

# Allegan County Water Study Workgroup

## Meeting Minutes

Date of meeting            Wednesday, January 11 2:00 pm

Member Name	Group	Attendance	Notes
Dean Kapenga	County Commission	Absent	
Chad Kraai	Well Driller	Zoom	
Brian Talsma	Conservation District	Zoom	
Doug Sweeris	Municipal Water Supply	In Person	
Erick Elgin	Academic	Zoom	
Jay Drozd	Agriculture	Absent	
John "Ric" Curtis	Community	In Person	Vice Chair
John Shagonaby	Tribal	Absent	Liz Binoniemi-Smith for John
Tom Kunetz	Community	In Person	Chair
Zachary Curtis	Consultant	Zoom	

Guests and staff:        In Person: Randy Rapp, Jill Dunham, arrived at 2:16 Jaclyn Hulst  
Zoom: Scott Jones and Dan Wedge; Lauren Schnoebelen and Liz Binoniemi-Smith

Next meeting:            Wednesday, January 18, 2023

### I. Approval of Agenda

- A. Agenda approved

### II. Action Items from previous meeting

- A. Jill will contact Sara (EGLE) to get a contact for Ingham/Eaton/Clinton work group. **DONE**
- B. Erick Elgin offered to provide a list of water conservation groups around the state. Erick will send by Jan 13.

### III. Discussion

- A. Presentation by Tri County (Ingham/Clinton/Eaton) Planning Commission (Lauren Schnoebelen)
  - 1. Very informative presentation – began at 2:05 Ended at 2:30, presentation is included in minutes.
  - 2. Q&A: Doug Sweeris asked several questions. Due to time limitations, Tom will compile any additional questions and email them to Lauren.
- B. Review of modified Scope of Work for Groundwater Protection Plan RFP (Kunetz)
  - 1. Tom reviewed the Scope with only typo corrections. Scope is included in minutes

C. Phase 2 Groundwater Study update (Z. Curtis)

1. Presentation is attached

D. Future Work Group meeting schedule (Kunetz)

Jan 18	Phase 2 Recommendation (Presentation Zach Curtis) RFP discussion as needed	
Feb 1 & 15	Monitoring well Locations; Recommendations to Board from Phase 2 Study	
Spring 2023	Review proposals for Water Supply Master Plan and Public Communication	
Summer 2023	Participate in information gathering sessions with the Water Supply Master Plan and the Public Communications RFP	

## IV. Action Items

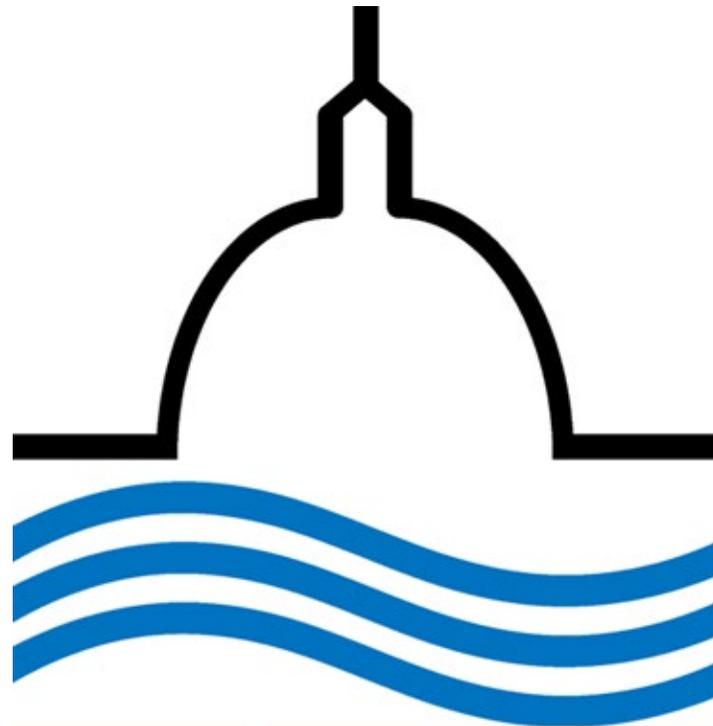
- A. Tom will send additional questions to Lauren for her response.
- B. Tom and Jill will work with Valdis to incorporate the Scope of Work into the full RFP.
- C. Erick Elgin offered to provide a list of water conservation groups around the state. Erick will send by Jan 13.

Meeting adjourned 4:00 pm



# Groundwater Management Board

Who We Are & What We Do



# Overview

- What is Groundwater and Why it Matters?
- What is the Groundwater Management Board?
- What We Do
- GMB Resources

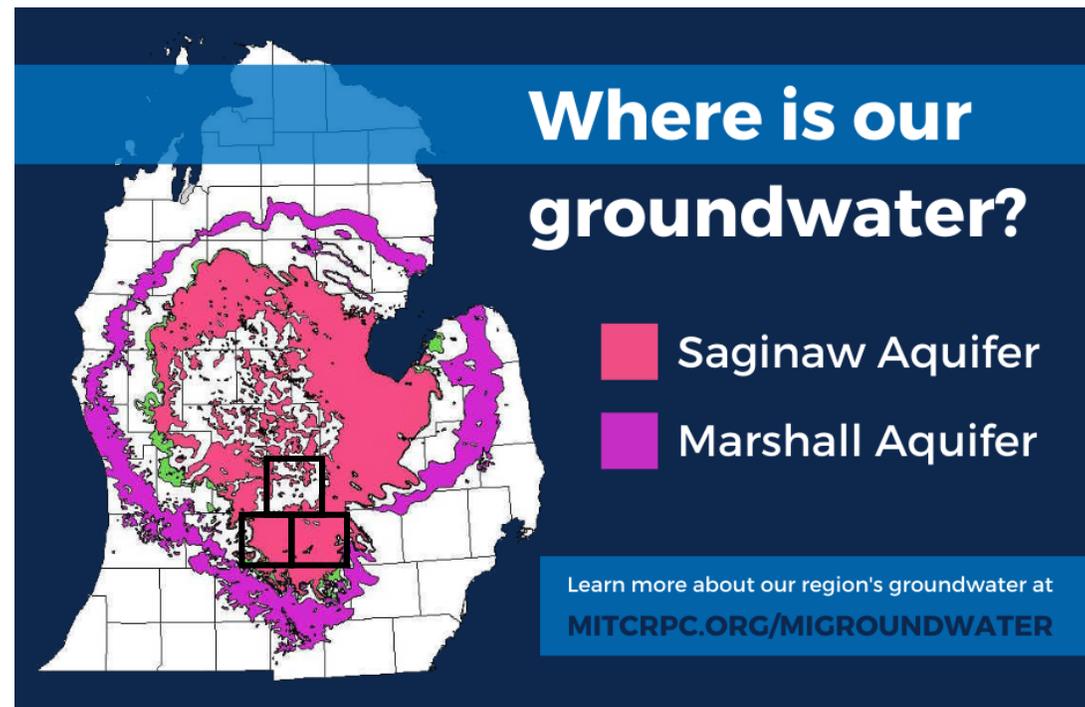




What is  
Groundwater and  
why does it matter?

# Groundwater 101

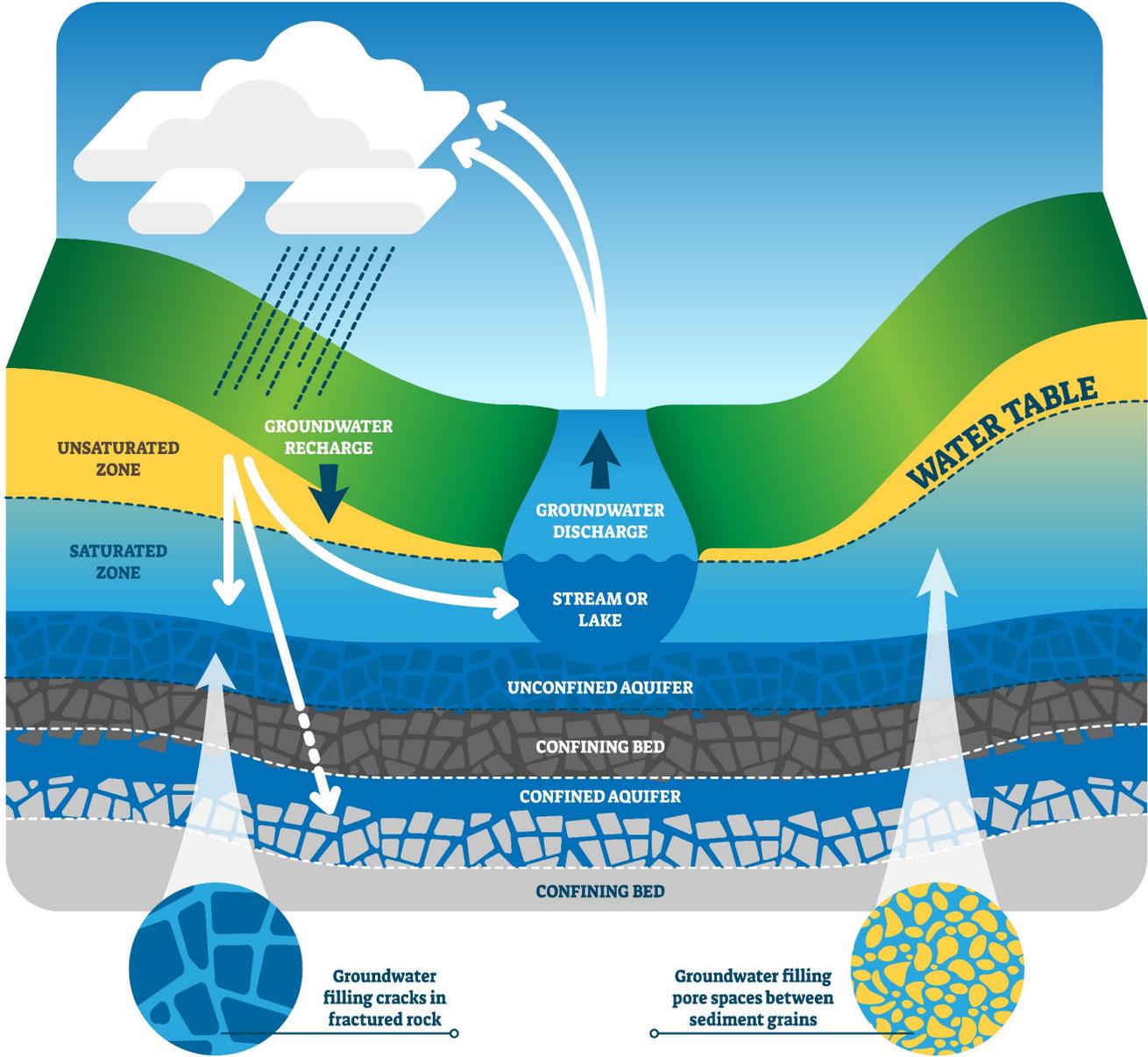
- The tri-county region relies almost exclusively on groundwater for our drinking water needs
- Groundwater is one part of the water cycle which helps to replenish local lakes and rivers
- Accessed through public municipal or private homeowner wells
  - Michigan leads the nation with over 1 million households with private drinking wells



# GROUNDWATER



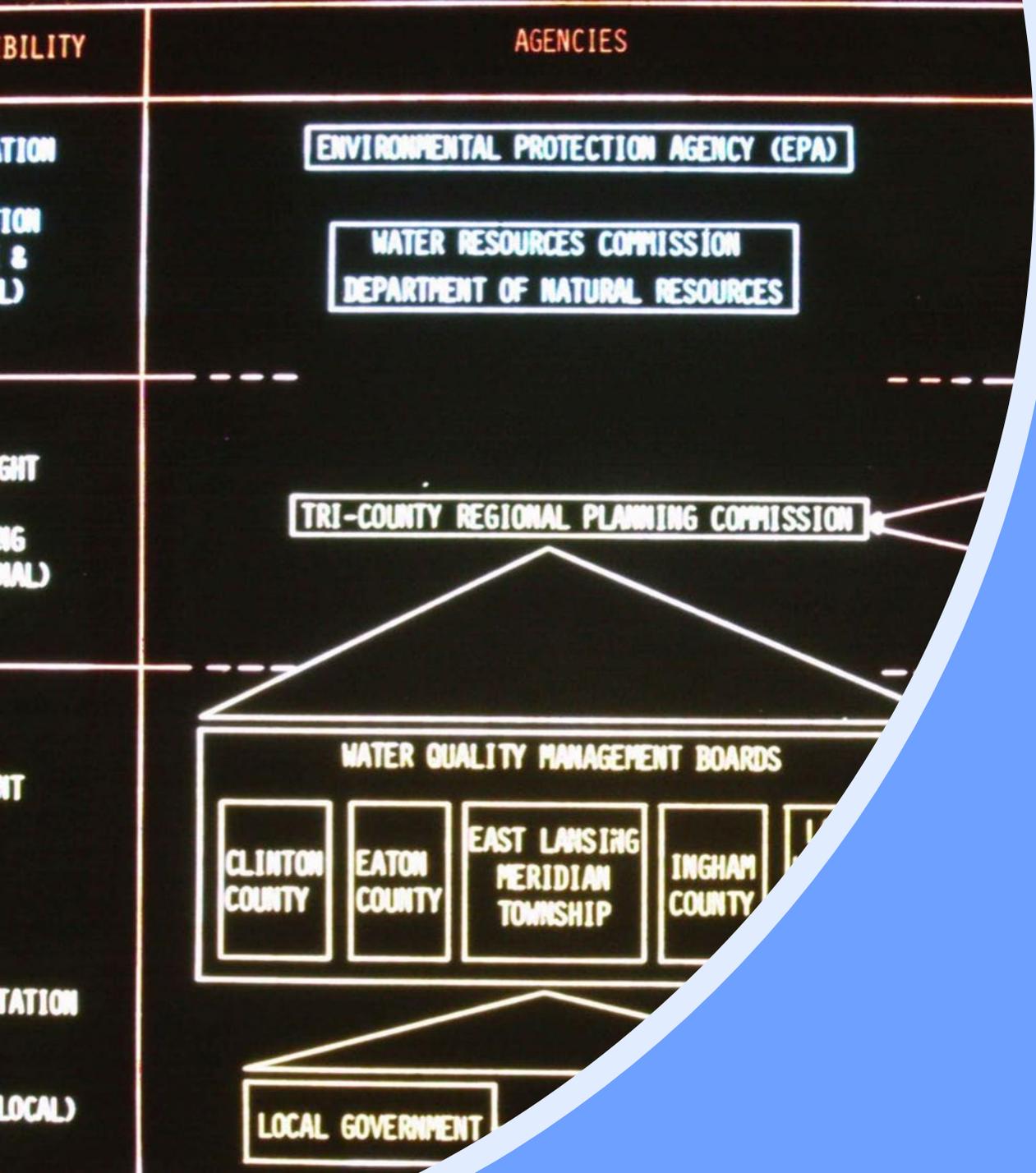
Groundwater Management Board



# Regional groundwater priorities

- Groundwater Testing & Monitoring
- Wellhead Protection
- Road Salt Best Practices
- PFAS Contamination
- Geothermal Energy Impacts
- Outreach & Education
- Drinking Water Infrastructure
- Policy Recommendations





# What is the Groundwater Management Board?

# History

- Established in 1982 and focused on using the results of the 208 Water Quality Program which provided detailed surface water and groundwater data
- Currently consisting of ten communities: City of East Lansing, City of Williamston, Delhi Charter Township, Delta Charter Township, Lansing Board of Water & Light/City of Lansing, Lansing Charter Township, Meridian Charter Township, Michigan State University, Village of Webberville, and Watertown Township





Groundwater  
Management  
Board

# Mission

*The Groundwater Management Board's mission is to provide a multi-jurisdictional forum for coordination and cooperation to help assure adequate quantities and qualities of groundwater are available to meet regional needs.*

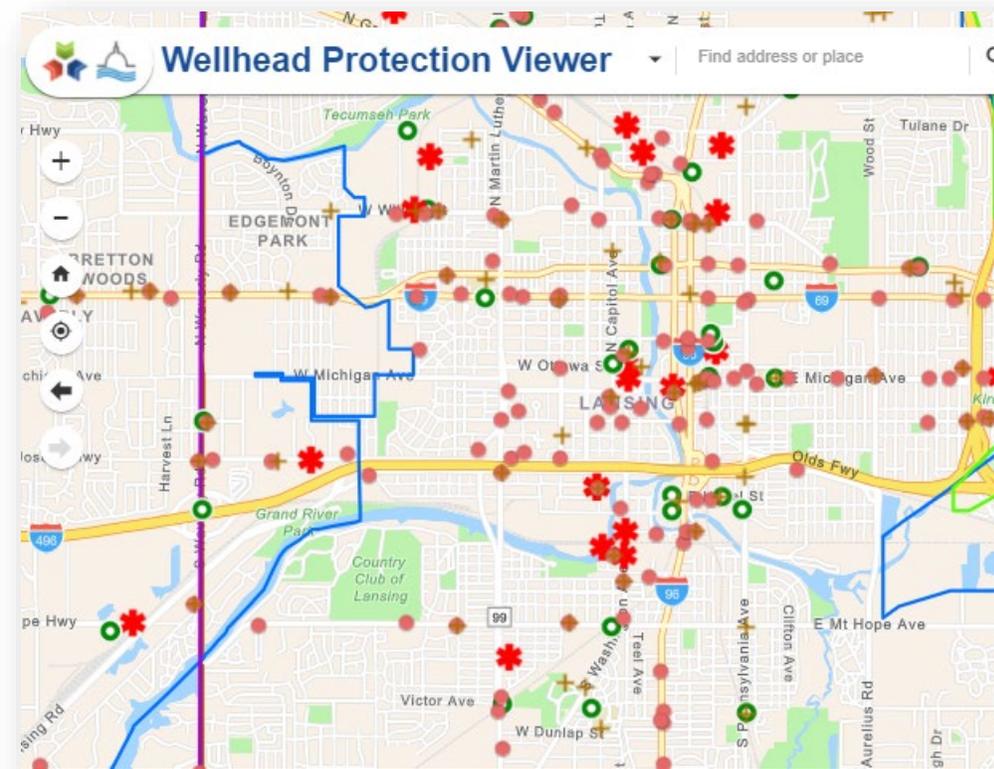


# What we Do

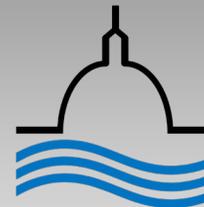
Programs, Wellhead Protection Grants,  
and Initiatives

# Wellhead Protection Viewer

- An interactive online mapping application that provides a variety of data to help communities and organizations make better informed development decisions
- It's a useful resource for planners looking to identify locations at greatest risk for groundwater contamination
- Records indicate the Viewer is used/accessed multiple times per day and over time has seen approximately 1,200 user sessions



# Wellhead and Groundwater protection Audit Tool



Groundwater Management Board

Developed to provide any community seeking guidance on their wellhead and groundwater protection strategies with a specific tool for evaluation

- Evaluates four important aspects of wellhead protection planning
- Recently used to update a GMB member's 2021 wellhead protection plan

**Wellhead and Groundwater Protection Audit Tool: [Municipality]**

**Master Plan**

This section is to be completed by relying on the community's master plan document as well as any supplementary adopted plans. This section is broken into two parts with specific questions for wellhead protection and groundwater protection. This is done in order to make direct wellhead protection planning clear. The groundwater specific part includes additional questions related to protecting groundwater resources which have an effect on wellheads. These two categories complement each other and help create a more comprehensive overview. Each question is to be answered with citations as to where the information is found in the legal documents to ensure quick access for reference.

**Wellhead Protection**

Question	Response
1) Are the wellhead protection areas (WHPAs) included in the plan?	
2) Are WHPAs defined?	
3) Does the community utilize overlay zones for WHPAs?	
4) Is there reference to designated Brownfield sites located within WHPAs?	

**Groundwater Protection**

# Groundwater Quality Survey

- Resampling of private household water quality from the Ingham County's 1980s Aquifer Study
- Provided an excellent opportunity to educate well owners on well protection, and determine future strategies for groundwater protection
- Over [20+ individual township groundwater](#) quality reports were produced from the study
- Expansion efforts to bring the groundwater survey to both Eaton and Clinton counties were started with a pilot study for sampling in Bath and DeWitt Townships

## GROUNDWATER QUALITY REPORT FOR INGHAM COUNTY

1983 | 2020



**2007 LBWL** – Create a local movie theatre campaign to increase awareness of groundwater and wellhead protection, update of regional aquifer model, integrate LBWL's contamination source inventory data into MapImage Viewer, and update the address database for the current contamination source inventory.

**2008 LBWL** – Movie Ads and permanent local groundwater display.

**2010 ELMWSA** – Specific land use/master plan, ordinance, and site plan review recommendations to further implement and strengthen wellhead protection; and conduct a series of presentation to educate decision makers on emerging environmental issues with direct impact on groundwater and wellhead protection efforts.

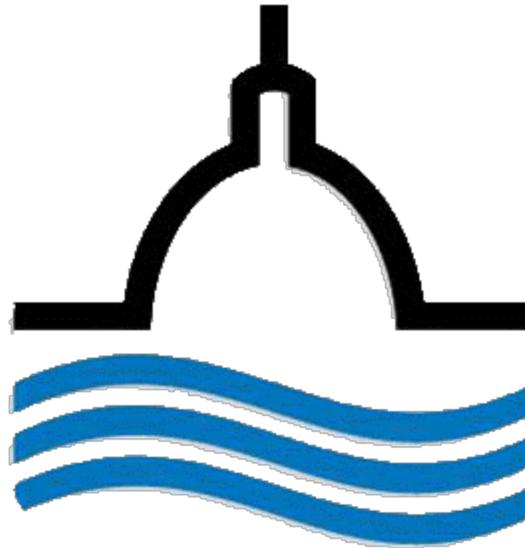
**2010 Delta Charter Township** – Update Delta wellhead protection plan, review and update local environmental permits checklist, and increase size and design upgrade to website.

**2012 ELMWSA** – Wellhead Protection Education and Education via social media and local cable productions.

**2012 Delta Charter Township** – Make available historic hydrologic and environmental studies and data relevant to wellhead protection areas.

**2013 Delta Charter Township** – Use the Byproduct Synergy network to recruit entities within the Potential Contamination Source Inventory to improve their "green" business practices by reevaluating their waste stream and the source of their raw materials.

**2014 ELMWSA** – Use the Byproduct Synergy network to recruit entities within the Potential Contamination Source Inventory to improve their "green" business practices by reevaluating their waste stream and the source of their raw materials.



**2015 East Lansing** – A gap analysis to evaluate the effectiveness of current programming, initiate, improve, expand and implement best management strategies, share successful programming between communities, and plan for long term sustainability.

**2016 Delta Charter Township** – Update Delta Charter Township wellhead protection plan, and research and compile a list of the historic and current groundwater testing in the Greater Lansing Area which will be added to the existing potential contamination source inventory database.

**2017 ELMWSA** – Develop and present wellhead and groundwater protection information and opportunities to support local efforts to civic and business groups; update EMWSA Wellhead Protection Plan; and training and education for local planners, engineers, and decision makers in the use of the Greater Lansing Area Potential Contaminant Source Inventory.

**2017 Westside Water** – Update Lansing Charter Township and Westside Water wellhead protection plan and develop and present wellhead and groundwater protection information and opportunities to support local efforts to civic and business groups.

**2018 ELMWSA** – Develop and present wellhead and groundwater protection information and opportunities to support local efforts to civic and business groups; update EMWSA Wellhead Protection Plan; training and education for local planners, engineers, and decision makers in the use of the Greater Lansing Area Potential Contaminant Source Inventory; and develop training and presentation materials on importance of groundwater protection for local elected officials.

**2019 Lansing** – Create and develop a best practices program to protect the groundwater with respect to geothermal heating and cooling systems; and create and maintain a Facebook page, posts and/or ads to educate the region on protecting the groundwater

**2020 ELMWSA** – Produce a 2020 Potential Contamination Source Inventory Report for East Lansing and Meridian Township, and to update this inventory locations in the cloud-based Wellhead Protection Viewer.

# GMB Member Wellhead Protection Grants

# Overview of GMB 2023 Initiatives

- Regional Groundwater Quality Data Template
- Updating the Lansing Metropolitan Area Groundwater Management Plan
- Branded Outreach Education Event Kits
- Updates to the Environmental Permits Checklist
- Development of an Outreach and Education Long Range Plan
- Research into Water Conservation Policies and Ordinances





# GMB Resources

# RESOURCE SHARING

- A monthly email that will contain the latest groundwater and water/wastewater industry information on:
  - Webinars, seminars, summits, and more
  - News articles
  - Announcements and press releases
  - Special reports, documents, and tools
- One of the most viewed and used digital communication services through Tri-County RPC



## Special Reports, Documents, and Tools

- Retailer Report Card released with [2021 report cards ranking retailers on toxic chemicals](#). One of the key findings was retailers aiming to be market leaders by making pledges such as eliminating PFAS from their food packaging.
- River Network released their [Equitable Water Infrastructure Toolkit](#) which help individuals identify the facts that affect water affordability, become familiar with water infrastructure funding and financing mechanisms; and understand the role and impact of local, state, and federal entities and community organizations in addressing affordability and sustainability.
- Christie Alwin shared EGLE's final [Chloride and Sulfate Water Quality Values Implementation Plan](#) that was presented at the June GMB meeting.

[WWW.MITCRPC.ORG/MIGROUNDWATER](http://WWW.MITCRPC.ORG/MIGROUNDWATER)

# Groundwater Management Board WEBPAGES

[mitcrpc.org/migroundwater](http://mitcrpc.org/migroundwater)



## How Do You Get Your Water?

### Urban Drinking Water

People live closer together in urban environments, which means they require a unique design to ensure enough resources, like water, can be shared amongst all who live there. In most urban communities, public water utilities and municipalities are created to help clean and supply drinking water to households and businesses throughout a specific area. In the tri-county region, these public utility companies use their wells to pump groundwater through an intense filtration and treatment process that complies with federal regulations. Then, they send the newly filtered water back underground via a pipe network that connects directly to the water pipes in your home or place of business.

The water you receive from your faucet goes through many steps to reach the clean, drinkable quality it has when you turn on the tap. If you have any concerns about the water you're receiving, check out the annual Consumer Confidence Report for your utility or municipality. If you have any further questions, always reach out to them directly. Public water utilities and municipalities work hard to give you clean water and want you to feel as confident about its quality as they do.

[FIND YOUR WATER PROVIDER](#)



## Well & Septic Maintenance

Because drinking wells are a direct link to our groundwater, it's important to keep in mind what materials and objects we bring into close proximity to them. Many common and necessary household chemicals can impact the safety of your well water, and it's especially important to consider the location of your septic system if you have one.

Refer to this helpful well-siting diagram based on the Center for Disease Control and Prevention's recommendations and check out our [resources](#) section for more information!

### Recommended Distance from Well Site



## More Resources for...

[Rural Communities & Private Well Owners](#)

[Caring for Your Septic System](#)

[Urban Communities: Find Your Local Provider](#)

[Public Officials & Community Leaders](#)

[Community Members](#)



### Rural Drinking Water

In less densely populated and more rural areas, most communities take a combination of approaches to supply residents with drinking water. Some towns and villages supply treated drinking water for the majority of their population, while some may still rely on private well water. Because of this split, homeowners might not know where their water actually comes from. A property may have originally gotten its water from a private well but could have transitioned to a public water supply as it changed hands from owner to owner. Over time and throughout the growth of a community, this heightens the risk of groundwater pollution as a result of improper care for forgotten or otherwise unprotected wells.

Even if you are certain your water comes from a public utility company, there is a chance your property could be home to an improperly abandoned well. Wells that are not properly sealed when abandoned pose a high risk of pollution by giving contaminants direct access to groundwater reserves and, in turn, the drinking water you bring into your home. Common household chemicals such as fertilizers, oil, and road salt are among the most likely pollutants to enter groundwater through improperly abandoned wells.

To find out if there are any abandoned wells on your property, check any historical property documents you may own, search your property on Michigan Welllog, or reach out to your local Health and Human Services Department for additional information and assistance.

[LEARN MORE](#)

### WATER QUALITY TESTING



### WELL INSPECTION



### SEPTIC SYSTEM INSPECTION



### SEPTIC SYSTEM PUMPING



# Thank you for your time



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@MIGroundwater



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**EMAIL US**

[migroundwater@mitrcpc.org](mailto:migroundwater@mitrcpc.org)

**Lauren Schnoebelen**

Environmental Sustainability Planner

Tri-County Regional Planning Commission

# Alleghan County Groundwater Work Group

Meeting

January 11, 2023

Alleghan Groundwater Study – Phase 2:  
Screening-level Modeling, Risk Analysis, and Ranking

A “Progress Report”

By Zachary Curtis, Hydrosimulatics INC

# Outline

- Reminder: Project Tasks / Objectives
- Summary of Project Status and Achievements
- Overview of Screening-Level Modeling
  - 24 Regional Groundwater Models
  - Overall Process for Single Model
  - Examples w/ Particle Tracking and Impact Zones
- Aquifer Vulnerability Map
  - Methodology and Input Layers
  - Countywide Map
- Next Steps:
  - Risk and Analysis and Ranking
  - Prioritization System

1 Identify Potential Impact Areas of Sites of Environmental Concern		
Task	Description	Deliverable
1.1	Download and process latest Static Water Level data from Wellogic	--
1.2	Delineate local flow patterns for all Sites of Environmental Concern using the data-driven approach (spatial interpolation of water levels): -- EGLE Sites of Environmental Concern (250) --PFAS sites (3) -- Landfills and Waste Handlers (40)	Flow pattern maps (2D)
1.3	Delineate local flow patterns for all Sites of Environmental Concern using the process-based approach	
1.4	Screening level calibration: comparison of process-based model with water levels (interpolated map and/or a graphical comparison of simulated and observed water levels)	
1.5	Perform forward particle tracking from source areas to delineate impact areas -- 2 year time-of-travel envelopes -- 10 year time-of-travel envelopes --20 year time-of-travel envelopes	Impact area maps with locations of critical groundwater receptors
1.6	Automate conversion of impact areas into GIS-shapefile, allowing for coping with hundreds of data layers and aggregating them into one (	Impact area GIS files

2	<b>Delineate Source Water Areas for Important Receptors</b>	
2.1	Delineate local flow patterns for all identified Type 1 wells requiring WHPA delineation (64) using the data-driven approach (spatial interpolation of water levels)	Flow pattern maps (2D)
2.2	Delineate local flow patterns for all identified Type 1 wells requiring WHPA delineation	
2.3	Screening level calibration: comparison of process based model with water levels (interpolated map and/or a graphical comparison of simulated and observed water levels)	
2.4	Perform backward particle tracking to delineate WHPAs for Type 1 Wells identified in Task 2.1	WHPAs / Source water areas
2.5	Automate conversion of impact areas into GIS-shapefile, allowing for coping with hundreds of data layers and aggregating them into one (	WHPA GIS files

3 Map Aquifer Vulnerability / Sensitivity to Surface Pollution		
3.1	Compile, process and prepare soil spatial layers to combine with Depth to Water Table, Net Recharge, Topography, and Hydraulic Conductivity layers from Phase 1	--
3.2	Assign Rating and Weighting for each Layers	--
3.3	Program and apply DRASTIC method integration	--
3.4	Iterate (Refine Weighting and Rating) to a final or "best estimate" map of aquifer vulnerability	Countywide aquifer sensitivity map
3.5	Create GIS Data layers with attributes	GIS Data Layer

<b>4 Develop and Apply Risk Ranking System with Allegan County</b>		
4.1	Develop integrated overlays of impact zone maps, WHPA maps, wells/receptors, sites of concerns, and vulnerability maps	Integrated overlays (maps)
4.2	Integrated qualitative assessment	
4.3	Present ranking methods to task force and seek feedback	
4.4	Finalize ranking methodology	Write-up of criteria
4.5	Apply final ranking methodology to develop final Ranking List for complete portfolio of sites of environmental concern	Tables and maps
4.6	Create GIS shapefile of sites of different priority-levels	GIS Shapefiles
<b>5 Documentation</b>		
5.1	Prepare of a Final Technical Report, including all maps and final Rankings	Final Report
5.2	Presentation to Allegan County Board of Commissioners	--

# Project Status and Achievements

Screening Level Modeling and Aquifer Vulnerability Mapping

# Project Status and Achievements

- Task 1 – Identify Potential Impact Areas of Sites of Environmental Concern
  - Underlying Groundwater models / SWL maps generated for all sites -> Complete ✓
  - Particle Tracking and Impact Area Delineation for all sites -> Essentially complete ✓
- Task 2 – Delineate Source Water Areas for Type 1 Community Wells
  - Underlying Groundwater models / SWL maps generated for all sites -> Complete ✓
  - Particle Tracking and Source Water Area Delineation for all sites -> Almost complete ✓
- Task 3 - Map Aquifer Vulnerability / Sensitivity to Surface Pollution
  - Input Layers and Ranking Maps prepared ✓
  - Countywide Map prepared ✓

# Project Status and Achievements (cont'd)

- Task 1 and Task 2 Deliverables:
  - SWL Maps (site “clusters”)
  - Maps of Particle Tracking, Impact Zones / Source Areas
  - GIS files of impact areas and source areas (well watersheds)
- HSA will finish documentation of Tasks 1, 2, and 3 in ≈2 weeks ...and make deliverables available to the County
- These deliverables, *combined* with other perspectives determined by the Work Group, will be used to develop a Risk Analysis and Ranking System (more on this later)
- The Risk Analysis and Ranking System will be applied to create a Site Prioritization List (focus of February 2023)
- All final results and description of methods will be provided in Final Report (mid- or late-February?)

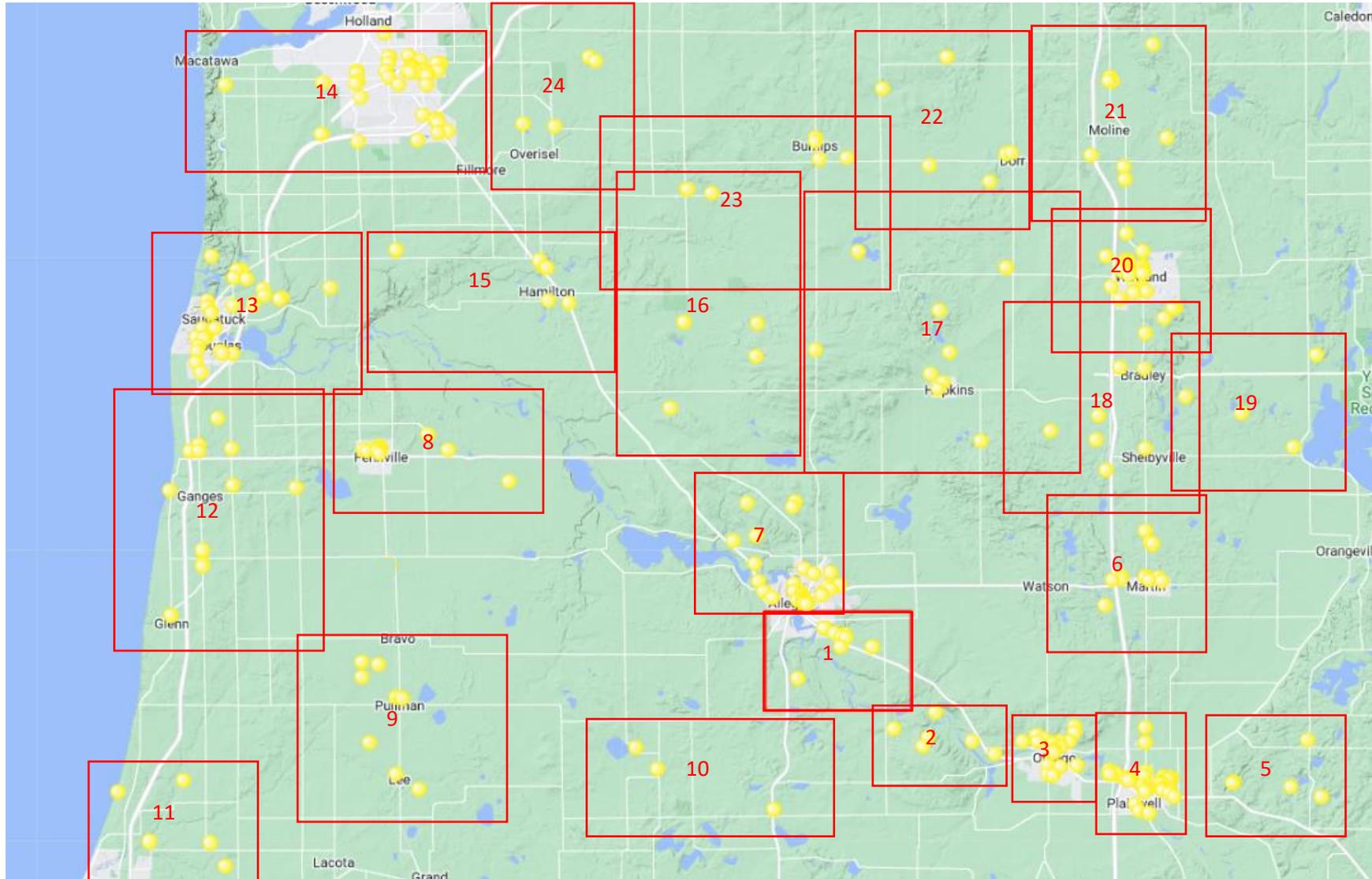
# Overview of Screening-Level Modeling

Groundwater Modeling, Particle Tracking, and Impact Area / Source Area Delineation

# Steps for Screening Level Modeling

1. Download, process the latest Wellogic Static Water Level (SWL) data
  - Model Calibration and Interpolation
2. Download, process the latest Sites of Env. Concern, Type 1 Wells
3. Groundwater Model Development (Site “Cluster”)
  - Review geology and lithology (aquifer material distribution)
  - SWL interpolation
    - Drift wells
    - Drift wells + Surface Water “points”
    - Resampling and smoothing filters
  - Process-based simulation
    - Inputs: Topography, bedrock, conductivity, recharge
    - Calibration to Wellogic SWLs
  - Comparison and evaluations (statistics, visual inspection)
4. Track Particles along water level surface
  - Forward tracking: release from sites of env. concern
  - Backward tracking: release around Type 1 wells
5. Delineate impact area / source area “envelope” for 2yr, 10yr, 20yr time-of-travel
6. Save impact area / source area as GIS shapefile

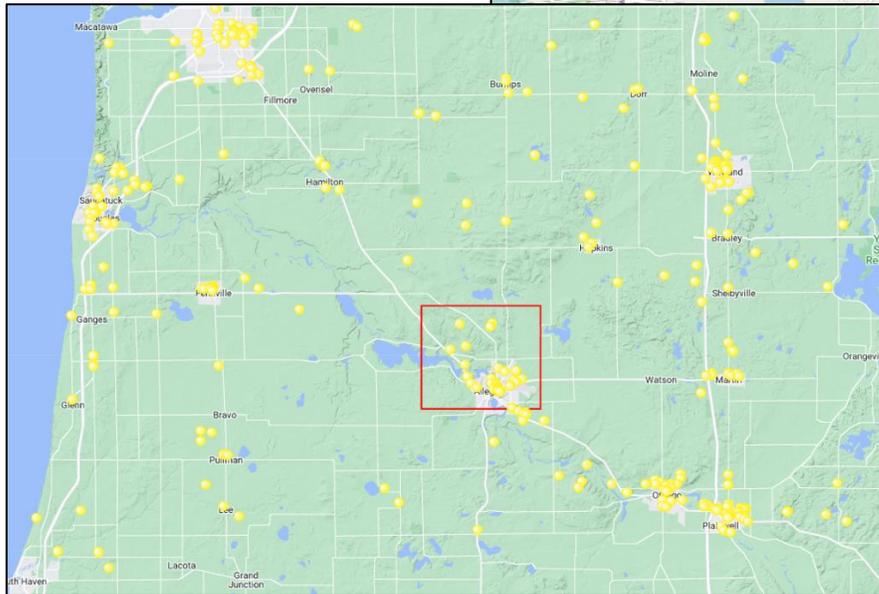
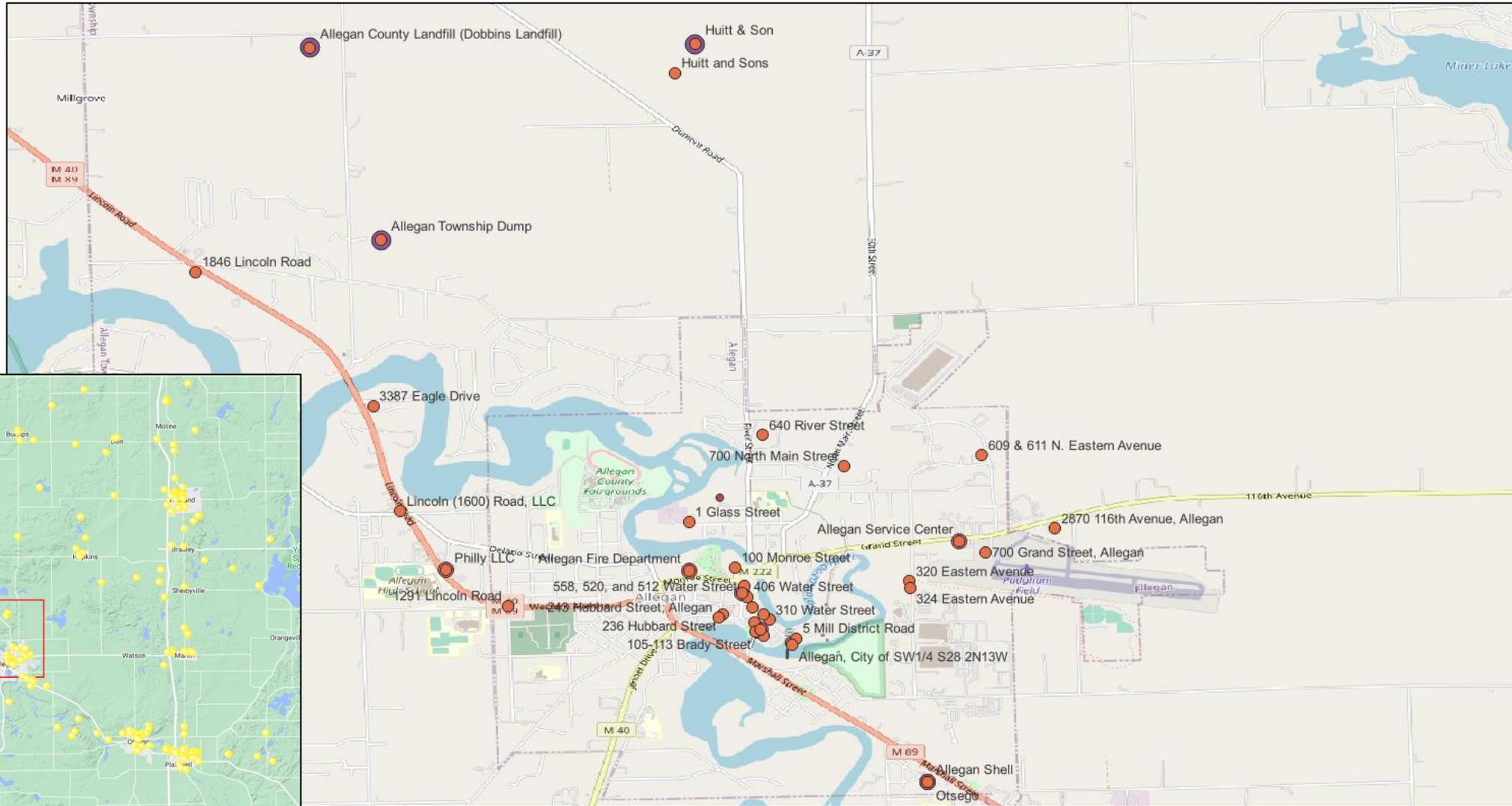
## 24 Regional Models around Site "Clusters"



# Examples of Groundwater Model Development

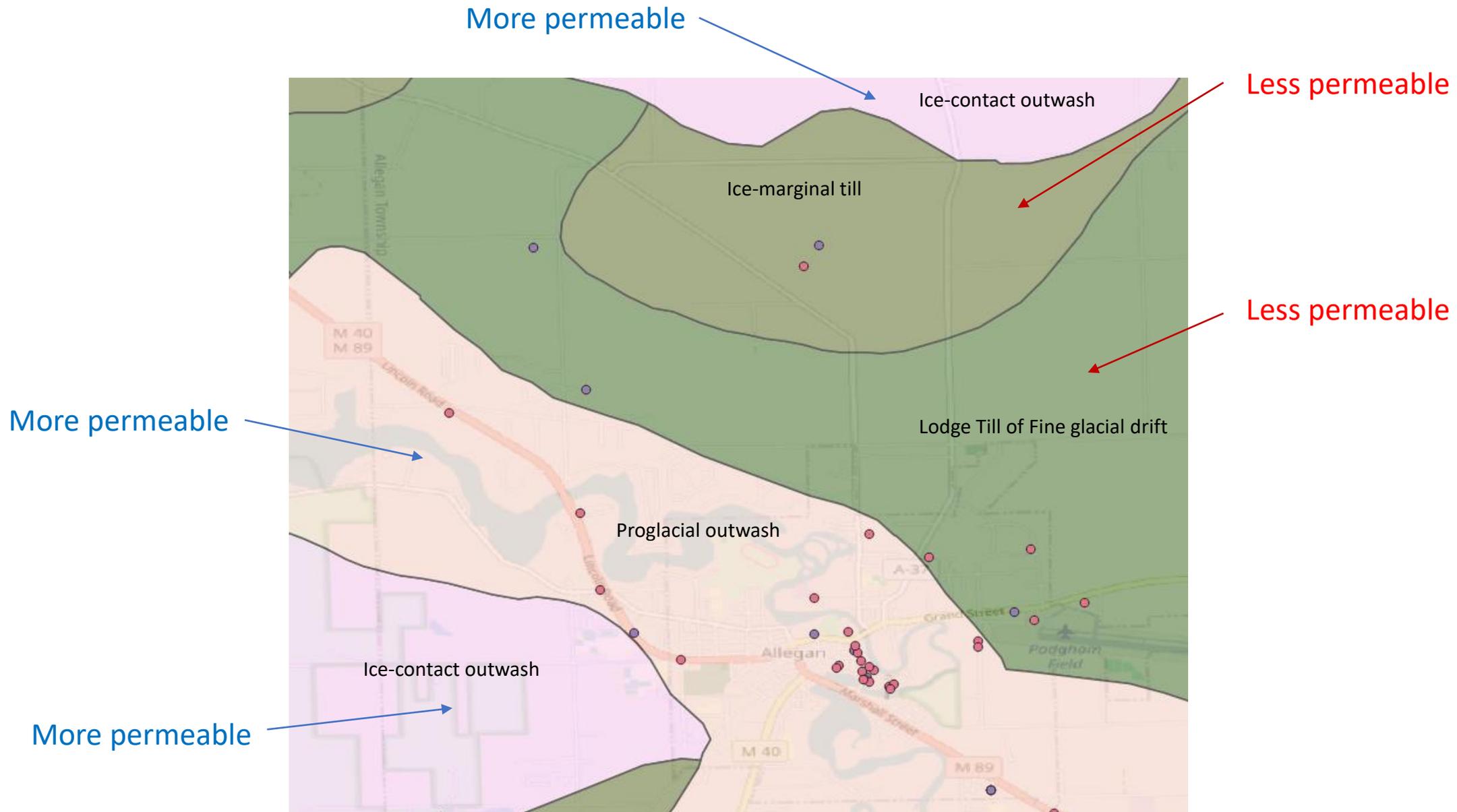
## CLUSTER 7

City of Allegan  
and area north  
of Allegan



# Visualize Geology

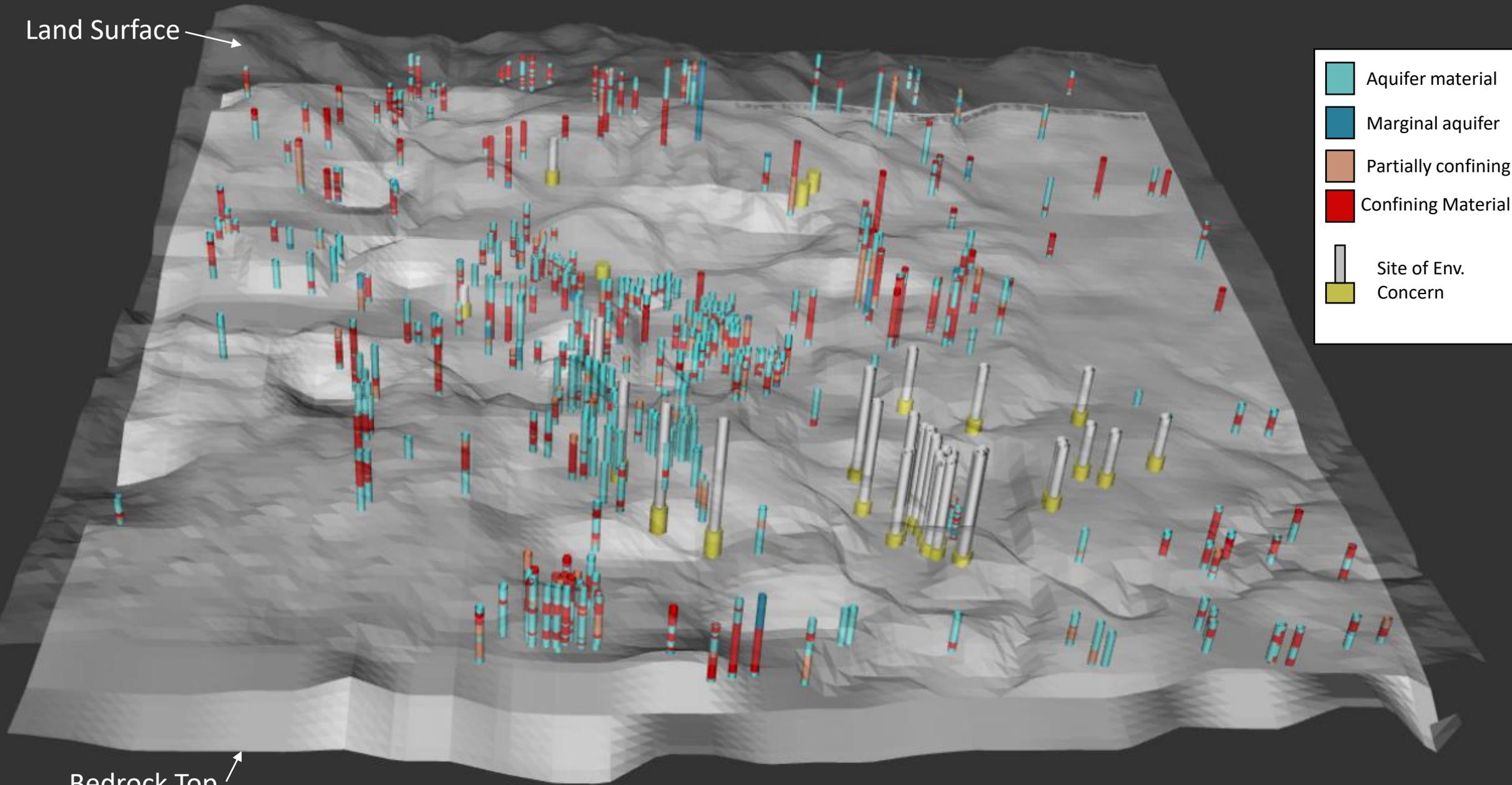
- Examine glacial land systems map (GWIM Project, State of Michigan)



# Visualize Lithology

- Examine categorized boreholes (see Phase 1)

Land Surface →



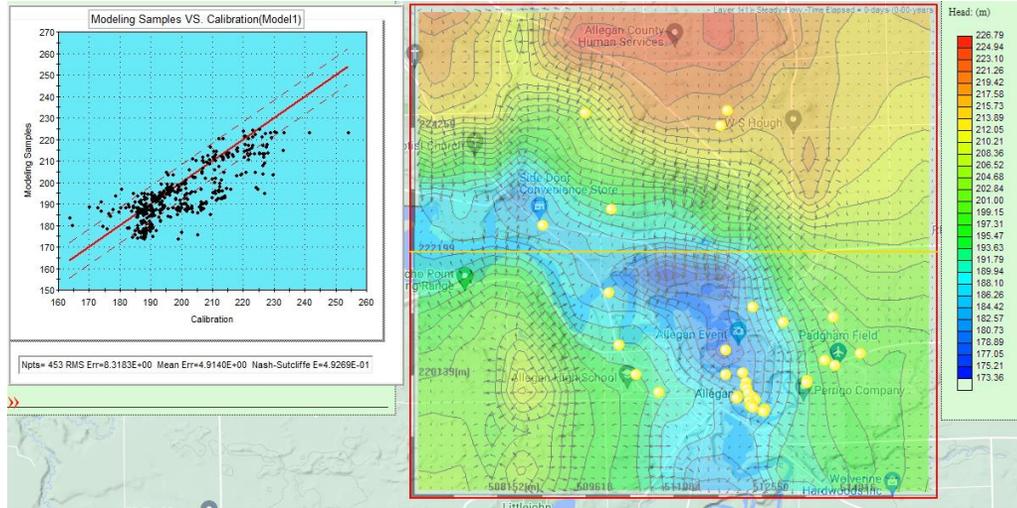
Bedrock Top ↗

-  Aquifer material
-  Marginal aquifer
-  Partially confining
-  Confining Material
-  Site of Env. Concern
-  Concern

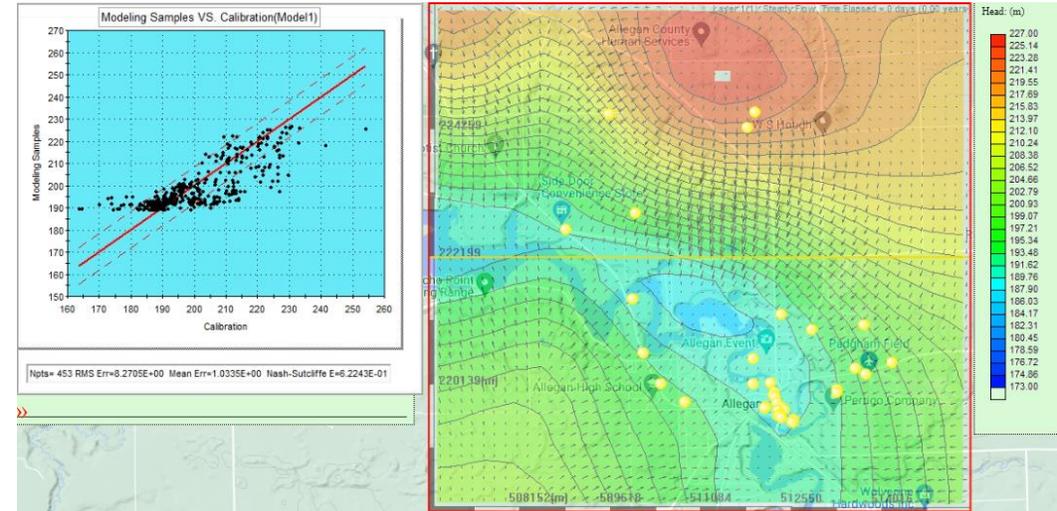
# Static INTERPOLATION

- Use direct data to visualize large-scale flow patterns
  - Experiment with mathematical modeling / data subsets
  - “Noisy” SWL data may produce “goofy” local features
- => use Process-based model for impact area analysis (in most cases)

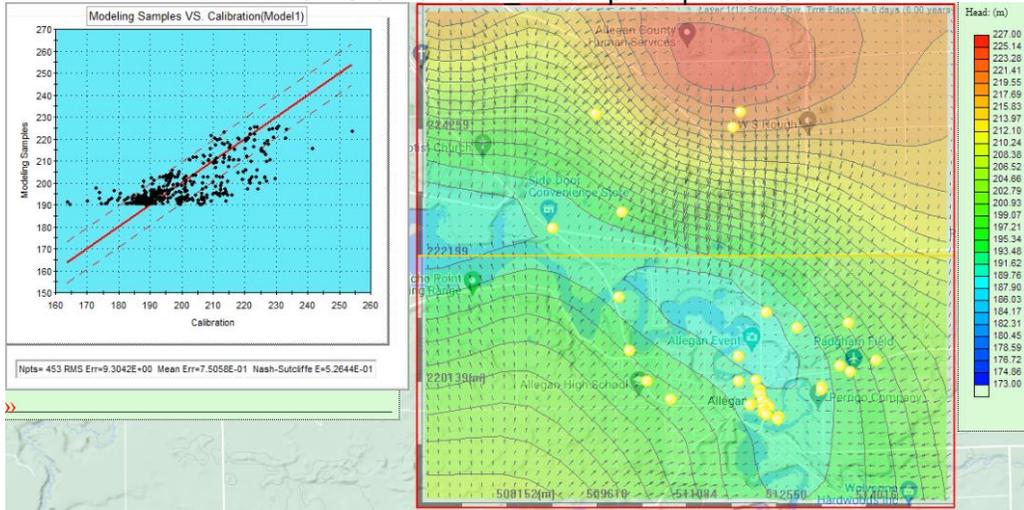
Drift Wells | Pass 00



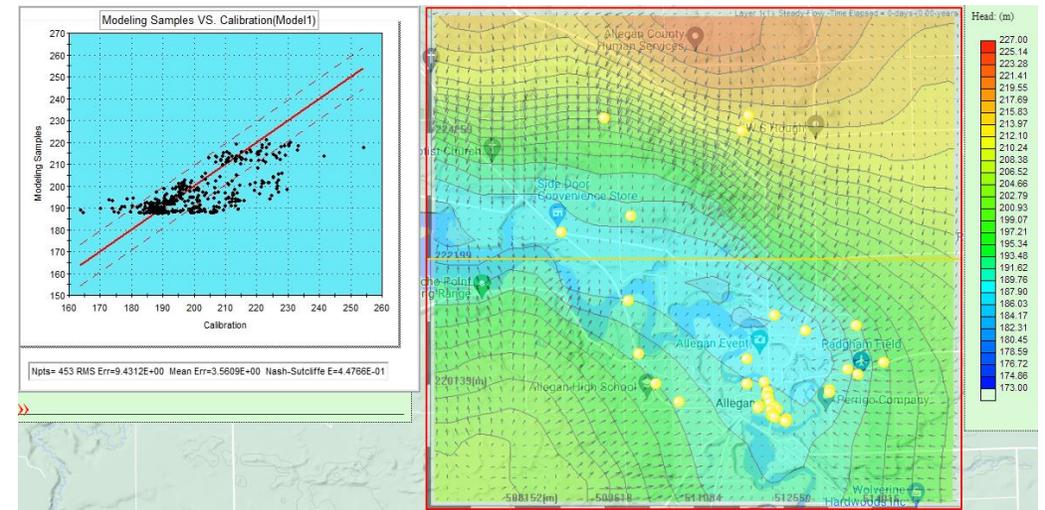
Drift Wells + all SW | Pass 10



Drift Wells + all SW resample 6 | Pass 10

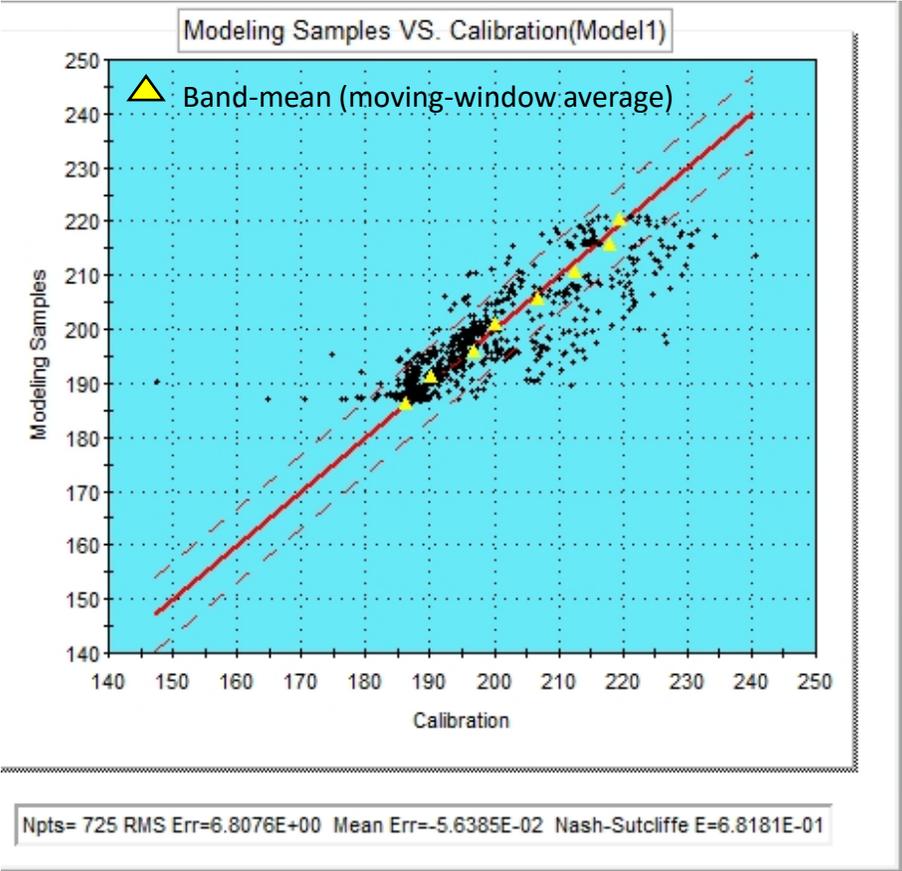


Drift Wells + Big SW\_ OutlierRMV\_resample 6 | Pass 00

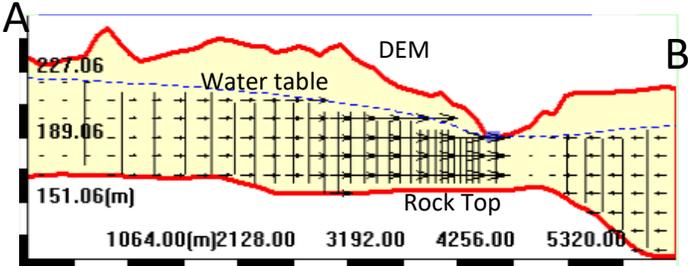
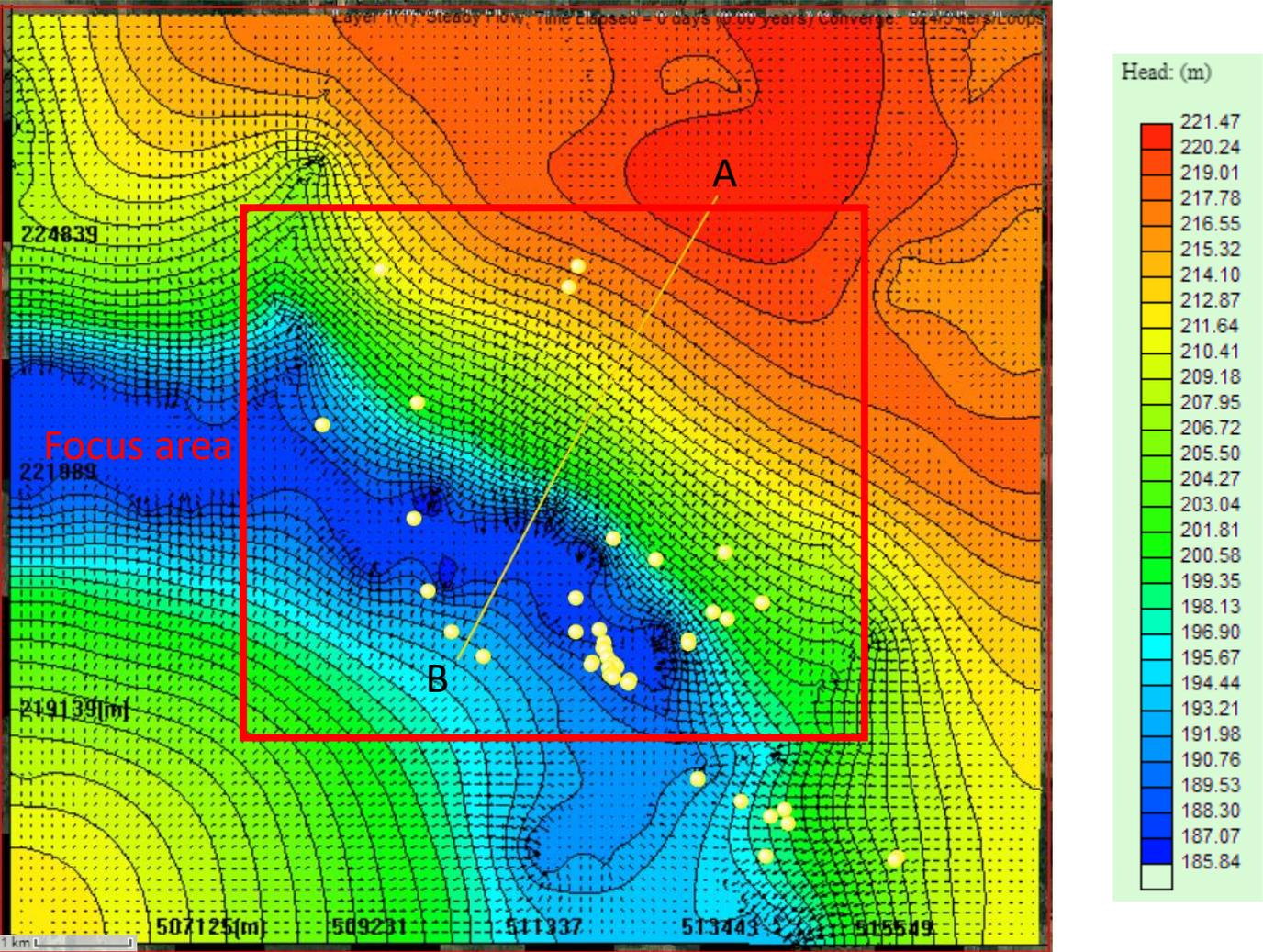


# Process-based Model

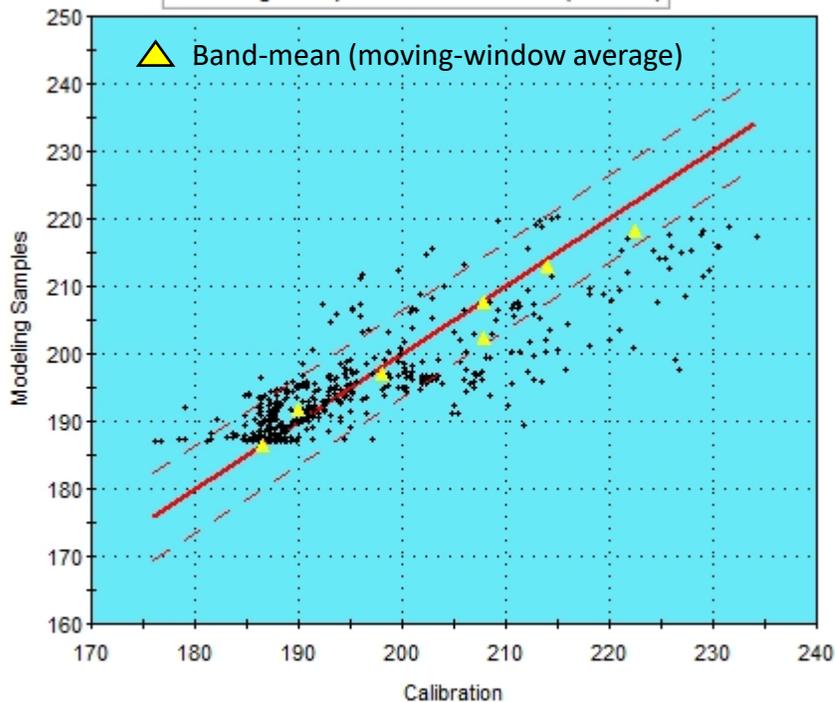
- Spatial framework data as input (DEM and seepage areas, rock top, hydraulic conductivity, recharge)
- Regional model for “boundary conditions”; child model for impact area analysis
- Calibrate to SWL data from Wellogic (and patterns from data-driven analysis)



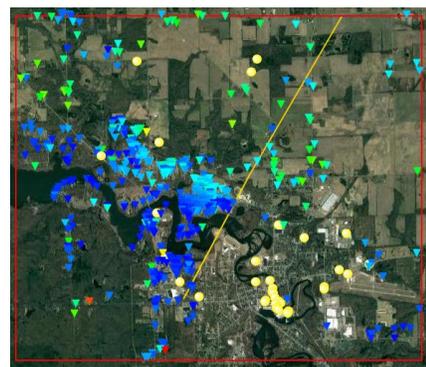
## Parent Model



Modeling Samples VS. Calibration(Model1)

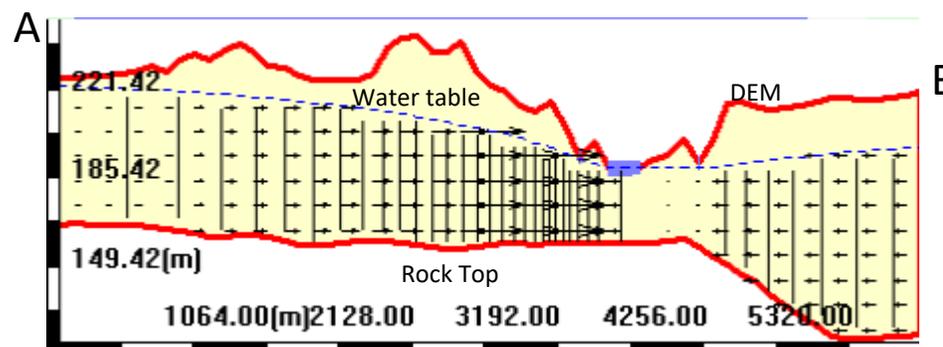
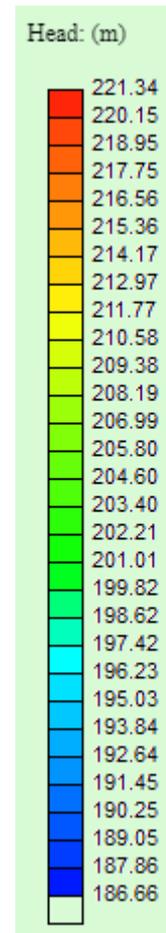
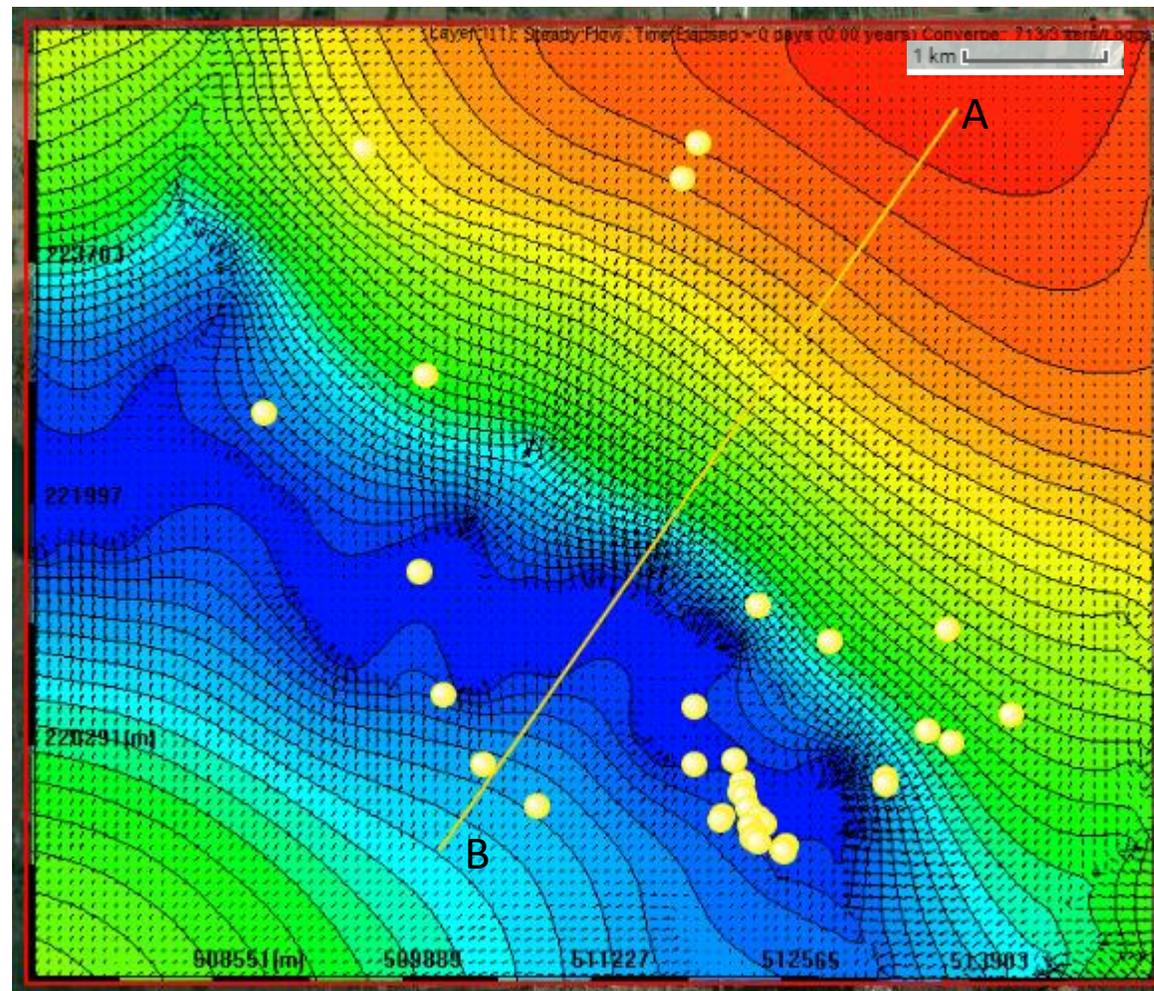


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Child Model

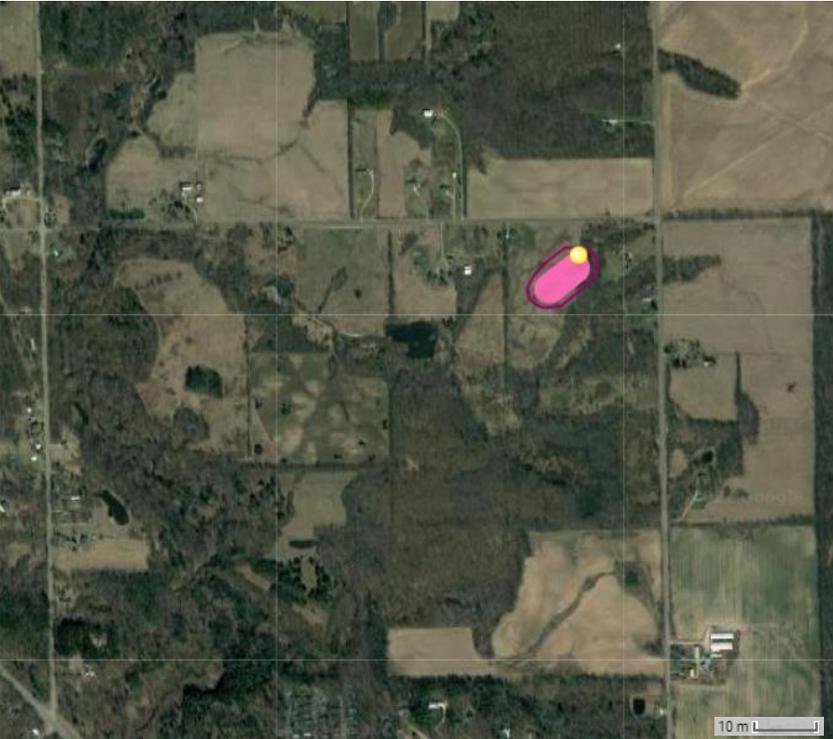
For particle tracking (impact area) analysis



Particle Tracking  
(impact area)  
Analysis

Example

City of Allegan



2 years

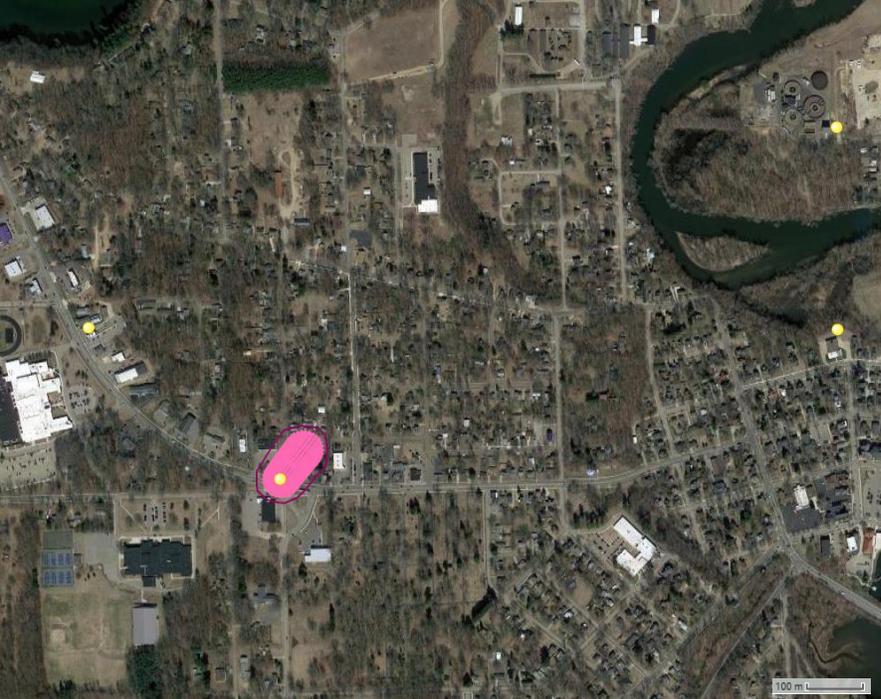


10 years



20 years

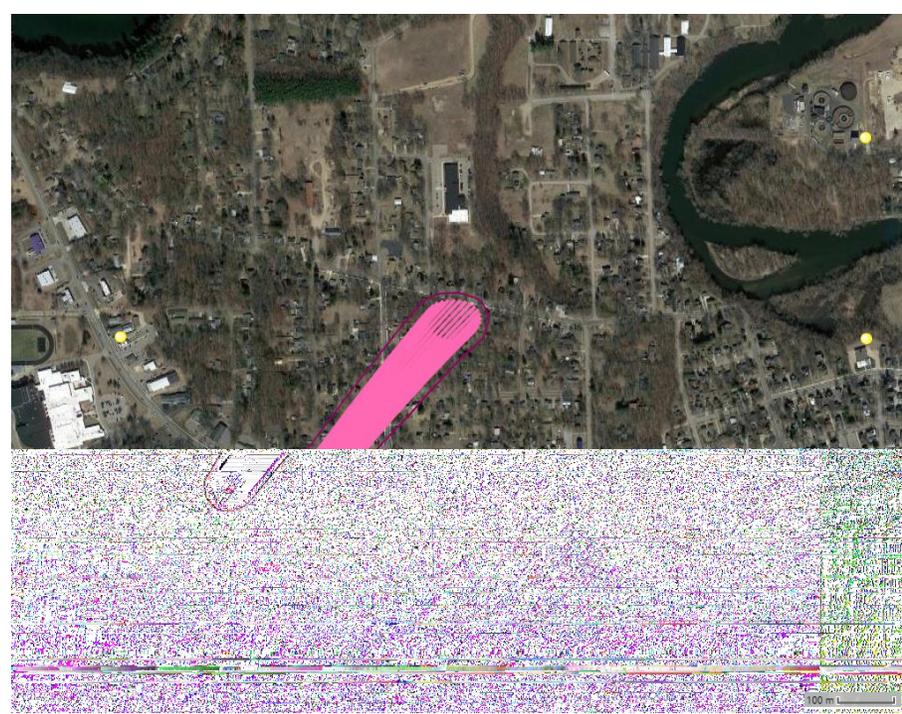
Site 94,  
Allegan County Landfill  
(Dobbins Landfill)



Particle Tracking  
(impact area)  
Analysis

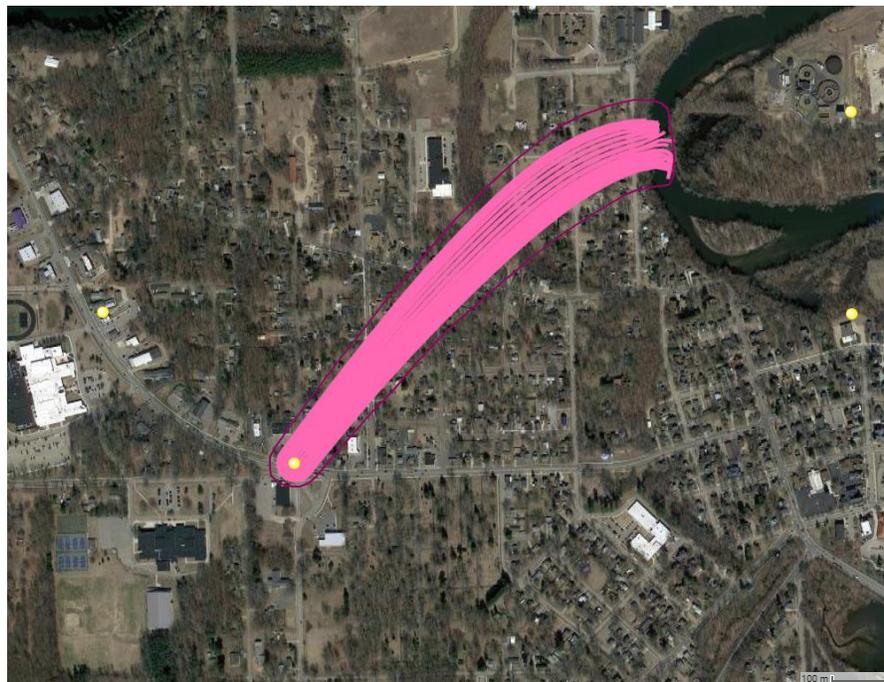
Example

City of Allegan



2 years

03000292,  
1291 Lincoln Road



10 years

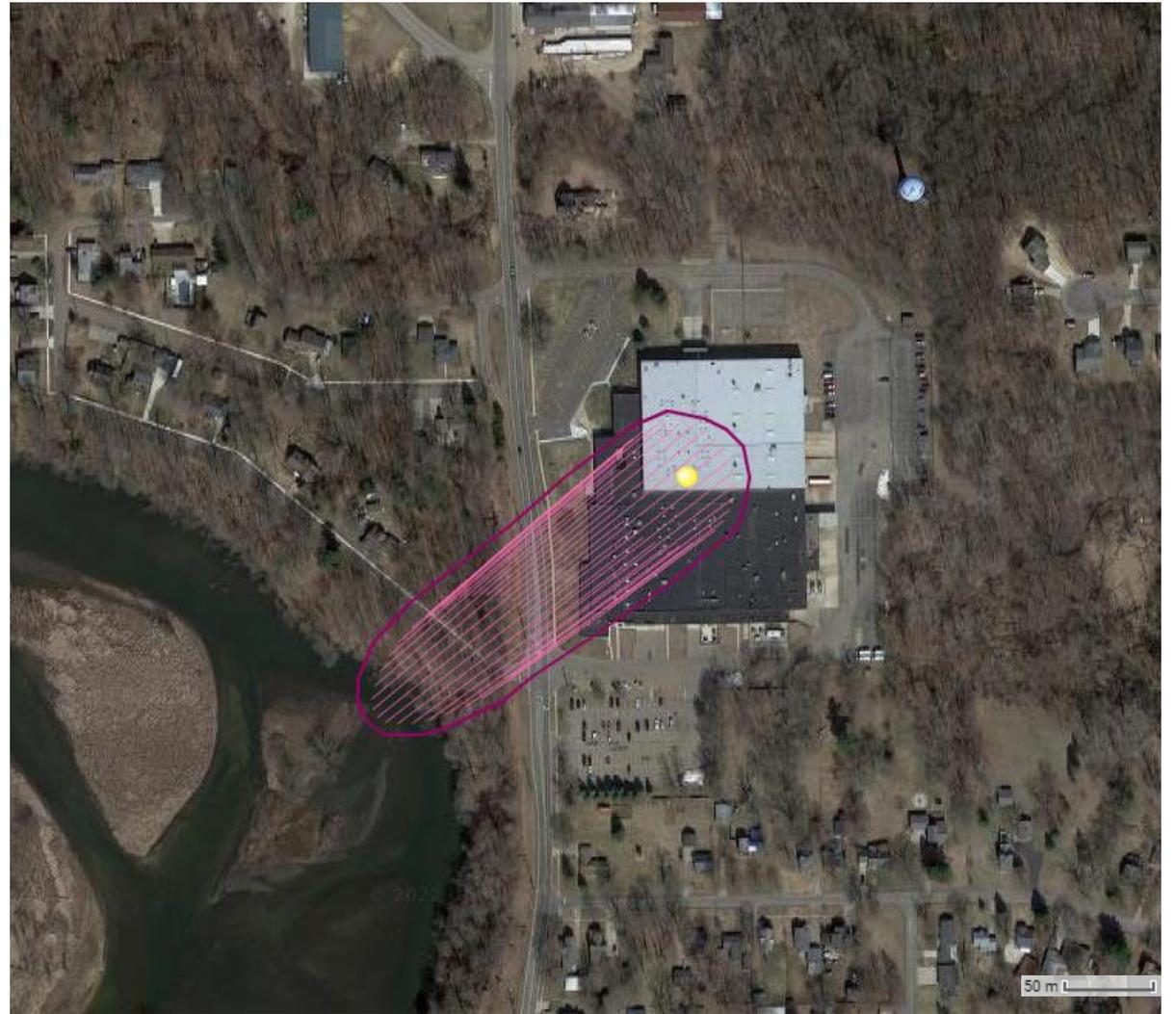
20years

Particle Tracking  
(impact area)  
Analysis

Example

City of Allegan

Almost “immediate” discharge to Kalamazoo River

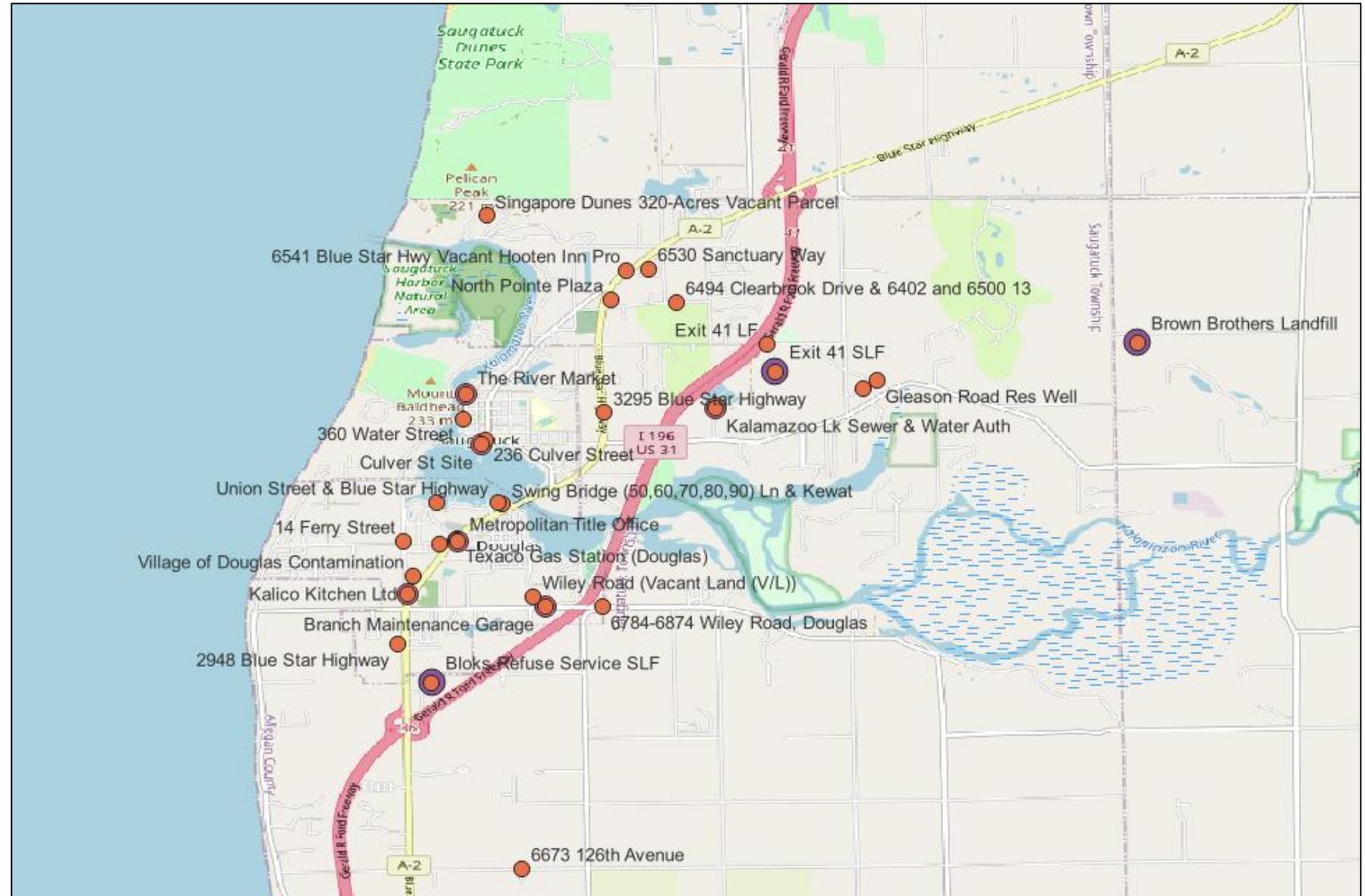
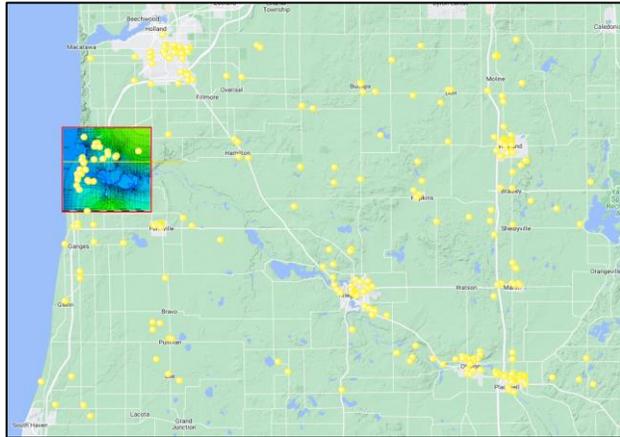


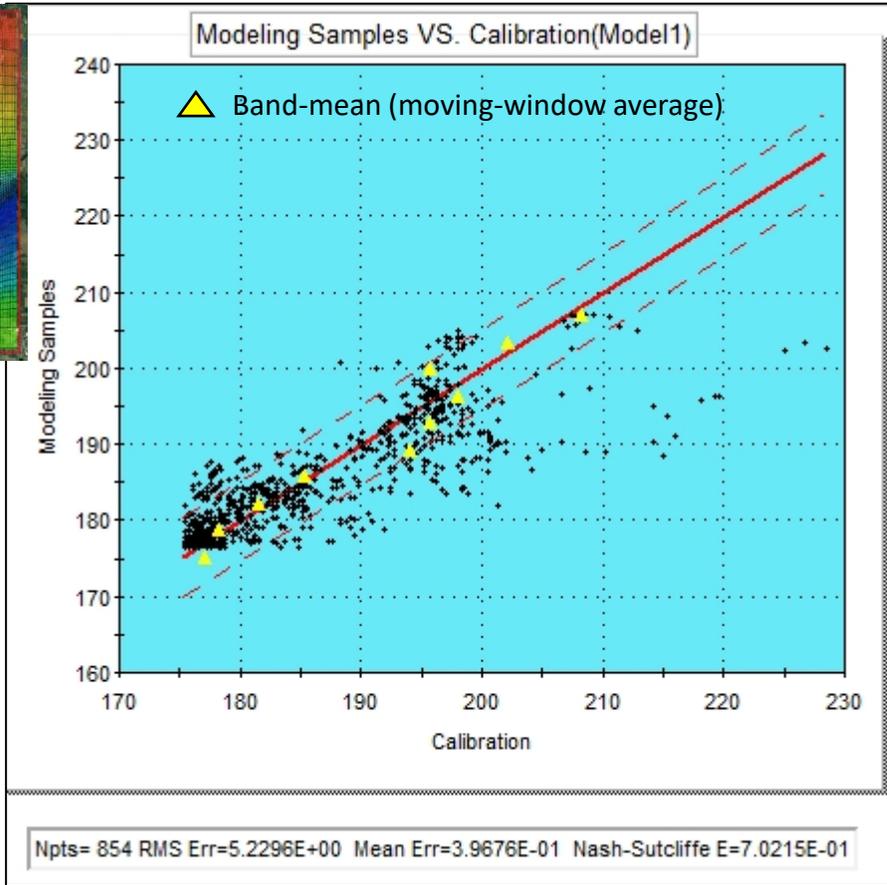
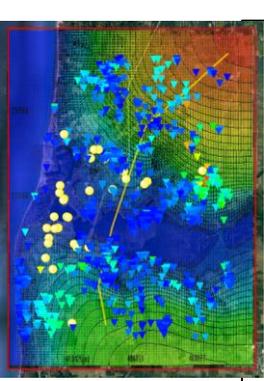
1 year

03000348,  
640 River Street

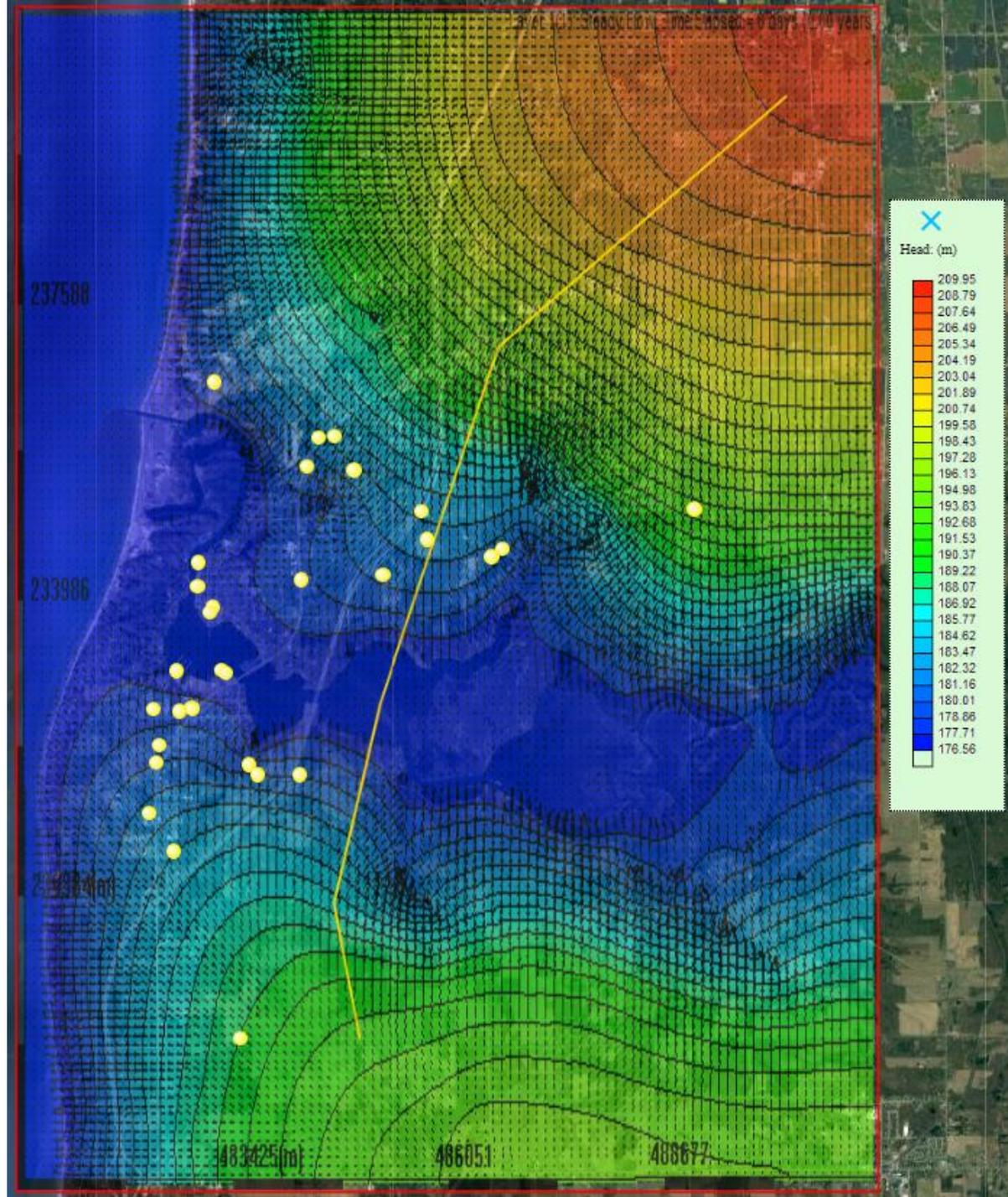
# CLUSTER 12

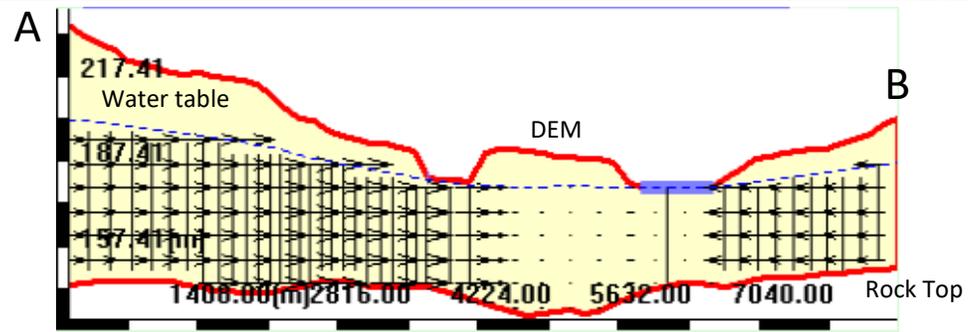
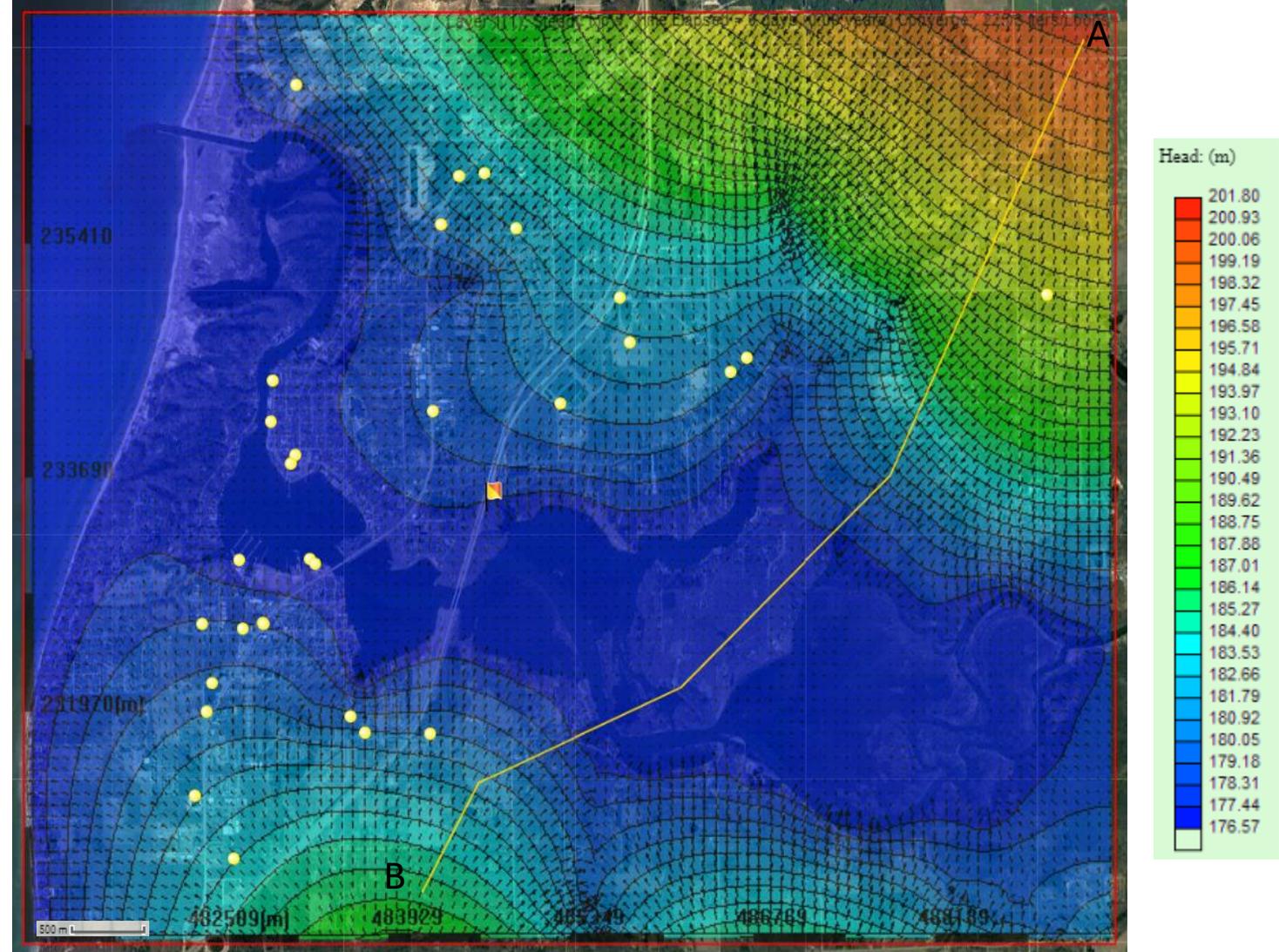
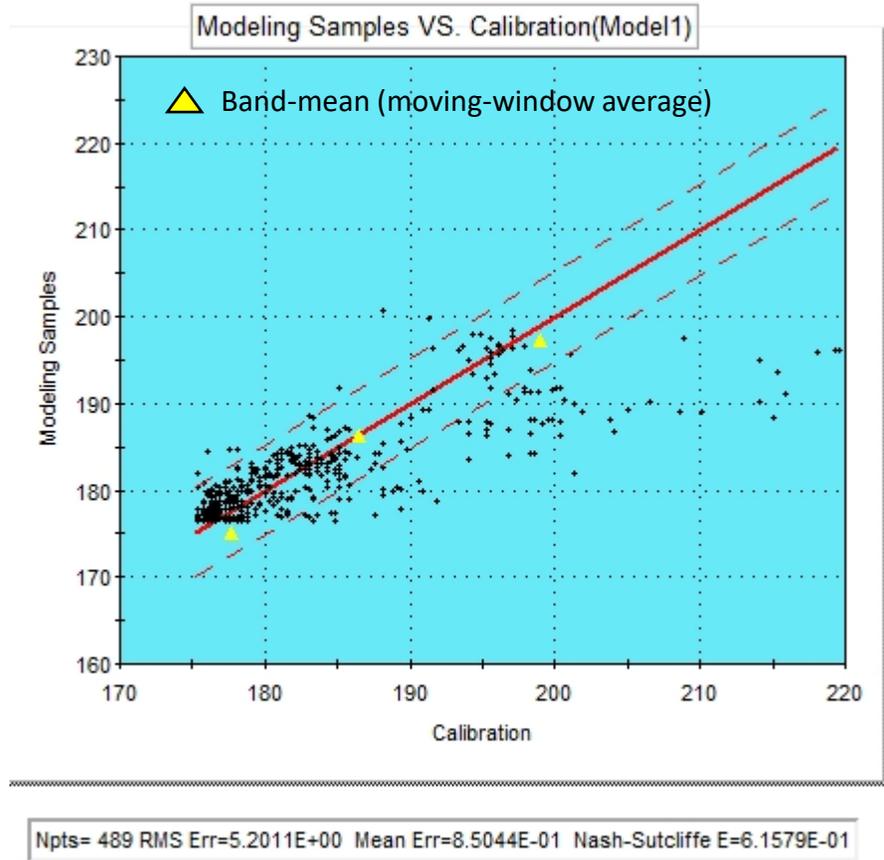
Saugatuck area





Parent Model







2 years

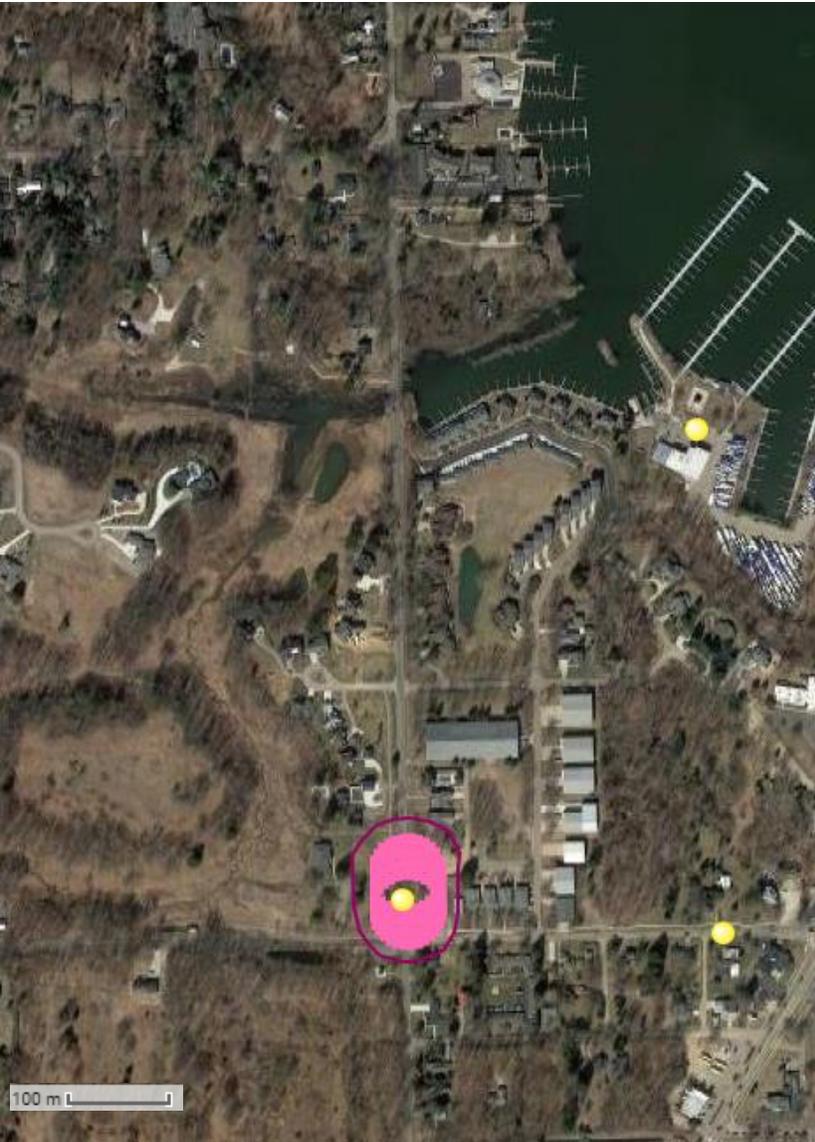


10 years

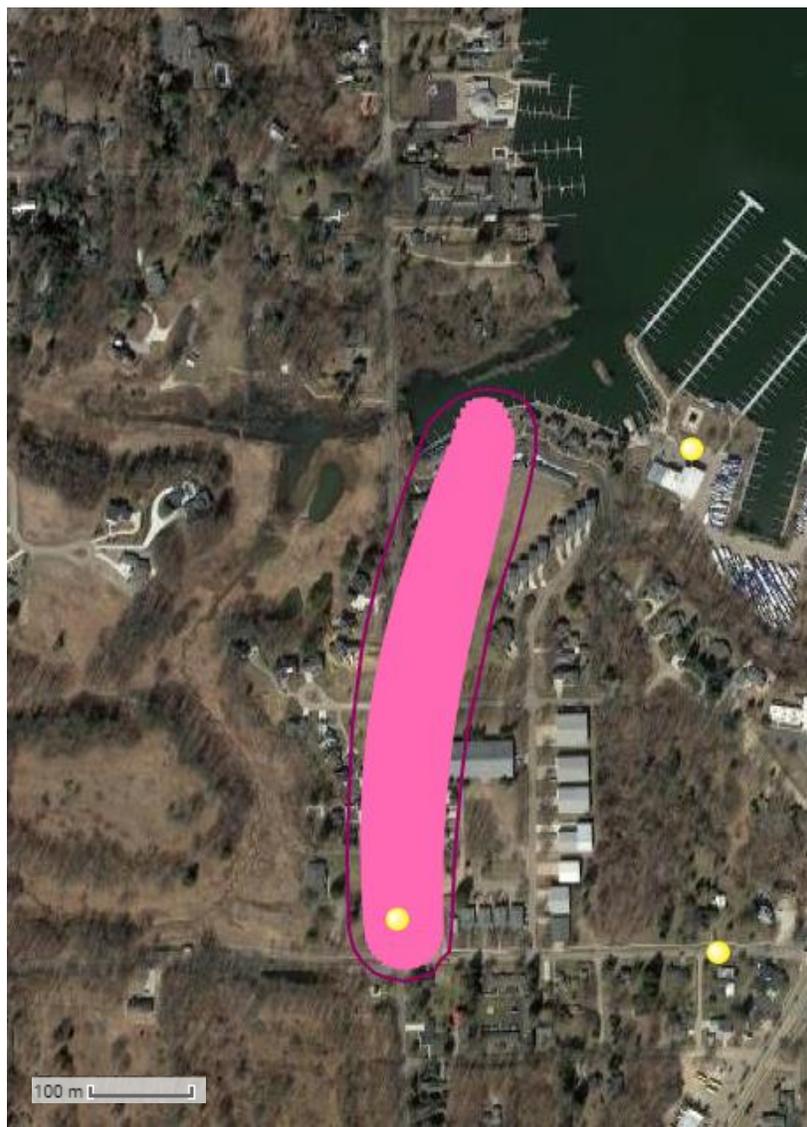


20 years

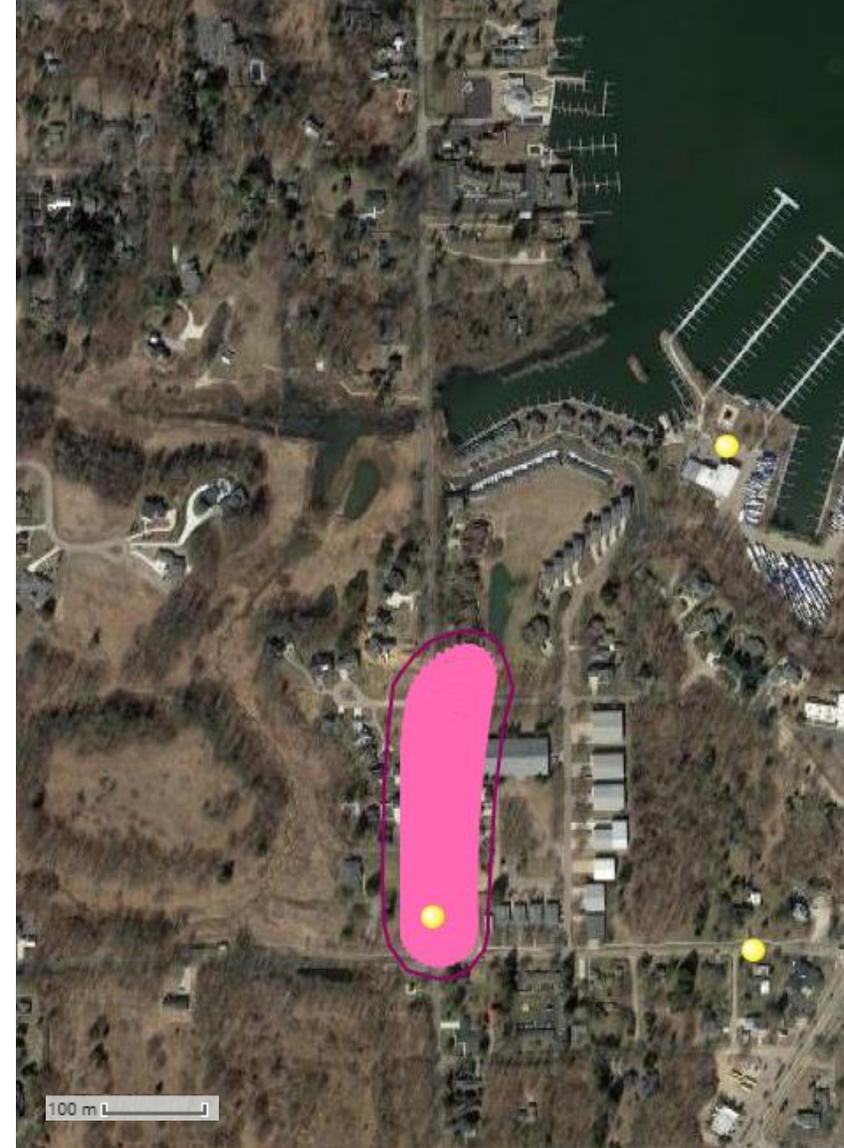
**03000351,  
6541 Blue Star Hwy Vacant  
Hooten Inn Property**



2 years



17 years



10 years

03000298,  
14 Ferry Street

Likely discharge of any potential contamination to Kalamazoo River after relatively short period (4yr)

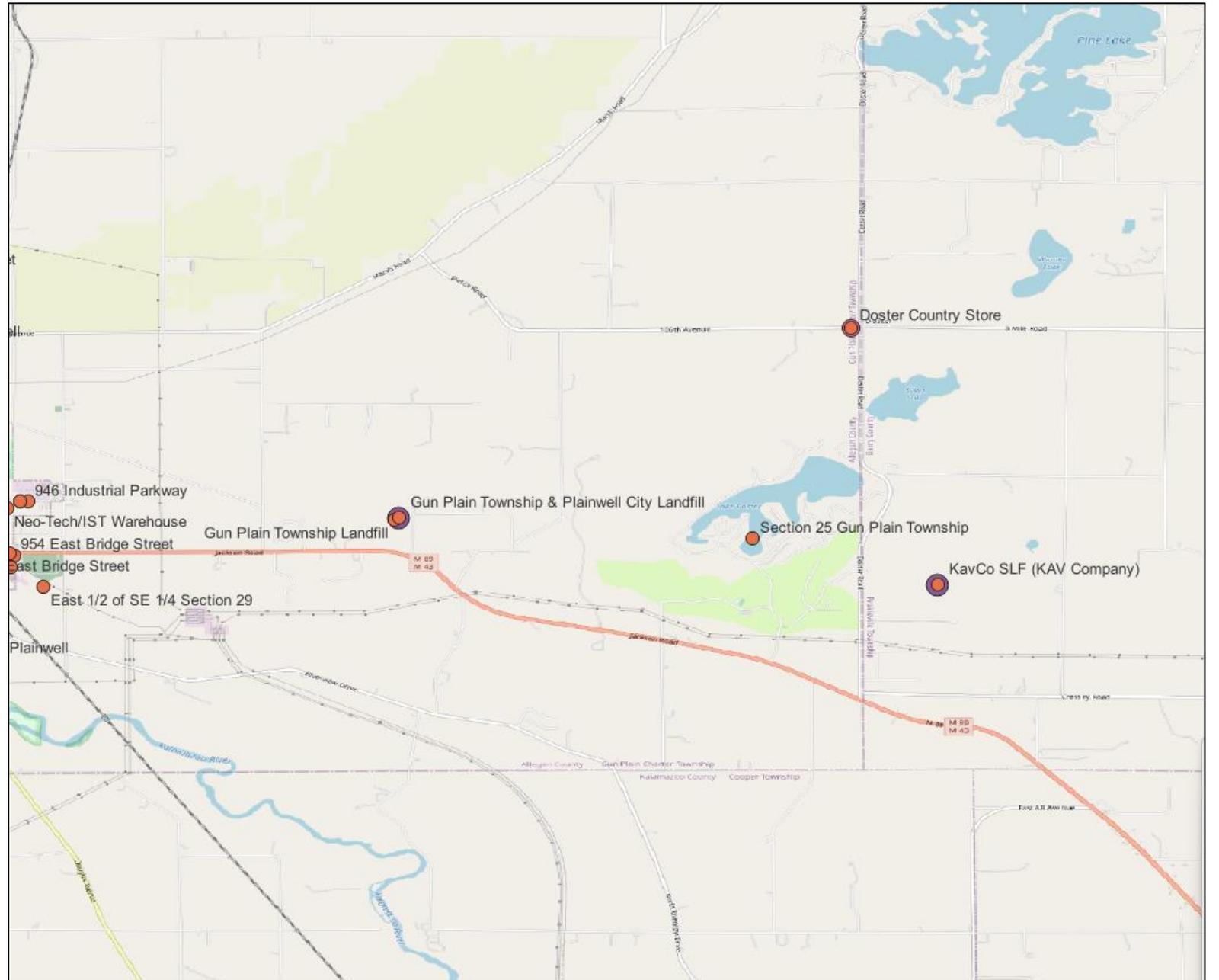
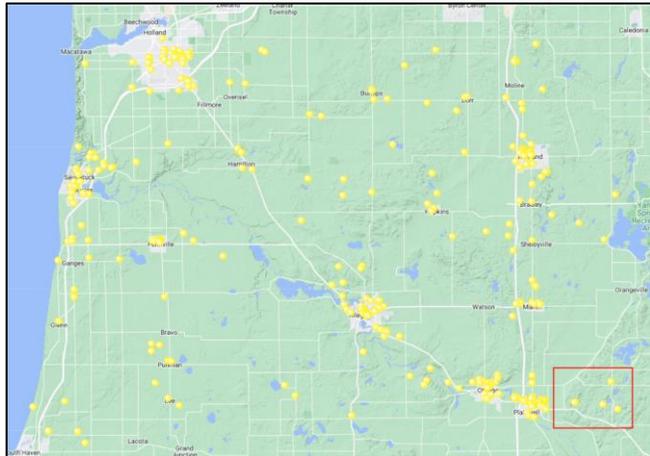
**03000396,  
Wiley Road (Vacant Land (V/L))**



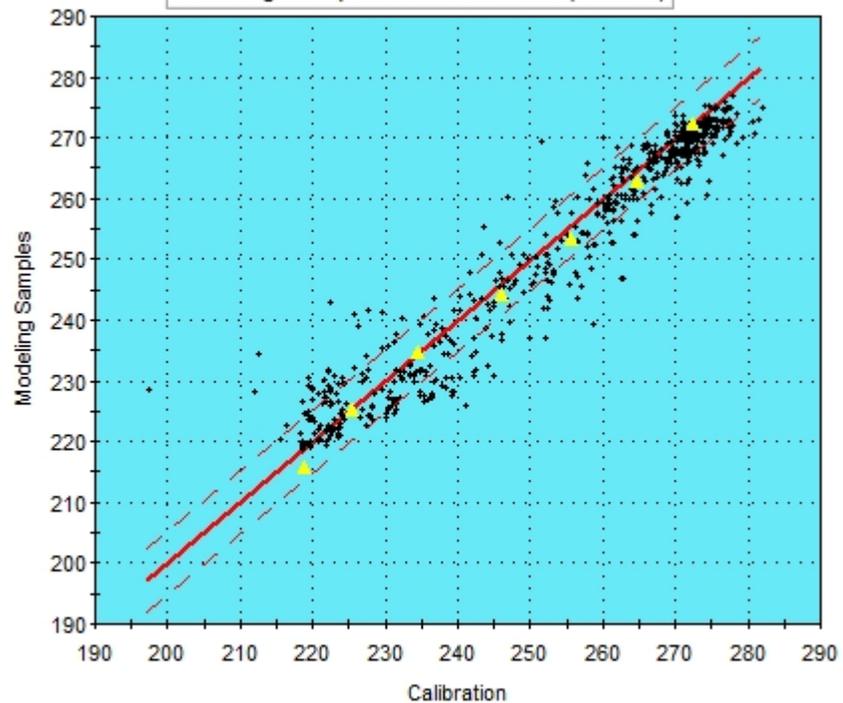
4 years

# CLUSTER 5

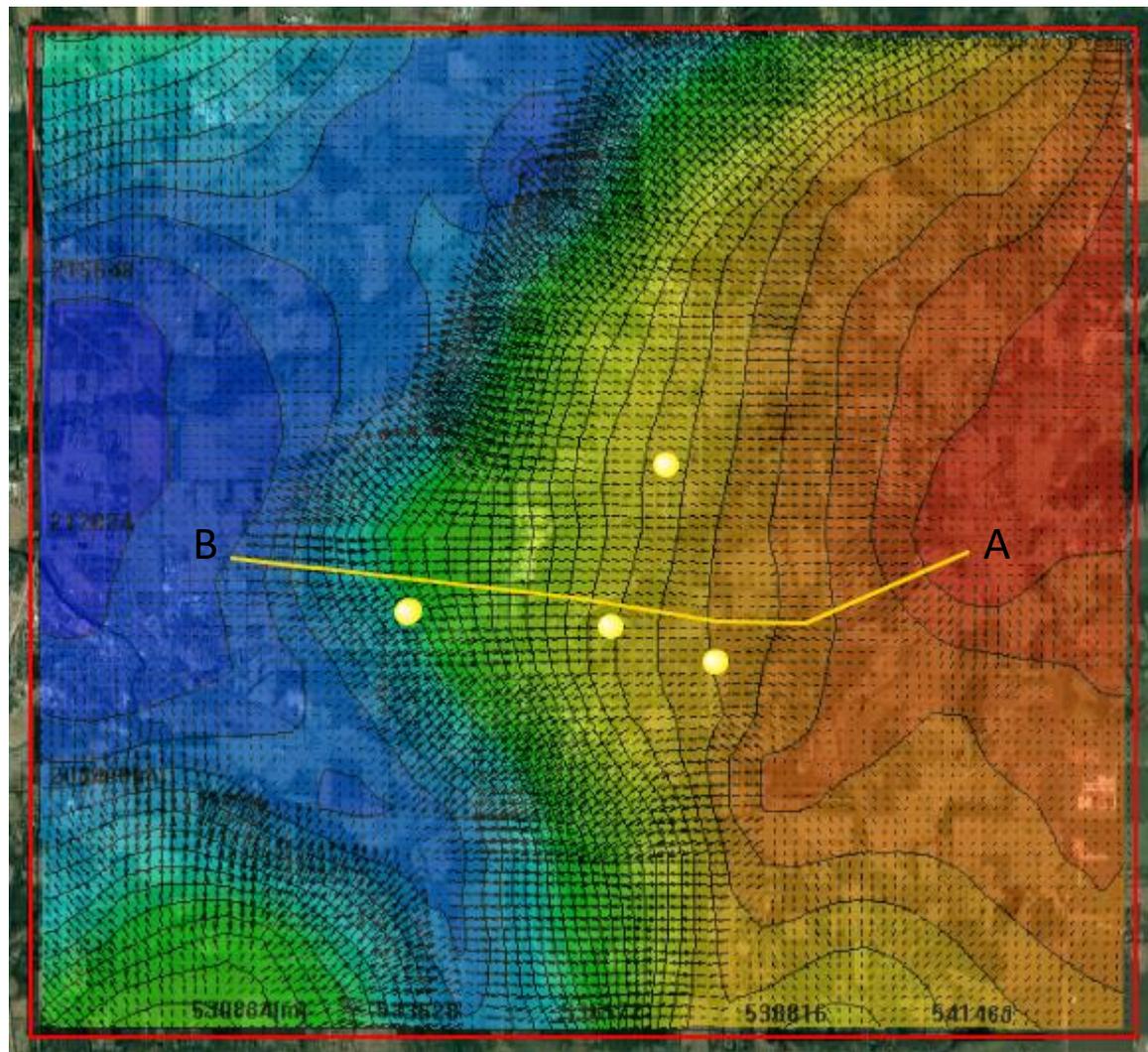
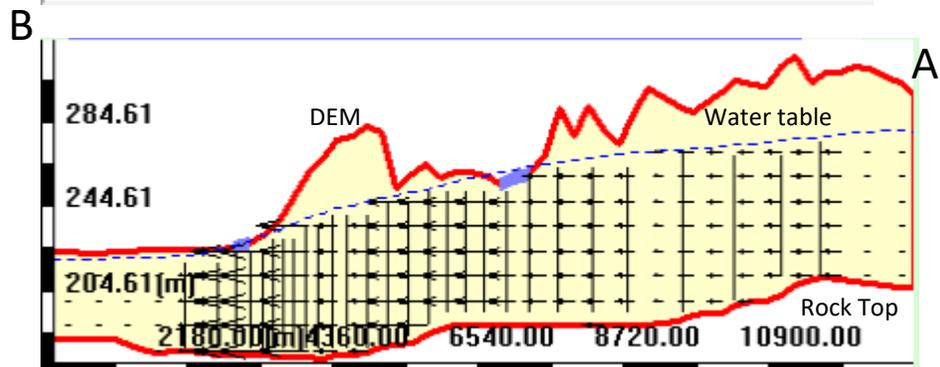
East of Plainwell



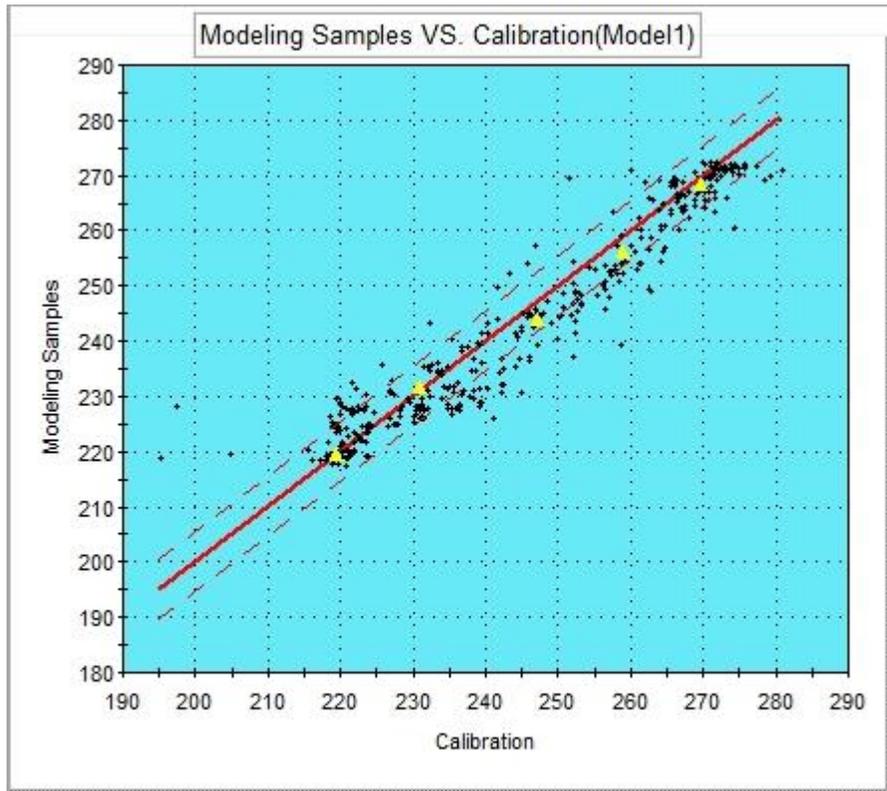
Modeling Samples VS. Calibration(Model1)



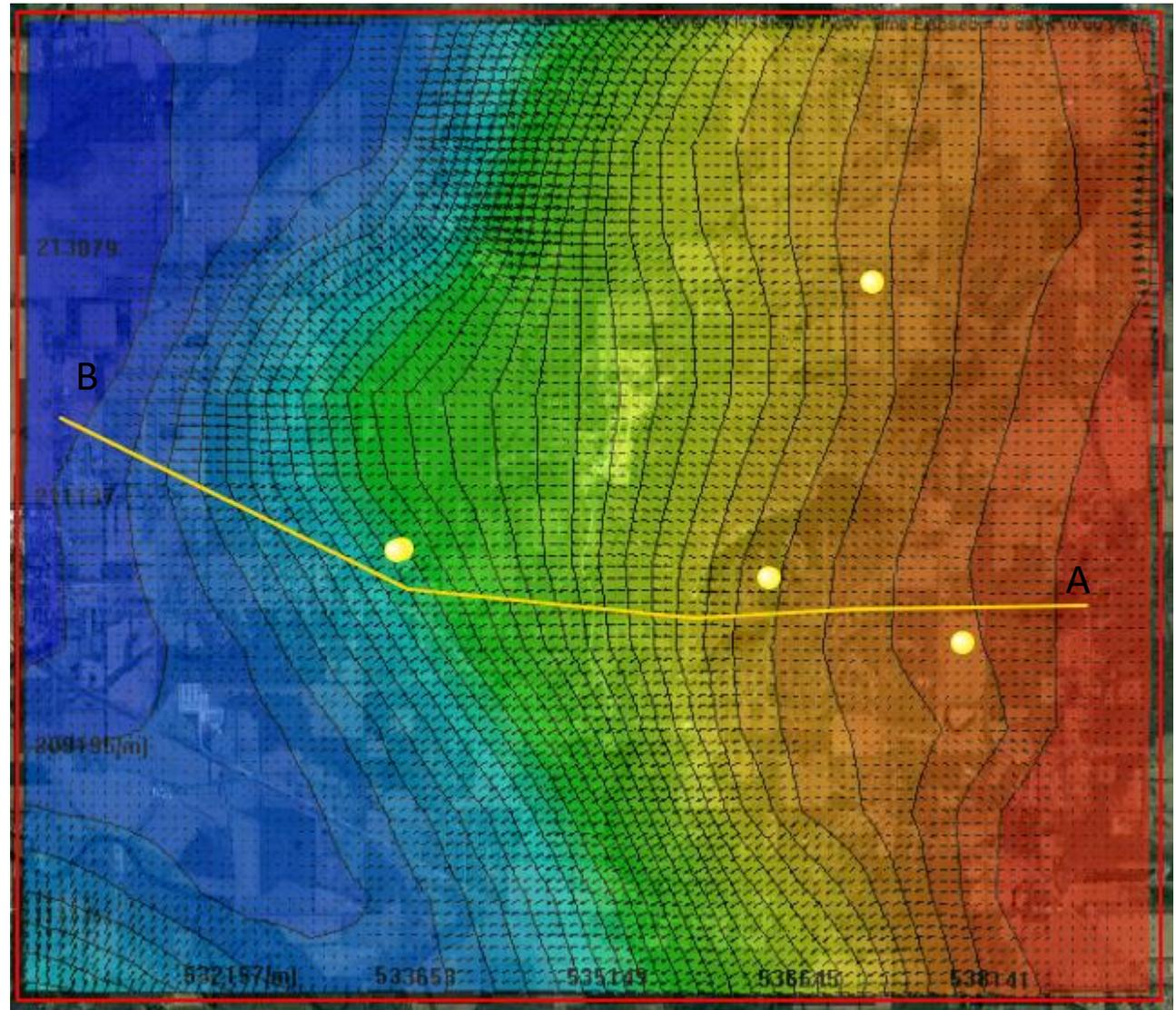
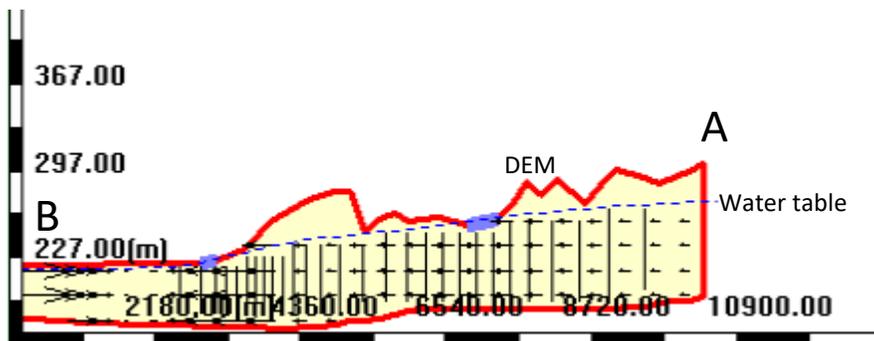
Npts= 616 RMS Err=5.0977E+00 Mean Err=1.0611E+00 Nash-Sutcliffe E=9.3041E-01



Parent Model



Npts= 381 RMS Err=5.4172E+00 Mean Err=7.7650E-01 Nash-Sutcliffe E=9.2475E-01



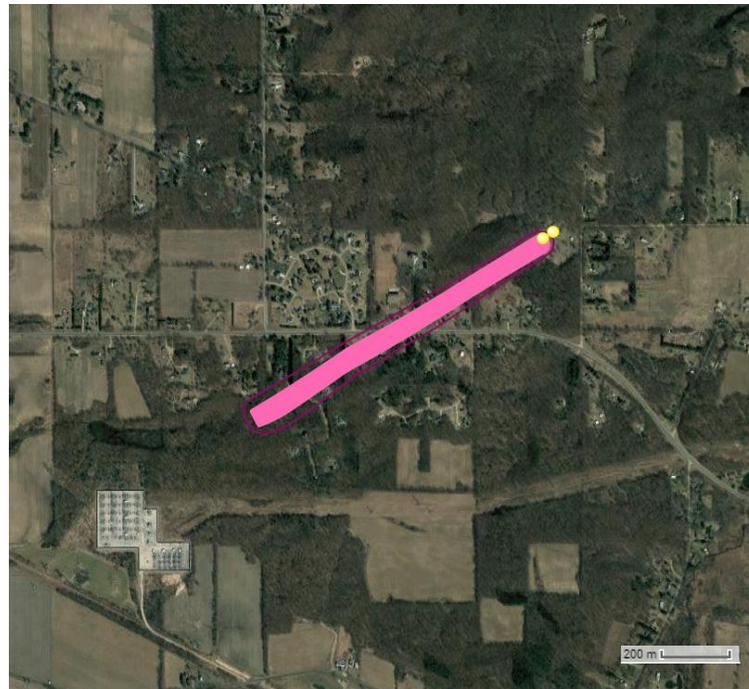
Child Model  
(SWL Interpolation)



2 years



10 years



20 years

03000057,  
Gun Plain Township Landfill

(Also valid for: Site 90, Gun Plain  
Township & Plainwell City Landfill  
...same property; markers almost  
directly on top of each other)



2 years



10 years

Site 178 (Landfill),  
KavCo SLF (KAV Company)

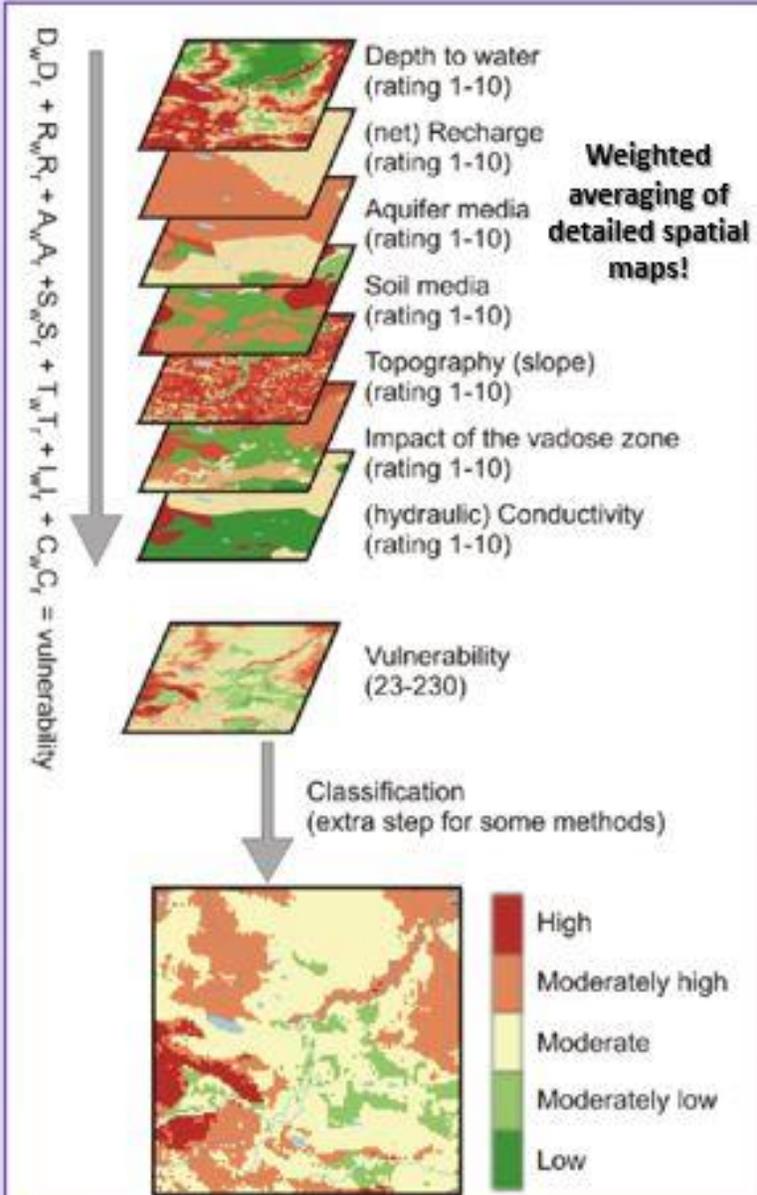


20 years

# Countywide Aquifer Vulnerability Map

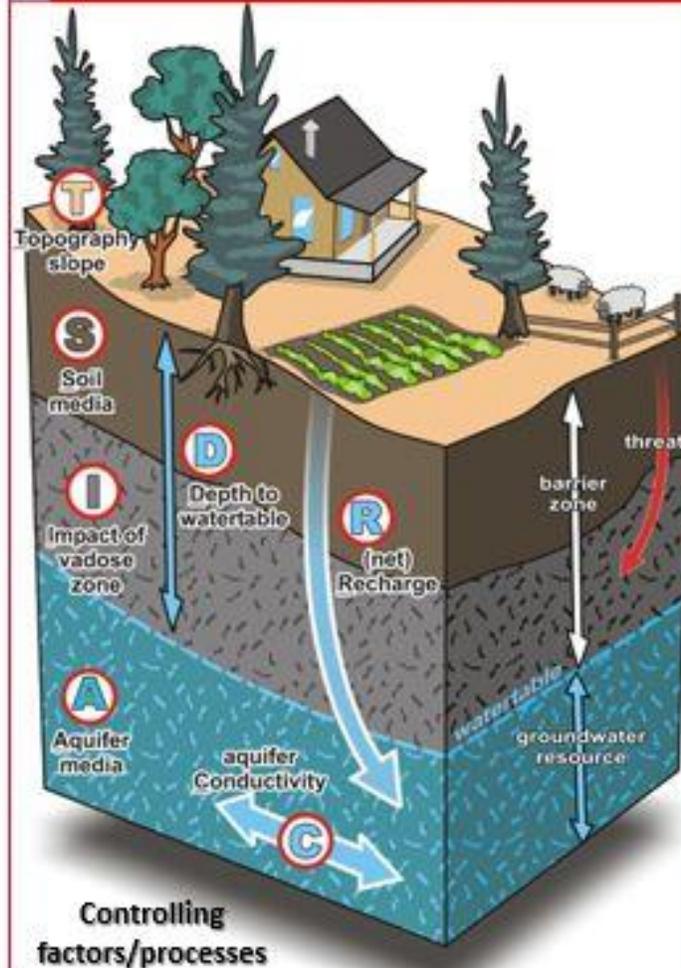
Groundwater Sensitivity to Surface Pollution

# Aquifer Vulnerability Mapping and Assessment



# DRASTIC

What Makes an Aquifer Vulnerable to Contamination?



## Calculation of DRASTIC Index

Layer	Weight
Depth to water (m)	5
Recharge (mm/y)	4
Aquifer media	3
Soil media	2
Topography (%)	1
Impact of vadose zone	5
Hydraulic conductivity	3

$$DI = D_w D_R + R_w \cdot R_R + A_w \cdot A_R + S_w \cdot S_R + T_w \cdot T_R + I_w \cdot I_R + C_w \cdot C_R$$

where  $DI$  = DRASTIC index

$D$  = depth of water table

$R$  = net recharge

$A$  = aquifer

$S$  = soil

$T$  = topography

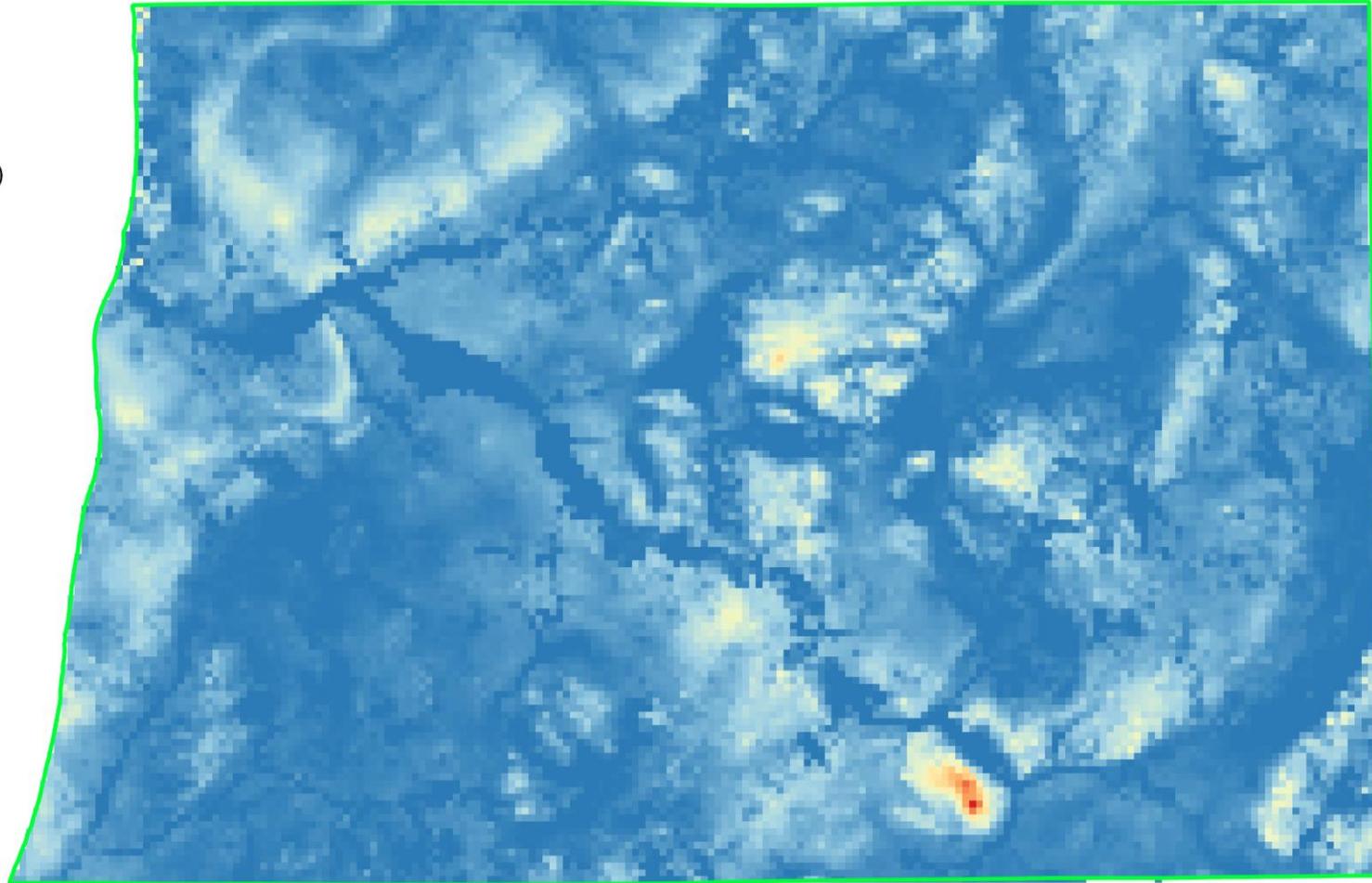
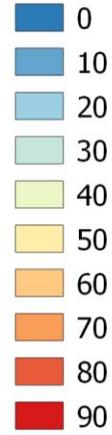
$I$  = impact of vadose zone

## Depth to Water

### Legend

 County Border

Depth To Water (m)

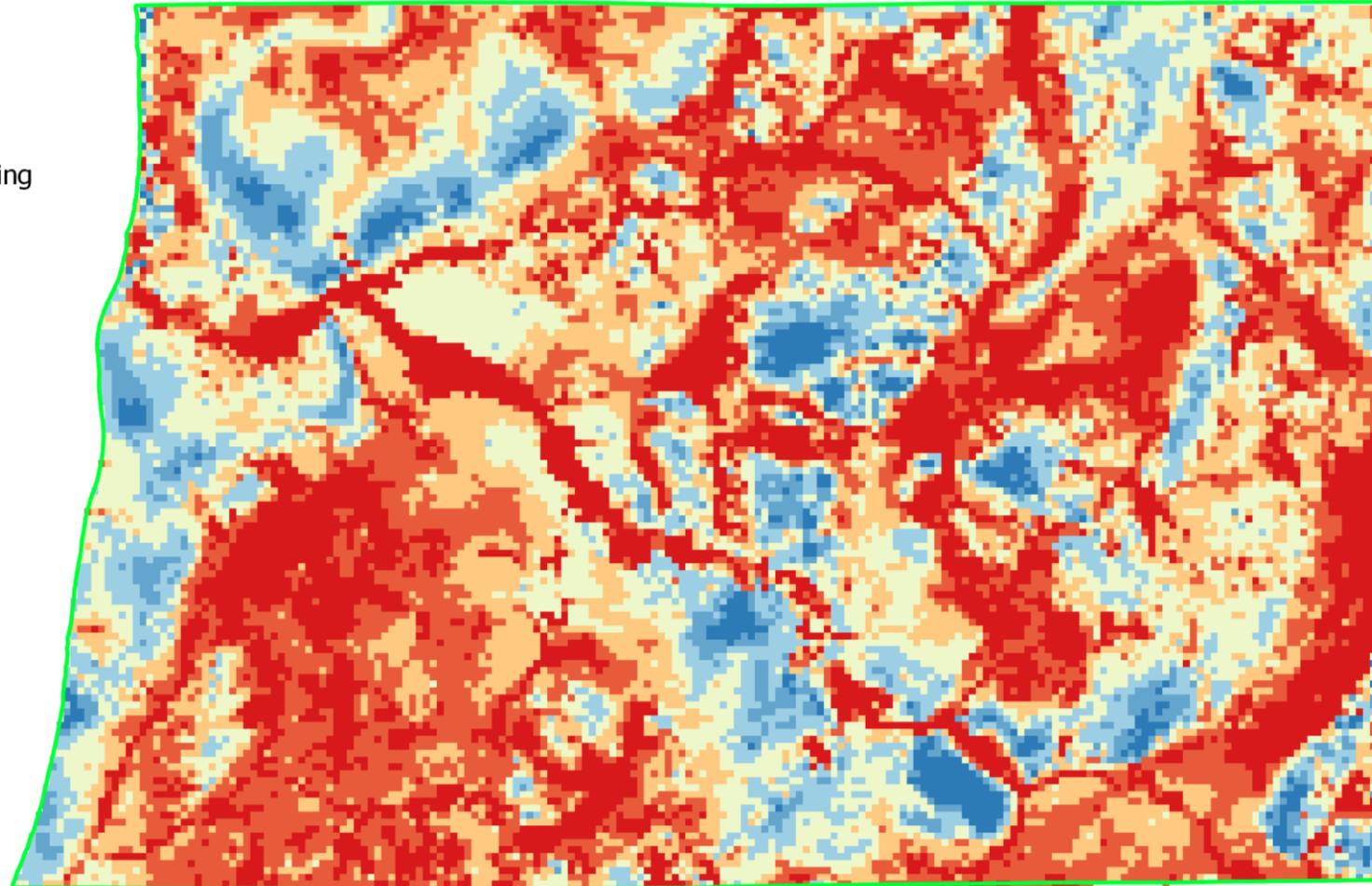
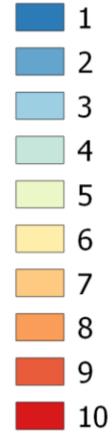


## Depth to Water Rating

### Legend

 County Border

Depth To Water rating



Depth to Water (m) – weight = 5

range	0–1.5	1.5–4.6	4.6–9.1	9.1–15.2	15.2–22.8	22.8–30.4	>30.4
rating	10	9	7	5	3	2	1

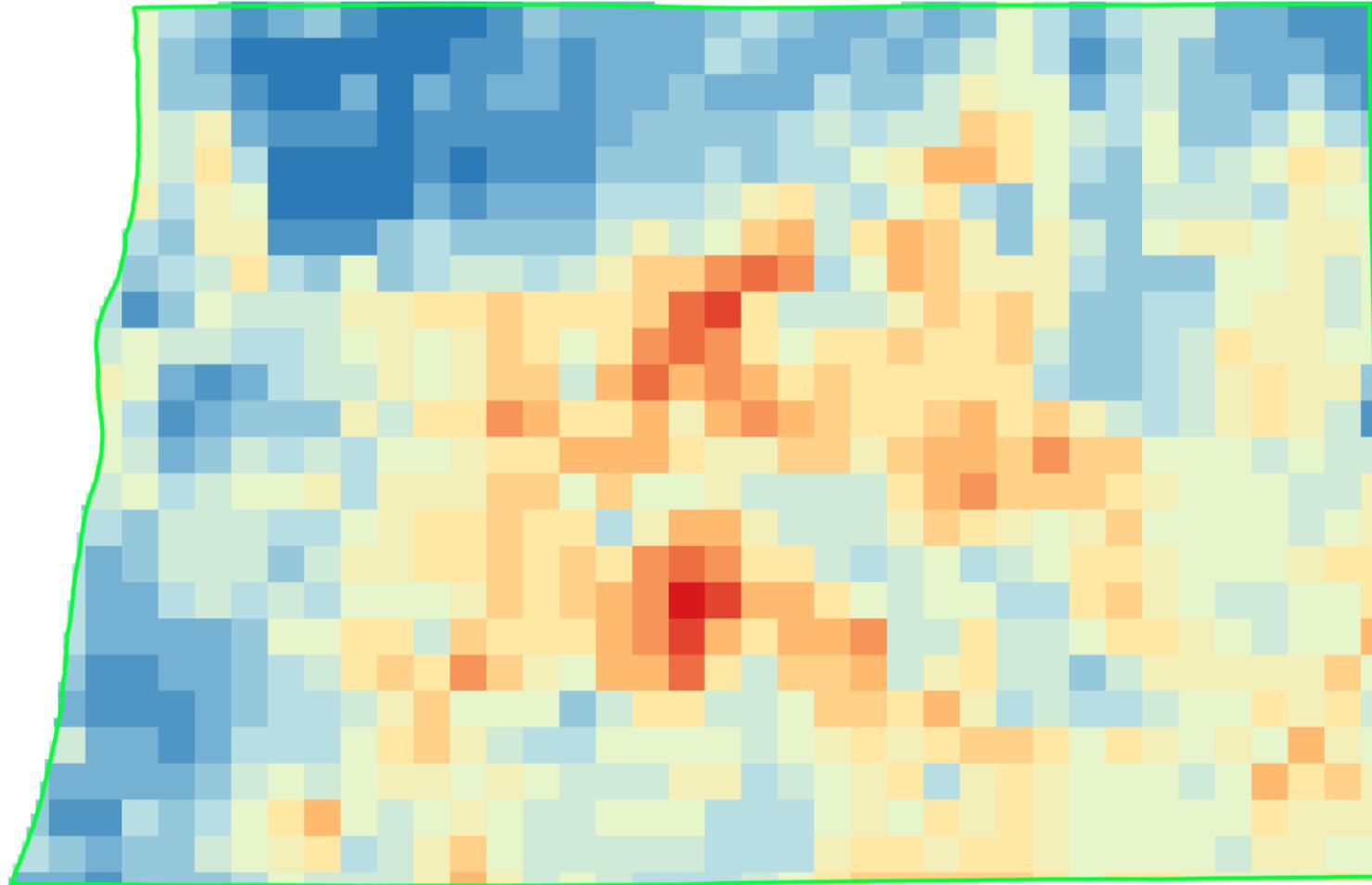
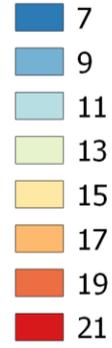
# DRASTIC

## Recharge

### Legend

 County Border

Recharge (in/year)



# DRASTIC

## Recharge Rating

### Legend

County Border

RechargeClass

8

9



Net Recharge (mm) – weight = 4

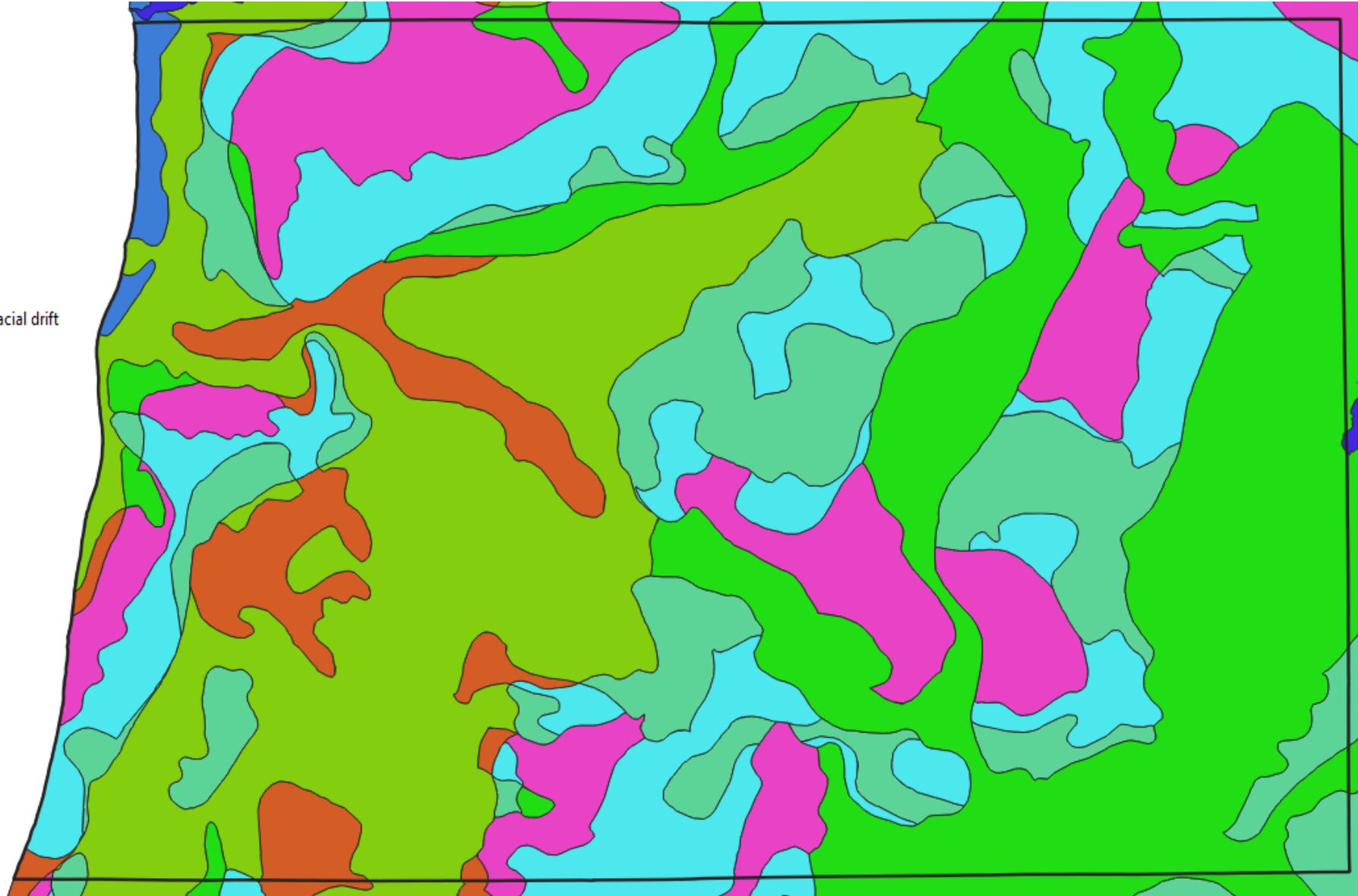
range	0–50.8	50.8–101.6	101.6–177.8	177.8–254	>254
rating	1	3	7	8	9

# DRASTIC

## Aquifer Media

### Glacial Geology

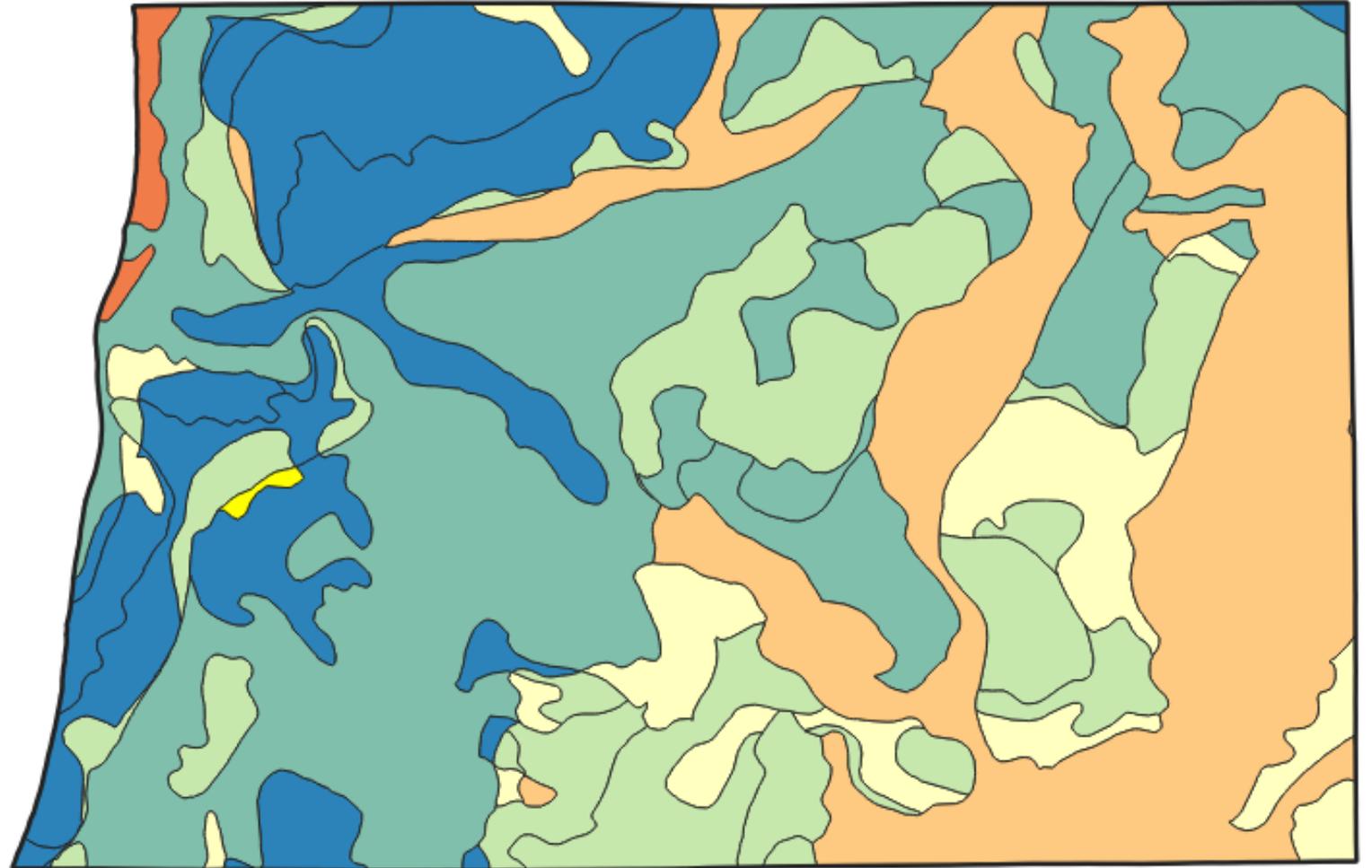
- Bedrock
- Coastal Dunes
- Ice-contact outwash
- ice-marginal till
- Lacustrine coarse
- Lacustrine Fine
- Lakes
- Lodge Till or Fine supraglacial drift
- Proglacial outwash
- Thin drift over bedrock
- 



# DRASTIC

## Aquifer Media

Ranking



Glacial Geology	Rating
Ice-marginal till	4,5 or 6
Lodge Till or Fine Supraglacial drift	4,5 or 6
Lacustrine Fine	4
Lacustrine coarse	5
Ice-contact outwash	6 or 7
Pro-glacial outwash	7 or 8
Coastal Dunes	9

# DRASTIC

## Soil Texture Classification

### Legend

 County Border

### Soil texture

 Sand

 Loamy sand

 Sandy loam

 Loam

 Silt loam

 Silt

 Sandy clay loam

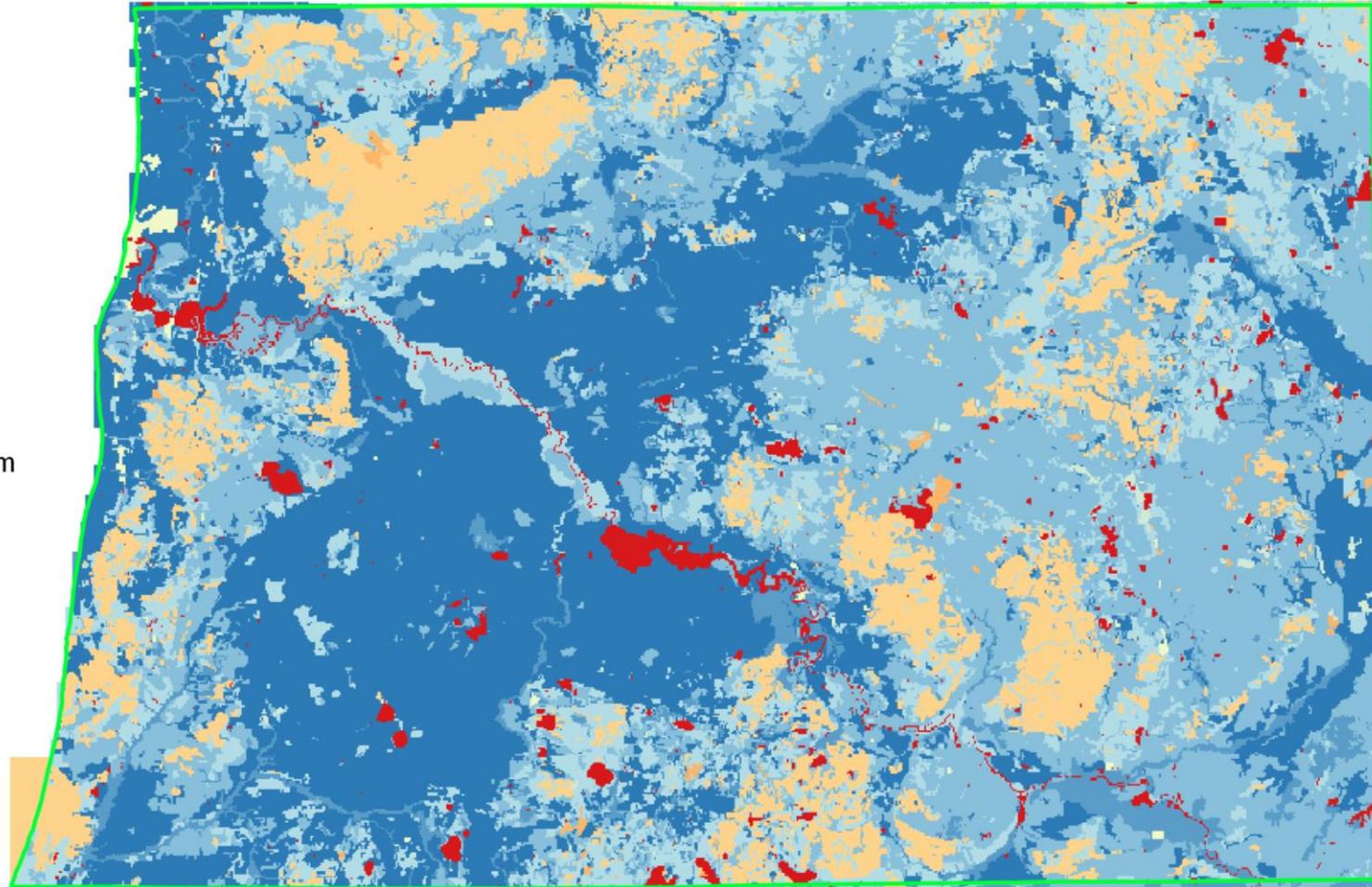
 Clay loam

 Silty clay loam

 Sandy clay

 Silty clay

 Clay



# DRASTIC

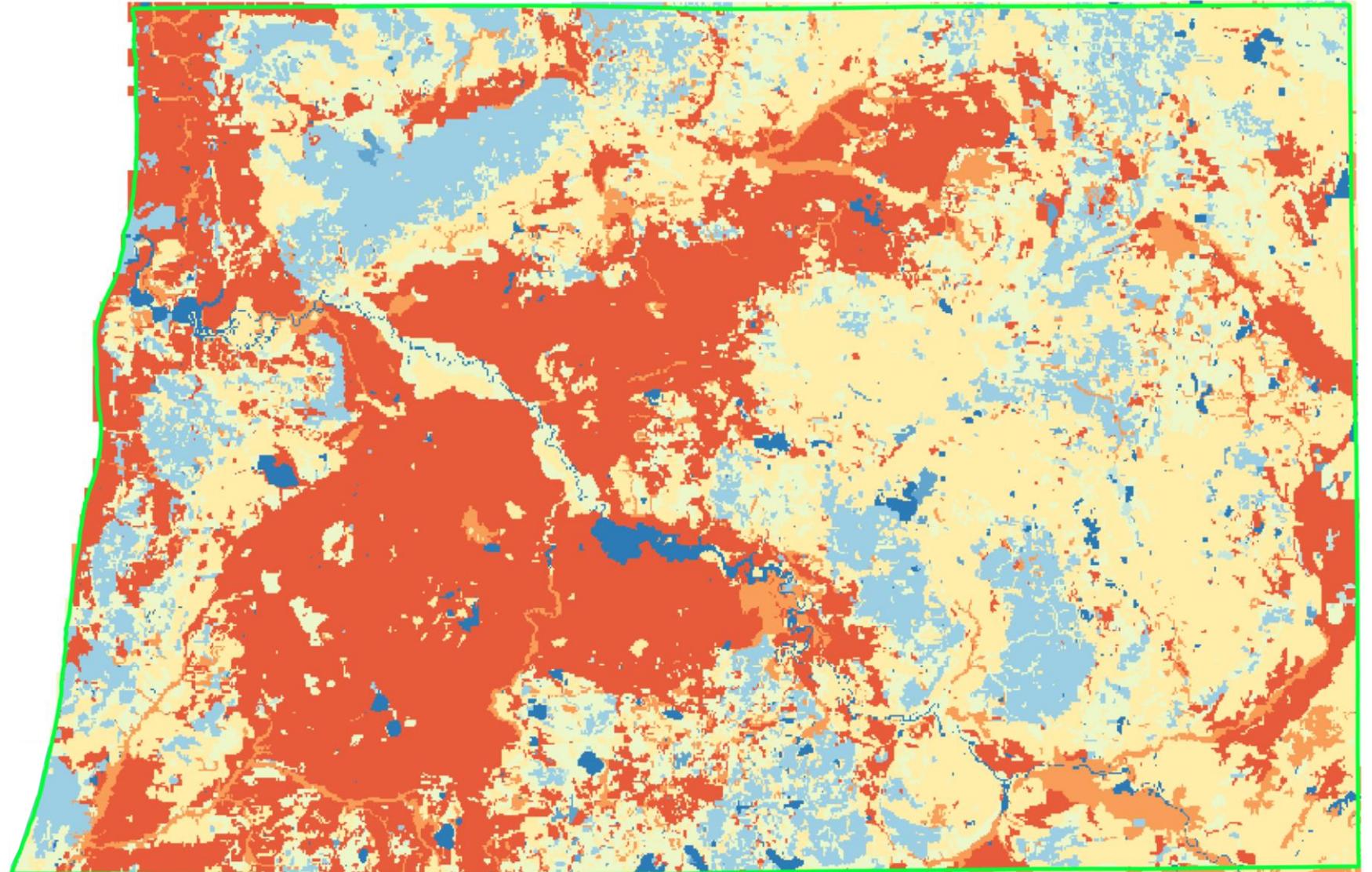
## Soil Rating

### Legend

 County Border

### Soil rating

-  1
-  2
-  3
-  4
-  5
-  6
-  7
-  8
-  9
-  10



## Topography (Slope)

### Legend

 County Border

DEM (m)

 175

 176

 188

 193

 196

 199

 202

 205

 207

 210

 214

 217

 221

 224

 227

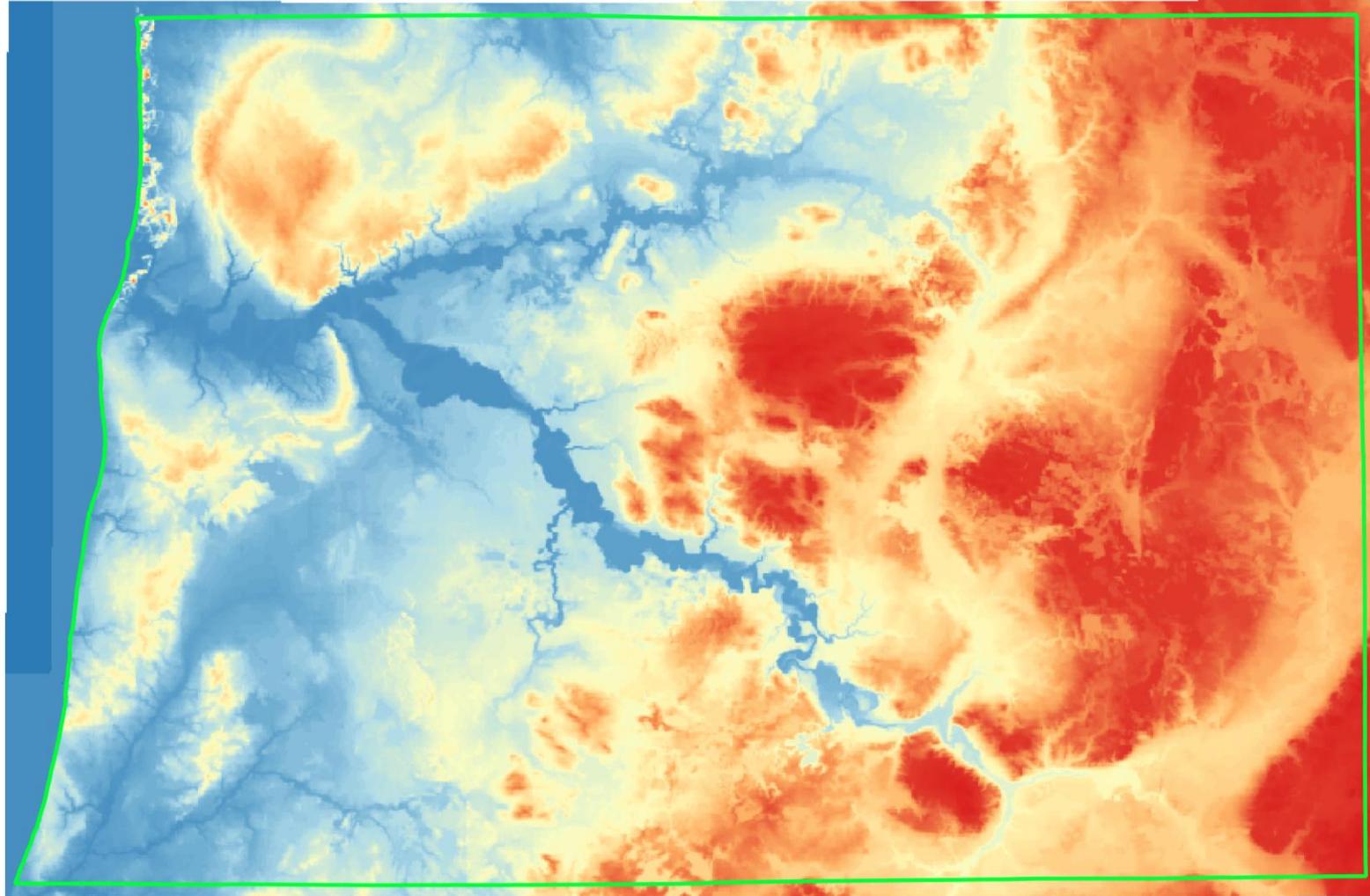
 232

 238

 245

 252

 304

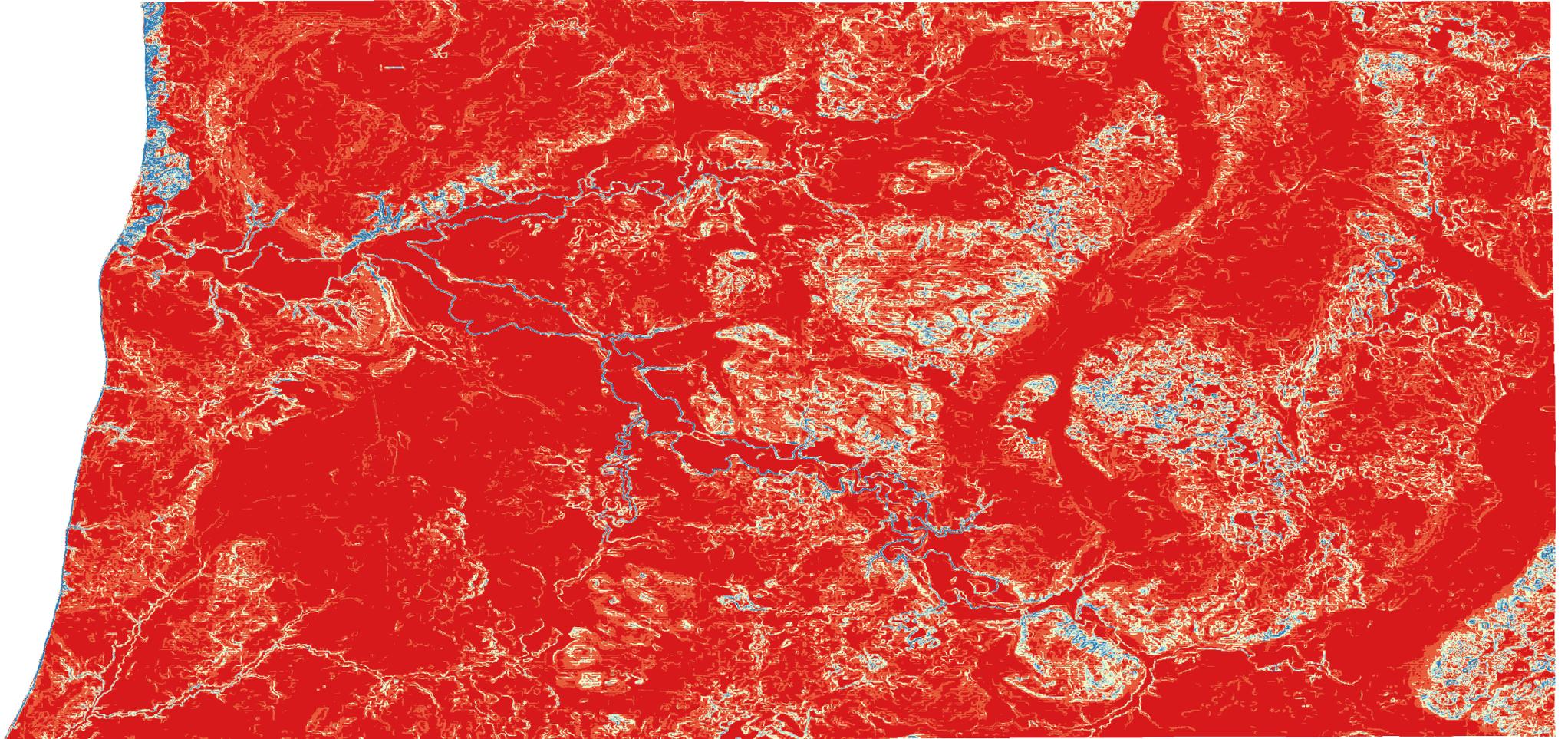
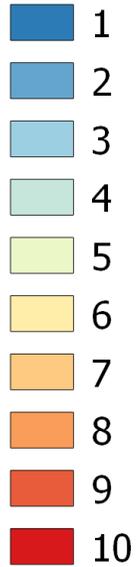


30m DEM

Additional area added outside county boundary to calculate slope at the edges.

## Topography (Slope) rating

Slope rating



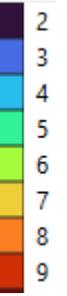
Topography (slope %) – weight = 1

range	0–2	2–6	6–12	12–18	>18
rating	10	9	5	3	1

# DRASTIC

## Impact of the Vadose Zone

Ranking



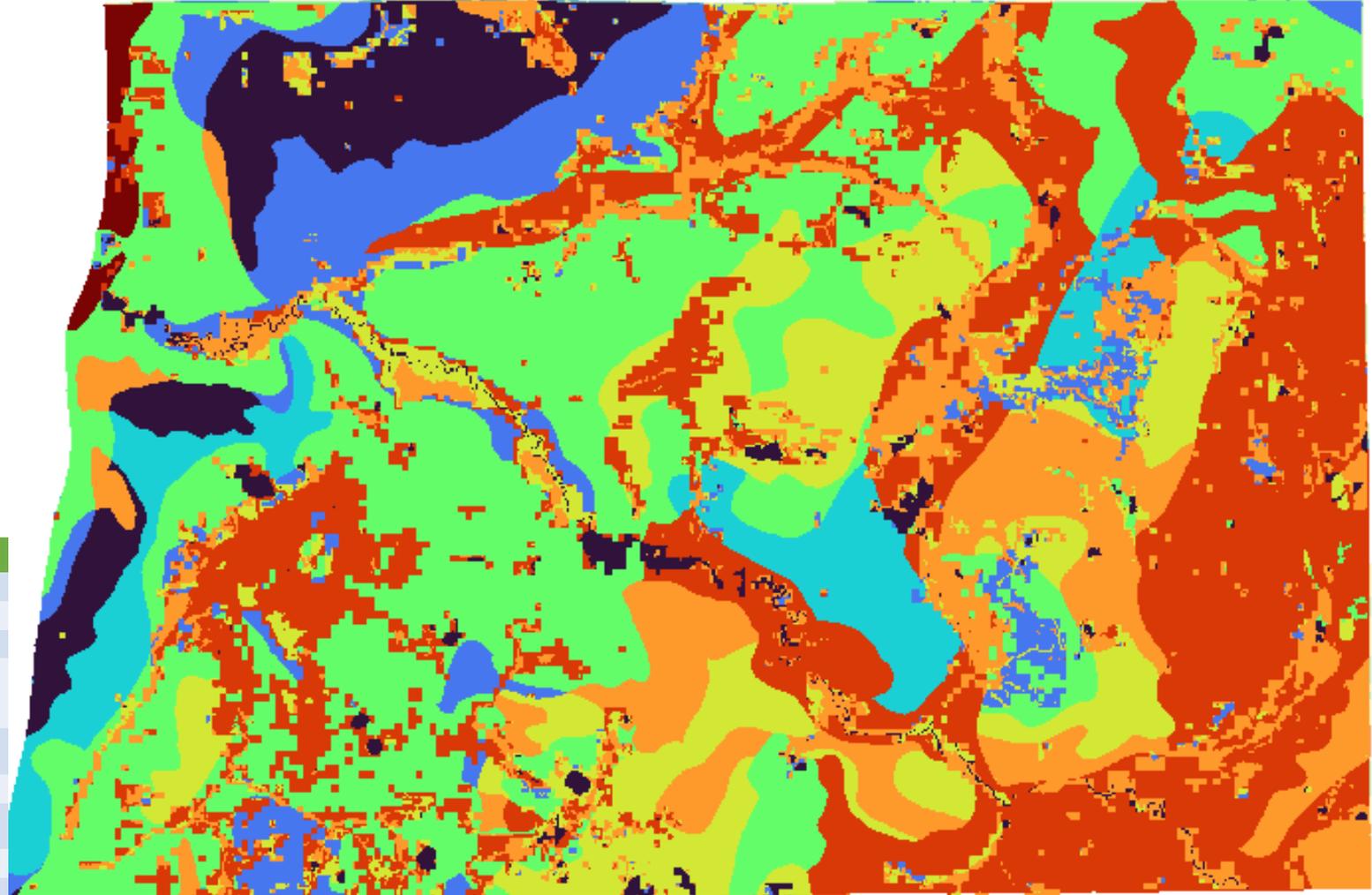
Vadose Zone based on glacial geology OR soil type, depending on Depth-to-Water (DTW)

If DTW <2m: vadose zone ranking based on soil type

If DTW >2m: vadose zone ranking based on glacial geology

Glacial Geology	Rating
Ice-marginal till	3,4,5 or 6
Lodge Till or Fine Supraglacial drift	2,3,4,5
Lacustrine Fine	3
Lacustrine coarse	5
Ice-contact outwash	5,6 or 7
Pro-glacial outwash	7 or 8
Coastal Dunes	9

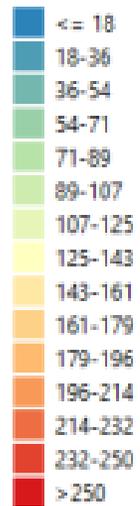
Soil Type	Rating
Sand	8
Loamy sand	7
Sandy loam	7
Loam	6
Silt loam	5
Silt	3
Sandy clay loam	4
Clay loam	3
Silty clay loam	2
Clay	2



# DRASTIC

## Hydraulic Conductivity

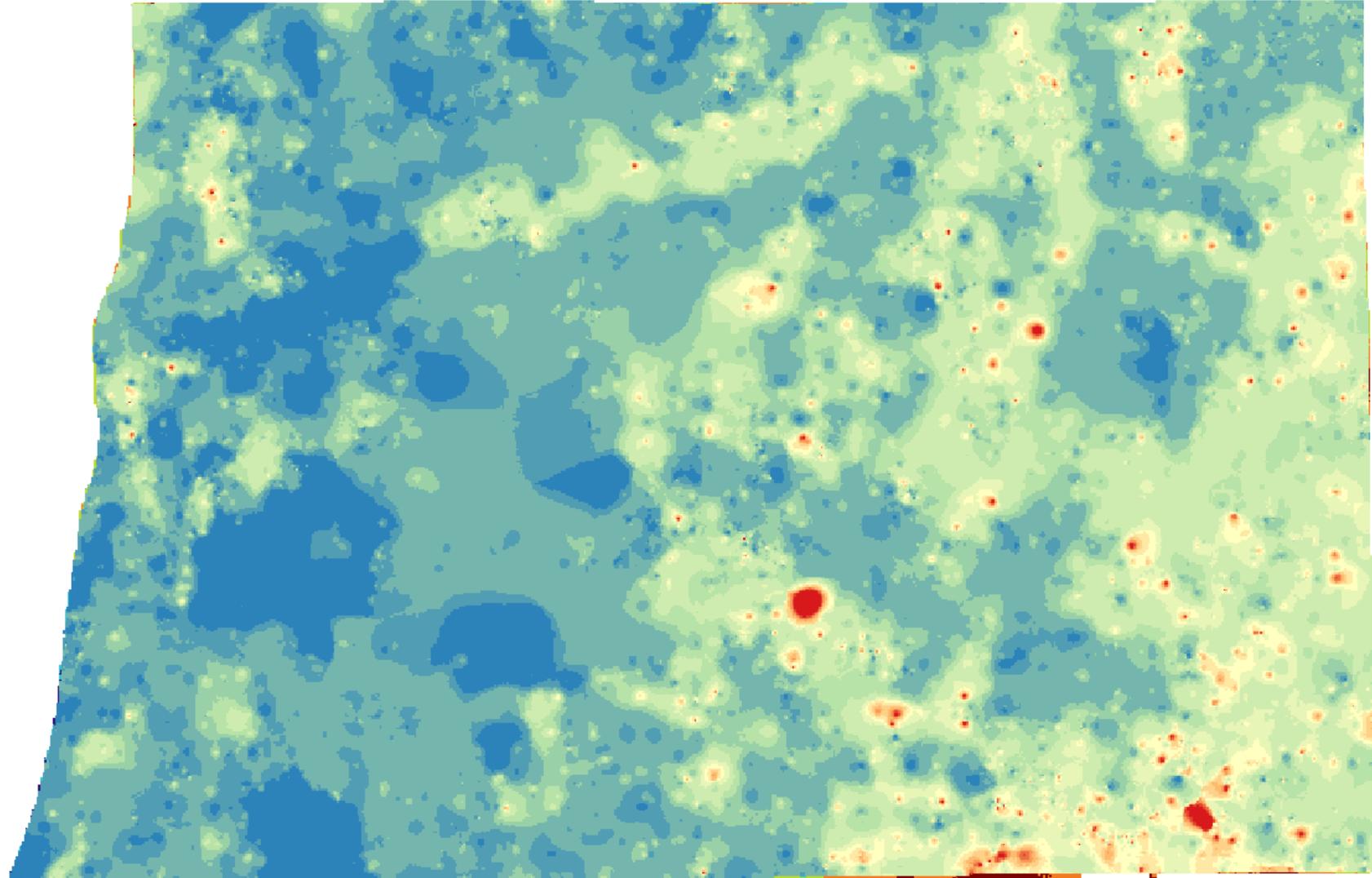
Hydraulic  
Conductivity  
(ft/day)



Slow

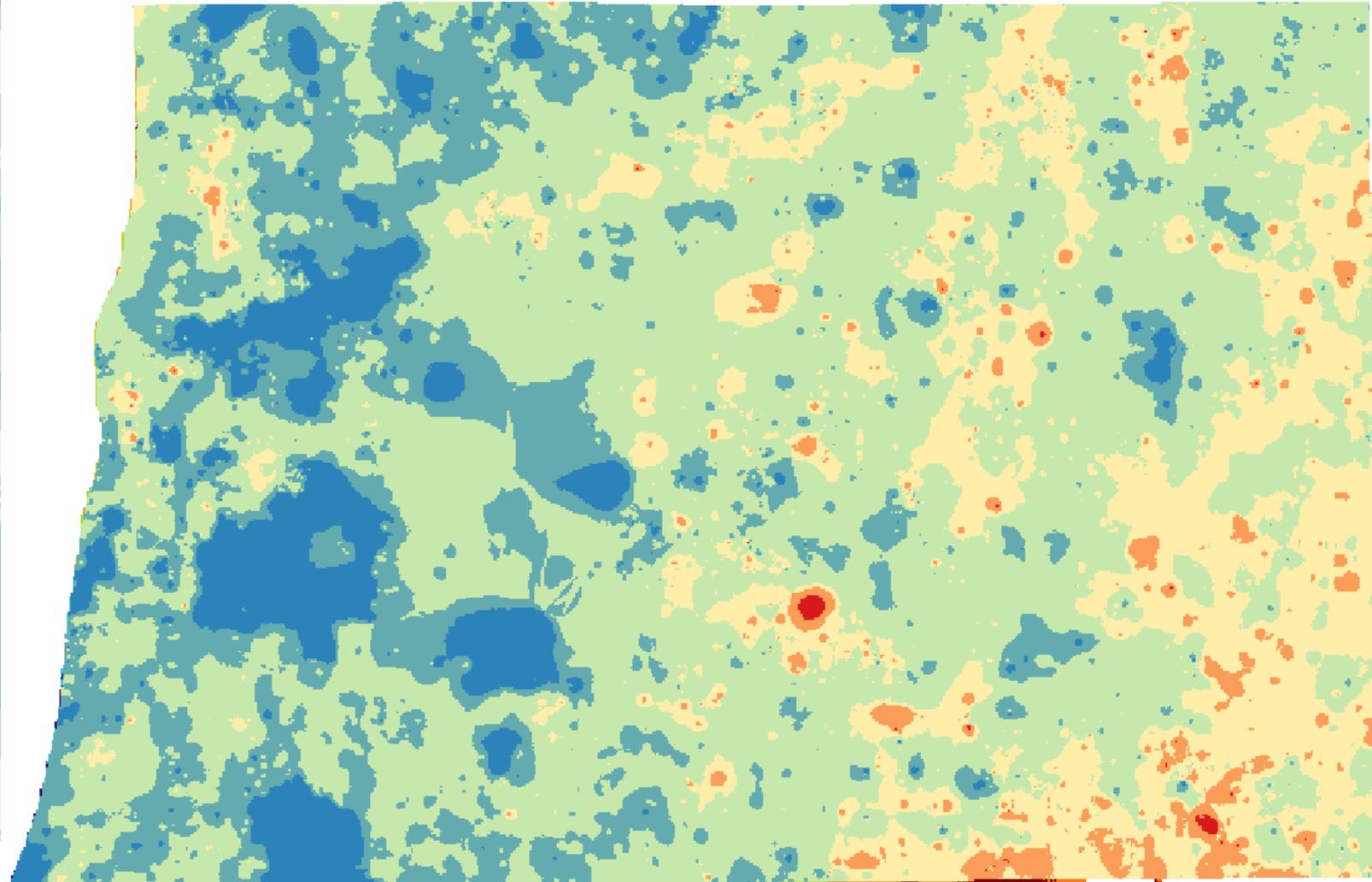
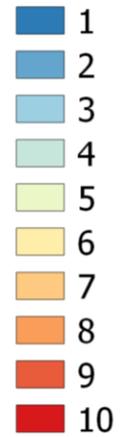


Fast



## Hydraulic Conductivity Rating

Conductivity Rating

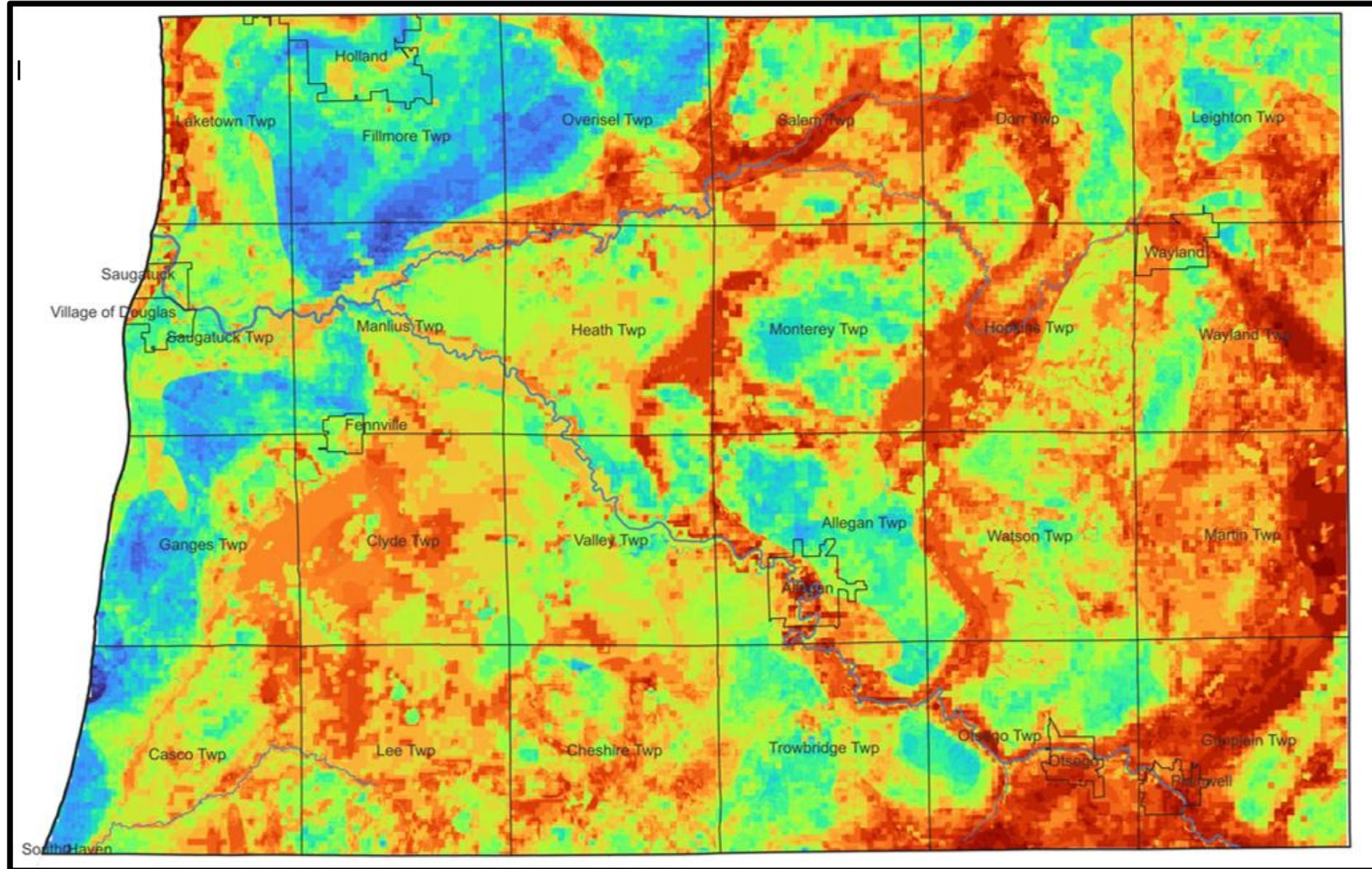


Hydraulic Conductivity of the Aquifer (m/day) – weight = 3

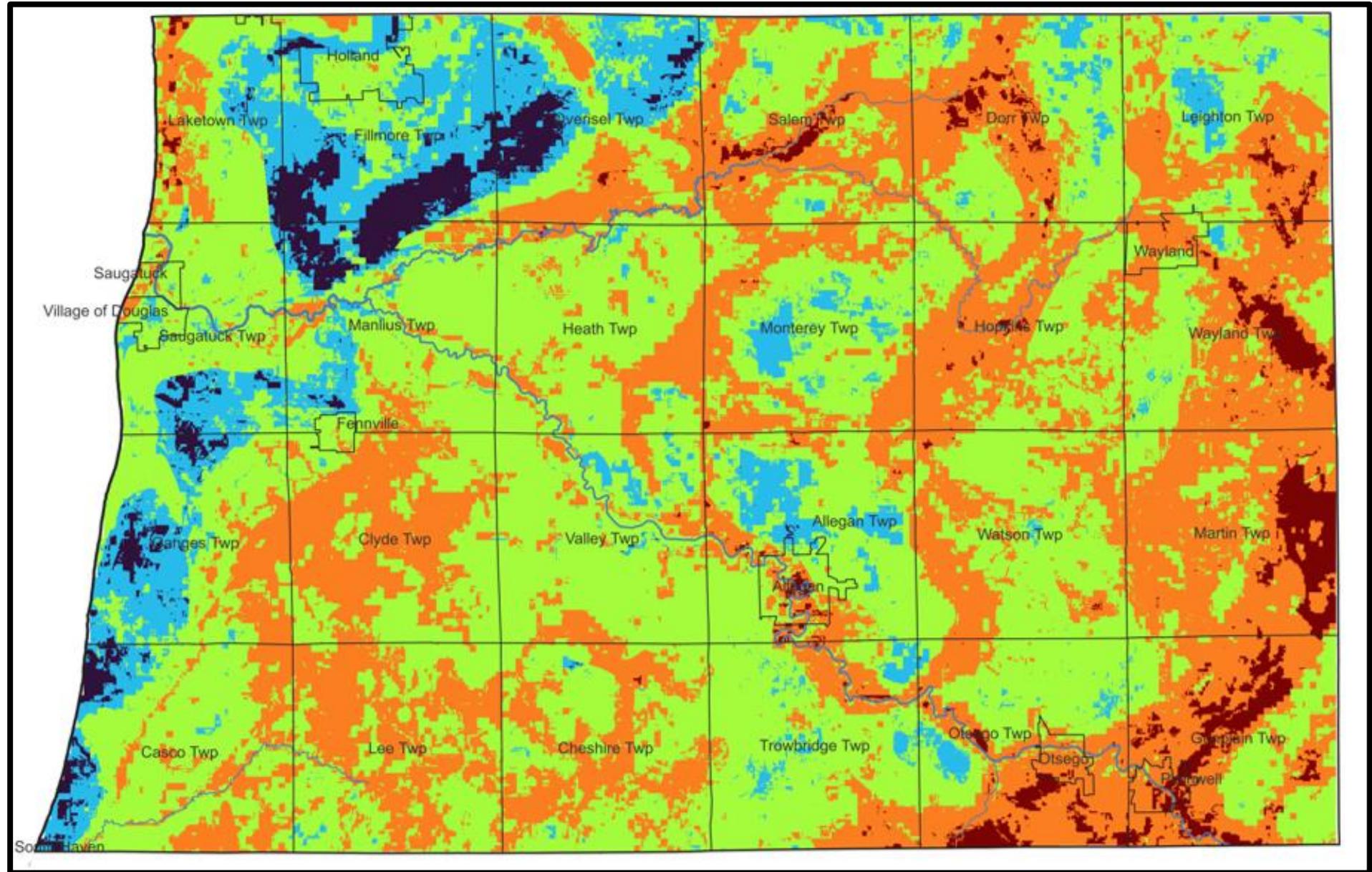
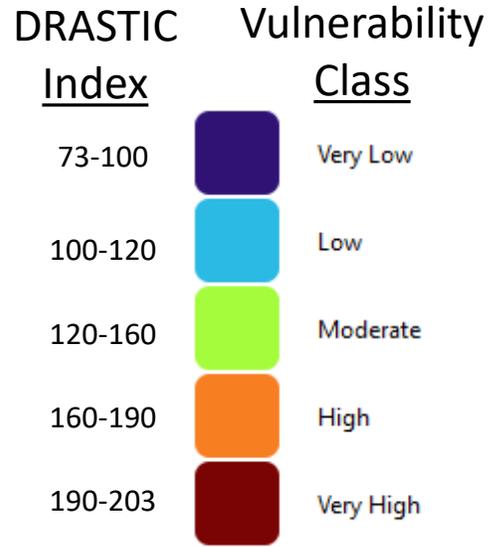
range	0.04–4.1	4.1–12.3	12.3–28.7	28.7–41	41–82	>82
rating	1	2	4	6	8	10

# DRASTIC Vulnerability Map

DRASTIC Index



# Vulnerability Class Map



# Risk Ranking System

Development and Application to Sites of Environmental Concern in Allegan County

# Development of a Risk Ranking System

Overall Risk of a site will be based on a set of (proposed) factors:

1. Occurrence of critical groundwater receptors within or near the impact areas
  - Receptors within / near shorter-term impact areas => higher risk
2. Degree of overlap / proximity of Type 1 WHPAs with impact areas
  - Receptors within / near shorter-term impact areas => higher risk
3. Aquifer vulnerability to surface contamination
  - Higher aquifer vulnerability => higher risk

# Integrated Analysis

- HSAINC will develop integrated overlays of:
  - Sites of environmental concern and their impact zones
  - Type 1 Wells and source area maps
  - Other groundwater receptors (private wells, aquatic ecosystems)
  - Aquifer vulnerability
- ... to aid in developing site-specific risk
- But an “index method” or weighting approach is needed to combine the layers of information

# Questions for Discussion

- An “index method” or weighting approach is needed:
  - How should a factor be rated?
    - low risk to high risk
  - How should the different factors be weighted?
    - less important to more important
- Are there other factors that should be considered (if info. available / enough time to integrate)?
  - For example:
    1. Contaminant loading
      - Sites with stronger loadings => higher risk
    2. Health-based criterion of contaminants
      - Concentrations exceeding guidelines => higher risk

# Suggested Next Steps

- HSAINC can take a “first shot” at defining an index method
- HSAINC will present this at a future Work Group meeting
  - Tasks 1-3 deliverables made available
- Work group finalizes risk ranking system (index method)
- HSAINC applies to the risk ranking system to create a priority list (site of environmental concern)