead, Arsenic, Mercury, Tetrachloroethylene (PCE), Trichloroethylene (TCE) 57
Relevant Drinking Water Standards 57
Lead Maximum Contaminant Level Goal (MCLG) 57
Lead Action Level: 57
Arsenic Maximum Contaminant Level (MCL) 57
Mercury Maximum Contaminant Level (MCL) 57
Tetrachloroethylene (PCE) Maximum Contaminant Level (MCL) 57
Trichloroethylene (TCE) Maximum Contaminant Level (MCL) 57
Human Health Perspectives 57
Lead 57
Arsenic 58
Mercury 58
Tetrachloroethylene (PCE) 58
Trichloroethylene (TCE) 58
RIDE Classification: 58
Ride Risk Category 58
Drinking water ingestion category 58
Groundwater-Surface Water Interface (GSI) 58
Sensitive Environmental Receptors 59
RIDE Reviewer Comments 59
Baseline Environmental Assessment (BEA) 59
Phase 2 Groundwater Study Comments 60
Recommended Off-Site Groundwater Data Collection (Target Wells) 60

PRIORITY RANK #11 62

Site Name: 101 124th Avenue 62
Site ID: 03000268 62
Local Unit of Government: Wayland Twp. 62
Dataset: Site of Environmental Concern (EGLE PART 201) 62
Relevant Drinking Water Standards 62
Lead Maximum Contaminant Level Goal (MCLG) 62
Lead Action Level: 62
Human Health Perspectives 62
Lead 62
RIDE Classification: 62
Ride Risk Category 62
Drinking water ingestion category 63
Groundwater-Surface Water Interface (GSI) 63
Sensitive Environmental Receptors 63
RIDE Reviewer Comments: 63
Baseline Environmental Assessment (BEA) 63
Phase 2 Groundwater Study Comments 64
Recommended Off-Site Groundwater Data Collection (Target Wells) 64

PRIORITY RANK #12 66

Site Name: 236 Hubbard Street 66
Site ID: 03000310 66
Local Unit of Government: City of Allegan 66
Dataset: Site of Environmental Concern (EGLE PART 201) 66
Substances of concern: Arsenic, vinyl chloride, Lead, Benzo(b)fluoranthene 66
Relevant Drinking Water Standards 66
Arsenic Maximum Contaminant Level (MCL) 66
Vinyl chloride Maximum Contaminant Level Goal (MCLG) 66
Lead Maximum Contaminant Level Goal (MCLG) 66
Lead Action Level: 66
Benzo(b)fluoranthene Maximum Contaminant Level Goal (MCLG) 66
Human Health Perspectives 66
Arsenic 66
Vinyl chloride 67
Lead 67
Benzo(b)fluoranthene 67
RIDE Classification: 67
RIDE Risk Category 67
Drinking water ingestion category 67
Groundwater-Surface Water Interface (GSI) 67
Sensitive Environmental Receptors 68
RIDE Reviewer Comments 68
Baselines Environmental Assessment(s) 68
Phase 2 Groundwater Study Comments 68
Recommended Off-Site Groundwater Data Collection (Target Wells) 69

PRIORITY RANK #13 70

Site Name: 1218 M-89 Highway ... 70
Site ID: 03000283 ... 70
Local Unit of Government: Allegan Twp. ... 70
Dataset: Site of Environmental Concern (EGLE PART 201) ... 70
Substances of concern: Lead, Iron, Manganese, Chromium, Arsenic ... 70
Relevant Drinking Water Standards ... 70
Lead Maximum Contaminant Level Goal (MCLG)... 70
Lead Action Level: ... 70
Arsenic Maximum Contaminant Level (MCL) ... 70
Chromium Maximum Contaminant Level Goal (MCL) ... 70
Human Health Perspectives ... 70
Lead... 71
Iron... 71
Manganese... 71
Arsenic... 71
Chromium... 71
RIDE Classification: ... 71
Drinking water ingestion category ... 71
Groundwater – Surface Water Interface ... 71
Sensitive Environmental Receptors ... 72
RIDE Reviewer Comments: ... 72
Baseline Environmental Assessment ... 72
Phase 2 Groundwater Study Comments ... 73
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 73

PRIORITY RANK #14 ... 75

Site Name: 637 West Sycamore Street, Wayland ... 75
Site ID: 03000436 ... 75
Local Unit of Government: City of Wayland ... 75
Dataset: Site of Environmental Concern (EGLE PART 201) ... 75
Substances of concern: Iron, Arsenic ... 75
Relevant Drinking Water Standards ... 75
Iron Secondary Drinking Water Standard ... 75
Arsenic Maximum Contaminant Level (MCL) ... 75
Human Health Perspectives ... 75
Iron... 75
Arsenic... 75
RIDE Classification: ... 75
Ride Risk Category... 75
Drinking water ingestion category ... 76
Groundwater-Surface Water Interface (GSI) ... 76
Sensitive Environmental Receptors... 76
RIDE Reviewer Comments: ... 76
Baseline Environmental Assessment(s) ... 77
Phase 2 Groundwater Study Comments ... 77
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 77

PRIORITY RANK #15 ... 79

Site Name: Ridderman Card-OP ... 79
Site ID: 00011505 ... 79
Local Unit of Government: Gunplain Twp. ... 79
Dataset: Leaky Underground Storage Tanks (Part 213) ... 79
Substances of concern: unknown ... 79
Phase 2 Groundwater Study Comments ... 79
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 79

PRIORITY RANK #16 ... 81

Site Name: Martin (LUST Site) ... 81
Site ID: 00015678 ... 81
Local Unit of Government: Village of Martin ... 81
Dataset: Leaky Underground Storage Tanks (Part 213) ... 81
Substances of concern: unknown ... 81
Phase 2 Groundwater Study Comments ... 81
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 81

PRIORITY RANK #17 ... 84

Site Name: 6494 Clearbrook Drive & 6402 and 6500 13 ... 84
Site ID: 03000439 ... 84
Local Unit of Government: Saugatuck Twp. ... 84
Dataset: Site of Environmental Concern (EGLE PART 201) ... 84
Substances of concern: Lead ... 84
Relevant Drinking Water Standards ... 84
Maximum Contaminant Level Goal (MCLG)... 84
Lead Action Level: ... 84
Human Health Perspectives ... 84
Lead... 84
RIDE Classification: ... 84
Ride Risk Category... 84
Drinking water ingestion category ... 85
Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the know extent of the contaminants of concern. ... 85
Groundwater-Surface Water Interface (GSI) ... 85
Sensitive Environmental Receptors... 85
RIDE Reviewer Comments ... 85
Baseline Environmental Assessment (BEA) ... 85
Phase 2 Groundwater Study Comments ... 86
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 86

PRIORITY RANK #18 ... 88

Site ID: 03000340 ... 88
Site Name: 558, 520, and 512 Water Street ... 88
Local Unit of Government: City of Allegan ... 88
Dataset: Site of Environmental Concern (EGLE PART 201) ... 88
Substances of concern: Lead, Mercury, Arsenic, Chromium, Cadmium ... 88
Lead Maximum Contaminant Level Goal (MCLG)... 88
Mercury Maximum Contaminant Level (MCL) ... 88
Arsenic Maximum Contaminant Level (MCL) ... 88
Chromium Maximum Contaminant Level (MCL) ... 88

Cadmium Maximum Contaminant Level (MCL) ... *88*
Human Health Perspectives ... 88
Lead ... *88*
Mercury ... *89*
Arsenic ... *89*
Chromium ... *89*
Cadmium ... *89*
RIDE Classification: ... 89
Ride Risk Category ... *89*
Drinking water ingestion category ... *89*
Groundwater-Surface Water Interface (GSI) ... *89*
Sensitive Environmental Receptors ... *90*
RIDE Reviewer Comments ... 90
Baseline Environmental Assessment(s) ... 90
Phase 2 Groundwater Study Comments ... 90
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 91
PRIORITY RANK #19 ... 92
Site ID: 03000281 ... 92
Site Name: 1185 M-89 Highway ... 92
Local Unit of Government: Allegan Township ... 92
Dataset: Site of Environmental Concern (EGLE PART 201) ... 92
Substances of concern: Benzo(ghi)perylene and Indeno(123-cd)pyrene ... 92
Relevant Drinking Water Standards ... 92
Benzo(ghi)perylene ... *92*
Indeno(123-cd)pyrene ... *92*
Human Health Perspectives ... 92
Polycyclic aromatic hydrocarbons ... *92*
RIDE Classification: ... 92
Ride Risk Category ... *92*
Drinking water ingestion category ... *93*
Groundwater-Surface Water Interface (GSI) ... *93*
Sensitive Environmental Receptors ... *93*
RIDE Reviewer Comments ... 93
Baseline Environmental Assessment (BEA) ... 93
Phase 2 Groundwater Study Comments ... 94
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 94
PRIORITY RANK #20 ... 96
Site ID: 03000407 ... 96
Site Name: 1227 M-89, Plainwell MI 49080 ... 96
Local Unit of Government: Otsego Township ... 96
Dataset: Site of Environmental Concern (EGLE PART 201) ... 96
Substances of concern: Lead, Iron, Manganese ... 96
Relevant Drinking Water Standards ... 96
Lead Maximum Contaminant Level Goal (MCLG) ... *96*
Lead Action Rule ... *96*
Iron Secondary Drinking Water Standard ... *96*
Manganese Secondary Drinking Water Standard ... *96*

Human Health Perspectives ... 96
Lead ... *96*
Iron ... *97*
Manganese ... *97*
RIDE Classification: ... 97
Ride Risk Category ... *97*
Drinking water ingestion category ... *97*
Groundwater-Surface Water Interface (GSI) ... *97*
Sensitive Environmental Receptors ... *97*
RIDE Reviewer Comments ... 98
Baseline Environmental Assessment (BEA) ... 98
Phase 2 Groundwater Study Comments ... 98
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 99
PRIORITY RANK #21 ... 101
Site ID: 03000384 ... 101
Site Name: East 1/2 of SE 1/4 Section 29 ... 101
Local Unit of Government: Gunplain Township (Plainwell) ... 101
Dataset: Site of Environmental Concern (EGLE PART 201) ... 101
Substances of concern: Arsenic, mercury, Polycyclic aromatic hydrocarbons (benzo(a)pyrene) ... 101
Relevant Drinking Water Standards ... 101
Arsenic Maximum Contaminant Level (MCL) ... *101*
Mercury Maximum Contaminant Level (MCL) ... *101*
Polycyclic aromatic hydrocarbons drinking water standard ... *101*
Human Health Perspectives ... 101
Arsenic ... *101*
Mercury ... *101*
Polycyclic aromatic hydrocarbons ... *101*
RIDE Classification ... 101
Ride Risk Category ... *102*
Drinking water ingestion category ... *102*
Groundwater-Surface Water Interface (GSI) ... *102*
Sensitive Environmental Receptors ... *102*
RIDE Reviewer Comments ... 102
Baseline Environmental Assessment(s) ... 103
Phase 2 Groundwater Study Comments ... 103
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 103
PRIORITY RANK #22 ... 105
Site ID: 00017433 ... 105
Site Name: Friendly 66 (Martin Pacific Pride) ... 105
Local Unit of Government: Village of Martin ... 105
Dataset: Leaky Underground Storage Tanks (EGLE PART 213) ... 105
Phase 2 Groundwater Study Comments ... 105
Phase 2 Groundwater Study Comments ... 105
PRIORITY RANK #23 ... 108
Site Name: Angle Steel Div (Kewaunee Scientific) ... 108
Site ID: 03000014 ... 108

Local Unit of Government: City of Plainwell ... 108
Dataset: Site of Environmental Concern (EGLE PART 201) ... 108
Substances of concern: Lead ... 108
Relevant Drinking Water Standards ... 108
Lead Maximum Contaminant Level Goal (MCLG)... 108
Lead Action Level: ... 108
Human Health Perspectives ... 108
Lead... 108
RIDE Classification ... 108
RIDE Reviewer Comments ... 108
Baseline Environmental Assessment(s) ... 109
Phase 2 Groundwater Study Comments: ... 109
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 109
PRIORITY RANK #24 ... 111
Site ID: 03000423 ... 111
Site Name: 101 Brady Street, Allegan ... 111
Local Unit of Government: City of Allegan ... 111
Dataset: Site of Environmental Concern (EGLE PART 201) ... 111
Substances of concern: Lead, Mercury, Arsenic, Cadmium, Chromium ... 111
Relevant Drinking Water Standards ... 111
Lead Maximum Contaminant Level Goal (MCLG)... 111
Lead Action Level: ... 111
Mercury Maximum Contaminant Level (MCL) ... 111
Arsenic Maximum Contaminant Level (MCL) ... 111
Cadmium Maximum Contaminant Level (MCL) ... 111
Chromium Maximum Contaminant Level (MCL) ... 111
Human Health Perspectives ... 111
Lead... 111
Mercury ... 112
Arsenic... 112
Cadmium ... 112
Chromium ... 112
RIDE Classification ... 112
Ride Risk Category... 112
Drinking water ingestion category ... 112
Groundwater-Surface Water Interface (GSI) ... 112
Sensitive Environmental Receptors... 113
RIDE Reviewer Comments ... 113
Baseline Environmental Assessment (BEA) ... 113
Phase 2 Groundwater Study Comments ... 114
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 115
PRIORITY RANK #25 ... 116
Site Name: 111 Hubbard Street ... 116
Site ID: 03000272 ... 116
Local Unit of Government: City of Allegan ... 116
Dataset: Site of Environmental Concern (EGLE PART 201) ... 116
Substances of concern: Lead, Chromium... 116

Relevant Drinking Water Standards ... 116
Lead Maximum Contaminant Level Goal (MCLG)... 116
Lead Action Level: ... 116
Chromium Maximum Contaminant Level (MCL) ... 116
Human Health Perspectives ... 116
Lead... 116
Chromium ... 116
RIDE Classification: ... 117
Ride Risk Category... 117
Drinking water ingestion category ... 117
Groundwater-Surface Water Interface (GSI) ... 117
Sensitive Environmental Receptors... 117
RIDE Reviewer Comments ... 117
Baseline Environmental Assessment (BEA) ... 118
Phase 2 Groundwater Study Comments ... 118
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 119
PRIORITY RANK #26 ... 120
Site Name: 243 Hubbard Street, Allegan ... 120
Site ID: 03000421 ... 120
Local Unit of Government: City of Allegan ... 120
Dataset: Site of Environmental Concern (EGLE PART 201) ... 120
Substances of concern: Arsenic, Lead ... 120
Relevant Drinking Water Standards ... 120
Maximum Contaminant Level Goal (MCLG)... 120
Lead Action Level ... 120
Arsenic Maximum Contaminant Level (MCL) ... 120
Human Health Perspectives ... 120
Lead... 120
Arsenic... 120
RIDE Classification: ... 121
Ride Risk Category... 121
Drinking water ingestion category ... 121
Groundwater-Surface Water Interface (GSI) ... 121
Sensitive Environmental Receptors... 121
RIDE Reviewer Comments ... 121
Baseline Environmental Assessment (BEA) ... 121
Phase 2 Groundwater Study Comments ... 122
Recommended Off-Site Groundwater Data Collection (Target Wells) ... 122
PRIORITY RANK #27 ... 124
Site Name: 4634 4671 East Washington Street & 3501 ... 124
Site ID: 03000426 ... 124
Local Unit of Government: Heath Twp. (Hamilton) ... 124
Dataset: Site of Environmental Concern (EGLE PART 201) ... 124
Substances of concern: Mercury, Arsenic ... 124
Relevant Drinking Water Standards ... 124
Mercury Maximum Contaminant Level Goal (MCLG) ... 124
Arsenic Maximum Contaminant Level (MCL) ... 124

Human Health Perspectives 124
Mercury *124*
Arsenic *124*
RIDE Classification: 124
Ride Risk Category *124*
Drinking water ingestion category *125*
Groundwater-Surface Water Interface (GSI) *125*
Sensitive Environmental Receptors *125*
RIDE Reviewer Comments 125
Baseline Environmental Assessment (BEA) 125
Phase 2 Groundwater Study Comments 126
Recommended Off-Site Groundwater Data Collection (Target Wells) 127

PRIORITY RANK #28 .... **128**

Site Name: Hamilton Farm Bureau Cooperative 128
Site ID: 00006437 128
Local Unit of Government: Heath Twp. 128
Dataset: Leaky Underground Storage Tanks (Part 213) 128
Substances of concern: unknown 128
Phase 2 Groundwater Study Comments 128

PRIORITY RANK #29 .... **130**

Site Name: 1840 142nd Avenue 130
Site ID: 3000302 130
Local Unit of Government: Dorr Twp. 130
Dataset: Site of Environmental Concern (EGLE PART 201) 130
Substances of concern: Lead, Mercury, Arsenic 130
Relevant Drinking Water Standards 130
Maximum Contaminant Level Goal (MCLG) *130*
Lead Action Level: *130*
Mercury Maximum Contaminant Level Goal (MCLG) *130*
Arsenic Maximum Contaminant Level (MCL) *130*
Human Health Perspectives 130
Lead *130*
Mercury *130*
Arsenic *131*
RIDE Classification: 131
Ride Risk Category *131*
Drinking water ingestion category *131*
Risks Present and Require Action in the Long-term: Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the know extent of the contaminants of concern. 131
Groundwater-Surface Water Interface (GSI) 131
Risks Controlled Interim 131
Sensitive Environmental Receptors *131*
RIDE Reviewer Comments 131
Baseline Environmental Assessment (BEA) 132
Phase 2 Groundwater Study Comments 132
Recommended Off-Site Groundwater Data Collection (Target Wells) 133

PRIORITY RANK #30 .... **135**

Site Name: 3506 M-40 135
Site ID: 3000324 135
Local Unit of Government: Heath Twp. 135
Dataset: Site of Environmental Concern (EGLE PART 201) 135
Substances of concern: Mercury, Benzene, Ethylbenzene, Xylenes 135
Relevant Drinking Water Standards 135
Mercury Maximum Contaminant Level Goal (MCLG) *135*
Benzene Maximum Contaminant Level (MCL) *135*
Ethylbenzene Maximum Contaminant Level Goal (MCL) *135*
Xylenes Maximum Contaminant Level Goal (MCL) *135*
Human Health Perspectives 135
Mercury *135*
Benzene *135*
Ethylbenzene *135*
Xylenes *135*
RIDE Classification: 136
Ride Risk Category *136*
Drinking water ingestion category *136*
Groundwater-Surface Water Interface (GSI) *136*
Sensitive Environmental Receptors *136*
RIDE Reviewer Comments: 136
Baseline Environmental Assessment (BEA) 136
Phase 2 Groundwater Study Comments: 137
Recommended Off-Site Groundwater Data Collection (Target Wells) 138

PRIORITY RANK #1

Site Name: 687 North 10th Street

Site ID: 03000356

Local Unit of Government: Gunplain Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Iron, Manganese

Relevant Drinking Water Standards

Iron Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards that aim to protect against cosmetic (e.g., tooth discoloration) effects or aesthetic effects in drinking water. The secondary standard for iron is 0.3 mg/L.

Manganese Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards in drinking water. The secondary standard for manganese is 0.05 mg/L.

Human Health Perspectives

Iron

Normal or elevated levels of iron are not known to cause health issues, but can lead to a metallic taste. Excessive amounts can cause stomach problems and nausea, and other potential health issues.

Manganese

Normal or elevated levels of manganese are not known to cause health issues, but an lead to a noticeable color, odor, or tase in water. Excessive amounts of manganese may be toxic.

RIDE Classifications

Ride Risk Category

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the

long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater – Surface Water Interface

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

The leading edge of groundwater contamination is located more than two years of groundwater travel from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments:

Not available

Baseline Environmental Assessment (BEA)

Dates of documents: December 2013 and February 2016 by PM Environmental Incorporated on behalf of Gun River MHC LLC.

At the time of the BEA, the property was occupied by a mobile home park. Sources document that the property was formerly used for agriculture. The development of the current mobile home took place between 1969 and 1972. An orchard was located on property from 1938 (approximately) until 1950. Note that orchards utilize specific herbicides and pesticides with higher metal contents then traditional farm crops.

The new purchaser, Gun River MHC LLC, intended to keep using the property as a mobile home park. It appears that is still the current use at the time of preparing this report.

Based on review of previous investigation, soil and groundwater contamination is present that exceeds Michigan's Part 201 Residential and Nonresidential Cleanup Criteria. Previous studies were completed in June 2010 (Phase 1 Environmental Site Assessment, or ESA) and December 2010 (Phase II ESA) by Arcadis and Consolidated Consulting Group, respectively.

The Phase I study notes the previous activity associated with the orchard and agriculture as a recognized environmental condition (REC). Also identified as potential RECs is the use of a wastewater treatment system, asbestos containing material in the office building, and three methamphetamine labs associated with the property.

The Phase II study consisted of collecting soil samples across the property and water samples from three water wells located on the property. Soil analytical results identified concentrations of various metals in each of the samples, some with concentrations above Part 201 cleanup criteria (in particular, iron and manganese, but also aluminum, selenium, and arsenic). Groundwater analytical results revealed various concentrations of metals in each of the samples collected, including some with concentrations above Part 201 Residential DW cleanup criteria. Groundwater concentrations of ethylbenzene, methyl-ethyl ketone (MEK), and toluene were identified, but were all below the most restrictive Part 201 cleanup criteria.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is in WHPA and about 575ft downstream from Type 1 wells
- several type2/3 wells about 1000ft south of site
-1 private well inside of 2yr impact area, several others just outside; 2 private wells in 10yr impact area, 1 private well in 20yr impact area; about 30 private wells just north and south of 10yr impact areas, several more further away

Non-drinking water risk:
- 1 irrigation wells about 350ft north of 10yr impact area

Surface water risk:
- discharge to Gun River (designated Trout stream) after ~20years of travel)

Aquifer Vulnerability
- Very high Vulnerability of 185 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

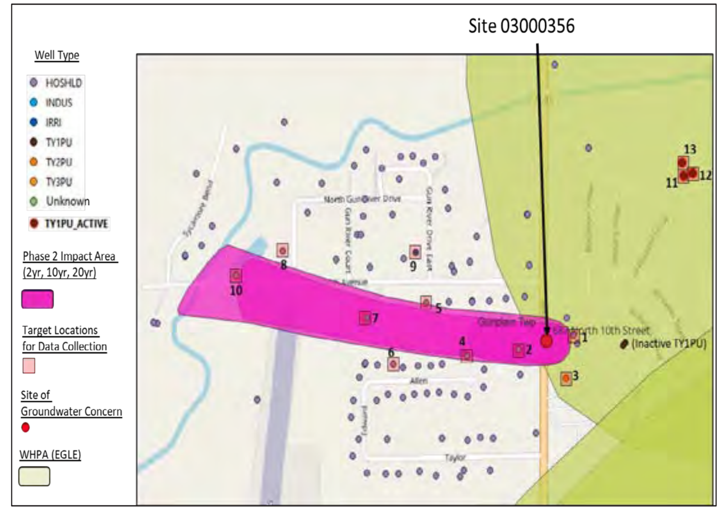


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000021438	685 10TH ST	HOSHLD	45	9/28/1988	Just upstream of site, along with a few other private wells
2	3000021891	680 10TH ST	HOSHLD	44	4/21/1998	Just downstream of the site, inside the 2yr impact area from Phase 2
3	3000001038	675 N. 10th Street	TY2PU	105	8/5/1997	Just south of the site
4	3000004758	1017 ALLEN COURT	HOSHLD	77	4/10/2003	Just downstream of the 2yr impact area from Phase 2, inside 10yr impact area
5	3000022260	1024 107TH AVE	HOSHLD	41	7/29/1996	Downstream of the 2yr impact area from Phase 2, on the edge of the 10yr impact area
6	3000000650	1041 ALLAN CT	HOSHLD	68	2/25/2000	Downstream of the 2yr impact area from Phase 2, south of the 10yr impact area
7	3000003510	TAYLOR DR.	HOSHLD	75	4/5/2002	Downstream of site, inside the 10yr impact area
8	3000022092	710 W GUN RIVER DR	HOSHLD	51	11/29/1985	Downstream of site, just north of 10yr impact area
9	3000022142	1033 107TH AVE	IRRI	50	5/16/1987	Downstream of site, north of 10yr impact area
10	3000022258	1073 107TH AVE	HOSHLD	41	9/16/1996	Just downstream of leading edge of 10yr impact area
11	3000011981	Brittany Street	TY1PU	90	3/13/2012	1300ft northeast of the site, PS well
12	3000001111	687 10TH ST	TY1PU	90	7/11/1986	1300ft northeast of the site, PS well
13	3000011980	Brittany Street	TY1PU	90	3/16/2012	1300ft northeast of the site, PS well

PRIORITY RANK #2

Site Name: 203 South Main Street

Site ID: 03000306

Local Unit of Government: City of Wayland

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Methylene chloride or Dichloromethane (DCM), Lead

Relevant Drinking Water Standards

Methylene chloride Maximum Contaminant Level Goal (MCLG)

5 parts per billion (or 0.005 mg/L)

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Human Health Perspectives

Methylene chloride

Short-term exposure above MCLG may result in neurotoxicity (damage to the central nervous system).

Long-term exposure above MCLG may result in liver toxicity, liver cancer, and lung cancer.

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

RIDE Classification

Ride Risk Category

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater – Surface Water Interface

Inadequate data to assign risk.

Sensitive Environmental Receptors

Inadequate data to assign risk.

RIDE Reviewer Comments:

Not available.

Baseline Environmental Assessment (BEA)

Dates of document: November 1999 by Kieser & Associates on behalf of City of Wayland.

The City of Wayland purchased the property in Oct. 1999 to accommodate future parking lot and/or library building expansions. At that time, it included a two-story framed structure containing six rental properties, a small utility shed, and a gravel drive and parking areas.

The intended use of the subject property will not include the significant storage or use of hazardous materials. The intended use is not expected to exacerbate existing contamination.

At the time of this report (April 2024), there appears to be a business located at this property, but there is not information available online. It is not clear if the property is still part of the City Library.

Prior to Oct. 1999, Phase I and Phase II reports had been completed which found contamination on-site which exceed Part 201 Generic Residential Cleanup Criteria.

According to Phase 1 sources, a local newspaper occupied the building and performed routine newspaper printing from 1885 to 1957 (Wayland Printing). Discharge of printing solvents and inks to a historic on-site septic system was a concern and motivated the Phase I and II studies.

Information regarding the storage and disposal of the chemicals related to the newspaper printing was not available.

The property had been rental apartments since the early to mid-1960s and changed ownership several times before the 1999 BEA.

No USTs were noted on site, but four fill pipes were observed on the exterior of the building and only one corresponding fuel tank was observed inside the basement (i.e., there is a potential for other buried heating oil tanks on the property).

Probing analysis indicated a buried concrete structure, potentially for the disposal of garbage.

Soil samples were collected at two locations in septic field area, 3 to 4 ft bgl and 11 to 12 feet bgl. Groundwater samples were collected at the water table from both borings.

In a soil sample total lead was detected at 25 mg/kg, above the Part 201 State-wide Default Background Level of 21 mg/kg.

Methylene chloride was detected at the deeper interval at 440 ug/kg, also above the Part 201 Residential and Commercial Drinking Water Protection Criterion of 100 ug/kg.

In other soil samples, detections of benzene at 1,300 ug/kg, total xylenes at 13,600 ug/kg, and total lead (230 mg/kg) were above respective Part 201 standards.

Groundwater results from both sampling locations showed no indication of contamination.

At the time of the BEA, the site was services by city water and sewer. The sewer system was installed around 1975; prior to that, a septic tank/drainage field waste located on the east side of the site, beneath the parking area.

A site reconnaissance revealed potential evidence of recent (circa 1990s) or historic signs of significant hazardous material storage on the property related to fuel oil.

Phase 2 Groundwater Study Comments

Drinking water risk:
- 2 yr. and part of 10yr impact area inside WHPA, Type 1 Well about 650ft southwest of 10yr impact area
- several private wells about 1a ways downstream of 20yr impact area

Non-drinking water risk:
- 1 irrigation well just outside/south of 10yr impact area, another about 1350ft upstream of site

Surface water risk:
- Rabbit River (designated trout stream) about 3000ft downstream of 20yr impact area

Aquifer Vulnerability:
- Very high vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000010615	439 W. SUPERIOR ST	IRRI	54	6/12/2009	Just south of leading edge of 10yr impact area from Phase 2
2	3000000283	WAYLAND WELL #3	TY1PU	251	--	PS well about 650ft south of 10yr impact area, but very deep
3	3000013166	3528 12th St	HOSHLD	49	6/4/2014	Downstream of 20yr impact area
4	3000030033	1203 Woodland Dr	HOSHLD	48	7/26/1997	Downstream of 20yr impact area
5	3000019968	1209 WOODLAND DR	HOSHLD	43	9/2/1987	Further downstream of 20yr impact area
6	3000019912	1215 WOODLAND DR	HOSHLD	34	3/5/1990	Furthest well downstream before reaching Rabbit River
7	3000019978	1207 HILLCREST DR	HOSHLD	49	5/25/1978	Downstream and a little south of 20yr impact area
8	3000009828	3514 12TH STREET	TTY2PU	64	12/4/2007	Downstream and a little south of 20yr impact area
9	3000019892	3564 12 ST	HOSHLD	60	3/4/1999	Downstream and a north of 20yr impact area
10	3000013269	1210 Woodland Dr	HOSHLD	61	7/9/2014	Downstream of 20yr impact area

PRIORITY RANK #3

Site Name: Wayland Self Serve

Site ID: 00015681

Local Unit of Government: City of Wayland

Dataset: Leaky Underground Storage Tanks (Part 213)

Substances of concern: unknown

The Remediation Information Data Exchange (RIDE) system from EGLE does not include any information on this location.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site and 2yr, 10yr, and portion of 20yr impact areas inside of WHPA; site is about 1200ft almost directly upstream of site

Non-drinking water risk:
- 1 irrigation well in 20yr impact area; another about 1400ft upstream of site

Surface water risk:
- Rabbit River (designated trout stream) about 4000ft downstream of 20yr impact area

Aquifer Vulnerability
• Very high Vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000000283	WAYLAND WELL #3	TY1PU	251	--	Type 1 PS well almost directly downstream from the site, but very deep
2	3000010615	439 W. SUPERIOR ST	IRRI	54	6/12/2009	Directly downstream of site, just beyond the leading edge of the 10yr impact area
3	3000009828	3514 12TH STREET	TY2PU	64	12/4/2007	First Baptist Church, downstream of 20yr impact area
4	3000001655	3514 12th Street	UNK	44	7/7/1974	First Baptist Church, downstream of 20yr impact area
5	3000019916	1203 135TH	HOSHLD	45	10/16/1991	Downstream of 20yr impact area

6	3000019990	1212 135 AVE	HOSHLD	40	7/22/1996	Downstream and a little south of 20yr impact area estimated path
7	3000019978	1207 HILLCREST DR	HOSHLD	49	5/25/1978	Downstream and just north of 20yr impact area estimated path
8	3000008952	1211 HILLCREST DR	HOSHLD	82	9/6/2006	Further downstream of 20yr impact area
9	3000012797	1235 135th Ave.	TY2PU	60	8/11/1986	Trinity Lutheran Church, futher downstream of 20yr impact area
10	3000019897	1205 WOODLAND	HOSHLD	55	5/7/1997	Downstream and north of 20yr impact area

PRIORITY RANK #4

Site Name: 114 Pine Street

Site ID: 3000277

Local Unit of Government: City of Wayland

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Arsenic

Also: petroleum Volatile and Semi Volatile Organic Compounds; chlorinated Volatile and Semi Volatile Organic Compounds

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater – Surface Water Interface

Inadequate data to assign risk.

Sensitive Environmental Receptors

Inadequate data to assign risk.

RIDE Reviewer Comments

The site has significant VI and NAPL characterization and risk evaluation needs.

Baseline Environmental Assessment (BEA)

Dates of document: November 2014 by Horizon Environmental on behalf of Jayda Gale Distilling INC.

The intended use of the property at the time of the Baseline Environmental Assessment (BEA) was to support operations at the adjacent downtown commercial building, Jayda Gale Distillery.

Prior to the purchase by Jayda Gale Distilling, Wayland Cleaners owned and operated at the property.

It was found that an underground storage tank (UST) was formerly used at the property for storing petroleum-based dry cleaning fluid. Apparently the UST was removed from the property sometime in the mid-1980s. Litte other information is available.

A septic system utilized prior to hookup of city sewer service was located on the property and was considered a recognized environmental condition (REC).

Sampling activities were limited to soil investigations, including six soil borings and soil samples collected from each.

In the suspected area of the former UST location, several volatile and semi-volatile organic compounds were detected at levels exceeding Part 201 generic residential cleanup criteria (GRCC). The highest concentrations of hazardous substances were for 1,2,3- and 1,3,5-Trimethylbezene, exceeding their respective Soil Saturation Screening Levels and Drinking Water Protection Criteria.

Soil samples collected in the suspected area of the septic system contained tetrachloroethylene at concentrations exceeding the drinking water criteria. Arsenic was also detected at concentrations exceeding its residential Drinking Water Protection, Groundwater Surface Water Interface Protection, and Direct Contact Criteria.

Groundwater samples were not collected, although visual and olfactory evidence of shallow groundwater impact due to the former UST was apparent.

Phase 2 Groundwater Study Comments

Drinking water risk:
- 2 yr. and part of 10yr impact area inside WHPA, Type 1 Well about 650ft southwest of 10yr impact area
- several private wells about 1a ways downstream of 20yr impact area

Non-drinking water risk:
- 1 irrigation well just outside/south of 10yr impact area, another about 1350ft upstream of site

Surface water:
- Rabbit River (designated trout stream) about 3200ft downstream of 20yr impact area

Aquifer Vulnerability:
- High vulnerability of 169 at site (164-177 => 0.8 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

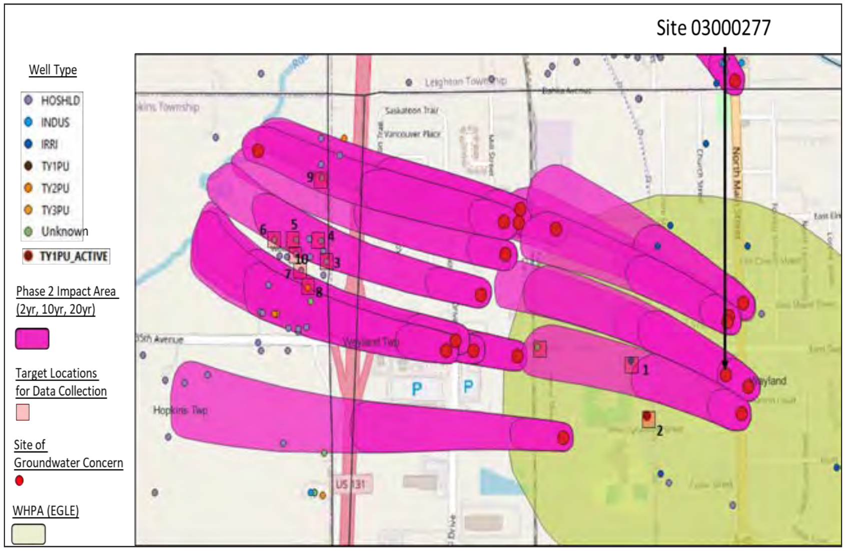


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000010615	439 W. SUPERIOR ST	IRRI	54	6/12/2009	Just south of leading edge of 10yr impact area from Phase 2
2	3000000283	WAYLAND WELL #3	TY1PU	251	--	PS well about 650ft south of 10yr impact area, but very deep
3	3000013166	3528 12th St	HOSHLD	49	6/4/2014	Downstream of 20yr impact area
4	3000030033	1203 Woodland Dr	HOSHLD	48	7/26/1997	Downstream of 20yr impact area
5	3000019968	1209 WOODLAND DR	HOSHLD	43	9/2/1987	Further downstream of 20yr impact area
6	3000019912	1215 WOODLAND DR	HOSHLD	34	3/5/1990	Furthest well downstream before reaching Rabbit River
7	3000019978	1207 HILLCREST DR	HOSHLD	49	5/25/1978	Downstream and a little south of 20yr impact area
8	3000009828	3514 12TH STREET	TTY2PU	64	12/4/2007	Downstream and a little south of 20yr impact area
9	3000019892	3564 12 ST	HOSHLD	60	3/4/1999	Downstream and a north of 20yr impact area
10	3000013269	1210 Woodland Dr	HOSHLD	61	7/9/2014	Downstream of 20yr impact area

PRIORITY RANK #5

Site Name: 585 10th St. Plainwell

Site ID: 3000211

Local Unit of Government: Gunplain Township

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Cadmium, Chromium, Ethylbenzene, xylenes, and 2-methylnapthalene

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Cadmium Maximum Contaminant Level (MCL)

5 parts per billion (or 0.005 mg/L)

Chromium Maximum Contaminant Level (MCL)

0.1 mg/L (0.1 parts per million)

Ethylbenzene Maximum Contaminant Level Goal (MCL)

0.7 mg/L (0.7 parts per million)

Xylenes Maximum Contaminant Level Goal (MCL)

10 mg/L (10 parts per million)

2-methylnapthalene

This is one of a group of chemicals called polycyclic aromatic hydrocarbons (PAHs). There is no information available from studies on humans to tell what effects can result from being exposed to individual PAHs at certain levels.

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Cadmium

Exposure above MCLG may result in kidney damage.

Chromium

Prolonged exposure above MCLG may result in allergic dermatitis (skin reactions).

Ethylbenzene

Short-term exposure above MCLG may result in drowsiness, fatigue, headache and mild eye and respiratory irritation.

Long-term exposure above MCLG may result in damage to the central nervous system, liver and kidneys.

Xylenes

Short-term exposure above MCLG may result in disturbances of cognitive abilities, balance, and coordination.

Long-term exposure above MCLG may result in damage to the liver, kidneys, central nervous system and eyes.

2-methylnapthalene

Breathing PAHs and skin contact seem to be associated with cancer in humans. Animal studies demonstrated that mice exposed through ingestion for 10 days (short-term exposure) had offspring with birth defects. Mice exposed for months developed problems in the liver and blood.

RIDE Classifications:

Ride Risk Category

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater – Surface Water Interface

Inadequate data to assign risk.

Sensitive Environmental Receptors

Inadequate data to assign risk.

Risk controlled – Interim

No sensitive habitat or resources exist on or near the site or facility.

RIDE Reviewer Comments:

Based on a 1998 BEA, the site was historically used as an automotive service center. Soil samples were collected from a network of drywell floor drains. Soil samples were analyzed for PTEX, PAH, Pd (lead), Cd (cadmium), and Cr (chromium).

Soil sample results indicated exceedances of Part 201 criteria for ethylbenzene, xylenes, and 2-methylnapthalene with max concentrations of 16,000, 251,000, and 9,000 ug/kg, respectively.

These soil borings were advanced to deeper intervals (12' bgs) and that deeper samples did not contain detectable concentrations of BTEX. Groundwater was not encountered during the investigation activities.

Soil sample concentrations of select VOCs (not acute compounds) exceed VIAP at locations beneath the building. Note that VOCs were only measured as BTEX, and a limited list of full VOCs. Concentrations of analyzed metals in soil samples exceed DC criteria, but are likely covered by impervious land cover.

Baseline Environmental Assessment (BEA)

Dates of document: January 1998 by Environmental Science & Planning, LLC on behalf of J-R Properties, LLC.

The intended use of the property at the time of the BEA was for the sale of maintenance of golf course maintenance products and mower gaging tools.

At the time of the preparation of this report (April 2024), there was a business located at this property: Repz Gym, a physical fitness center.

The property was formerly undeveloped field until roughly 1950. Then, it was used as an implement sales, machinery and equipment sales company, service garage, and more recently as a retail space for antique and furniture sales.

At the time of the BEA, the owner was performing some limited automotive servicing – including oil changes. Waste oil and fluids were stored in 55-gallon drums seen during site reconnaissance (but no signs of leaks or spills observed).

There were no records of UST/AST usage, nor any Uniform Hazardous Waste Manifest records with the MDEQ.

Three dry wells in vehicle bays contained soil and sediment stained with petroleum-related compounds.

Other recognized environmental conditions (REC) identified include: usage of a septic tank; presence of an outdoor burn area and a former excavated area of unknown origin, and evidence of potential impact to soils next to and underneath blow-down vent pipe from historical spray paint booth.

Soil sampling revealed the presence of ethylbenzene, xylenes, and 2-methylnapthalene with max concentrations of 16,000, 251,000, and 9,000 ug/kg, respectively. These concentrations exceeded the Part 201 Generic Residential Cleanup Criteria, 20X Drinking Water Values of 1,500 ug/kg for ethylbenzene, 5,600 ug/kg for xylene isomers.

Cadmium, chromium, and lead were discovered at concentrations that exceeded the Part 201 Generic Residential Cleanup Criteria.

Groundwater samples were not collected as part of this BEA.

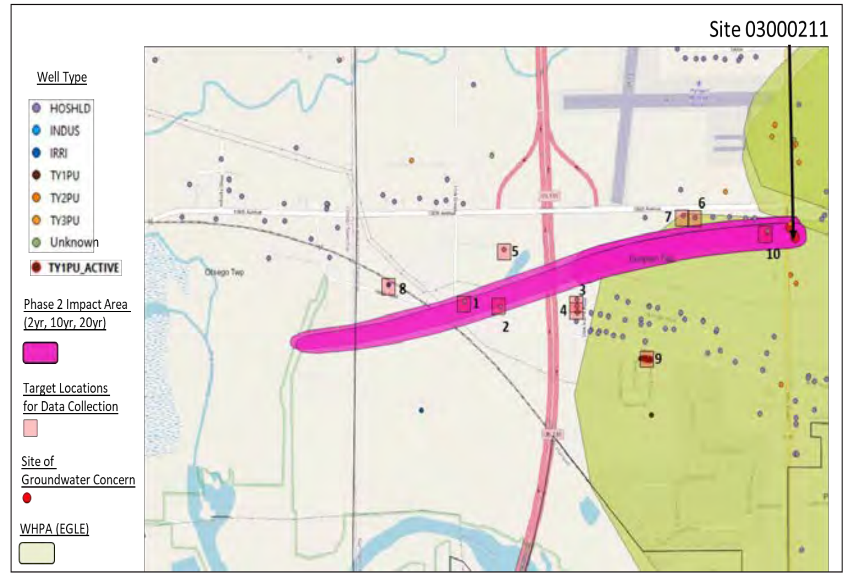
Phase 2 Groundwater Study Comments:

Drinking water risk:
• Household wells in 2yr impact area, 2 wells in 20yr impact area, many just outside impact areas
• Type 2 PS well in 2yr impact area, two others <400ft south of site
• Site, 2, yr. and 10yr impact areas inside of WHPA; multiple type 1 well 900ft outside of 10yr impact area
Non-drinking water risk:
•Two irrigation wells <700ft outside of 20 yr. impact area
Surface water risk:
-Wetlands and Kalamazoo River downstream of site:
Aquifer Vulnerability:
- Very high Vulnerability of 185 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000022489	1143 MILLER RD	HOSHLD	44	8/13/1997	Downstream from site, within the 20yr. Impact area from Phase 2
2	3000022509	1123 MILLER RD	HOSHLD	35	9/1/1993	Downstream from site, within the 20yr. Impact area from Phase 2
3	3000022573	566 CLAN ALPINE ST	HOSHLD	41	7/28/1995	Just south of leading edge of 10yr impact area
4	3000003701	564 CLAN ALPINE	HOSHLD	41	7/22/2002	Just south of leading edge of 10yr impact area
5	3000022542	595 11TH ST	HOSHLD	33	6/17/1986	North of 20yr impact area from Phase 2
6	3000022492	1042 106TH AVE	HOSHLD	44	10/20/1997	Just north of 10yr impact area from Phase 2
7	3000016685	1050 106th Ave	HOSHLD	37	11/2/2016	Just north of 10yr impact area from Phase 2
8	3000017082	1181 Miller Rd	IRRI	49	3/11/2020	North of 20yr impact area from Phase 2
9	3000012106	Gun River Estates	TY1PU	93	6/20/2012	Cluster of active TY1PU wells south of 10yr impact area, owned by Gun River Estates West
10	3000008369	590 10th St.	HOSHLD	112	4/6/2006	Within 2yr impact area from Phase 2



PRIORITY RANK #6

Site Name: 3603 N. Main Street

Site ID: 03000325

Local Unit of Government: Leighton Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Xylene, 2-methylnapthalene, ethylbenzene

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Ethylbenzene Maximum Contaminant Level (MCL)

0.7 mg/L (0.7 parts per million)

Xylenes Maximum Contaminant Level (MCL)

10 mg/L (10 parts per million)

2-methylnapthalene Maximum Contaminant Level (MCL)

This is one of a group of chemicals called polycyclic aromatic hydrocarbons (PAHs). There is no information available from studies on humans to tell what effects can result from being exposed to individual PAHs at certain levels.

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Ethylbenzene

Short-term exposure above MCLG may result in drowsiness, fatigue, headache and mild eye and respiratory irritation.

Long-term exposure above MCLG may result in damage to the central nervous system, liver and kidneys.

Xylenes

Short-term exposure above MCLG may result in disturbances of cognitive abilities, balance, and coordination.

Long-term exposure above MCLG may result in damage to the liver, kidneys, central nervous system and eyes.

2-methylnapthalene

Breathing PAHs and skin contact seem to be associated with cancer in humans. Animal studies demonstrated that mice exposed through ingestion for 10 days (short-term exposure) had offspring with birth defects. Mice exposed for months developed problems in the liver and blood.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the Long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater – Surface Water Interface

Risks Present and Require Action in the Long-term

*T*he groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risk Present and Require Action in the long-term

The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2016 BEA: The site was developed in the 1950's with the construction of a portion of the current slab-on-grade building. Additions to the building were added in the 1960's and 1970's. Operations at the site have included snowmobile sales, small engine sales/repair, gun sales/repair, and metal landscaping edging manufacturing. As a part of due diligence investigation activities, eight soil borings were advanced at the site for the collection of three soil samples (one for VOCs and PNAs, two for Pb only) and six groundwater samples (VOCs and PNAs). Soils encountered during the investigation were primarily sand to a maximum explored depth of 9 feet bgs with groundwater encountered at depths ranging from 4.3' bgs to 6.5' bgs. Samples were analyzed for gasoline range VOCs, PNAs, and Pb. Based on the laboratory analytical results soil samples exceeded nonresidential Part 201 criteria and VIAP (non-acute) for the following compounds with maximum concentrations noted in ug/kg as follows: toluene - 15,000; ethylbenzene - 8,400; xylenes - 60,000; 124TMB - 110,000; 135TMB - 27,000; fluorene - 6,300; and Pb - 3,500,000. Based on the laboratory analytical results ground samples exceeded nonresidential Part 201 criteria and VIAP (non-acute) for the following compounds with maximum concentrations noted in ug/L as follows: 2MN - 180; 124TMB - 130; and phenanthrene - 2.3. Primary sources of soil contamination at the site are associated with a former heating oil UST installed adjacent to the building. Maximum groundwater COC concentrations are likely associated with historic petroleum fuel storage and dispensing operations at the northerly adjacent parcel. The parcel and surrounding parcels are serviced by municipal water. The primary exposure pathway of concern is indoor air inhalation as sample TA-4 is located adjacent to the building and its COC concentrations are indicative of residual LNAPL. The direct contact pathway is also a concern as soil sample DEC-6 was collected at a former gun range backstop berm and noted a lead concentration of 3.5M ug/kg at 0.5'.

all 800-662-9278.

status, disability, political beliefs, height, weight, genetic information, or sexual orientation in the administration of any of its

d regulations. Questions or concerns should be directed to the Nondiscrimination Compliance Coordinator at EGLE-

he public

Baseline Environmental Assessment (BEA)

Dates of document: September 2016 by Dixon Environmental Consulting, INC. on behalf of Curv-Rite, Inc.

The intended use of the property was for warehousing aluminum landscape edging and edging restraints, and for parking for employees.

Historically, the site was first identified as a portion of an agricultural field in 1938. The western portion of the current building was constructing in the late 1950s, and additions were construction in the 1960s and 1970s. Heating fuel oil was stored in an underground storage tank (UST) located on property. At the time of the BEA, the UST was still present, although the use of heating oil was no longer necessary.

Several family owner businesses operated at the property from the late 1950s through the 1980s, including: sale and warehousing of snowmobiles, mini-bikes, go-carts, and saws, as well as sporting good/gun sales, lawn mower sales, and small engine repair. A gun firing range was also present on the property.

During the Phase 1 Environmental Site Assessment (ESA), a recognized environmental condition (REC) was identified on the western portion of the site that historically utilized the heating fuel oil stored in the UST. The UST was permanently closed and removed from the property on June 14, 2016.

As part of the BEA site reconnaissance, the firing range utilizing a soil mound as a bullet trap / backstop was identified as a REC because of the potential of leaching lead fragments from bullets that end up in the soil. Additionally, the former use of aboveground storage tanks (ASTs) and USTs at a gas station on an adjacent property was identified as an REC.

Sampling activities include conducting eight soil borings on the site. Six of the soil boring were converted into temporary well points for groundwater sampling.

Soil and groundwater analytical results revealed concentrations of lead, fluorene, phenanthrene, ethylbenzene, 2-methylnapthalene, toluene, and 1,2,4-trimethylbenzene, 13,5- trimethylbenzene and xylenes (total) in excess of the current Part 201 generic residential cleanup criteria (GRCC) for soil and/or groundwater. Specifically, groundwater samples exceed the GRCC for 2-methylnapthalene, 1,2,4-trimethylbenzene, and phenanthrene.

Phase 2 Groundwater Study Comments:

Drinking water risk:
- 2 private wells in 10yr impact area, 10 private wells in 20yr impact area, another 25+ just outside of impact areas, and another ~20 further west
-type 2 well <500ft from 10 yr. impact area

Non-drinking water risk:
- industrial well in 2yr impact area
- 1 irrigation well just outside of 2yr impact area, another just north of 20yr impact area

Surface water risk:
'-discharge to Rabbit River (trout stream) after ~20yr of travel

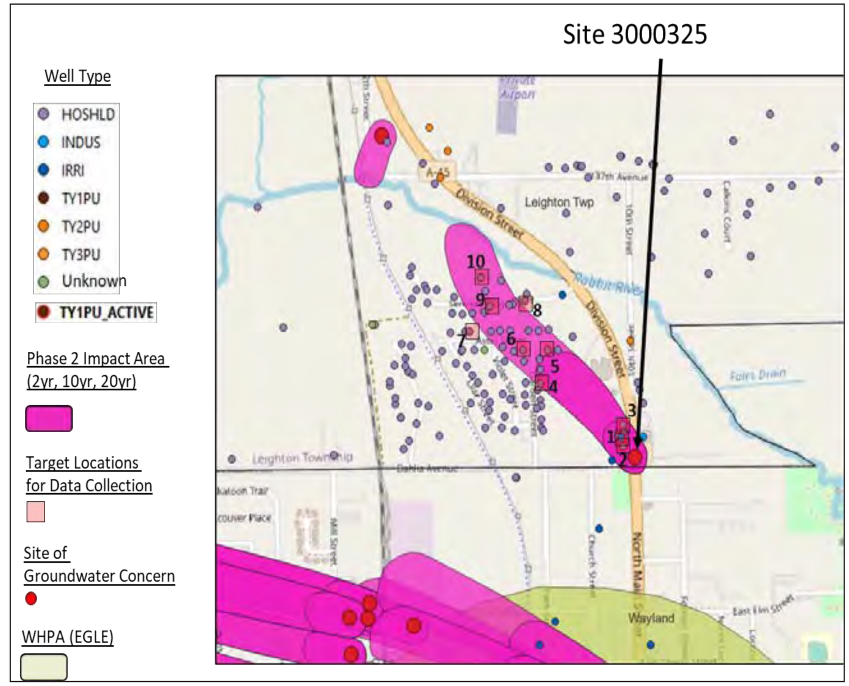
Aquifer vulnerability:
- Very high vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000021740	3610 N Main St	INDUS	49	2/16/1973	Industrial well just downstream from site
2	3000030427	3608 N Main St	HOSHLD	42	6/11/1998	Private well just downstream from site

3	3000030021	3616 10TH ST	HOSHLD	40	9/2/1996	Private well on leading edge of 2yr impact area
4	3000028260	3625 GARDEN ST	HOSHLD	44	3/30/1989	Private well on leading edge of 10yr impact area
5	3000030467	1030 Aster St	HOSHLD	48	4/19/1991	Private well on leading edge of 10yr impact area
6	3000030851	3636 Garden St	HOSHLD	49	7/16/1998	Private well downstream of leading edge of 10yr impact area
7	3000030852	1059 Aster St	HOSHLD	46	5/30/1969	Just west of the 20yr impact area
8	3000011975	1038 Serenity Ridge	HOSHLD	195	3/19/2012	Just east of the 20yr impact area; deep well
9	3000011895	1050 Serenity Ridge	HOSHLD	190	12/7/2011	Inside 20yr impat area; deep well
10	3000011296	1657 SEVENTY RIDGE	HOSHLD	190	2/2/2010	Further downstream inside of 20yr impact area; deep well



PRIORITY RANK #7

Site Name: 712 East Bridge Street

Site ID: 03000360

Local Unit of Government: City of Plainwell

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Xylene, Benzene, Vanadium

And other Petroleum Volatile and Semi Volatile Organic Compounds

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCL)

The MCL is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Xylene Maximum Contaminant Level (MCL)

10 mg/L (10 parts per million)

Benzene Maximum Contaminant Level (MCL)

5 parts per billion (or 0.005 mg/L or 0.005 parts per million)

Vanadium

The EPA is currently conducting research on Vanadium in public drinking water systems nationwide to assess their occurrence and levels and to determine if further regulatory action is warranted.

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Xylenes

Short-term exposure above MCLG may result in disturbances of cognitive abilities, balance, and coordination.

Benzen*e*

Short-term exposure may cause temporary nervous system disorders, anemia, or depressed immune system function.

Long-term exposure may cause chromosome aberrations or cancer.

Vanadium

Nausea, mild diarrhea, and stomach cramps have been reported, but the health effects in humans are not fully understood.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater-Surface Water Interface (GSI)

Risk Present and Require Action in the long-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.)

RIDE Reviewer Comments:

Not available.

Baseline Environmental Assessment (BEA)

Dates of document: February 2010 by Soil and Materials Engineers, Inc. on behalf of Paragon Energy Systems.

Paragon Energy Systems purchased the property in January 2010. The intended use to redevelop the property into a showroom and storage for alternative fuel (e.g., wood and corn) stoves and furnaces. No hazardous substances would be stored on property for the intended use.

Historically, the site was originally developed with a fruit evaporator and lumber storage by 1892. The property was developed to a lumber and coal storage yard by 1904 and continued to be used for that purpose until the late 1950s, when coal storage stopped. Use as a lumber storage facility continued until 2001 when the property was vacated. It appears a landscaping company was operating on property sometime between 2001 and 2008.

At the time of the preparation of this report (April 2024), it appears the Energy Mill business occupies the property.

The 2009 Phase I Environmental Site Assessment (ESA) identified multiple recognized environmental conditions (EOCs) on the property, including: the historical use of the property for lumber and coal storage yard; the presence of a soil mound and potentially hazardous materials within it; a former underground storage tank (UST) located near the building on the property; and potential migration of contamination from adjacent properties, which includes historical saw mill operations, the use of a LUST, metal parts manufacturing.

A Phase II ESA study found the following substances in soil and ground samples that measured at concentrations above Part 201 Residential and Commercial I Drinking Water Protection Criteria (DWPC) and/or Part 201 Groundwater Surface Water Interface Protection Criteria (GSIPC): benzene, naphthalene, 1,23-trimethylbenzene, 13,5-trimethylbenzene, and xylenes.

Manganese and selenium were measured in soil samples concentrations above Part 201 Residential and Commercial I DWPC and or Part 201 GSIPC. Benzo(a)pyrene was measured at concentrations above the Part 201 Residential and Commercial I Direct Contact Criteria (DCC).

In one or more groundwater samples lead and vanadium were measured at concentrations exceeding the Part 201 Residential and Commercial Drinking Water Criteria.

Phase 2 Groundwater Study Comments

Drinking water risk:
- site is just inside WHPA, about 1000ft east of Type 1 wells; another WHPA north (upstream) of site with type 1 wells about 2200ft from the site
- 1 private wells in 20yr impact area, another few just outside of 10yr and 20yr impact areas; several others in vicinity

Non-drinking water risk:
- 2 industrial wells about 185ft southwest of site
- 1 irrigation well about 1900ft southeast of site, another about 2400ft southeast of site

Surface water risk:
- No interaction with surface water in 20yr travel

Aquifer Vulnerability:
- High vulnerability of 168 at site (164-177 => 0.8 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
3000000040	PLAINWELL CITY WELL #4	TY1PU	58	--	PS well is about 900ft south of site
3000001241	329 S SHERWOOD AVE	TY1PU	55	12/4/1998	PS well is about 900ft south of site

PRIORITY RANK #8

Site Name: 798 E. Bridge Street Fmrly 760 E. Bridge

Site ID: 03000367

Local Unit of Government: City of Plainwell

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Mercury, Arsenic, Chromium

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Mercury Maximum Contaminant Level (MCL)

2 parts per billion (ppb), or 0.002 mg/L

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Chromium Maximum Contaminant Level (MCL)

0.1 mg/L (0.1 parts per million)

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Mercury

Short-term or long-term exposure to mercury may cause kidney damage.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Chromium

Prolonged exposure above MCLG may result in allergic dermatitis (skin reactions).

RIDE Classifications:

***R**ide Risk Category*

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the known extent of the contaminants of concern.

Groundwater – Surface Water Interface

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

The leading edge of groundwater contamination is located more than two years of groundwater travel from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments:

Not available

Baseline Environmental Assessment (BEA)

BEA was conducted in 2017 for Plainwell Community Schools at the property address.

A complete BEA report is not available on RIDE at this time. A limited form submitted February 2017 with title “B201702519PL”.

The BEA identifies a new concern and the available information indicates further follow up is needed when resources become available.

The recognized environmental conditions (RECs) identified at the site include: historic use of the property as a foundry, metal products factory, and a machine shop; a heating oil UST ; nearby railroad tracks on the adjoining property. The UST was closed in place in 1997.

Five soil samples were collected and analyzed for contamination. Mercury was detected in one sample at 54 ug/Kg, which also contained 1,2,4-Trimethylbenzene at 110 UG/Kg, toluene at 240 ug/Kg, ethylbenzene at 51 ug/Kg, and xylenes at 370 ug/Kg. Mercury, ethylbenzene and xylenes concentrations exceeded screening levels.

Two groundwater samples were collected and analyzed for contamination. One sample revealed arsenic at 380 ug/L, chromium at 180 ug/L, lead at 530 ug/L and mercury at 2.7 ug/L – all concentrations that are above respective screening levels. Toluene was detected below screening levels.

Phase 2 Groundwater Study Comments

Drinking water risk:
- site and impact areas inside WHPA, site is about 920ft north of Type 1 Wells

Non-drinking water risk:
- 1 industrial well ~750ft north of site

Surface water risk:
- discharge to Kalamazoo River after ~6 years.

Aquifer Vulnerability:
- Very high Vulnerability of 191 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
3000000040	PLAINWELL CITY WELL #4	TY1PU	58	--	PS well is about 900ft south of site
3000001241	329 S SHERWOOD AVE	TY1PU	55	12/4/1998	PS well is about 900ft south of site

PRIORITY RANK #9

Site ID: 03000288

Site Name: 1258, 1260 Lincoln Road & Village EMH Pk

Local Unit of Government: Allegan Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Nitrate and benzo(a)pyrene

Relevant Drinking Water Standards

Nitrate Maximum Contaminant Level (MCL)

10 mg/L (10 parts per million)

Benzo(a)pyrene Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure that is without risk.

Human Health Perspectives

Nitrate

Short-term exposure above MCL may cause serious illness and sometimes death, especially in infants. The primary issue is Methemoglobinemia , or oxygen deprivation in blood cells that causes shortness of breath and blueness of the skin.

Long-term exposure above MCLG may cause: diuresis, increased starchy deposits and hemorrhaging of the spleen.

Benzo(a)pyrene:

Short-term exposure above MCL may cause red blood cell damage, leading to anemia; suppressed immune system.

Long-term exposure above MCLG may cause developmental and reproductive effects, or cancer.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors within the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the short-term

Groundwater contamination exceeds drinking water criteria and a public or private water supply well that is producing from the contaminated aquifer, is located within two years groundwater travel time from the known extent of contaminants of concern.

Groundwater-Surface Water Interface (GSI)

Risk Controlled – Interim

Groundwater contamination is not reasonably expected to vent to surface waters, or does not exceed GSI criteria, or mixing zone-based GSI criteria established by EGLE.

Sensitive Environmental Receptors

Risk Controlled – Interim

No sensitive habitat or resources exist on or near the site or facility.

RIDE Reviewer Comments:

COMMENTS of Reviewer: Based on a 1999 BEA: This site was developed as early as 1972 as a mobile home park. Evaluated sources of contamination were former burn pits where household refuse was disposed of on-site and also a sanitary drain field. Two soil surficial soil samples were collected from the burn pit area and analyzed for PNAs. Three monitoring wells were installed to depths of up to 55' feet bgs to evaluate nitrate concentrations in groundwater at locations representative of natural background levels and levels downgradient of a septic tank drain field. Laboratory analytical results of soil sample SS-2 (0-1') indicated a benzo(a)pyrene concentration of 4,400 ug/kg which exceeds residential DC criteria. The nitrate concentration of the groundwater sample collected from MW-3 (downgradient of septic tank drain field) was 41 mg/L which exceeds DW criteria. Soils encountered at the site during the installation of the monitoring wells were primarily sand and groundwater was encountered at 45-50' bgs. Potential exposure pathways of concern would be direct contact with soils at the burn pit location [as B(a)P exceeds DC in surficial soils at this location] and groundwater ingestion as the site is serviced by Type I water wells (intakes at 85-108') and the groundwater sample collected onsite from MW-3 (50-55') had a nitrate concentration of 41 mg/L which exceeds the DW criteria of 10 mg/L. It is likely that the Type I water wells onsite are producing from the same aquifer as that sampled by MW-3 and the extent of contamination is not defined. Nitrate concentrations should be monitored regularly in water produced by the onsite Type I water wells, if not already mandated by the Allegan County Health Department.

Baseline Environmental Assessment (BEA)

Date of documents: 09/1999 by Dell Engineering, INC. in concern of Allegan Mobiles Estates, LLC. and Lakeshore Property Management.

The intended use of the property was continued operations as a mobile home park.

At the time of preparation of this report (April 2024), it appears that the "Rock-N-Horse Antiques & Collectables" business operates at the subject property.

The property straddles the border between Allegan and Trowbridge Townships, such that the western and eastern parcels of the property are in Allegan Twp., while the southern parcel is in Trowbridge Twp. At the time of the BEA, septic system drain fields were present in the western and southern parcels; the eastern parcel used to have a septic system, but it was abandoned (but not removed) before the BEA by filling the tank with gravel. This was identified as a recognized environmental condition (REC).

A previous Phase I Environmental Site Assessment (ESA) identified as a REC an open area used for burning yard waste and household trash on the site's southern parcel. Subsequent soil sampling carried out in June 1999 revealed elevated concentrations of polynuclear aromatic hydrocarbons (PNAs) above the Part 201 residential cleanup criterion for direct human contact.

The Phase I ESA also involved collecting and analyzing groundwater samples from downgradient of the drain field in the southern parcel of the property. Subsequent sampling of the site was performed in 1999, including in the upgradient area (relative to the drain field) to determine background concentrations of nitrates on site. Nitrate concentrations from samples adjacent to the drain field on the southern parcel were above the drinking water criterion. (One sample had a nitrate concentration of 40 mg/L, which is four times the Maximum Contaminant Level of 10 mg/L.)

Based on the findings from groundwater sampling in the southern parcel, it is possible that groundwater contamination may be present in or downgradient of the former leach field on the eastern parcel.

The BEA noted that operations by Allegan Mobile Estates and Lakeshore Property Management may include discharge of residential-type sanitary sewage. To differentiate potential future releases from any pre-existing contamination, the existing septic system leach fields were to be abandoned and the site septic systems were to be connected to city sanitary sewer.

Phase 2 Groundwater Study Comments

Drinking water risk:
- site is inside WHPA, ~700ft upstream/northeast of Type 1 wells
- 1 type 2 and 1 type 3 well in 2 yr. impact area, 2 type 2 wells just upstream of site, multiple type 2 wells and 1 type 3 well north of 2 and 10yr impact areas
- 2 private wells in 10yr impact area, several others just south, several private wells just outside of or downstream of 20yr impact area

Non-drinking water risk:
- 1 irrigation wells 1300ft downstream of 20yr impact area

Surface water risk:
•Wetlands in 20yr impact area, Kalamazoo River downstream of 20yr impact area

Aquifer Vulnerability:
• High vulnerability of 175 at site (164-177 => 0.8 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

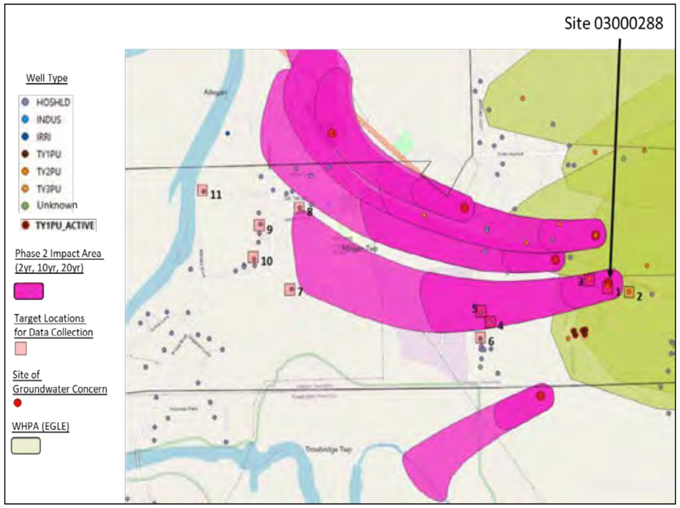


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000007935	1258 LINCOLN RD	TY3PU	64	7/12/2003	Type 3 PS well right next to the site (same property??)
2	3000001862	1250 Lincoln Rd.	TY2PU	99	--	Type 2 PS just upstream of site / 2yr impact area
3	3000001864	1256 Lincoln Rd.	TY2PU	96	5/6/1982	Type 2 PS well just downstream of site, within 2yr impact area
4	3000000375	1235 29TH ST	HOSHLD	90	12/18/1994	West of site, within 10yr impact area
5	3000003179	1239 29TH STREET	HOSHLD	72	9/26/2024	West of site, within 10yr impact area
6	3000010778	1227 29TH ST	HOSHLD	56	5/29/2009	West of site, just outside (south) of 10yr impact area
7	3000017666	1261 Bridge Rd.	HOSHLD	87	3/18/2021	Juts downstream of 20yr impact area
8	3000024281	2985 OAKTREE LN	HOSHLD	83	12/2/1997	Juts downstream of 20yr impact area
9	3000022932	1268 BRIDGE RD	HOSHLD	86	3/13/1998	A little further downstream of 20yr impact area
10	3000011061	1258 BRIDGE ST	HOSHLD	94	8/21/2009	A little further downstream of 20yr impact area
11	3000022947	1286 BRIDGE RD	HOSHLD	105	6/13/1994	A ways (~1100ft) downstream of 20yr impact area, right next to Kalamazoo River)

PRIORITY RANK #10

Site Name: 150 North Main Street

Site ID: 03000265

Local Unit of Government: City of Wayland

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Arsenic, Mercury, Tetrachloroethylene (PCE), Trichloroethylene (TCE)

Also: zinc, selenium and copper.

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Mercury Maximum Contaminant Level (MCL)

2 parts per billion (ppb), or 0.002 mg/L

Tetrachloroethylene (PCE) Maximum Contaminant Level (MCL)

5 parts per billion (ppb) or 0.005 mg/L

Trichloroethylene (TCE) Maximum Contaminant Level (MCL)

5 parts per billion (ppb) or 0.005 mg/L

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Mercury

Short-term or long-term exposure to mercury may cause kidney damage.

Tetrachloroethylene (PCE)

Exposure to TCE may cause liver problems or increased risk of cancer.

Trichloroethylene (TCE)

Exposure to TCE may cause liver problems or increased risk of cancer.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the short-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the short-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater-Surface Water Interface (GSI)

Risk Controlled Interim

Groundwater contamination is not reasonably expected to vent to surface waters, or does not exceed GSI criteria, or mixing-zone based GSI criteria established by EGLE.

Sensitive Environmental Receptors

Risk Controlled Interim

No sensitive habitat or resources exist on or near the sites or facility.

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on information provided in a 2019 BEA: The sits has been an active gas station since the 1950's and has operated as an automotive service center. The site is a LUST facility with at least one release (2014). This 2014 release was later closed with a Tier I evaluation with no land use restrictions. Active soil vapor mitigation systems are in operation at two buildings at the site. The source of contamination at the site is likely attributed to historic petroleum fuel storage and dispensing as well as automotive repair activities. Soils present at the site are sand dominant and the depth to groundwater is approximately 17-18 feet bgs.

While there is likely additional sample data associated with the site's 213 investigation(s), data evaluated as a part of this review is limited to that presented in the 2019 BEA. Soil sample analytical results also indicate that soil sample HA-1 (5.5-6') exceeded DW and VIAP criteria for Tetrachloroethylene and Trichloroethylene (both recognized as acute vapor risks). According to the 2019 BEA, potential VI risks are addressed onsite by vapor mitigation systems. Residential properties are located immediately to the east of the site. The BEA does not mention any vapor assessment or mitigation activities conducted at off-site parcels. An easterly adjacent residence shows an active household drinking water well installed at 42' bgs (126 E. Maple).

Baseline Environmental Assessment (BEA)

Date of documents: 04/2019 by Dell Engineering, INC. prepared for Management Systems, LLC.

The intended use of the property is as a gasoline filling station, convenience store, and automotive repairing and towing service garage. This appears to be the historical use of the property as well (more on this below).

A Phase I Environmental Site Assessment (ESA) was conducted in 2015, with a follow up Phase II study and supplemental soil samplings events in 206, 2017, and 2018.

The Phase I study identified the following recognized environmental conditions (RECs):

- operations as an automobile repair shop were ongoing since at least the 1950s. Significant staining associated with the use and storage of oils and other hazardous substances was observed on the ground at the property.
- A gasoline released in relation to underground storage tanks (USTs) that were removed from the ground in 2014. Impacted soils were excavated and analyzed for gasoline constituents. This Leak UST (or LUST) is considered closed because the soil samples did not show concentrations above applicable Risk Based Screening Levels.

The Phase II study involved soil and groundwater sampling on the property to further investigate the concerning historical and current use of the property.

VOCs were detected in soil samples above method detection limits, including concentrations of tetrachloroethylene (PCE) and trichloroethylene (TCE) that exceeded Part 201 Residential Drinking Water

Protection criterion. Additionally, (i) select PNAs/PAHs were detected above method detection limits, but none of the detections were at concentrations above Part 201 GRCC; and (ii) select metals above method detection limits, including concentrations of arsenic, copper, lead, selenium, and zinc that exceeded Part 201 Residential Drinking Water Protection and/or Groundwater Surface Water Interface Protection criteria.

In terms of groundwater samples, there were no target VOCs or PNAs/PAHs that were detected at concentrations above method detection limits. One target metal, barium, was detected above the method detection limit, but the concentration did not exceed Part 201 Statewide Default Background Levels of Part 201 GRCC.

As noted by the EGLE Ride reviewer, residential properties with groundwater wells exist adjacent to the subject property, but groundwater data were not collected from these properties for the BEA or previous related studies.

Based on the analytical results obtained from sampling, impacted soil is present in the northeastern portion of the property. The horizontal and vertical extent of the impact has not been defined.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- 2 yr. and part of 10yr impact area inside WHPA, Type 1 Well about 15000ft south of 10yr impact area
- several private wells about 1000ft north of 20yr impact area
Non-drinking water risk:
- 1 irrigation well about 1000ft south of 10yr impact area
Surface water risk:
- Rabbit River (designated trout stream) about 3200ft downstream of 20yr impact area
Aquifer Vulnerability
- High vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

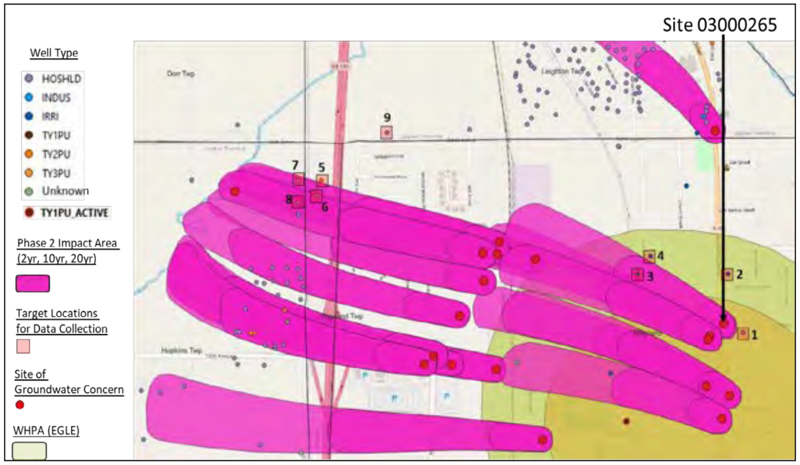


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000028245	126 E MAPLE	HOSHLD	42	8/20/1977	Just upstream of site
2	3000028216	312 NORTH MAIN	IRRI	26	9/20/1977	About 550ft north of the site
3	3000028322	311 PARK ST	IRRI	38	6/30/1983	Directly downstream from site, inside 10yr impact area
4	3000028267	338 PARK ST	IRRI	49	8/16/1988	Just north of leading edge of 10yr impact area
5	3000004337	3587 12th Street	TY2PU	66	7/14/1995	Downstream of 20yr impact area
6	3000019900	3575 12TH ST	HOSHLD	60	1/16/1998	Downstream of 20yr impact area
7	3000011595	3584 12TH ST	HOSHLD	60	11/18/2010	Further downstream of 20yr impact area
8	3000013856	3568 12TH	HOSHLD	58	11/16/2014	Further downstream of 20yr impact area, and a little south
9	3000030433	1165 DAHLIA AVE	HOSHLD	55	9/16/1982	Downstream of 20yr impact area and north

PRIORITY RANK #11

Site Name: 101 124th Avenue

Site ID: 03000268

Local Unit of Government: Wayland Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater-Surface Water Interface (GSI)

Risk Present and Require Action in the long-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risk Present and Require Action in the long-term

The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments:

Not available.

Baseline Environmental Assessment (BEA)

Date of documents: September 2023 by Marshall Associates prepared for Gun Lake Leasing, LLC.

The intended use of the property is the exterior storage of RVs, requiring no material changes in development.

The property was vacant from at least 1938 to 1981. The current structure that is on the property was built in 1987 and operated as an automobile repair shop until 2000. From 2000-2010, Hot Rod Custom & Supply Inc occupied the property, and from 2014 to present (time of BEA) it was Eradico Pest Services.

An earlier BEA (2010) identified a recognized environmental condition (REC), namely, elevated levels of tetrachloroethene in soils and lead in a potable well above EGLE's Generic Residential Cleanup Criteria (GRCC).

In 2023, a potable well on the property was sampled and analyzed for lead; it was not identified in the groundwater at levels above EGLE's GRCC.

A full delineation of the nature / extent of the hazardous substances was not performed as part of this BEA, but prior assessments suggest the contamination above GRCCs is present 1- to 4-feet below ground surface. The soil is comprised of sand and clay.

Phase 2 Groundwater Study Comments

Drinking water risk:
- 3 type2 or type 3 wells within 500ft of site, another 3 about 1000ft north/northeast of site
- 1 private well in 2yr impact area, several others nearby the site and 10yr impact area, 10+ private wells just north (~600ft) of 20yr impact areas

Non-drinking water risk:
- 1 irrigation well in 2yr impact area, another ~700ft north of site

SW risk:
• wetlands in 10yr impact areas

Aquifer vulnerability:
• Vulnerability of 183 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

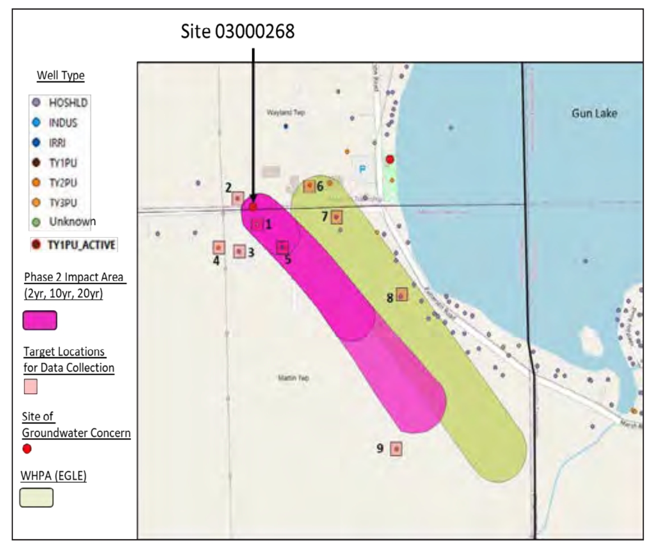


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000022598	110 124TH AVE	HOSHLD	52	5/10/1990	Directly adjacent to the site
2	3000010997	111 124TH AVE	HOSHLD	66	7/20/2009	Just upstream/northwest of site
3	3000022601	108 124TH AVE	HOSHLD	50	8/15/1989	Just west/southwest of site and 2yr impact area
4	3000008961	116 124TH AVE	TY3PU	43	6/15/2006	West/southwest of the site and 2yr impact area
5	3000015143	2392 Sterling Lane	IRRI	40	6/27/2017	Downstream of site, near leading edge of 2yr impact area
6	3000000995	77 124th Ave.	TY2PU	54	8/11/1994	East of site and 2yr impact area
7	3000032261	RN #1	HOSHLD	43	12/14/1972	East of leading edge of 2yr impact area
8	3000032253	PATTERSON RD	HOSHLD	57	5/4/1968	East of leading edge of 10yr impact area
9	3000007402	--	TESTW	200	3/30/2005	Deep test well near leading edge of 20yr impact area

PRIORITY RANK #12

Site Name: 236 Hubbard Street

Site ID: 03000310

Local Unit of Government: City of Allegan

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Arsenic, vinyl chloride, Lead, Benzo(b)fluoranthene

Also: naphthalene, phenanthrene, fluoranthene; Cr (Chromium), Hg (Mercury), and Se (Selenium)

Relevant Drinking Water Standards

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Vinyl chloride Maximum Contaminant Level Goal (MCLG)

2 parts per billion (or 0.002 parts per million or 0.002 mg/L)

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Benzo(b)fluoranthene Maximum Contaminant Level Goal (MCLG)

0.2 parts per billion (or 0.0002 parts per million or 0.0002 mg/L)

Human Health Perspectives

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Vinyl chloride

The effects of drinking high levels of vinyl chloride are unknown. Animal studies suggest long-term exposure to vinyl chloride can damage sperm and testes. Inhalation over the long-term is believed to produce liver damage, nerve damage, and immune system reactions.

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Benzo(b)fluoranthene

This is one of the chemicals in the Polycyclic Aromatic Hydrocarbons group. It is a suspected (probable) carcinogen to humans, and may cause reproductive damage. Short-term exposure can cause skin or eye irritation.

RIDE Classification:

RIDE Risk Category

Risk Present and Require Action in the short-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the short-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater-Surface Water Interface (GSI)

Risk Present and Require Action in the short-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located within two years groundwater travel time from a surface water body, or

the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risk Present and Require Action in the short-term

The leading edge of the groundwater contamination is located within two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2001 BEA: The site was residential in use until 1944 at which point use transitioned to auto repair and salvage until the 1990's. The site is now operated by the City of Otsego DPW as offices and vehicle maintenance use. Sources of contamination are associated with historic automobile servicing and salvage operations. Due diligence sampling activities included the installation of 12 soil borings at depths of up to 12 feet bgs to facilitate soil and groundwater sample collection. In total, seven soil sample and ten groundwater samples were collected. Soil and groundwater samples were analyzed for MI 10 metals, VOCs, and PNAs. Soils encountered during the investigation were native sands overlain by varying thicknesses of fill material. Groundwater was encountered in each boring at depths ranging from 4 to 11 feet bgs. Groundwater flow direction was not calculated but is assumed to flow toward the Kalamazoo River which borders the site to the south. Soil sample analytical results indicated exceedances of DC criteria in Arsenic and Lead with maximum concentrations noted at 18,000 ug/kg and 530,000 ug/kg, respectively; and exceedances of GSIP criteria in Cr, Hg, and Se with max concentrations of 24,000, 3,200, and 2,000 ug/kg, respectively. Groundwater sample analytical results indicated exceedances of GSI criteria in naphthalene, phenanthrene, fluoranthene, and arsenic with max concentrations of 14, 5.9, 5.1, and 150 ug/L, respectively; and exceedances of DW criteria in benzo(b)fluoranthene, vinyl chloride, and arsenic with max concentrations of 2.1, 17, and 150 ug/L, respectively. It should also noted that the maximum VC concentration of 17 ug/L was measured at 4' bgs (SP-6) and exceeds nonresidential VIAP criteria.

call 800-662-9278.

Baselines Environmental Assessment(s)

Date of documents: August 2021 by Miller, Canfield, Paddock & Stone, PLC. prepared for Shoreline Insurance Services.

The correspondence document from the 2001 BEA suggests that the BEA "does not provide sufficient information to demonstrate that the subject property is a facility defined by Part 201". However, the RIDE classification review form identifies recognized environmental conditions (RECs) and soil and groundwater concentrations exceeded DC, GSIP, and GSI criteria. Please refer to the RIDE classification form.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is inside WHPA, about 615ft from type 1 wells; across the Kalamazoo River from another WHPA and Type 1 wells (Kalamazoo likely river a hydraulic barrier, providing water to wells)

Non-drinking water risk:
- No non-drinking water wells in vicinity

Surface water risk:
discharge to Kalamazoo River after ~5 years.
AQ vulnerability:
• Very high vulnerability of 191 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

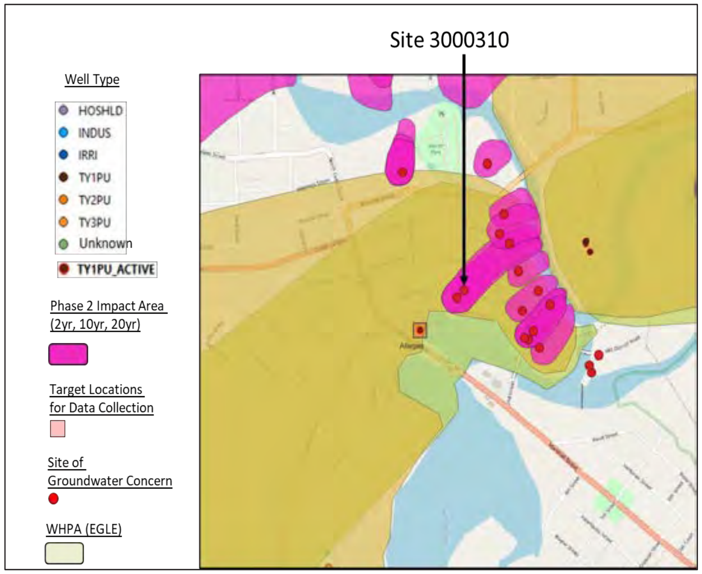


Table: Information of existing wells targeted for groundwater data collection.

WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
3000000269	ALLEGAN GRISWALD WELL #4	TY1PU	60	--	Type 1 PS well directly upstream (450 ft) of site

PRIORITY RANK #13

Site Name: 1218 M-89 Highway

Site ID: 03000283

Local Unit of Government: Allegan Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Iron, Manganese, Chromium, Arsenic

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Iron Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards that aim to protect against cosmetic (e.g., tooth discoloration) effects or aesthetic effects in drinking water. The secondary standard for iron is 0.3 mg/L.

Manganese Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards in drinking water. The secondary standard for manganese is 0.05 mg/L.

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Chromium Maximum Contaminant Level Goal (MCL)

0.1 mg/L (0.1 parts per million)

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Iron

Normal or elevated levels of iron are not known to cause health issues, but can lead to a metallic taste. Excessive amounts can cause stomach problems and nausea, and other potential health issues.

Manganese

Normal or elevated levels of manganese are not known to cause health issues, but an lead to a noticeable color, odor, or tase in water. Excessive amounts of manganese may be toxic.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Chromium

Prolonged exposure above MCLG may result in allergic dermatitis (skin reactions).

RIDE Classification:

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater – Surface Water Interface

Inadequate data to assign risk.

Sensitive Environmental Receptors

Inadequate data to assign risk.

RIDE Reviewer Comments:

COMMENTS of Reviewer: Based on a 2018 BEA: The site has historically been used for agriculture and commercial (trailer sales) land uses. The current use of the site is an Arby's restaurant built in 1999. As a part of due diligence activities, seven soil samples were submitted for laboratory analysis of TAL metals only (based on metals contamination documented at the northerly adjacent Home Depot site). The results of the laboratory analyses of the soil samples identified arsenic in subsurface soils at the AKT-1 (11,000 ug/kg), AKT-3, and AKT- 4 soil boring locations above DWP, GSIP, and DC criteria; total chromium in subsurface soils at the AKT-1, AKT-2 (19,000 ug/kg), AKT-3, and AKT-4 soil boring locations at concentrations exceeding the GSIP Criteria; iron in subsurface soils at the AKT-1 (16,000,000 ug/kg) and AKT-3 soil boring locations at concentrations exceeding DWP Criteria; magnesium in subsurface soils at the AKT-1 (29,000,000 ug/kg), AKT-2, AKT-3, and AKT-4 soil boring locations at concentrations exceeding the DWP Criteria; and manganese in subsurface soils at the AKT-3 soil boring location at concentrations of 470,000 ug/kg, exceeding the DWP Criteria. Soils encountered in the soil borings were sand dominant. Soil borings were advanced to depths of up to 20' bgs and groundwater was not encountered. The site is nearly entirely paved, and the site and surrounding parcels are serviced by municipal water. Two Type I water wells are located approximately 600 feet southeast of the site. A portion of the site may be located in a WHPA. To fully evaluate the risk of GW ingestion and GSI, groundwater sample collection may be appropriate - depth to GW should be 20-25' at this site.

r call 800-662-9278.

Baseline Environmental Assessment

Date of documents: August 2018 by AKT Peerless Environmental prepared for FCPT Holdings LLC.

The intended use of the property is restaurant operations in the 19-year old building located on the property. Significant quantities of hazardous wastes are not expected to be generated.

Prior to development as restaurant property, the site was residential land use as early as the 1910s. By the 1960s, the site was also part of a larger surrounding Curtis Trailer Sales facility as well as a seasonal campground. A paved parking lot was developed in the early 1990s associated with a former Kmart store (now Home Depot).

A Phase I Environmental Site Assessment (ESA) in 2018 identified a recognized environmental condition (REC) based on environmental assessments on neighboring properties, namely, the identification of elevated metal concentrations in excess of Part 201 residential cleanup criteria. No sampling results from the subject property were available for review at the time of the Phase 1 study.

A Phase II study in 2018 by AKT Peerless consisted of soil borings and the collection of seven soil samples (groundwater was not encountered during the subsurface investigation).

Analytical results reveal arsenic in subsurface soils at concentrations above the Residential Drinking Water Protection (DWP), Surface Water Interface Protection Criteria (GSIP) and Direct Contact (DC) criteria; total chromium at concentrations exceeding the GSIP Criteria; iron concentrations exceeding the DWP Criteria; magnesium concentrations exceeding the DWP Criteria, and manganese concentrations exceeding the DWP criteria. The presence of these metals was throughout the property.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- 2 yr. and part of 10yr impact area inside WHPA, Type 1 Well about 1500ft southwest of 10yr impact area
- several private wells about 1000ft north of 20yr impact area

Non-drinking water risk
- 1 irrigation well about 700ft south of 10yr impact area

Surface water risk:
- Rabbit River (designated trout stream) about 3300ft downstream of 20yr impact area

Aquifer Vulnerability
• High Vulnerability of 169 at site (164-177 => 0.8 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

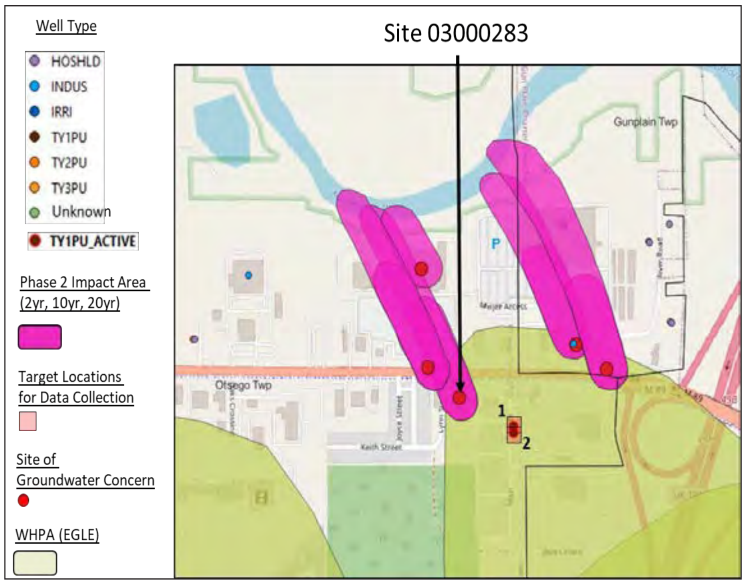


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000001151	Andrews MHP, Well 1	TY1PU	--	1/1/1964	Type 1 PS well just east of site/2yr impact area
2	3000001153	Andrews MHP, Well 2	TY1PU	41.5	4/4/1974	Type 1 PS well just east of site/2yr impact area

PRIORITY RANK #14

Site Name: 637 West Sycamore Street, Wayland

Site ID: 03000436

Local Unit of Government: City of Wayland

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Iron, Arsenic

Relevant Drinking Water Standards

Iron Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards that aim to protect against cosmetic (e.g., tooth discoloration) effects or aesthetic effects in drinking water. The secondary standard for iron is 0.3 mg/L.

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Human Health Perspectives

Iron

Normal or elevated levels of iron are not known to cause health issues, but can lead to a metallic taste. Excessive amounts can cause stomach problems and nausea, and other potential health issues.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the long-term

Based on the site CSM and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the

long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from known extent of the contaminants of concerns.

Groundwater-Surface Water Interface (GSI)

Risk Present and Require Action in the long-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risk Present and Require Action in the long-term

The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments:

COMMENTS of Reviewer: Based on a 2021 BEA: The site is a 17.53a vacant wooded parcel. The site was used for row crop production as early as 1938 and had gone fallow by 1979 and wooded by 1981. An oil well was drilled on the property in 1957 and was actively producing at the time of the BEA. As a part of due diligence activities, five soil borings were advanced to a maximum depth of 6.5 feet bgs for the collection of four soil samples and four groundwater samples for the analysis of VOCs, PNAs, metals, mercury, and chloride. Based on the soil sample analytical results, the maximum concentrations of the following COCs in ug/kg, exceeded nonresidential Part 201 criteria: arsenic (6,300 - DWP, GSIP); and iron (9,100,000 - DWP). Based on the groundwater analytical results, the only COC to exceed Part 201 Criteria was iron at a concentration of 2,700,000 ug/L. Relevant exposure pathways would be GSI as the site is bisected by a creek and ingestion as a municipal well is located approximately 1,000' NE of the site.

Baseline Environmental Assessment(s)

Date of documents: Sept. 2023 by Rose and Westra, a Division of GZA GeoEnvironmental, and prepared for 637S LLC.

The intended purpose of the site is redevelopment into a multi-family residential units.

At the time of the BEA, the site was wooded and vacant. An active oil well was present on the southeast portion of the site.

Historically, the site was agricultural land (at least as far back as 1938). The oil well was added to the property in 1967 and appears to include a reserve pit commonly used during oil well development. By about 1980 the site appears to have gone fallow and by 1981, it was wooded.

The 2021 Phase I Environmental Site Assessment (ESA) identified the following recognized environmental conditions (RECs):

- Release of contaminants and petroleum hydrocarbons to soil and potentially groundwater from historic oil and gas operations conducted over 55 years
- Likely migration of contaminants and petroleum products from the aboveground storage tank battery located just off-site

In July 2021 sampling activities were conducted, including six soil borings and the conversion of three of the soil borings into temporary groundwater monitoring wells.

In each of the groundwater samples iron was identified at concentrations greater than the residential and nonresidential aesthetic drinking water criterion (DWC). At two locations the iron concentration exceeded the health-based DWC of 2 mg/L. Groundwater contamination may be widespread in proximity to and down gradient from the oil-field equipment.

Arsenic was identified in soil samples at concentrations exceeding the Statewide Default Background Levels.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- 2yr impact area overlapping with WHPA, Type 1 well about 1000ft upstream of site, several others just downstream or north of 20yr impact area
- Type 3 well ~500ft south of 20yr impact area
'- 4 private wells in 20yr impact area
Non-drinking water risk:
- 1 irrigation well about 500ft south of 20yr impact area, another about 1200ft northeast of site
Surface water risk:
- wetlands and 1st order stream in 10yr and 20yr impact areas, portion of wetland in 2yr impact area
Aquifer Vulnerability
• Very high vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

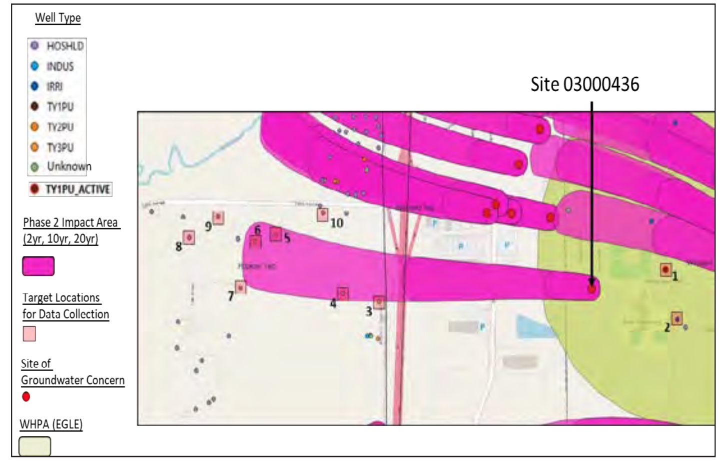


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000000283	WAYLAND WELL #3	TY1PU	251	--	Type 1 PS well, very deep
2	3000028281	333 CEDAR	IRRI	41	6/7/1974	Upstream/east of site
3	3000019913	3456 12TH ST	OTHER-SHOP	40	10/20/1988	Just downstream of leading edge of 10yr impact area, inside 20yr impact area
4	3000014343	3456 12th St	HOSHLD	45	1/22/2016	Downstream of leading edge of 10yr impact area, inside 20yr impact area
5	3000020011	1250 135TH AVE	HOSHLD	56	7/20/1988	Inside 20yr impact area
6	3000018157	1260 135th Ave	HOSHLD	70	11/26/2021	Inside 20yr impact area, just inside leading edge
7	3000019920	3461 13TH ST	HOSHLD	39	7/13/1987	Just downstream of leading edge of 20yr impact area
8	3000005872	3482 13TH ST.	HOSHLD	42	4/4/1990	Downstream of leading edge of 20yr impact area
9	3000019986	1288 135TH AVE	HOSHLD	40	7/31/1974	Downstream of leading edge of 20yr impact area
10	3000019921	1226 135TH ST	HOSHLD	48	6/6/1987	North of 20yr impact area

PRIORITY RANK #15

Site Name: Ridderman Card-OP

Site ID: 00011505

Local Unit of Government: Gunplain Twp.

Dataset: Leaky Underground Storage Tanks (Part 213)

Substances of concern: unknown

The Remediation Information Data Exchange (RIDE) system from EGLE does not include any information on this location.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
• Household wells in 2yr impact area, 2 wells in 20yr impact area, many just outside impact areas
• Type 2 PS well in 2yr impact area, two others <400ft south of site
• Site, 2, yr. and 10yr impact areas inside of WHPA; multiple type 1 well 900ft outside of 10yr impact area
Non-drinking water risk:
•Two irrigation wells <700ft outside of 20 yr. impact area
Surface water risk:
•Wetlands and Kalamazoo River downstream of Kalamazoo River
Aquifer Vulnerability
• Very high Vulnerability of 185 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

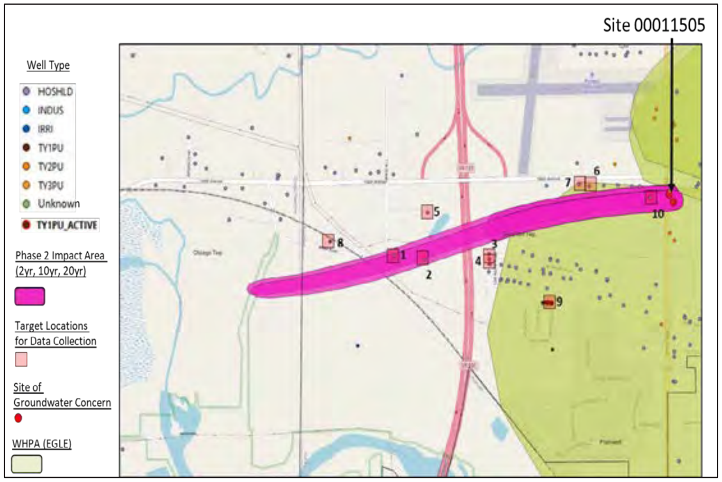


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000022489	1143 MILLER RD	HOSHLD	44	8/13/1997	Downstream from site, within the 20yr. Impact area from Phase 2
2	3000022509	1123 MILLER RD	HOSHLD	35	9/1/1993	Downstream from site, within the 20yr. Impact area from Phase 2
3	3000022573	566 CLAN ALPINE ST	HOSHLD	41	7/28/1995	Just south of leading edge of 10yr impact area
4	3000003701	564 CLAN ALPINE	HOSHLD	41	7/22/2002	Just south of leading edge of 10yr impact area
5	3000022542	595 11TH ST	HOSHLD	33	6/17/1986	North of 20yr impact area from Phase 2
6	3000022492	1042 106TH AVE	HOSHLD	44	10/20/1997	Just north of 10yr impat area from Phase 2
7	3000016685	1050 106th Ave	HOSHLD	37	11/2/2016	Just north of 10yr impat area from Phase 2
8	3000017082	1181 Miller Rd	IRRI	49	3/11/2020	North of 20yr impact area from Phase 2
9	3000012106	Gun River Estates	TY1PU	93	6/20/2012	Cluster of active TY1PU wells south of 10yr impact area, owned by Gun River Estates West
10	3000008369	590 10th St.	HOSHLD	112	4/6/2006	Within 2yr impact area from Phase 2

PRIORITY RANK #16

Site Name: Martin (LUST Site)

Site ID: 00015678

Local Unit of Government: Village of Martin

Dataset: Leaky Underground Storage Tanks (Part 213)

Substances of concern: unknown

The Remediation Information Data Exchange (RIDE) system from EGLE does not include any information on this location.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is just inside WHPA, about 1000ft east of Type 1 wells; another WHPA north (upstream) of site with type 1 wells about 2200ft from the site
- 1 private wells in 20 yr. impact area, another few just outside of 10 yr. and 20yr impact areas; several others in vicinity

Non-drinking water risk:
- 2 industrial wells about 185ft southwest of site
- 1 irrigation well about 1900ft southeast of site, another about 2400ft southeast of site

Surface water risk:
•No interaction with surface water in 20yr travel

Aquifer Vulnerability
• High Vulnerability of 168 at site (164-177 => 0.8 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

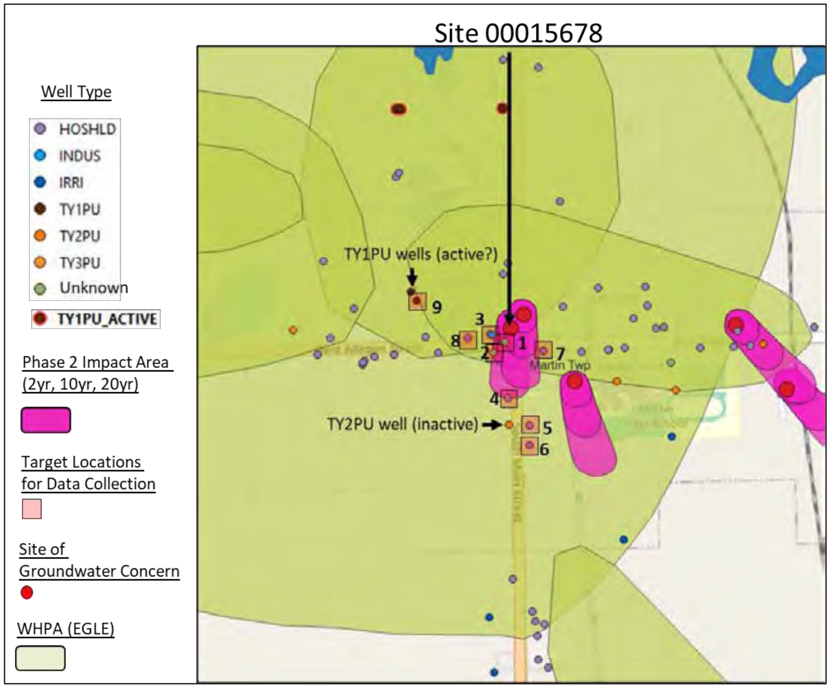


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000032240	ALLEGAN ST	UNK	52	12/23/1988	Directly downstream of site, within 2yr impact area
2	3000025957	W ALLEGAN ST	OTJHER-TELEPHONE BUILDING (?)	48	6/8/1982	Downstream of site on the edge of 10yr impact area
3	3000023637 03000023643	1011 W ALLEGAN ST	INDUS	100 102	7/7/1983 7/3/1983	Two industrial wells just west of site / 2 yr. impact area
4	3000025943	1574 10TH ST	HOSHLD	32	4/18/1979	Downstream of site on leading edge of 20yr impact area
5	3000025932	1569 10TH ST	HOSHLD	42	12/12/1977	Downstream of leading edge of 20yr impact area
6	3000025915	1563 10TH ST	HOSHLD	75	8/25/1992	Further downstream of leading edge of 20yr impact area
7	3000023764	990 E ALLEGAN ST	HOSHLD	49	10/31/1988	East of 10yr impact area
8	3000023640	1017 W ALLEGAN ST	HOSHLD	45	9/11/1979	West of 10yr impact area
9	3000000221	BEECH LANE APARTMENTS WELL #1	TY1PU	88	8/24/1982	Type 1 PS well west of the site; site is within its WHPA

PRIORITY RANK #17

Site Name: 6494 Clearbrook Drive & 6402 and 6500 13

Site ID: 03000439

Local Unit of Government: Saugatuck Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead

Relevant Drinking Water Standards

Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Human Health Perspectives

Lead

Short-term or low levels of exposure of lead may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive

environmental receptors within the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the know extent of the contaminants of concern.

Groundwater-Surface Water Interface (GSI)

Risk Present and Require Action in the long-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risk Present and Require Action in the long-term

The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments

Not available.

Baseline Environmental Assessment (BEA)

Date of documents: 02/15/2022 by Triterra on behalf of Saugatuck Golf Club, LLC (the Submitter) purchasing the Property.

The property is approximately 115 acres and primarily occupied by the Clearbrook Golf Course. At the time of the preparation of this report (April 2024), that is still the case.

The historical and current uses of the Property were evaluated in a 2021 Phase I Environmental Site Assessment (ESA) completed by Driesenga & Associates, Inc. The study identified the following recognized environmental conditions (RECs):

- Lack of containment structure at the fuel storage and dispensing area, which means motor oil, diesel and gasoline may have infiltrated into the underlying soil in the vicinity.
- Lack of containment structure beneath a plastic aboveground storage tank (AST) holding unknown fluid.

- A burn pile where oil was poured to initiate firing of wood product, some of which may have infiltrated into the underlying soils.
- Uncontrolled dump area in a wooded lot on property, near Goshorn Creek.
- The historic interior waste stream (including that of use petroleum products from maintenance operations and chemical storage) is not established/documented in any way.

Subsurface investigations were carried out in 2012 by PM Environmental and in 2022 by Triterra.

The 2012 investigation consisted of eight soil borings and six temporary monitoring wells. Laboratory analysis of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), arsenic, cadmium, chromium, and lead were performed. No contamination was detected at concentrations exceeding the Part 201 Residential Generic Cleanup Criteria (GCC).

The 2022 investigation consisted of soil sampling at seven soil boring locations. The samples were analyzed for VOCs, PAHs, and the "Michigan 10 Metals" (arsenic, barium, cadmium, total chromium, copper, lead, selenium, silver, zinc and mercury).

In multiple samples, lead was identified at concentrations exceeding the Part 201 Drinking Water Criteria. The maximum concentration observed was 9 ppb (parts per billion). Some other target parameters were detected at concentrations above respective method detection limits, but below the Part 201 Residential GCC and Screening Levels. In addition, the extent of contamination has not been delineated. Thus, there is a potential that these substances may be present at levels above the Part 201 Residential GCC and Screening Levels.

Phase 2 Groundwater Study Comments

Drinking water risk:
- site and all impact areas are inside WHPA, about 2900ft from type 1 well, and ~5400ft from two other type 1 wells
- type 2 well just west of 2yr impact area

Non-drinking water risk:
- 1 irrigation well just west of the site, another ~700ft upstream, and two more further upstream of site

Surface water risk:
- discharge to 1st order Goshorn creek after 5years

Aquifer Vulnerability:
• Somewhat high vulnerability 138 at site (138-151 => 0.6 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

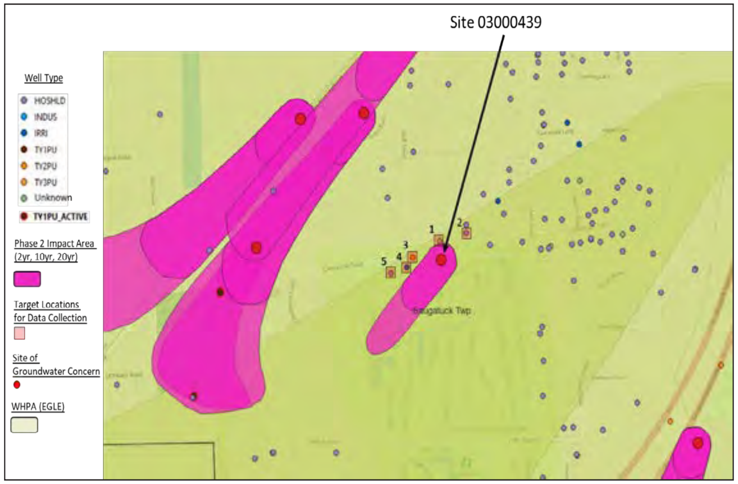


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000010294	6487 Clearbrook Dr.	HEATP	125	11/7/2008	HEATP well just upstream of site / 2yr impact area
2	3000010294	6487 Clearbrook Dr.	HEATP	125	11/7/2008	HEATP well just upstream of site / 2yr impact area
3	3000001903	6494 Clearbrook Drive	TY2PU	99	--	Type 2 PS well just west of 2yr impact area
4	3000017539	6494 Clearbrook Dr.	IRRI	126	12/3/2020	irrigation well, just west of 2yr impact area
5	3000025770	6494 CLEARBROOK DR.	HOSHLD	43	9/20/1969	Household well owned by Clearbrook golf course (?), just west of 2yr impact area

PRIORITY RANK #18

Site ID: 03000340

Site Name: 558, 520, and 512 Water Street

Local Unit of Government: City of Allegan

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Mercury, Arsenic, Chromium, Cadmium

Also: barium, selenium, zinc, copper, and some Petroleum Volatile and Semi Volatile Organic Compounds

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Mercury Maximum Contaminant Level (MCL)

2 parts per billion (ppb), or 0.002 mg/L

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Chromium Maximum Contaminant Level (MCL)

0.1 mg/L (0.1 parts per million)

Cadmium Maximum Contaminant Level (MCL)

5 parts per billion (or 0.005 mg/L)

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Mercury

Short-term or long-term exposure to mercury may cause kidney damage.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Chromium

Prolonged exposure above MCLG may result in allergic dermatitis (skin reactions).

Cadmium

Exposure above MCLG may result in kidney damage.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors within the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the short-term

Groundwater contamination exceeds drinking water criteria and a public or private water supply well that is producing from the contaminated aquifer, is located within two years groundwater travel time from the known extent of contaminants of concern.

Groundwater-Surface Water Interface (GSI)

Risks Present and Requires Action in the Short-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located within two years groundwater travel time of a surface water body or the

plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer within two years travel time.

Sensitive Environmental Receptors

Risks Present and Requires Action in the Short-term

The leading edge of the groundwater contaminant plume is located within two years groundwater travel time distance of a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments

Not available.

Baseline Environmental Assessment(s)

Date of documents: 01/2008 by Environmental Resources Management on behalf of 558 Water LLC and Terpstra Inc.

At the time of this BEA, Terpstra Inc. intended to operate a hardware business on a portion of the 2.5-acre property. There were tenants in other buildings (used as a hair salon and antiques storage) that were expected to stay the same. Operations at the site will not involve significant hazardous substance use.

The site history includes contaminated fill and releases from gasoline filling stations activities on adjacent properties. More specifically, a plume of gasoline constituents migrating from the adjacent gas stations was identified as a recognized environmental conditions (REC) in a Phase I Environmental Site Assessment (ESA).

A Phase II ESA was performed as part of this BEA that involved seven soil borings, two surface samples, and three groundwater samples. The soil and groundwater samples were analyzed for the Michigan 10 Metals (arsenic, barium, cadmium, total chromium, copper, lead, selenium, silver, zinc and mercury), VOCs, and PNAs. Analytical results indicate concentrations of arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, and/or zinc in soils, and concentrations of arsenic and selenium in groundwater, which exceed one or more Part 201 generic residential cleanup criteria.

The petroleum constituents migrating from the nearby LUST sites are expected to degrade over time. The Hunter's Shell Part 213 remedy is monitored natural attenuation. With respect to fate and transport, data is not available to show any impacts are migrating or have migrated.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is inside WHPA, about 1500ft downstream from type 1 wells; across the Kalamazoo River from another WHPA and Type 1 wells (Kalamazoo River likely a hydraulic barrier, providing water to wells)
Non-drinking water risk:
• No non-drinking water wells in vicinity

Surface water risk:
- "immediate" discharge to Kalamazoo River

Aquifer Vulnerability
• Extremely High vulnerability of
203 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

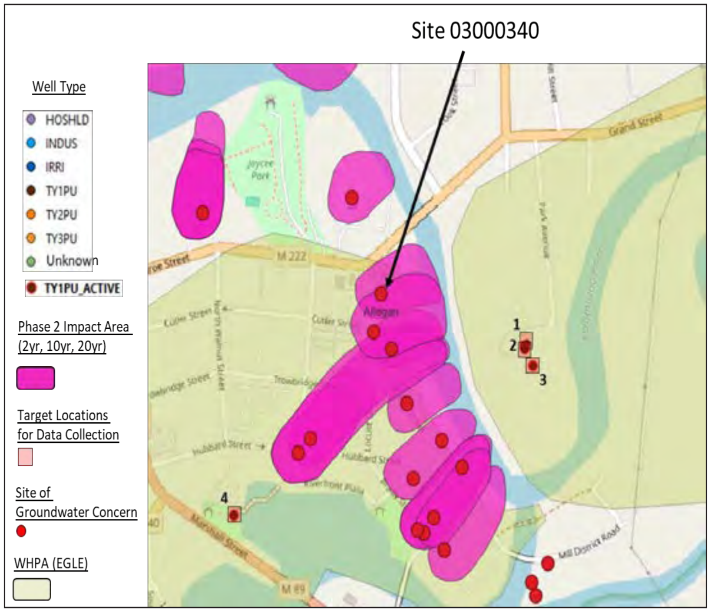


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000000266	ALLEGAN PINGREE PK WELL #1	TY1PU	89	1/1/1972	Type 1 PS well across the Kalamazoo River from site
2	3000000267	ALLEGAN PINGREE PK WELL #2	TY1PU	80	--	Type 1 PS well across the Kalamazoo River from site
3	3000011265	100 Park Ave.	TY1PU	77	12/9/2010	Type 1 PS well across the Kalamazoo River from site
4	3000000269	ALLEGAN GRISWALD WELL #4	TY1PU	60	--	Type 1PS well, about 1500ft upstream of site

PRIORITY RANK #19

Site ID: 03000281

Site Name: 1185 M-89 Highway

Local Unit of Government: Allegan Township

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Benzo(ghi)perylene and Indeno(123-cd)pyrene

Relevant Drinking Water Standards

Benzo(ghi)perylene

This is one of a group of chemicals called Polycyclic Aromatic Hydrocarbons (PAHs). There is no information available from studies on humans to tell what effects can result from being exposed to individual PAHs at certain levels.

Indeno(123-cd)pyrene

This is also a chemical in the group of PAHs.

Human Health Perspectives

Polycyclic aromatic hydrocarbons

Breathing PAHs and skin contact seem to be associated with cancer in humans. Animal studies demonstrated that mice exposed through ingestion for 10 days (short-term exposure) had offspring with birth defects. Mice exposed for months developed problems in the liver and blood.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive

environmental receptors within the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in invidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from the known extent of the contaminates of concern.

Groundwater-Surface Water Interface (GSI)

Risks Controlled – Interim

Groundwater contamination is not reasonably expected to vent to surface waters, or does not exceed GSI criteria, or mixing zone-based GSI criteria established by EGLE.

Sensitive Environmental Receptors

Risks Controlled – Interim

No sensitive habitat or resources exist on or near the site or facility.

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2015 BEA: The site was used for agricultural/residential purposes up to the late 1960s at which point commercial operations began in the form of auto body repair and a truck stop that stored and dispensed petroleum fuels. The site is current operated and has been a Wendy's restaurant since 1985. The BEA documents that seven soil borings were installed at the site as a part of due diligence activities and resulted in the analysis of three soil samples and three groundwater samples which were tested for VOCs, PNAs, and metals (Cd, Cr, Pb, and Zn). The results of all samples were below lab detection limits or Part 201 criteria with exception of one groundwater sample (RWB-1 20.0-20.4'). The groundwater sample collected from RWB-1 indicated a Benzo(ghi)perylene concentration of 1.3 ug/L and an Indeno(123-cd)pyrene concentration of 2.7 ug/L, both exceeding Part 201 DW criteria. Soils encountered during the soil boring activities were sand dominant and groundwater was present in all soil boring at approximately 20 - 21 feet bgs. Groundwater flow direction was not calculated, but is assumed to be to the north toward the Kalamazoo River. Based on information available on GeoWebFace, the site and surrounding properties are serviced by municipal water. GeoWebFace also notes the presence of an industrial use private water well at the site which was registered to a former owner in 1973. The current disposition of this well is unknown. Two Type I water wells are located approximately 550 feet southwest of the site. The site is located in a WHPA.

Baseline Environmental Assessment (BEA)

Date of documents: 02/2015 by Rose & Westra, Inc. on behalf of WM Limited Partnership.

BEA was conducted in 2015 but the report itself was not available in RIDE. A limited form submitted August 2015 with title "B201502241PL". The following is from that form.

The current property use is a restaurant. The following recognized environmental conditions (RECs) are associated with the property: historical use as a truck stop, auto body shop, and possible fueling operations on the property.

Seven soil borings were completed and temporary monitoring wells were placed in three of the borings. Samples were analyzed for VOCs, SVOCs, cadmium, chromium, lead and zinc. Laboratory analysis revealed one groundwater sample with concentrations of Benzo(g,h,i)perylene and Ideno(1,2,3-cd)pyrene that exceeded Drinking Water Criteria. No other exceedances were detected in the soil or groundwater.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site and 2yr impact areas inside WHPA, site is within 750ft of wells but slightly downstream
- multiple private wells north/northeast of site

Non-drinking water risk:
• No non-drinking water wells in vicinity

Surface water risk:
- discharge to Kalamazoo River after ~4 years

Aquifer Vulnerability
• Very High vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

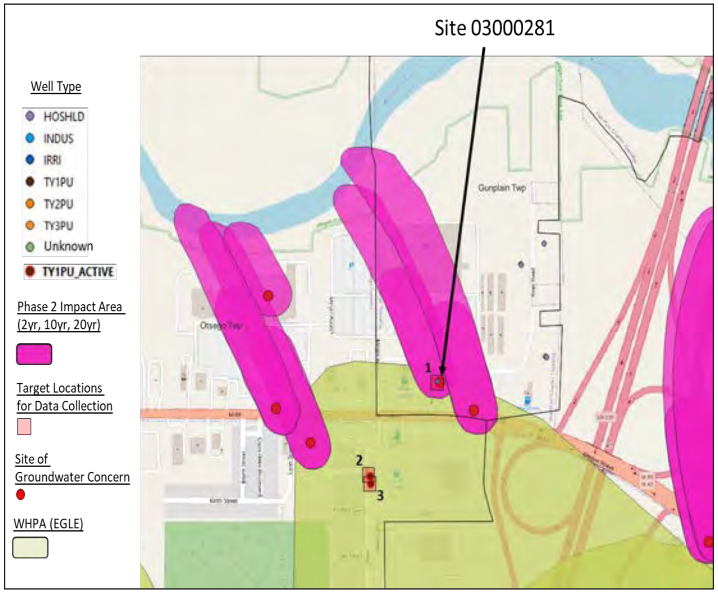


Table: Information of existing wells targeted for groundwater data collection.

1	3000029437	1185 M-89	INDUS	34	11/14/1973	Industrial well right next to the site (on same property?)
2	3000001151	Andrews MHP, Well 1	TY1PU	--	1/1/1964	Type 1 Well about 625 ft southwest (somewhat upstream) from site
3	3000001153	Andrews MHP, Well 2	TY1PU	41.5	4/4/1974	Type 1 Well about 650 ft southwest (somewhat upstream) from site

PRIORITY RANK #20

Site ID: 03000407

Site Name: 1227 M-89, Plainwell MI 49080

Local Unit of Government: Otsego Township

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Iron, Manganese

Also: vanadium, antimony.

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Rule

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Iron Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards that aim to protect against cosmetic (e.g., tooth discoloration) effects or aesthetic effects in drinking water. The secondary standard for iron is 0.3 mg/L.

Manganese Secondary Drinking Water Standard

This substance follows non-enforceable secondary standards in drinking water. The secondary standard for manganese is 0.05 mg/L.

Human Health Perspectives

Lead

Short-term or low levels of exposure may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Iron

Normal or elevated levels of iron are not known to cause health issues, but can lead to a metallic taste. Excessive amounts can cause stomach problems and nausea, and other potential health issues.

Manganese

Normal or elevated levels of manganese are not known to cause health issues, but can lead to a noticeable color, odor, or tase in water. Excessive amounts of manganese may be toxic.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Long-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the know extent of the contaminants of concern.

Groundwater-Surface Water Interface (GSI)

Risks Present and Require Action in the Long-term

*T*he groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risks Present and Require Action in the Long-term

The leading edge of the groundwater contamination is located more than two years groundwater travel time from a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments

Not available.

Baseline Environmental Assessment (BEA)

Date of documents: most recent: 12/2019 by CBRE on behalf of MDC Coast 21, LLC for the commercial property located at 1227 M89, Plainwell, Allegan County, Michigan.

At the time of the BEA, the 8.25-acre property included a single-story building that was operated by Home Depot since 2013. Prior to that, the property was occupied by Kmart. The building itself was constructed in 1992. From at least 1961 to 1992, the property was occupied by Curtis Trailer Sales. Before 1961, and dating back to at least 1938, the property was used for agriculture.

The property was expected to continue to operate as a commercial retail business.

A Phase I Environmental Site Assessment (ESA) was completed by CBRE in 2019. The study identified the following recognized environmental conditions (RECs):

- Curtis Trailer Sales operated in part before environmental regulations. Excavations of about 230 cubic yards of impacted soils from beneath three floor drains were disposed off-Site. “Clean closure” was considered achieved in comparison to Act 307 Type B Remediation Criteria.
- Potential off-site impacts were noted from the Twin Cities Phillips 66 gas station on the adjoining property, and a former paper sludge/historic landfill to the east was identified.

The Phase II ESA consisted of drilling five soil boring and the completion of each boring into a groundwater monitoring well. Samples were analyzed for TAL metals, TPH-gasoline, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and polychlorinated biphenyls (PCBs).

Analytical results did not detect any VOCs, SVOCs, PCBs and or TPH-gasoline in the soil samples. A variety of metals were detected in the soil samples, including detections of antimony, arsenic, iron, manganese, magnesium, selenium and/or thallium that were at concentrations in excess of Part 201 residential cleanup criteria.

Analytical results did not detect any VOCs, SVOCs, PCBs and or TPH-gasoline in the groundwater samples, with the exception of methylene chloride in one sample that was detected at a concentration above the Part 201 residential cleanup criteria. It was “suspected that the detected methylene chloride was a laboratory contaminant; however, QA/QC data was not available to quantify the result.”

The following metals detected in one or more groundwater samples at concentration in excess of the Part 201 residential cleanup criteria: antimony, lead, iron, manganese and/or vanadium.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site and 2yr impact areas inside WHPA, site is within 800ft of wells but slightly downstream
- multiple private wells north/northeast of site

Non-drinking water risk:
• No non-drinking water wells in vicinity
Surface water risk:
- discharge to Kalamazoo River after ~4 years
Aquifer Vulnerability
• Very High vulnerability of 179 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

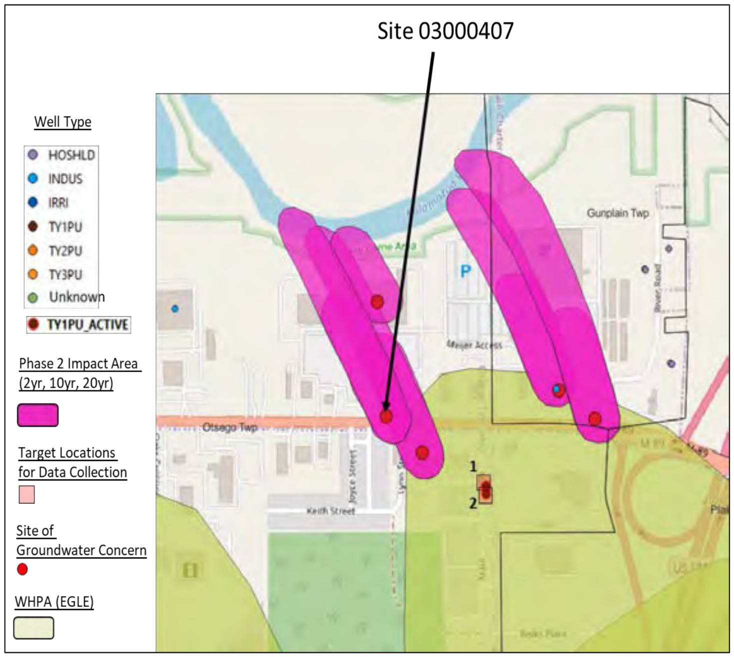


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000001151	Andrews MHP, Well 1	TY1PU	--	1/1/1964	Type 1 PS well just east of site/2yr impact area
2	3000001153	Andrews MHP, Well 2	TY1PU	41.5	4/4/1974	Type 1 PS well just east of site/2yr impact area

PRIORITY RANK #21

Site ID: 03000384

Site Name: East 1/2 of SE 1/4 Section 29

Local Unit of Government: Gunplain Township (Plainwell)

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Arsenic, mercury, Polycyclic aromatic hydrocarbons (benzo(a)pyrene)

Relevant Drinking Water Standards

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Mercury Maximum Contaminant Level (MCL)

2 parts per billion (ppb), or 0.002 mg/L

Polycyclic aromatic hydrocarbons drinking water standard

There is no established drinking water standard for the PAH group or individual PAHs at certain levels.

Human Health Perspectives

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Mercury

Short-term or long-term exposure to mercury may cause kidney damage.

Polycyclic aromatic hydrocarbons

Breathing PAHs and skin contact seem to be associated with cancer in humans. Animal studies demonstrated that mice exposed through ingestion for 10 days (short-term exposure) had offspring with birth defects. Mice exposed for months developed problems in the liver and blood.

RIDE Classification

Ride Risk Category

Risk Present and Require Action in the Long-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally greater than 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from the known extent of the contaminates of concern.

Groundwater-Surface Water Interface (GSI)

Risks Present and Require Action in the Long-term

The groundwater contaminant plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located more than two years groundwater travel time from a surface water body, or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer in more than two years.

Sensitive Environmental Receptors

Risks Controlled Interim

No sensitive habitat or resources exist on or near the site or facility.

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2001 BEA: The site is a 2.62a parcel and is vacant. The property was acquired by adjacent owner Preferred Plastics to develop as an access road. The site is a former railroad easement. The railroad structures were removed from the site between 1986 and 1993. Debris associated with the railroad operations is located on the northwest portion of the property. As a part of due diligence activities, one surficial soil sample was collected for the analysis of PNAs and metals. No soil borings were advanced and no groundwater samples were collected. Based on the laboratory analytical results, nonresidential Part 201 Criteria were exceeded by the following COCs with maximum concentrations listed as: arsenic (18,000 - DWP, GSIP); and mercury (1,900 - DWP, GSIP). Properties to the southwest, northeast, and east of the parcel are serviced by private wells. An unnamed surface water body (pond) is adjacent to the site's northern boundary. Therefore the ingestion and GSI pathways are relevant.

Baseline Environmental Assessment(s)

Date of documents: most recent: 12/2001 by Rose & Westra INC on behalf of Preferred Plastics, Inc.

Preferred Plastics intends to use the 2.6-acre property for an access road from 8th street to their plant on the adjacent property. The intended use will not involve significant hazardous substance use.

At the time of the BEA, the property was vacant. Until 1986 the property functioned as a railroad easement operated by Consolidated Rail Corporation. Between 1986 and 1993, the Department of Natural Resources (DNR) acquired the property and removed the railroad structures; however, at the time of the BEA there was still debris and materials associated with railroad operations left on the property, including coal and steel rails. This was identified as a recognized environmental conditions (REC) during a 2001 Phase I Environmental Site Assessment (ESA).

Rose and Westra samples soil near the debris and tested the sample for heavy metals and polynuclear aromatic hydrocarbons (PNAs). The sample contained arsenic, mercury, and benzo(a)pyrene at concentrations above the Part 201 generic residential cleanup criteria (GRCC). Other metals and PNAs were detected but at concentrations below the Part 201 GRCC. Chromium was detected at concentrations below the Statewide Default Background Levels.

Rose and Westra did not advanced any soil boring nor collect any groundwater samples as part of their 2001 BEA.

At the time of the preparation of this report (April 2024), it appears that Preferred Plastics still operates at their 800 E Bridge St. location.

Phase 2 Groundwater Study Comments

Drinking water risk:
- impact areas inside WHPA, 10yr impact areas within 150ft of wells
- multiple private wells south of 10yr impact area

Non-drinking water risk:
• No non-drinking water wells in vicinity

Surface water risk:
- discharge to Kalamazoo River after ~16 years

Aquifer Vulnerability:
• Very High vulnerability of 181 at site (177-190 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000001539	820 M-89	HOSHLD	57	9/21/2000	Private well just north of leading edge of 2yr impact area
2	3000001241	329 S SHERWOOD AVE	TY1PU	55	12/4/1998	Type 1 PS well just north of leading edge of 10yr impact area
3	3000000040	PLAINWELL CITY WELL #4	TY1PU	58	--	Type 1 PS well just north of leading edge of 10yr impact area
4	3000026810	925 JAMES ST	HOSHLD	36	11/8/1991	Private well just south of 20yr impact area
5	3000015844	894 Riverview Dr	HOSHLD	40	7/13/2018	Private well just south of leading edge of 10yr impact area
6	3000015777	933 James St	HOSHLD	49	5/30/2018	Private well just south of 20yr impact area

PRIORITY RANK #22

Site ID: 00017433

Site Name: Friendly 66 (Martin Pacific Pride)

Local Unit of Government: Village of Martin

Dataset: Leaky Underground Storage Tanks (EGLE PART 213)

Substances of concern: unknown

The Remediation Information Data Exchange (RIDE) system from EGLE does not include any information on this location.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is just inside WHPA, about 1100ft east of Type 1 wells; another whpa north (upstream) of site with type 1 wells about 2100ft from the site
- 2 private wells north (upstream) of site, another few just outside of 20yr impact area; several others in vicinity

Non-drinking water risk:
- 2 industrial wells about 375ft southwest of site
- 1 irrigation well about 1900ft southeast of site, another about 2400ft southeast of site

Surface water risk:
•No interaction with surface water in 20yr travel

Aquifer Vulnerability
• High Vulnerability of 168 at site (164-177 => 0.8 score)

Phase 2 Groundwater Study Comments

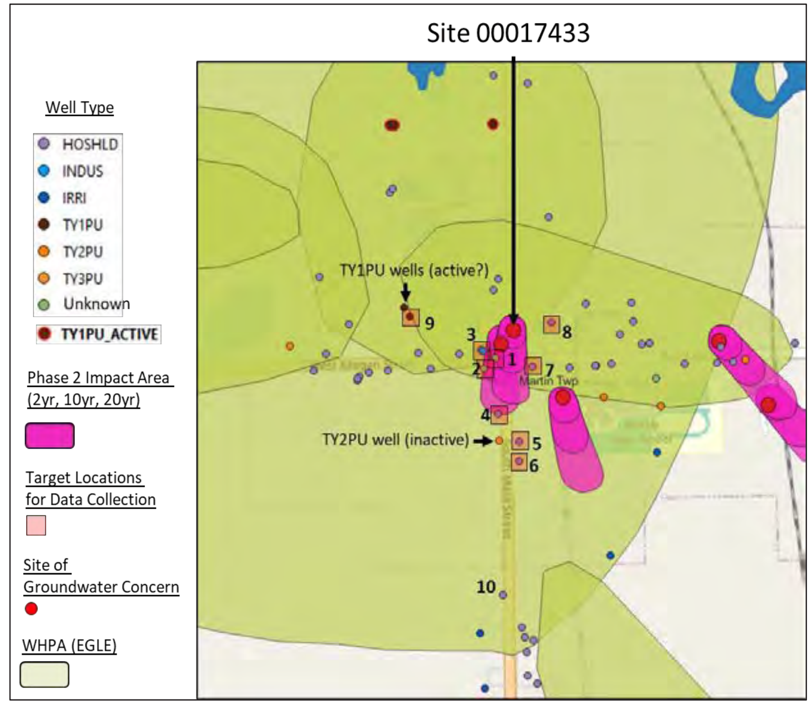


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000032240	ALLEGAN ST	UNK	52	12/23/1988	Directly downstream of site, within 2yr impact area
2	3000025957	W ALLEGAN ST	OTJHER-TELEPHONE BUILDING (?)	48	6/8/1982	Downstream of site on the edge of 10yr impact area
3	3000023637 03000023643	1011 W ALLEGAN ST	INDUS	100 102	7/7/1983 7/3/1983	Two industrial wells just west of site / 2 yr impact area
4	3000025943	1574 10TH ST	HOSHLD	32	4/18/1979	Downstream of site on leading edge of 20yr impact area

5	3000025932	1569 10TH ST	HOSHLD	42	12/12/1977	Downstream of leading edge of 20yr impact area
6	3000025915	1563 10TH ST	HOSHLD	75	8/25/1992	Further downstream of leading edge of 20yr impact area
7	3000023764	990 E ALLEGAN ST	HOSHLD	49	10/31/1988	East of 10yr impact area
8	3000025935	982 LEE ST	HOSHLD	77	5/28/1980	East of site
9	3000000221	BEECH LANE APARTMENTS WELL #1	TY1PU	88	8/24/1982	Type 1 PS well west of the site; site is within its WHPA
10	3000032001	1512 10th St	HOSHLD	129	2/21/2023	Quite a bit downstream from 20yr impact area

PRIORITY RANK #23

Site Name: Angle Steel Div (Kewaunee Scientific)

Site ID: 03000014

Local Unit of Government: City of Plainwell

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Human Health Perspectives

Lead

Short-term or low levels of exposure of lead may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

RIDE Classification

Not available.

RIDE Reviewer Comments

Not available.

Baseline Environmental Assessment(s)

A BEA document was not available for this site. Several short memos/documents were available and contained the following information:

In 1987 a soil gas survey was conducted, focusing on the lands east of the site known as A-1 Disposal. This area is directly adjacent to an area with a history of extensive groundwater contamination. Apparently, the contamination was due to seepage from nearby wastewater lagoons and accidental spills related to industrial activities. A "Request for Geological Services" document available in RIDE suggests the type of contaminants include: heavy metals (tens to thousands of ppm), solvents (tens to thousands of ppb), and aromatic hydrocarbons (varied concentrations).

A total of 101 sampling sites from the study area were analyzed. Five sites were determined to warrant further investigation, at which soil borings were advanced. At four of the five locations, a temporary monitoring well was installed for collecting groundwater samples. The analytical results do not appear to be available in the provided report, or elsewhere in the RIDE system.

In 1994 a Geoprobe study was conducted, but it is not clear if any water quality data were collected and at which concentrations substances may have been detected.

Phase 2 Groundwater Study Comments:

Drinking water risk:
- site and impact areas inside WHPA, site is about 1300ft north of Type 1 Wells
NDW risk:
- - 1 industrial well ~500ft north of site
SW risk:
- discharge to Kalamazoo River after ~6 years.
Aq. vulnerability:
- Very high vulnerability of 191 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

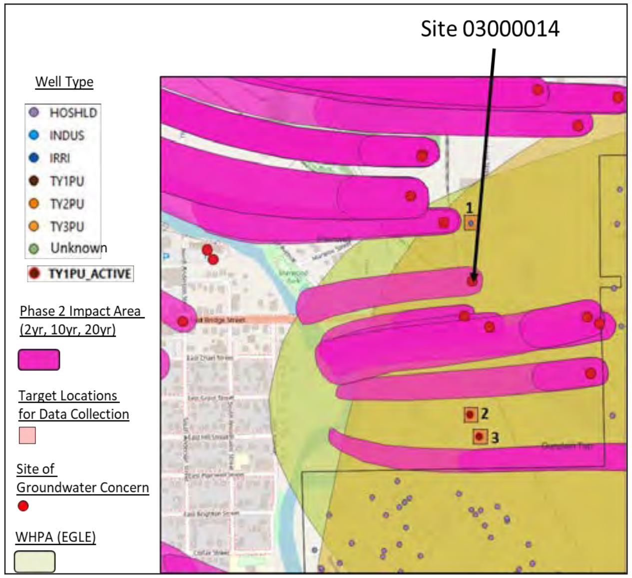


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000023580	323 ACORN ST	INDUS	30	3/24/1967	Industrial well ~500ft north of the site
2	3000000040	PLAINWELL CITY WELL #4	TY1PU	58	--	Type 1 PS well about 1150ft south of site
3	3000001241	329 S SHERWOOD AVE	TY1PU	55	12/4/1998	Type 1 PS well about 1300ft south of site

PRIORITY RANK #24

Site ID: 03000423

Site Name: 101 Brady Street, Allegan

Local Unit of Government: City of Allegan

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Mercury, Arsenic, Cadmium, Chromium

Also: copper, zinc, and silver.

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Mercury Maximum Contaminant Level (MCL)

2 parts per billion (ppb), or 0.002 mg/L

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Cadmium Maximum Contaminant Level (MCL)

5 parts per billion (or 0.005 mg/L)

Chromium Maximum Contaminant Level (MCL)

0.1 mg/L (0.1 parts per million)

Human Health Perspectives

Lead

Short-term or low levels of exposure of lead may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Mercury

Short-term or long-term exposure to mercury may cause kidney damage

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

Cadmium

Exposure above MCLG may result in kidney damage.

Chromium

Prolonged exposure above MCLG may result in allergic dermatitis (skin reactions).

RIDE Classification

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors within the short-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are from the present to 2 years.

Drinking water ingestion category

Risk Present and Require Action in the long-term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in *incidental* ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from the known extent of the contaminates of concern.

Groundwater-Surface Water Interface (GSI)

Risks Present and Requires Action in the Short-term:

The groundwater *contaminant* plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located within two years groundwater travel time of a surface water body or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer within two years travel time.

Sensitive Environmental Receptors

Risks Present and Requires Action in the Short-term

The leading edge of the groundwater contaminant plume is located within two years groundwater travel time distance of a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.).

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2020 BEA: The site is a 0.41a parcel that is currently vacant with no structures. Historically, the parcel was operated as a hotel, residences, a grocery, laundry, ag implement shop, blacksmith, bakery, and tin shop. The site was then redeveloped with one multi unit commercial building housing an automotive gas and service station from at least 1918 to 1955, and an automotive body shop from at least 1953 to 1985. The site also was used as a laundry or dry cleaner from at least 1888 until 1966. From the 1980s through the 1990s the site was used for office and retail space. All building structures were demolished between 1999 and 2003. As a part of due diligence activities, seven soil borings were advanced to depths of up to 28' bgs. Groundwater was encountered at two of the seven borings at depths of 18' or 20' bgs. Soils were generally found to be sand to 20+ feet bgs, underlain by clay. From these borings, ten soil samples and two groundwater samples were submitted for analysis of VOCs, PNAs, and MI 10 Metals. Based on the soil sample analytical results, the maximum noted concentrations (ug/kg) of the following COCs exceeded nonresidential Part 201 Criteria and/or VIAP SLs: n-butylbenzene (12,000 - DWP, VIAP nonacute); sec-butylbenzene (12,000 - DWP); isopropylbenzene (5,100 - GSIP, VIAP nonacute); naphthalene (3,000 - GSIP, VIAP nonacute); n-propylbenzene (19,000 - DWP); and arsenic (5,400 - DWP, GSIP). Based on the groundwater sample analytical results, the maximum noted concentrations (ug/L) of the following COCs exceeded nonresidential Part 201 Criteria: arsenic (220 - DW, GSI); barium (12,000 - DW, GSI); cadmium (150 - DW, GSI); chromium (660 - DW, GSI); copper (14,000 - DW, GSI); lead (35,000 - DW, GSI); mercury (28 - DW, GSI, VIAP); silver (DW, GSI); and zinc (85,000 - DW, GSI). Based on the proposed future land use (hotel), and the location of the Kalamazoo River adjacent to the site, the primary pathways of concern are indoor air inhalation (should the site be developed) and GSI as the groundwater sample that contained concentrations of COCs that exceeded GSI was located approximately 20-25' from the river.

call 800-662-9278
status, disability, political beliefs, height, weight, genetic information, or sexual orientation in the administration of any of its

Baseline Environmental Assessment (BEA)

Date of documents: most recent: November 2020 by Intertek Professional Service Industries (PSI), Inc. on behalf of CL REX, LLC.

The intended use of the 0.4-acre property is the development of a four-story, 80-room hotel, including a lounge/lobby area on its first floor. There is no intention by CL Rex to store or use hazardous materials at the property beyond typical materials/quantities associated with hotel operations.

Historical use of the site generally for commercial purposes. Historical uses of the adjacent properties consisted of residential, commercial, and industrial utility.

The BEA summarizes and synthesizes a number of previous studies at the property, including multiple Phase 1 Environmental Site Assessments (ESAs), a Phase II ESA, and other related reports, spanning from 1999 to 2020.

The 2020 Phase II ESA by PSI included an assessment of three recognized environmental conditions (RECs) identified in the 2019 Phase I ESA by AKT Peerless, namely:

1. previous subsurface investigations conducted at the subject property between 2003 and 2007 identified the presence of hazardous substances or petroleum products in soil and/or groundwater at concentrations exceeding the Part 201 Residential Cleanup Criteria (GRCC).
2. Four underground storage tanks (USTs) were present on the site until they were removed in 2007. Although analysis of collected samples indicated no evidence of a release, previous assessments did not indicate if piping and/or dispensers were encountered during UST removal, and the contents of the USTs were not determined; therefore, appropriate laboratory. methodologies meeting the State of Michigan UST removal protocols may not have been used.
3. The property historically operated as an automotive service and gas station from at least 1918 to at least 1955, as an automotive sales and service shop since at least 1928 until to at least 1955, as an automotive body shop since at least 1953 until at least 1985, and as a dry cleaner since at least 1888 until at least 1966. The former site uses have likely resulted in on-site soil and groundwater contamination (as identified in REC1 above).
4. Two gasoline USTs were identified just northeast of the property. One of the tanks was removed in 2007 but the potential presence of the remaining UST represents a REC.
5. The adjacent property (to the northwest) historically operated as an automotive service and repair shop, which commonly involves using and storing various hazardous substances and petroleum products.

Phase II subsurface investigation by PSI revealed the following:

1. Two new samples collected at previous sampling locations exceeded DC criteria for lead. New sampling locations did not exceed EGLE GRCC for Michigan 10 Metals (including lead).
2. PSI collected soil and groundwater samples in the vicinity of the where the 4 USTs were located. VOC results were below laboratory MDLs, and lead results were below EGLE GRCC.
3. PSI collected soil and groundwater samples in the vicinity of the former dry cleaning operations. Concentrations of contaminants of concern, or COCs (e.g., etrachloroethene (PCE), and PCE breakdown products which include trichloroethene (TCE), cis 1,2-Dichloroethene, and vinyl chloride) did not exceed laboratory method detection limits. There were no detections of COCs in samples collected from the former automotive repair and filling station at 101/103/105 Brady Street). Groundwater samples were collected from the former automotive repair and body shop at 111 Brady Street. COCs (metals) were detected at concentrations exceeding EGLE GRCC.
4. COCs were not detected in samples collected from 115 Brady street.
5. A new area of contamination was encountered with detected VOCs at concentrations above the Part 201 GRCC.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is inside WHPA, about 1200ft downstream from type 1 wells; across the Kalamazoo River from another WHPA and Type 1 wells (Kalamazoo River likely a hydraulic barrier, providing water to wells)
Non-drinking water risk:
• No non-drinking water wells in vicinity
Surface water risk:
"immediate" discharge to Kalamazoo River (~2yr)

Aquifer Vulnerability
• Very high Vulnerability of 191 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

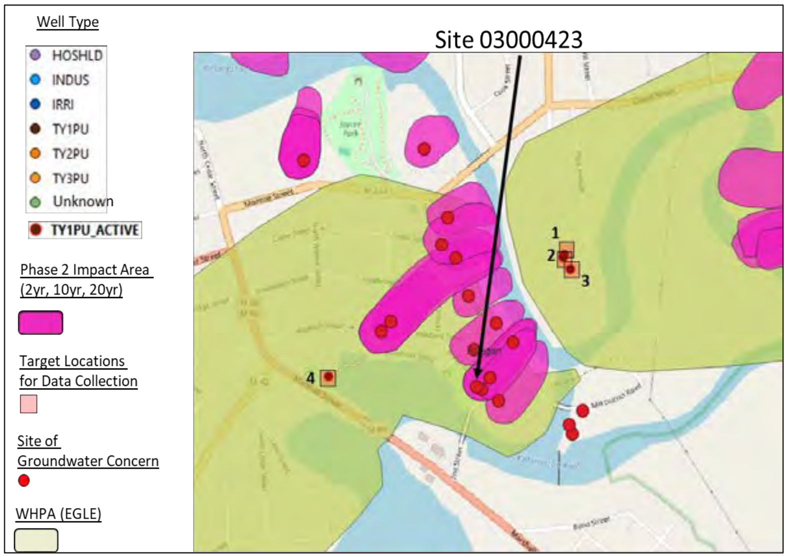


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000010294	6487 Clearbrook Dr.	HEATP	125	11/7/2008	HEATP well just upstream of site / 2yr impact area
2	3000010294	6487 Clearbrook Dr.	HEATP	125	11/7/2008	HEATP well just upstream of site / 2yr impact area
3	3000001903	6494 Clearbrook Drive	TY2PU	99	--	Type 2 PS well just west of 2yr impact area
4	3000017539	6494 Clearbrook Dr.	IRRI	126	12/3/2020	irrigation well, just west of 2yr impact area
5	3000025770	6494 CLEARBROOK DR.	HOSHLD	43	9/20/1969	Household well owned by Clearbrook golf course (?), just west of 2yr impact area

PRIORITY RANK #25

Site Name: 111 Hubbard Street

Site ID: 03000272

Local Unit of Government: City of Allegan

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Chromium

Relevant Drinking Water Standards

Lead Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Chromium Maximum Contaminant Level (MCL)

0.1 mg/L (0.1 parts per million)

Human Health Perspectives

Lead

Short-term or low levels of exposure of lead may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Chromium

Prolonged exposure above MCLG may result in allergic dermatitis (skin reactions).

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Long-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risks Controlled Interim

Groundwater contamination is not reasonably expected to vent to surface waters, or does not exceed GSI criteria, or mixing zone-based GSI criteria established by EGLE.

Groundwater-Surface Water Interface (GSI)

Risks Present and Requires Action in the Short-term

The groundwater *contaminant* plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located within two years groundwater travel time of a surface water body or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer within two years travel time.

Sensitive Environmental Receptors

Risks Controlled Interim:

No sensitive habitat or resources exist on or near the site or facility.

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2001 BEA: 12 soil samples were submitted for analysis of VOCs, PNAs, PCBs, and metals (Pb, Cd, Cr). The maximum depth of exploration was 10 feet bgs and no groundwater was encountered, therefore groundwater samples were not collected. Based on the soil sample analytical results all detected compounds reported concentrations less than Part 201 criteria excepting a detection of Cr at 31,000 ug/kg exceeding residential DWP criteria (TP2 1-3') and a detection of Pb at 580,000 ug/kg exceeding residential DC criteria (TP6 6-8'). Based on recent aerial images, the site appears to be covered with asphalt pavement which would reduce the likelihood of Cr at sample location TP2 leaching to groundwater. The depth of soil sample TP6 at six feet bgs reduces the risk of a residential direct contact exposure scenario.

Baseline Environmental Assessment (BEA)

Date of documents: most recent: January 2020 by AKT Environmental Consulting, Inc. on behalf of the City of Allegan.

The City of Allegan intends to use the property as a parking lot. No significant hazardous substances will be used on the property.

As of the time of the preparation of this report (April 2024), it appears the property is still being used solely as a parking lot.

From at least 19884 through 1918 a boarding house was located on the property. From 1918 to 1937 the property was used as an auto repair shop. The repair shop was demolished, and a gas station was built. The gas station building was demolished in the 1970s.

A 1998 Phase I Environmental Site Assessment (ESA) performed by Soil and Materials Engineers, Inc. identified the following recognized environmental conditions (RECs):

- historical gas station operations from 1938 to 1978, with an unknown status of the underground storage tank (UST) system.
- Historical auto repair activities from 1918 to 1937.

A 2000 Phase II ESA conducted by AKT Environmental Consulting consisted of subsurface investigations, namely, excavation of nine test pits and collection of12 soil samples. Samples were analyzed for volatile organic compounds (VOCs), polynuclear aromatics (PNAs), polychlorinated biphenyls (PCBs), cadmium, chromium, and lead.

Chromium concentrations in one soil sampled exceed the Part 201 Generic Residential Drinking Water Protection Criteria. Lead concentrations in another soil sample exceeded the Part 201 Generic Residential Soil Direct Contact Criteria. All other target substances were either not detected above method detection limit or detected at concentrations below the Part 201 Generic Residential Cleanup Criteria.

Other possible contamination identified in AKT's Phase II study includes a heating oil UST located on the property that may have caused a released based on the historical use of the UST system. Additionally, abandoned product lines associated with a former gasoline station UST system may have impacted the site.

At the time of the BEA, the City of Allegan intended to remove the heating oil UST and product lines associated with the former gas station, as well as any impacted soil, and then cover the entire property with asphalt paving.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is inside WHPA, about 1150ft downstream from type 1 wells; across the Kalamazoo River from another WHPA and Type 1 wells (Kalamazoo likely river a hydraulic barrier, providing water to wells)

Non-drinking water risk:
• No non-drinking water wells in vicinity
Surface water risk:
"immediate" discharge to Kalamazoo River (~1.5yr)
Aquifer Vulnerability
• Vulnerability of 191 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

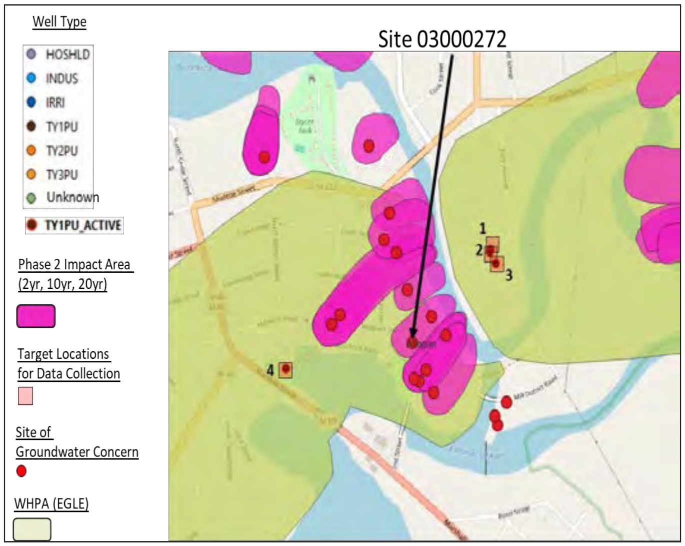


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000000266	ALLEGAN PINGREE PK WELL #1	TY1PU	89	1/1/1972	Type 1 PS well across the Kalamazoo River from site
2	3000000267	ALLEGAN PINGREE PK WELL #2	TY1PU	80	--	Type 1 PS well across the Kalamazoo River from site
3	3000011265	100 Park Ave.	TY1PU	77	12/9/2010	Type 1 PS well across the Kalamazoo River from site
4	3000000269	ALLEGAN GRISWALD WELL #4	TY1PU	60	--	Type 1PS well, about 1500ft upstream of site

PRIORITY RANK #26

Site Name: 243 Hubbard Street, Allegan

Site ID: 03000421

Local Unit of Government: City of Allegan

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Arsenic, Lead

Relevant Drinking Water Standards

Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Human Health Perspectives

Lead

Short-term or low levels of exposure of lead may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Long-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Inadequate data to assign risk.

Groundwater-Surface Water Interface (GSI)

Inadequate data to assign risk.

Sensitive Environmental Receptors

Inadequate data to assign risk.

RIDE Reviewer Comments

Not available.

Baseline Environmental Assessment (BEA)

Date of documents: most recent: October 2020 by SME, Inc. on behalf of Tantrick Properties, LLC.

The intended use is operating the on-premises building as a restaurant.

At the time of the preparation of this report (April 2024), Tantrick Brewing Co. is still operating at the property.

The 0.04-acre property was undeveloped land until the 1940s when a commercial building was added. Multiple businesses have occupied the building, including a printing company and furnace sales company in the 1950s. From the 1970s through the 1990s, the Longbranch Saloon occupied the building. Various owners have owned the building since 1996, including two banks.

A 2020 Phase I Environmental Site Assessment (ESA) performed by SME identified the following recognized environmental conditions (RECs).

- Historical printing operations, which have the potential for releases of hazardous substances and/or petroleum products.

- Potential for migration of historical release of hazardous substances of petroleum products onto the property from the north-adjoining former gas filling and vehicle service station and the nearby former dry cleaner.

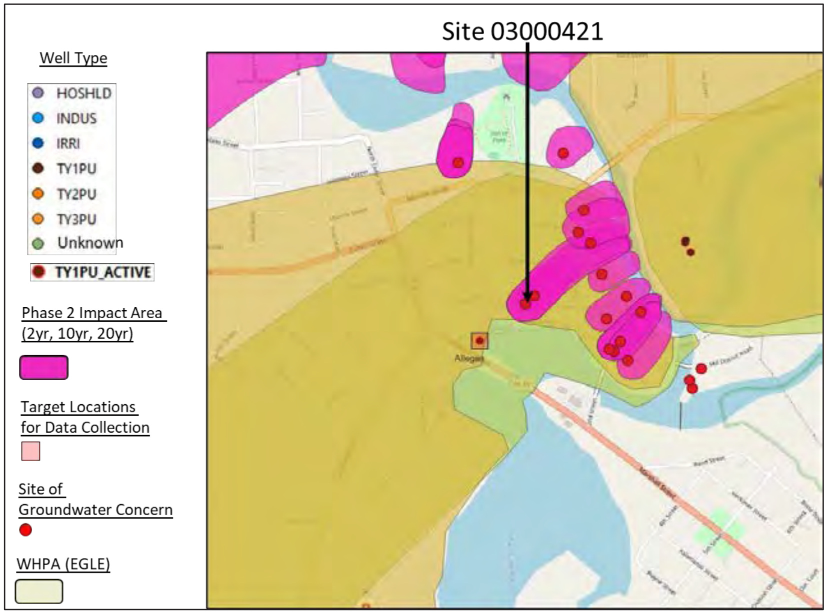
The 2020 Phase II study consisted of soil sampling and laboratory analysis of chemical concentrations. Groundwater samples were not collected because of access issues. Samples were analyzed for VOCs, arsenic, barium, cadmium, chromium, hexavalent chromium, copper, lead, mercury, selenium, silver and zinc. Arsenic and lead were each detected in one or more samples at concentrations exceeding one or more Part 201 criteria

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is inside WHPA, about 550ft from type 1 wells; across the Kalamazoo River from another WHPA and Type 1 wells
Non-drinking water risk:
• No non-drinking water wells in vicinity
Surface water risk:
- discharge to Kalamazoo River after ~5 years.
Aquifer Vulnerability
• Very high vulnerability of 191 at site (190-203 => 1.0 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
3000000269	ALLEGAN GRISWALD WELL #4	TY1PU	60	--	Type 1 PS well directly upstream (450 ft) of site



PRIORITY RANK #27

Site Name: 4634 4671 East Washington Street & 3501

Site ID: 03000426

Local Unit of Government: Heath Twp. (Hamilton)

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Mercury, Arsenic

Also: zinc

Relevant Drinking Water Standards

Mercury Maximum Contaminant Level Goal (MCLG)

2 parts per billion (ppb), or 0.002 mg/L

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Human Health Perspectives

Mercury

Short-term or long-term exposure to mercury may cause kidney damage

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive

environmental receptors in the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Inadequate data to assign risk.

Groundwater-Surface Water Interface (GSI)

Inadequate data to assign risk.

Sensitive Environmental Receptors

Inadequate data to assign risk.

RIDE Reviewer Comments

Not available.

Baseline Environmental Assessment (BEA)

Date of documents: most recent: October 2020 by Dixon Environmental Consulting on behalf of Endeavor Ag and Energy LLP.

The property is a compilation of eight parcels. At the time of the BEA, the intended use of the 5.22-acre property was not known. All parcels were vacant, with the exception of Parcel 3 that included a single-story commercial building operated by The Gate Youth Center. The vacant parcels consisted of parking lots, lawn areas, and overgrown, fielded areas.

From the 1920s to the 2010s various buildings occupied the property, including include commercial buildings and parking areas in the western portion of the property; residential/agricultural activities in the southern portion; and two gasoline service stations, an automobile dealership, and a welding shop. The commercial and residential buildings on the western/southern portions of the property were removed, but the commercial building on Parcel 3 was maintained as a gasoline filling station. In 2011 the gasoline filling station operations stopped, and the building was renovated into a local church and youth center (The Gate Youth Center).

A 2009 Phase I Environmental Site Assessment (ESA) was completed by Superior Environmental Corp. The Phase I ESA identified the following recognized environmental conditions (RECs): a Leaking Underground Storage Tank (LUST), historical vehicle repair and fueling operations, the potential for abandoned underground storage tanks (USTs), and the material threat of migrating contamination.

Dixon Environmental Consulting completed their own Phase I ESA in Dec. 2020 and confirmed/refined the RECs at the site:

- A former gasoline and diesel filling/service station with two USTs (6,000-gallon and 10,000-gallon capacities) was historically operated at Parcel 3 of the subject site. This parcel was listed as a LUST site because of two releases discovered and reported during 1994 UST replacement

operations. The open 2011 LUST status, the former gasoline and diesel filling/service station operations and historical releases with documented contaminated soil at Parcel 3 were identified as RECs.
- There is a potential for a significant volume of fill material present at the parcels that make up the property, including gravel, broken bricks, and cinders. The origin of the materials was not determined.
- A former gasoline filling and service station operated on two parcels (Parcels 6 and 7) that make up the property. An abandoned 500-gallon UST was discovered and removed on August 13, 2015. Detectable polynuclear aromatic hydrocarbons (PNAs) were present in the closure samples, however, no additional sampling was performed.
- The residential and agricultural buildings on the southern portion of the property were removed, but details relating to the building features and operations were unavailable. The historical operations may have included the use of coal, heating fuel oil, gasoline/diesel for fueling equipment and/or agrochemicals. Heating fuel oil, gasoline and/or diesel fuel used at the site may have been stored in a UST.
- The western adjoining property (3606 Lincoln Road) was identified as a Resource Conservation and Recovery Act (RCRA) site. A violation pertaining to the general requirements for generators was noted at this site during a 1994 compliance inspection. The BEA for this site identified historical operations as a gas filling/serving station and industrial activities. Subsequent sampling revealed detectable concentrations of inorganic metallic constituents, PNAs and volatile organic compounds (VOCs) in the soil.

Dixon Environmental Consulting completed a Phase II ESA during the fall of 2020 consisting of a Ground Penetrating Radar (GPS) Survey and soil and groundwater sampling and laboratory analysis.

The GPR Survey found numerous anomalies consistent with foundation and building debris existing at the former building location areas of the property. Test pitting and boring results confirmed that the anomalies were historical building debris (concrete/rubble debris) and abandoned USTs

Nineteen soil boring were advanced and a total of ten soil samples were collected for chemical analysis. Five soil borings were converted into temporary monitoring wells, and one shallow groundwater sample was collected from each temporary well. The soil and groundwater samples were chemically analyzed for polynuclear aromatic hydrocarbons (PNAs), the Standard VOC List, leaded gasoline range VOC and certain inorganic metallic constituents: arsenic, barium, cadmium, chromium (total), copper, lead, mercury, selenium, silver, and zinc.

Based on the results, concentrations of arsenic, mercury and zinc, exceeded the current GRCC in various soil samples. No other hazardous substances analyzed exceeded the laboratory method detection limits or the GRCC.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is just downstream of WHPA, about 1100ft downstream from type 1 wells;
-2 type 2 wells ~500ft southwest of site, 2 more about 400ft east of site, 3 more ~700ft south of site, still

more further south/southeast of site
- several private wells ~400ft+ upstream of site
Non-drinking water risk:
- 1 irrigation wells ~2250ft upstream of site, another about 1900ft east of site, others still further south of site
Surface water risk:
- 2yr or less discharge to Rabbit River (designated trout stream)
Aquifer Vulnerability
- Somewhat high Vulnerability of 151 at site (151-164 => 0.7 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)

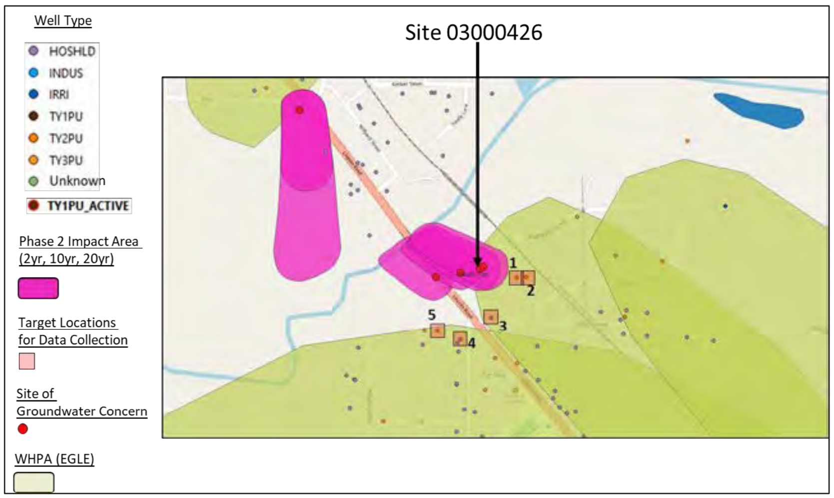


Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000013589	4670 Washington St. Office	TY3PU	50	11/19/2014	Just upstream/southeast of the site
2	3000001060	Box 186, E. Washington	TY2PU	50	7/7/1969	Upstream/southeast of site
3	3000007141	4665 135TH AVE	HOSHLD	91	8/10/2004	South of the site
4	3000012865	3494 HUBBARD ST	TY3PU	80	11/16/2002	South/southwest of the site
5	3000013117	3494 Hubbard St	TY3PU	--	11/15/2012	South/southwest of the site

PRIORITY RANK #28

Site Name: Hamilton Farm Bureau Cooperative

Site ID: 00006437

Local Unit of Government: Heath Twp.

Dataset: Leaky Underground Storage Tanks (Part 213)

Substances of concern: unknown

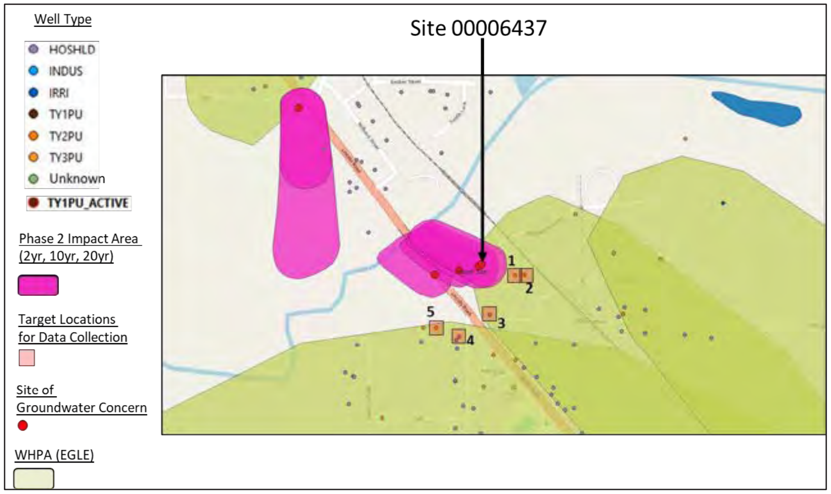
The Remediation Information Data Exchange (RIDE) system from EGLE does not include any information on this location.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- site is just downstream of WHPA, about 1100ft downstream from type 1 wells;
-2 type 2 wells ~500ft southwest of site, 2 more about 400ft east of site, 3 more ~700ft south of site, still more further south/southeast of site
- several private wells ~400ft+ upstream of site
Non-drinking water risk:
• 1 irrigation wells ~2250ft upstream of site, another about 1900ft east of site, others still further south of site
Surface water risk:
• 2yr or less discharge to Rabbit River (designated trout stream)
Aquifer Vulnerability
- Somewhat high Vulnerability of 151 at site (151-164 => 0.7 score)

Table: Information of existing wells targeted for groundwater data collection.

Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000013589	4670 Washington St. Office	TY3PU	50	11/19/2014	Just upstream/southeast of the site
2	3000001060	Box 186, E. Washington	TY2PU	50	7/7/1969	Upstream/southeast of site
3	3000007141	4665 135TH AVE	HOSHLD	91	8/10/2004	South of the site
4	3000012865	3494 HUBBARD ST	TY3PU	80	11/16/2002	South/southwest of the site
5	3000013117	3494 Hubbard St	TY3PU	--	11/15/2012	South/southwest of the site



PRIORITY RANK #29

Site Name: 1840 142nd Avenue

Site ID: 3000302

Local Unit of Government: Dorr Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Lead, Mercury, Arsenic

Relevant Drinking Water Standards

Maximum Contaminant Level Goal (MCLG)

The MCLG is zero because there is no level of exposure to lead that is without risk.

Lead Action Level:

There is a lead action rule (USEPA regulation) that requires water supply systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb in more than 10% of customer taps sampled, the system must undertake a number of additional actions to control corrosion.

Note: the Michigan Safe Drinking Water Act in 2018 was expanded to better protect drinking water from lead. A specific aspect of the new law is that the Action Level for lead in drinking water will be lowered from the current level of 15 parts per billion (ppb) to 12 ppb on January 1, 2025.

Mercury Maximum Contaminant Level Goal (MCLG)

2 parts per billion (ppb), or 0.002 mg/L

Arsenic Maximum Contaminant Level (MCL)

10 parts per billion (or 0.010 parts per million or 0.010 mg/L)

Human Health Perspectives

Lead

Short-term or low levels of exposure of lead may cause the following issues to children: behavior and learning problems, lower IQ and hyperactivity, hearing problems, and anemia. In rare cases, ingestion may cause seizures, coma or death.

Exposure to adults may cause: cardiovascular effects such as increased blood pressure and incidence of hypertension, damaged kidneys, and reproductive problems.

Mercury

Short-term or long-term exposure to mercury may cause kidney damage

Arsenic

Arsenic is a known carcinogen. Long-term exposure may cause skin damage (thickening or discoloration) or circulatory, pulmonary, immunological, or neurological system problems (e.g., numbness and partial paralysis), in addition to the increased risk of cancers of the bladder, lungs, skin, kidney, liver, and prostate.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Long-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the long-term. For the purpose of classification, potential exposures or threats considered to be long-term generally are greater than 2 years.

Drinking water ingestion category

Risks Present and Require Action in the Long-term: Groundwater contamination exceeds drinking water criteria and non-potable water supply wells, producing from a different interval of the aquifer, are located within the know extent of the contaminants of concern.

Groundwater-Surface Water Interface (GSI)

Risks Controlled Interim

Groundwater contamination is not reasonably expected to vent to surface waters, or does not exceed GSI criteria, or mixing zone-based GSI criteria established by EGLE.

Sensitive Environmental Receptors

Inadequate data to assess risk.

RIDE Reviewer Comments

COMMENTS of Reviewer: Based on a 2022 BEA: The site was residential in use until approximately 1944 when it became mixed res/nonres use. The property was used for tool manufacturing as early as 1962 to at least 2017. Potential sources of contamination at the site are an adjacent former railroad, drum storage area, and metal scrap storage area. Soil samples collected at the site in 2008 were evaluated and used to determine that the site is a facility. Samples were analyzed for VOCs, PNAs, and MI 10 metals. Specifically, soil sample analytical results exceeded nonresidential Part 201 criteria (DWP GSIP) with maximum concentrations in ug/kg for: arsenic at 9,600 (GP-3 1-1.5'); and mercury at 6,700 (HA-1 1-1.5'). Five groundwater samples were analyzed, included an onsite drinking water well (intake at 53'). The GW samples were analyzed for VOCs, PNAs, and Cu Pb Se and Zn. The only groundwater exceedance (DW) noted was in the Pb concentration of 6.8 ug/L measured in the sample collected from GP-3 (8-10'). Relevant pathways of concern would be ingestion as the site and surrounding properties are serviced by private water wells. The GSI pathway is also applicable with Red Run (creek) being ~375' to the southwest of the site.

r call 800-662-9278.

Baseline Environmental Assessment (BEA)

Date of documents: most recent: September 2022 by Marshall Associated on behalf of Forging Ahead Properties, LLC.

Forcing Ahead Properties, LLC intends to lease the property for warehouse and office space.

At the time of the 2022 BEA, the 1.6-acre property contained two structures – one built in 1994 with additions in 1985, 1986, and 1993, and another built in 1998. Both buildings were unoccupied but were most recently occupied by Dorr Industries for office, metal stamping, screw machining, welding, and final product assembly. The property was occupied for tool manufacturing from 1962 to at least 2017.

A 2022 Phase I Environmental Site Assessment (ESA) identified one recognized environmental condition (REC): the presence of hazardous substances in soil/groundwater samples collected in the property in 2008, including arsenic, mercury, and lead at concentrations exceeding the Part 201 Generic Residential Cleanup Criteria. Specifically, in two soil samples arsenic was measured at 9,600 µg/kg and 7,500 µg/kg, and in another sample, mercury was measured at 6,700 µg/kg. In one groundwater sample lead was measured at 6.8 µg/L.

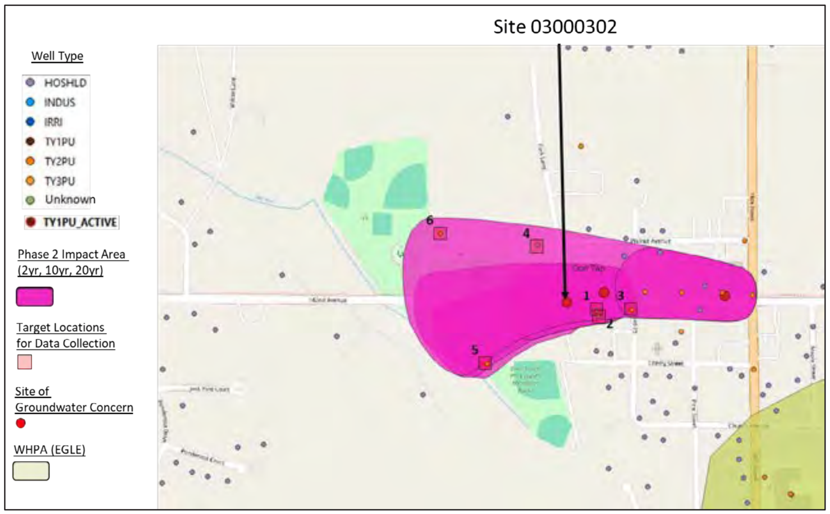
It was noted in the BEA that a full delineation of the nature/extent of contamination is now known, but the results suggest that hazardous substances are present near the former railroad and 55-gallon drum storage area and metal scrap storage area.

Phase 2 Groundwater Study Comments

Drinking Water Risk:
- Type 2 well in 4.5 yr. impact zone, -5 type 2/type3 wells just upstream of site, a few others in vicinity (north and south east of site
- 20+ private wells just upstream
Non-drinking water risk:

- No non-drinking water wells in vicinity
Surface water risk:
-discharge to Red Run stream after ~4.5yr
Aquifer Vulnerability
- Very high Vulnerability of 190 at site (190-203 => 0.9 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)



Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000025470	1836 142ND AVE	HOSHLD	75	7/14/1997	Just south of site, inside 2yr impact area
2	3000011613	Box 186, E. Washington	HOSHLD	71	7/26/2011	Just south of site, inside 2yr impact area
3	3000001142	1830 142 Ave. PO Box 335	TY2PU	69	7/1/1989	just upstream of site, on edge of 2yr impact area
4	3000022353	4210 PARK ST	HOSHLD	90	--	just north of the 5yr impact area
5	3000016287	1858 142nd Ave	TY2PU	65	6/30/1980	West/downstream of site, inside 5yr impact area
6	3000015753	1879 142nd Avenue	TY2PU	80	4/24/2018	North/northwest of site

PRIORITY RANK #30

Site Name: 3506 M-40

Site ID: 3000324

Local Unit of Government: Heath Twp.

Dataset: Site of Environmental Concern (EGLE PART 201)

Substances of concern: Mercury, Benzene, Ethylbenzene, Xylenes

Also: 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbezene, and naphthalene

Relevant Drinking Water Standards

Mercury Maximum Contaminant Level Goal (MCLG)

2 parts per billion (ppb), or 0.002 mg/L

Benzene Maximum Contaminant Level (MCL)

5 parts per billion (or 0.005 mg/L or 0.005 parts per million)

Ethylbenzene Maximum Contaminant Level Goal (MCL)

0.7 mg/L (0.7 parts per million)

Xylenes Maximum Contaminant Level Goal (MCL)

10 mg/L (10 parts per million)

Human Health Perspectives

Mercury

Short-term or long-term exposure to mercury may cause kidney damage

Benzen*e*

Short-term exposure may cause temporary nervous system disorders, anemia, or depressed immune system function.

Ethylbenzene

Short-term exposure above MCLG may result in drowsiness, fatigue, headache and mild eye and respiratory irritation.

Xylenes

Short-term exposure above MCLG may result in disturbances of cognitive abilities, balance, and coordination.

RIDE Classification:

Ride Risk Category

Risk Present and Require Action in the Short-term

Based on the conceptual site model (CSM) and migration of contaminants, there is a potential for exposure or threat to human health, safety, or welfare, or to the environment, or sensitive environmental receptors in the short-term. For the purpose of classification, potential exposures or threats considered to be short-term generally are from the present to 2 years.

Drinking water ingestion category

Risks Present and Require Action in the Long-Term

Soil is contaminated above the leaching to groundwater criteria or groundwater is contaminated above drinking water criteria; and potable wells, or non-potable water supply wells that may result in incidental ingestion or inhalation exposures, are producing from the contaminated aquifer, but are located more than two years groundwater travel time from the known extent of the contaminates of concern.

Groundwater-Surface Water Interface (GSI)

Risk Present and Require Action in the Short-term

The groundwater *contaminant* plume exceeds GSI criteria, and the leading edge of the contaminated groundwater plume is located within two years groundwater travel time of a surface water body or the plume is entering a storm sewer and the contamination will reach the outfall of the storm sewer within two years travel time.

Sensitive Environmental Receptors

Risks Present and Requires Action in the Short-term

The leading edge of the groundwater contaminant plume is located within two years groundwater travel time distance of a sensitive habitat or resources (e.g., sport fish, economically important species, threatened or endangered species, wetlands, etc.)

RIDE Reviewer Comments:

Not available.

Baseline Environmental Assessment (BEA)

Date of documents: most recent: March 2005 by Equity Resource Environmental on behalf of DP Enterprises of Hamilton, LLC.

The intended use of the property was industrial, namely, machinery reconditioning and storage. The intended use will include hazardous substance(s) to be used in significant quantities that are different than the known hazardous substances known or likely property contaminants.

At the time of this BEA The 1.61-acre property was being utilized by Hamilton Systems, a business that reconditions and sells used industrial equipment. The operations involved one large industrial building and gravel and concrete parking areas. This building was originally built in the 1920s.

There is also evidence of a former gas station on the property.

In 2005, Phase I and Phase II Environmental Site Assessments (ESAs) were conducted. The Phase I ESA identified the following recognized environmental conditions (ERCs):

- a gasoline underground storage tank (UST) and pump island were formerly located on the southeastern portion of the subject property.
- Historical fuel oil usage (and an associated orphan UST) was likely on the property.
- The property operated as an automotive service facility from about 1920 to 1972, and was an industrial facility from 1972 to 1996. The historical waste practices are unknown, and the age of the concrete floor is concerning.
- In the building an indoor concrete pit used for historic metal fabricating equipment was identified. Evidence of petroleum products was observed in the pit.
- The potential for improper historical disposal of petroleum products and/or hazardous substances on the exterior of the building was recognized.
- Petroleum products and/or hazardous substances had the potential to be dumped into floor drains connected to the on-site septic system.

The Phase II ESA included obtaining 18 soil samples at nine soil boring locations. A potable water sample was also collected from the on-site water well.

The analytical results of the soil samples revealed 3 samples that exceeded applicable risk-based criteria. One sample contained elevated concentrations of mercury benzene, ethylbenzene, xylenes, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbezene, and naphthalene which exceeded applicable risk-based criteria.

The groundwater sample did not have any substances that exceeded risk-based criteria.

Phase 2 Groundwater Study Comments:

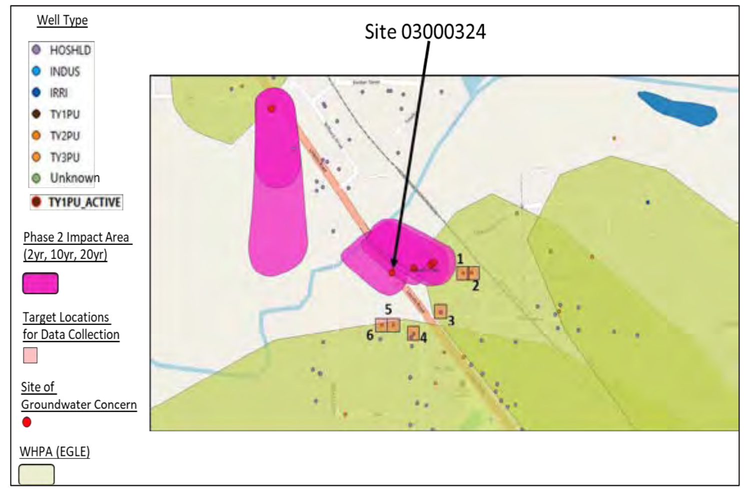
Drinking Water Risk:
- site is just downstream of WHPA, about 1100ft downstream from type 1 wells;
-2 type 2 wells ~350ft south of site, 2 more about 500ft east of site, 3 more ~700ft south of site, still more further south/southeast of site
- several private wells ~400ft+ upstream of site

Non-drinking water risk:
- 1 irrigation wells ~2250ft upstream of site, another about 1900ft east of site, others still further south of site

Surface water risk:
• 2yr or less discharge to Rabbit River (designated trout stream)

Aquifer Vulnerability
- Somewhat high Vulnerability of 149 at site (138-151 => 0.6 score)

Recommended Off-Site Groundwater Data Collection (Target Wells)



Label	WELLID	WELL_ADDR	WELL_TYPE	WELL_DEPTH	CONST_DATE	Comments
1	3000013589	4670 Washington St. Office	TY3PU	50	11/19/2014	East of the site
2	3000001060	Box 186, E. Washington	TY2PU	50	7/7/1969	east of site
3	3000007141	4665 135TH AVE	HOSHLD	91	8/10/2004	Souteasth of the site
4	3000012865	3494 HUBBARD ST	TY3PU	80	11/16/2002	South of the site
5	3000013117	3494 Hubbard St	TY3PU	--	11/15/2012	South of the site
6	3000013117	3494 Hubbard St	TY3PU	--	11/15/2022	South/southwest of the site

APPENDIX F

Non-Point Source Pollution Analysis & Risk Ranking

WRITEUP OF NON-POINT SOURCE POLLUTION ANALYSIS AND RISK RANKING

Non-point source pollution refers to impaired groundwater quality due to distributed or large-scale processes that may be natural or anthropogenic in nature. For example, naturally occurring minerals or metals like (iron or arsenic) in the subsurface may cause NPS pollution. On the other hand, human activities like road deicing or application of agricultural fertilizers are known to cause NPS.

Analysis of NPS pollution was completed by analyzing water quality samples from the WaterChem statewide database. WaterChem stores the results from analyses completed at the Drinking Water Analysis Laboratory established by the Michigan Safe Drinking Water Act. In a previous study, a team at Michigan State University (MSU) geocoded (digitized and georeferenced) the statewide WaterChem database under a jointly funded MSU-DEQ (now EGLE) water resources partnership. This geocoded database, now containing 30 years of analytical data (1983-2013), was used to improve the understanding of groundwater quality / NPS pollution in Allegan County.

The following chemical constituents of groundwater were analyzed: nitrate, chloride, sodium, iron, lead, arsenic and manganese. Point based maps showing sample concentrations as different colors symbols sizes (or above certain thresholds) were created, as well as township- / village- / city-based "NPS Pollution Index" maps. First, the data were subdivided into subsets for the townships and cities/villages in Allegan County. Median (50th percentile) and 75th concentrations were calculated for each township/village/city. A water quality index (WQI) for 50th and 75th percentile concentrations was calculated for each chemical/element by normalizing (dividing) the percentile concentration by the Maximum Contaminant Level (MCL) or secondary MCL.

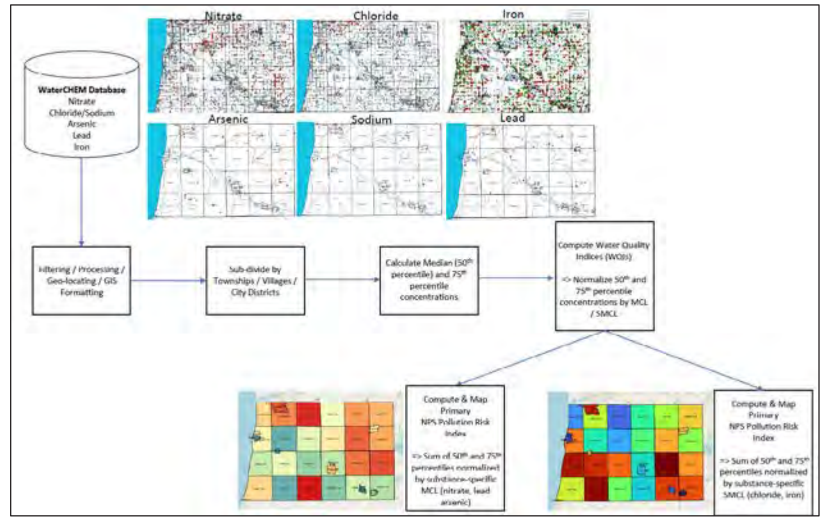
A "Primary NPS Pollution Index" was calculated by summing the WQI for the contaminants known to adversely impact human health: nitrate, lead, and arsenic (i.e., those in the available dataset with a MCL or Action Level). A similar "Secondary NPS pollution severity" index was computed for chemicals with non-mandatory water quality standards chloride and iron.

The MCL / SMCLs for the chemicals analyzed are:

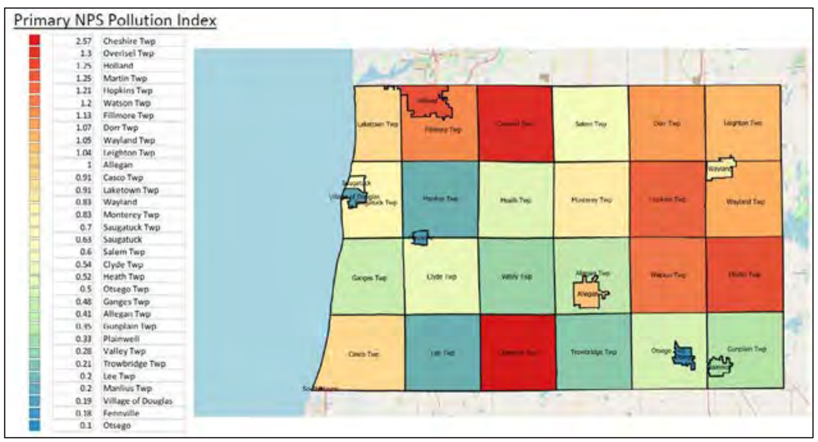
- Nitrate: 10 mg/L
- Chloride: 250 mg/L
- Iron: 0.3 mg/L
- Arsenic: 0.010 mg/L
- Lead (action level): 0.015 mg/L

Cheshire Township ranks highest in terms of Primary NPS Pollution Risk due to the high arsenic concentrations, followed by Overisel Twp., City of Holland, Martin Twp., and Hopkins Twp. The townships of Watson, Fillmore, and Dorr also have high ranking Primary NPS Pollution Risk.

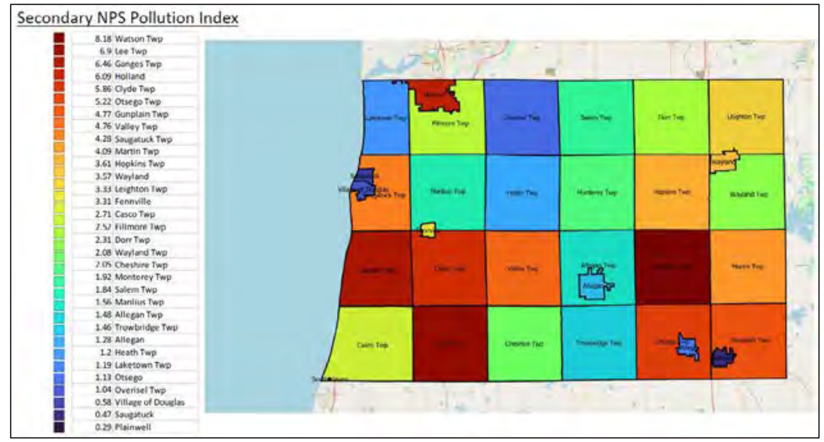
Watson Township ranks highest in terms of secondary water quality severity index due to high iron concentrations followed by Lee, Ganges, City of Holland (relatively high iron and chloride concentrations), Clyde Township, and Otsego Township (high iron concentrations). The townships of Valley, Gunplain, Saugatuck, and Martine also have high ranking secondary water quality severity indexes.



Township/Village	Nitrate 50th % WQI	Nitrate 75th % WQI	Chloride 50th % WQI	Chloride 75th % WQI	Iron 50th % WQI	Iron 75th % WQI	Arsenic 50th % WQI	Arsenic 75th % WQI	Lead 50th % WQI	Lead 75th % WQI	PRIMARY Water Quality Index	SECONDARY Water Quality Index
Ganges Twp	0	0.05	0.024	0.076	1.63	4.73333	0	0.325	0	0.1	0.48	6.46
Holland	0.16	0.395	0.16	0.432	1.833	3.666	0.27	0.405	0	0.023	1.25	6.09
Clyde Twp	0	0.07	0.024	0.1	1.65	4.0833	0	0.4	0	0.0667	0.54	5.86
Otsego Twp	0	0.09	0.036	0.084	1.7666	3.333	0.09	0.25	0	0.06667	0.50	5.22
Valley Twp	0	0.02	0.024	0.076	2.167	2.49167	0.04	0.1	0	0.11667	0.28	4.76
Gunplain Twp	0	0.18	0.04	0.084	0.8833	3.7583	0	0.1	0	0.06667	0.35	4.77
Saugatuck Twp	0	0.03	0.036	0.12	0.7	3.425	0.2	0.4	0	0.06667	0.70	4.28
Martin Twp	0.07	0.6775	0.052	0.176	0.883	2.98333	0	0.5	0	0	1.25	4.09
Hopkins Twp	0	0.01	0.064	0.144	1	2.4	0.5	0.695	0	0	1.21	3.61
Wayland	0	0.295	0.028	0.092	1	2.45	0.02	0.31	0.0667	0.1333	0.83	3.57
Leighton Twp	0	0.14	0.016	0.064	1	2.25	0.2	0.3	0.06667	0.333	1.04	3.33
Fennville	0.05	0.13	0.116	0.236	1.183	1.775	0	0	0	0	0.18	3.31
Casco Twp	0	0.07	0.028	0.084	0.7	1.9	0	0.775	0	0.0667	0.91	2.71
Fillmore Twp	0	0.01	0.06	0.224	0.333	1.9	0.3	0.75	0	0.06667	1.13	2.52
Dorr Twp	0	0	0.024	0.088	0.5333	1.6667	0.39	0.675	0	0	1.07	2.31
Wayland Twp	0	0.05	0.02	0.06	0.6667	1.33	0.1	0.7	0.067	0.1333	1.05	2.08
Cheshire Twp	0	0.01	0.024	0.076	0.5	1.45	1.05	1.425	0.013333	0.06667	2.57	2.05
Monterey Twp	0	0.11	0.024	0.058	0.5	1.333	0.1	0.2	0.16667	0.25	0.83	1.92
Lee Twp	0	0.08	0.028	0.108	0.333	6.433333	0	0.1	0	0.0167	0.20	6.90
Salem Twp	0.01	0.16	0.048	0.12	0.667	1	0	0.385	0	0.046667	0.60	1.84
Manlius Twp	0	0.12	0.036	0.128	0.33	1.06667	0	0.075	0	0	0.20	1.56
Allegan Twp	0	0.09	0.032	0.088	0.433	0.925	0	0.25	0	0.0667	0.41	1.48
Trowbridge Twp	0	0.01	0.034	0.093	0.333	1	0	0.1	0.033333	0.06667	0.21	1.46
Watson Twp	0	0.05	0.032	0.08	1.333	6.733333	0.5	0.65	0	0	1.20	8.18
Allegan	0	0.04	0.06	0.12	0.433	0.6667	0.35	0.5	0	0.106667	1.00	1.28
Heath Twp	0.02	0.35	0.04	0.156	0	1	0	0.15	0	0	0.52	1.20
Laketown Twp	0	0.02	0.032	0.104	0	1.05	0.35	0.475	0	0.06667	0.91	1.19
Otsego	0.01	0.085	0.1043	0.15	0.35	0.525	0	0	0	0	0.10	1.13
Overisel Twp	0.01	0.52	0.068	0.301	0	0.6667	0.3	0.47	0	0	1.30	1.04
Village of Douglas	0	0.01	0.132	0.279	0.0667	0.1	0	0.05	0.0667	0.067	0.19	0.58
Saugatuck	0	0.03	0.096	0.376	0	0	0.3	0.3	0	0	0.63	0.47
Plainwell	0.06	0.15	0.088	0.204	0	0	0	0.075	0.013333	0.026667	0.33	0.29



Primary NPS Pollution Index



Secondary NPS Pollution Index

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APPENDIX G
Population Projections

Population Projections

Overall, population projections serve as a cornerstone in the formulation of policies and strategies that inform strategic planning and resource management of groundwater in the face of dynamic environmental and demographic changes.

Population growth in Allegan County has been forecasted to year 2050 using statistical averaging techniques. These methodologies are designed to offer a broad overview of future growth trends. The generalizations are constrained by their reliance on historical trends documented by the United States Census Bureau data. Despite their limitations in scope, these projections serve as valuable tool for gauging the county's prospective growth. This section delves into four distinct projection techniques, providing insights into the future trajectory of the County in terms of population growth/loss.

The Arithmetic Increase Method

The Arithmetic Increase Method is generally applicable to larger established communities. This method assumes a direct correlation between past population changes and future population changes and is the generally accepted method for estimating population changes when planning capital improvements projects for communities. The Arithmetic method projects future population counts based on the increase or decrease in the average number of persons per year calculated based on the population change in the past couple of decades. The Arithmetic Method projections are based on an average increase or decrease in each jurisdiction in Allegan County.

The Arithmetical Method projects the county-wide growth to be slightly over 10,000 by the end of 2050, or an overall growth of about 9% (see Table 1). The largest growth areas (by township) are predicted for Allegan, Leighton, Dorr, Heath, Manlius, Otsego, Salem and Saugatuck Townships, and the City of Fennville. While most of the cities and townships may experience an average annual increase in their population, others are predicted to decline – these are Casco, Cheshire, Clyde, Fillmore, and Lee Townships.

Table 1. Arithmetic Method Population Projections.

Jurisdiction	2000	2010	2020	Annual Change	Projections		
					2030	2040	2050
Allegan City	4,838	4,998	5,222	9.6	5,318	5,414	5,510
Allegan Township	4,054	4,406	4,689	15.9	4,848	5,007	5,165
Casco Township	3,021	2,823	2,796	-5.6	2,740	2,684	2,627
Cheshire Township	2,285	2,199	2,211	-1.9	2,193	2,174	2,156
Clyde Township	2,126	2,084	2,060	-1.7	2,044	2,027	2,011
Dorr Township	6,579	7,439	7,922	33.6	8,258	8,594	8,929
Douglas City	1,214	1,232	1,378	4.1	1,419	1,460	1,501
Fennville City	1,412	1,398	1,745	8.3	1,828	1,912	1,995
Fillmore Township	2,798	2,681	2,778	-0.5	2,773	2,768	2,763
Ganges Township	2,516	2,530	2,574	1.5	2,589	2,603	2,618
Gun Plain Township	5,821	5,895	6,148	8.2	6,230	6,312	6,393
Heath Township	3,063	3,317	3,937	21.9	4,156	4,374	4,593
Holland City	7,248	7,016	7,730	12.1	7,851	7,971	8,092
Hopkins Township	2,651	2,601	2,760	2.7	2,787	2,815	2,842
Laketown Township	5,453	5,505	5,928	11.9	6,047	6,166	6,284
Lee Township	4,164	4,015	3,805	-9.0	3,715	3,626	3,536
Leighton Township	3,668	4,934	7,001	83.3	7,834	8,668	9,501
Manlius Township	2,700	3,017	3,312	15.3	3,465	3,618	3,771
Martin Township	2,536	2,629	2,723	4.7	2,770	2,817	2,863
Monterey Township	2,085	2,356	2,436	8.8	2,524	2,612	2,699
Otsego City	3,876	3,956	4,120	6.1	4,181	4,242	4,303
Otsego Township	4,899	5,594	5,903	25.1	6,154	6,405	6,656
Overisel Township	2,620	2,911	3,133	12.8	3,261	3,390	3,518
Plainwell City	3,761	3,804	3,788	0.7	3,795	3,802	3,808
Salem Township	3,480	4,446	5,156	41.9	5,575	5,994	6,413
Saugatuck City	1,097	925	865	-5.8	807	749	691
Saugatuck Township	2,376	2,944	3,443	26.7	3,710	3,977	4,243
Trowbridge Township	2,515	2,502	2,530	0.4	2,534	2,538	2,541
Valley Township	1,827	2,018	2,221	9.9	2,320	2,418	2,517
Watson Township	2,064	2,063	2,176	2.8	2,204	2,232	2,260
Wayland City	3,889	4,079	4,435	13.7	4,572	4,708	4,845
Wayland Township	3,047	3,088	3,573	13.2	3,705	3,836	3,968

The Growth Rate Method

The Growth Method is similar to the arithmetic method in that population projections are based on the rate of growth in each jurisdiction in the past. The rate of growth from the past years is used to estimate the projections for future years assuming that the growth rate trend follows the historical average.

The Growth Rate Method projects the county-wide growth to be slightly over 13,000 by the end of 2050, or a growth of about 11% (see Table 2). The largest growth areas (by township) are predicted for Allegan, Dorr, Heath, Leighton, Manlius, Otsego, Overisel, Salem and Saugatuck Townships, and the City of Fennville. These results are similar to the results of Arithmetic Method, and predict most cities and townships will have a positive growth rate except Casco, Cheshire, Clyde, Fillmore, and Lee Townships.

Table 2. Growth Rate Method Population Projections.

Jurisdiction	2000	2010	2020	% Annual Change	Projections		
					2030	2040	2050
Allegan City	4,838	4,998	5,222	0.19%	5,325	5,429	5,536
Allegan Township	4,054	4,406	4,689	0.38%	4,869	5,056	5,250
Casco Township	3,021	2,823	2,796	-0.19%	2,744	2,693	2,643
Cheshire Township	2,285	2,199	2,211	-0.08%	2,193	2,176	2,158
Clyde Township	2,126	2,084	2,060	-0.08%	2,044	2,028	2,012
Dorr Township	6,579	7,439	7,922	0.49%	8,318	8,734	9,171
Douglas City	1,214	1,232	1,378	0.33%	1,425	1,473	1,523
Fennville City	1,412	1,398	1,745	0.60%	1,852	1,965	2,085
Fillmore Township	2,798	2,681	2,778	-0.01%	2,774	2,770	2,766
Ganges Township	2,516	2,530	2,574	0.06%	2,589	2,604	2,619
Gun Plain Township	5,821	5,895	6,148	0.14%	6,234	6,321	6,410
Heath Township	3,063	3,317	3,937	0.67%	4,211	4,504	4,817
Holland City	7,248	7,016	7,730	0.17%	7,866	8,004	8,145
Hopkins Township	2,651	2,601	2,760	0.11%	2,789	2,819	2,849
Laketown Township	5,453	5,505	5,928	0.22%	6,057	6,189	6,324
Lee Township	4,164	4,015	3,805	-0.22%	3,722	3,641	3,561
Leighton Township	3,668	4,934	7,001	1.91%	8,459	10,221	12,351
Manlius Township	2,700	3,017	3,312	0.54%	3,495	3,687	3,890
Martin Township	2,536	2,629	2,723	0.18%	2,773	2,823	2,875
Monterey Township	2,085	2,356	2,436	0.41%	2,538	2,644	2,754
Otsego City	3,876	3,956	4,120	0.16%	4,184	4,250	4,316
Otsego Township	4,899	5,594	5,903	0.49%	6,200	6,513	6,841
Overisel Township	2,620	2,911	3,133	0.47%	3,283	3,440	3,604
Plainwell City	3,761	3,804	3,788	0.02%	3,795	3,802	3,809
Salem Township	3,480	4,446	5,156	1.09%	5,748	6,408	7,144
Saugatuck City	1,097	925	865	-0.55%	818	774	732
Saugatuck Township	2,376	2,944	3,443	1.02%	3,811	4,219	4,670
Trowbridge Township	2,515	2,502	2,530	0.02%	2,534	2,538	2,541
Valley Township	1,827	2,018	2,221	0.51%	2,338	2,460	2,589
Watson Township	2,064	2,063	2,176	0.14%	2,206	2,236	2,266
Wayland City	3,889	4,079	4,435	0.34%	4,588	4,747	4,911
Wayland Township	3,047	3,088	3,573	0.43%	3,728	3,890	4,059

Constant Proportion Method

The Constant Proportion Method of projecting population trends assumes that each jurisdiction will continue to represent the same percentage of Allegan County's projection population in the years 2030, 2040, 2050. The population projections of Allegan County used for this method are estimated by the Michigan Department of Transportation-Statewide & Urban Travel Analysis Section and University of Michigan-Research Seminar in Quantitative Economics (July 2022). Using these population projections and extending those trends through 2050.

The Constant Proportion Method projects the county-wide growth to be slightly over 13,000 by the end of 2050, or a growth of about 11% (see Table 3). As expected with this method, the largest growth areas between the years of 2000 and 2020 will continue to show the greatest growth due to the constraints of this model. As with the previous methods, the larger growth areas are Allegan, Dorr, Heath, Leighton, Manlius, Otsego, Overisel, Salem and Saugatuck Townships, and the City of Fennville.

Table 3. Constant Proportion Method Population Projections.

Jurisdiction	2000	2010	2020	% of County	Projections		
					2030	2040	2050
Allegan City	4,838	4,998	5,222	4.3%	5,530	5,751	5,796
Allegan Township	4,054	4,406	4,689	3.9%	4,966	5,164	5,204
Casco Township	3,021	2,823	2,796	2.3%	2,961	3,079	3,103
Cheshire Township	2,285	2,199	2,211	1.8%	2,341	2,435	2,454
Clyde Township	2,126	2,084	2,060	1.7%	2,181	2,269	2,286
Dorr Township	6,579	7,439	7,922	6.6%	8,389	8,725	8,793
Douglas City	1,214	1,232	1,378	1.1%	1,459	1,518	1,529
Fennville City	1,412	1,398	1,745	1.4%	1,848	1,922	1,937
Fillmore Township	2,798	2,681	2,778	2.3%	2,942	3,060	3,083
Ganges Township	2,516	2,530	2,574	2.1%	2,726	2,835	2,857
Gun Plain Township	5,821	5,895	6,148	5.1%	6,511	6,771	6,824
Heath Township	3,063	3,317	3,937	3.3%	4,169	4,336	4,370
Holland City	7,248	7,016	7,730	6.4%	8,186	8,514	8,580
Hopkins Township	2,651	2,601	2,760	2.3%	2,923	3,040	3,063
Laketown Township	5,453	5,505	5,928	4.9%	6,278	6,529	6,580

Lee Township	4,164	4,015	3,805	3.2%	4,029	4,191	4,223
Leighton Township	3,668	4,934	7,001	5.8%	7,414	7,711	7,771
Manlius Township	2,700	3,017	3,312	2.7%	3,507	3,648	3,676
Martin Township	2,536	2,629	2,723	2.3%	2,884	2,999	3,022
Monterey Township	2,085	2,356	2,436	2.0%	2,580	2,683	2,704
Otsego City	3,876	3,956	4,120	3.4%	4,363	4,538	4,573
Otsego Township	4,899	5,594	5,903	4.9%	6,251	6,501	6,552
Overisel Township	2,620	2,911	3,133	2.6%	3,318	3,451	3,477
Plainwell City	3,761	3,804	3,788	3.1%	4,011	4,172	4,204
Salem Township	3,480	4,446	5,156	4.3%	5,460	5,679	5,723
Saugatuck City	1,097	925	865	0.7%	916	953	960
Saugatuck Township	2,376	2,944	3,443	2.9%	3,646	3,792	3,821
Trowbridge Township	2,515	2,502	2,530	2.1%	2,679	2,787	2,808
Valley Township	1,827	2,018	2,221	1.8%	2,352	2,446	2,465
Watson Township	2,064	2,063	2,176	1.8%	2,304	2,397	2,415
Wayland City	3,889	4,079	4,435	3.7%	4,697	4,885	4,922
Wayland Township	3,047	3,088	3,573	3.0%	3,784	3,935	3,966
Allegan County	105,683	111,405	120,498	100%	127,609	132,720	133,747

Averaged Growth Projection

Finally, since all three methods appear to show similar trends in population patterns, we averaged all three methods to distill them into one conclusion; the predicted increase in population between 2020 and 2050 will be about 13,694 people (roughly 14,000 people) (see Table 4). The larger growth areas appear to be in the areas of Allegan, Dorr, Fennville, Heath, Leighton, Manlius, Monterey, Otsego, Overisel, Salem, Saugatuck, and Wayland Townships, and the Cities of Fennville and Douglas. These townships represent the northeast part of the county where the bedrock is an important source of groundwater, and along a diagonal trend from the southeast corner of the county at Plainwell to the northwest along the M-89 and M-40 corridors, and in Manlius Township along M-89.

Table 4. Averaged Growth Population Projections.

		Projections						
Jurisdiction	**2020**	**2030**	**2040**	**2050**		**2020-2030**	**2020-2040**	**2020-2050**
Allegan City	5,222	5391	5532	5614		3.2%	5.9%	7.5%
Allegan Township	4,689	4894	5076	5207		4.4%	8.2%	11.0%
Casco Township	2,796	2815	2819	2791		0.7%	0.8%	-0.2%
Cheshire Township	2,211	2242	2262	2256		1.4%	2.3%	2.0%
Clyde Township	2,060	2090	2108	2103		1.4%	2.3%	2.1%
Dorr Township	7,922	8322	8684	8964		5.0%	9.6%	13.2%
Douglas City	1,378	1434	1484	1518		4.1%	7.7%	10.1%
Fennville City	1,745	1843	1933	2006		5.6%	10.8%	14.9%
Fillmore Township	2,778	2830	2866	2871		1.9%	3.2%	3.3%
Ganges Township	2,574	2634	2681	2698		2.3%	4.1%	4.8%
Gun Plain Township	6,148	6325	6468	6542		2.9%	5.2%	6.4%
Heath Township	3,937	4178	4405	4593		6.1%	11.9%	16.7%
Holland City	7,730	7967	8163	8272		3.1%	5.6%	7.0%
Hopkins Township	2,760	2833	2891	2918		2.6%	4.7%	5.7%
Laketown Township	5,928	6127	6295	6396		3.4%	6.2%	7.9%
Lee Township	3,805	3822	3819	3773		0.5%	0.4%	-0.8%
Leighton Township	7,001	7902	8867	9874		12.9%	26.6%	41.0%
Manlius Township	3,312	3489	3651	3779		5.3%	10.2%	14.1%
Martin Township	2,723	2809	2880	2920		3.1%	5.8%	7.2%
Monterey Township	2,436	2547	2646	2719		4.6%	8.6%	11.6%
Otsego City	4,120	4243	4343	4397		3.0%	5.4%	6.7%
Otsego Township	5,903	6202	6473	6683		5.1%	9.7%	13.2%
Overisel Township	3,133	3287	3427	3533		4.9%	9.4%	12.8%
Plainwell City	3,788	3867	3925	3940		2.1%	3.6%	4.0%
Salem Township	5,156	5594	6027	6427		8.5%	16.9%	24.6%
Saugatuck City	865	847	825	794		-2.1%	-4.6%	-8.2%
Saugatuck Township	3,443	3722	3996	4245		8.1%	16.1%	23.3%
Trowbridge Township	2,530	2582	2621	2630		2.1%	3.6%	4.0%
Valley Township	2,221	2336	2441	2524		5.2%	9.9%	13.6%
Watson Township	2,176	2238	2288	2314		2.9%	5.2%	6.3%
Wayland City	4,435	4619	4780	4893		4.1%	7.8%	10.3%
Wayland Township	3,573	3739	3887	3998		4.6%	8.8%	11.9%

APPENDIX H

List of Files & Data Sources Provided to Allegan County

File types used to develop maps, figures, and infographics as part of the Allegan County Groundwater Assessment Report include:

- Map Data: ArcGIS
    - Geodatabase file (.gdb)
    - Shapefile (.shp)
    - Image file (.tiff)
- 3D Geological Models (Detailed Lithology, Glacial Geology and Bedrock Subcrop Depictions)
    - MAGNET4WATER (software developed by Hydrosimulatics INC.)
- Vector-based Illustrations
    - InDesign (.idml)
    - Illustrator (.ai)
- Photographs & Other Flattened Image Files:
    - .jpg
    - .pdf
    - .png
- Document Formatting: InDesign (.idml)
- Exported GAR Document: .pdf

As part of this project, a packaged export of the InDesign file will be shared with Allegan County once the GAR has been finalized. This will include all of the reference files used to develop the report. Data used for the creation of maps will be shared as a Geodatabase.

The following is a list of maps, figures, and infographics developed for this report, general methods for creation, and links to data sources.

Chapter 1 Infographics (pgs 11-15, 19)

- Created adobe suite products (Illustrator, Photoshop, InDesign, etc.)

3D Glacial Geology depiction

- Quaternary Geology Map “draped” on 3D DEM surface with side enclosure
- Map accessible from: State of Michigan GIS Open Data portal, specific map URL: https://gis-michigan.opendata.arcgis.com/datasets/0d4a5156177a464a837830c176261e6d_5/explore
- 3D rendering done with MAGNET4WATER platform: www.magnet4water.net

3D Bedrock Subcrop depiction (pg 17)

- Bedrock geology (subcrop) map “draped” on 3D DEM surface with side enclosure
- Map accessible from: State of Michigan GIS Open Data portal, specific map URL: https://gis-michigan.opendata.arcgis.com/datasets/d676f3f2007e4d61ad07faf0fb6bc4fd_0/explore?location=44.758764%2C-86.135708%2C6.93
- 3D rendering done with MAGNET4WATER platform

Map 1 – Aquifer Yield Estimates

- This is a *calculated* layer created by Hydrosimulatics INC. as part of the Phase 1 study
- A .tiff raster file was provided to Williams & Works and can be included with the data package for Allegan County

Map 2 – Long-term Mean Recharge

- Layer originally created for Groundwater Mapping and Inventory Project (GWIM), a joint MSU-DEQ project in 2000s
- A .tiff raster file was provided to Williams & Works and can be included with the data package for Allegan County
- Section-based layer also available from: State of Michigan GIS Open Data portal, specific map URL: https://gis-michigan.opendata.arcgis.com/datasets/104e696173d640dfbd7d957148d0b992_8/explore?location=42.568587%2C-85.805095%2C10.75

Figure 2.1 - Concept of a groundwater divide and source groundwater areas

- Created adobe suite products (Illustrator, Photoshop, InDesign, etc.)

Figure 2.2 – Flow Model results for submodels used in Groundwater Protection Area (GPA) Delineation

- Created using MAGNET4WATER groundwater modeling platform
- .tiff files of flow maps and shapefiles of GPA were provided to Williams & Works and can be included with the data package for Allegan County

Map 3 – Final Groundwater Protection Area Delineation

- Map created by Williams & Works; GPA shapefile created by Hydrosimulatics
- GPA shapefile used to create the map was provided to Williams & Works and can be included with the data package for Allegan County

Map 4 – Wellhead Protection Areas – Type 1 Wells

- Layer combining WHPAs available from State of Michigan web portal (traditional or provisional WHPAs) and new WHPAs created by Hydrosimulatics INC. during Phase 2 study
- Traditional and Provisional WHPAs are available from: State of Michigan GIS Open Data portal, specific map URL: https://gis-michigan.opendata.arcgis.com/datasets/868e2d670a2641d48e0b150a84769e18_0/explore?location=42.707084%2C-86.089172%2C11.68
- Combined layer was provided to Williams & Works and can be included with the data package for Allegan County (new WHPAs created in Phase also have already been provided directly to Allegan County)

Map 5 – 351 sites of Groundwater Concern

- Sites of Environmental Concern (Part 201) are accessible from State of Michigan RIDE Mapper: https://experience.arcgis.com/experience/caac24695429449bbf6cc6d89c111d3b/
- Historical or operational landfills or waste handlers are accessible from : State of Michigan GIS Open Data portal, specific map URL: https://gis-egle.hub.arcgis.com/datasets/9a923b49b1824f45b27a58c37526fec9_0/explore?location=42.917880%2C-85.983010%2C9.89 , https://gis-egle.hub.arcgis.com/datasets/43afb115983b4c62900c7ab129e0a3e0_6/explore?location=42.849692%2C-85.773950%2C9.88 , https://gis-michigan.opendata.arcgis.com/datasets/61be1d68d9ba43848bc2173c98836f56_5/explore?location=42.643792%2C-85.539004%2C10.66 , https://gis-michigan.opendata.arcgis.com/datasets/eddb0a8743e640928d6a1a9fe6277b94_7/explore?location=42.715215%2C-85.762209%2C10.66
- Active (Open) Leaking Underground Storage Tank (LUST) sites are accessible from State of Michigan RIDE Mapper: https://experience.arcgis.com/experience/caac24695429449bbf6cc6d89c111d3b/
- PFAS sites: available from EGLE MPART Web Application: https://egle.maps.arcgis.com/apps/webappviewer/index.html?id=bdec7880220d4ccf943aea13eba102db

Map 6 – Risk Ranking of the 351 Sites of Groundwater Concern

- This layer was created by Hydrosimulatics INC. as part of this study; the map was created by Williams and Works
- Shapefile used to create the map was provided to Williams & Works and can be included with the data package for Allegan County

Map 7 – Highest Priority Sites of Groundwater Concern (Top 30)

- This layer was created by Hydrosimulatics INC. as part of this study; the map was created by Williams and Works
- Shapefile used to create the map was provided to Williams & Works and can be included with the data package for Allegan County

Map 8 – Risk Ranking of Primary Non-Point Source Pollution

- This layer was created by Hydrosimulatics INC. as part of this study; the map was created by Williams and Works
- Shapefile used to create the map was provided to Williams & Works and can be included with the data package for Allegan County

Map 9 – Risk Ranking of Secondary Non-Point Source Pollution

- This layer was created by Hydrosimulatics INC. as part of this study; the map was created by Williams and Works
- Shapefile used to create the map was provided to Williams & Works and can be included with the data package for Allegan County

Map 10 - Graphics of "Input layers" for Composite Groundwater Risk map

- Water quality shapefile data (e.g., nitrate, chloride, etc.) are from statewide processing of WaterChem data (completed 2014). Hydrosimulatics provided these datasets to Williams & Works and they can be included with the data package for Allegan County
- Social Vulnerability Index shapefile data was downloaded from the CDC/ATSDR interactive web viewer https://www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html
- Map created by Williams & Works using point data from WaterChem (see above).

Maps 11 – 16 – Location and Demand Distribution of Water Wells

- Wellogic data can be downloaded from: State of Michigan GIS Open Data portal, specific map URL: https://gis-michigan.opendata.arcgis.com/search?collection=Dataset&q=Wellogic
- Shapefile data displayed in ArcGIS Pro

Maps 17 - Projected Groundwater Demand by Local Government Unit 2050

- Data was created by Williams & Works and compiled as an excel spreadsheet that was projected into ArcGIS Pro. Associated shape files created through this process will be provided to the County.

Maps 18 - Areas of Low Transmissivity and Projected Groundwater Demand by LGU 2050

- Transmissivity maps were provided as shape files by Hydrosimulatics as part of the Phase I Allegan County Groundwater Study research and overlaid on the projected groundwater demand map (Map 17) in ArcGIS Pro.

ALLEGAN COUNTY

GROUNDWATER ASSESSMENT REPORT