Groundwater Modeling

Uses and Benefits for the Aggregate Industry

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Michigan Aggregates Association
2024 Annual Meeting

Today's Topics

1. Safety Moment
2. What is a groundwater model?
3. Modeling as a planning and design tool
4. Modeling as a permitting tool

Travel Safety - driving

Driving is statistically one of the most dangerous things we will do each day, and is something most of us do as a course of business

Rental cars

- Take a moment to get to know your car before driving off
- Set all of the mirrors so that you can use them effectively
- Find all of the controls you may need (blinker, windshield wiper, parking brake, etc.)
- Understand where and how big your blind spots are
- Get comfortable with the vehicle before heading out
- Always park so that your first move in exiting the spot is moving forward
- Plan your route to avoid heavy congestion if possible

HALEY ALDRICH

What is a Groundwater Model?

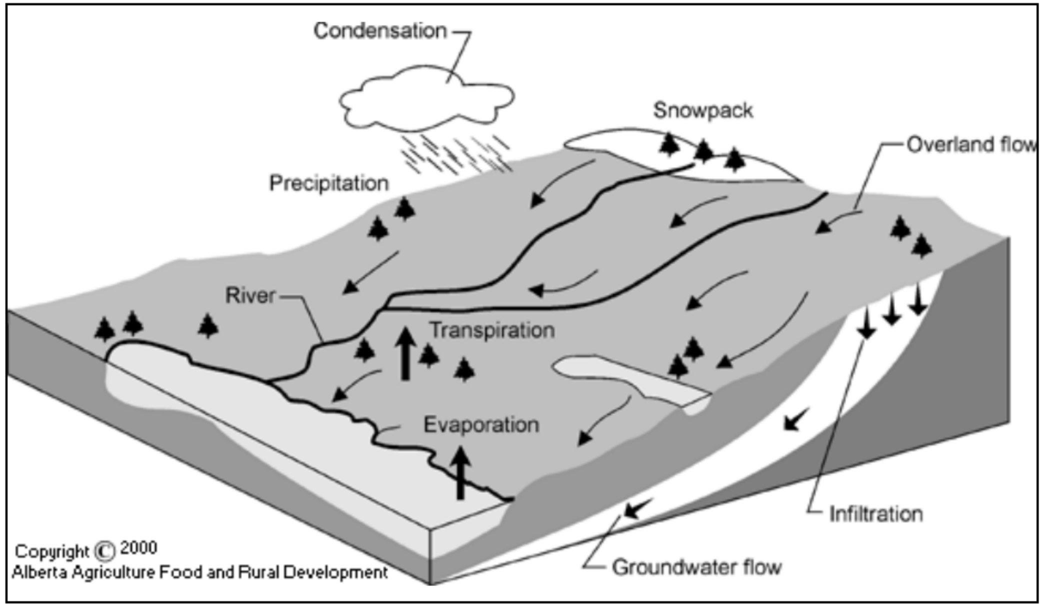
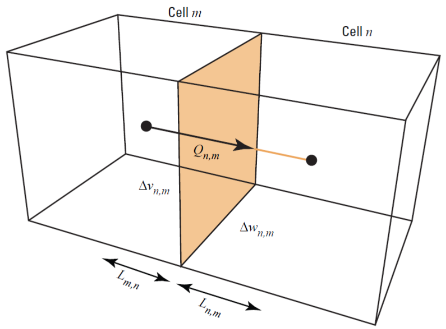
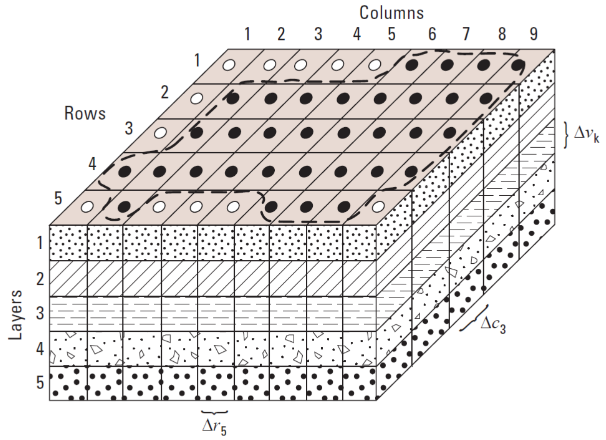


Figure 1 - Components of the hydrologic cycle

Source: EGLE Water Budget Guidance

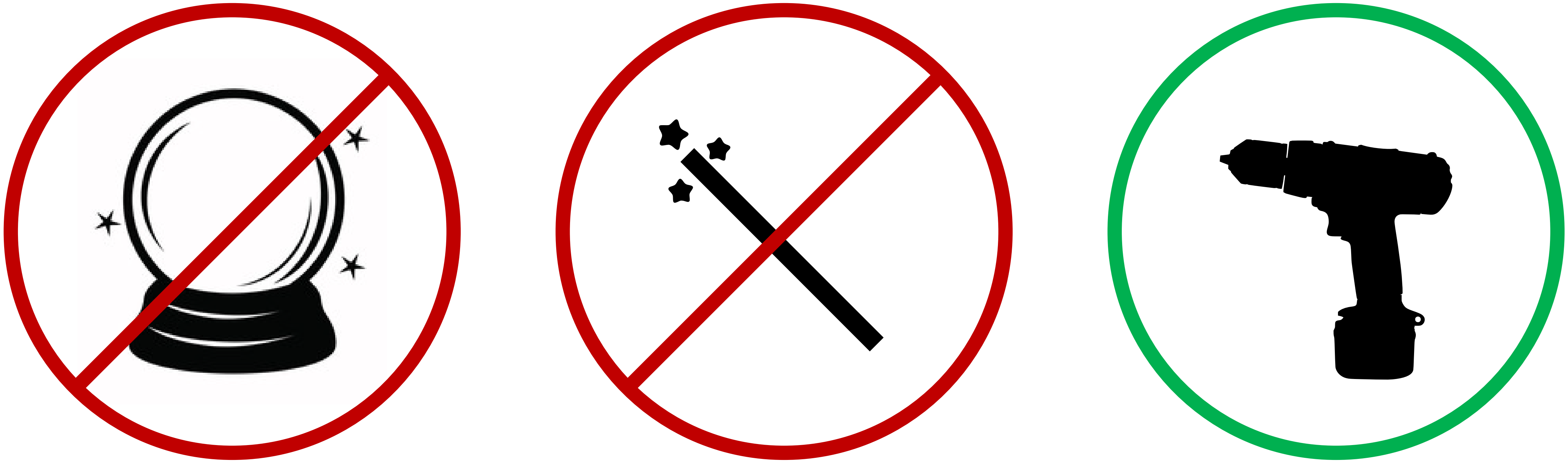
$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)+Q'_s=SS\frac{\partial h}{\partial t}$$





Source: USGS MODFLOW Technical Documentation

What is a Groundwater Model?



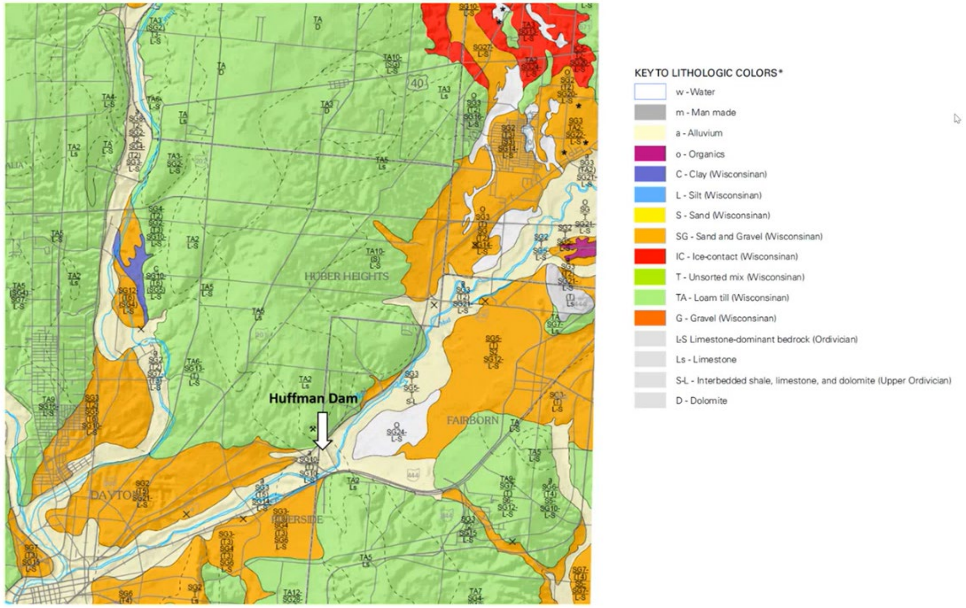
Models are a useful tool, when needed

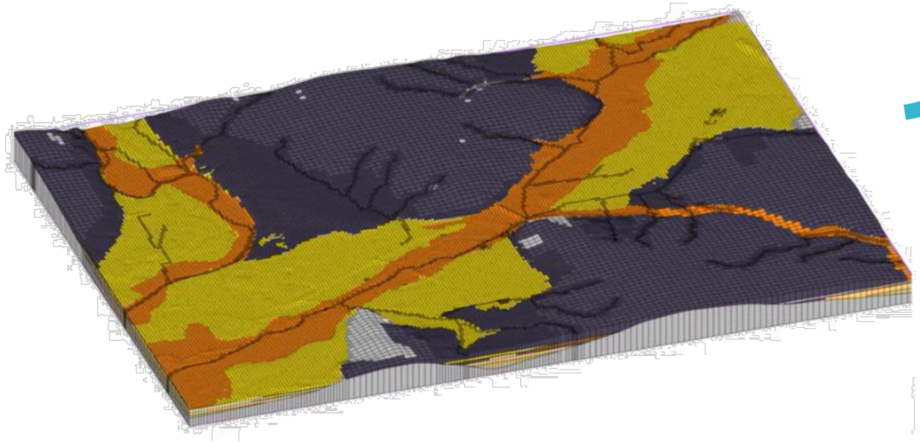
Why would I need a groundwater model?

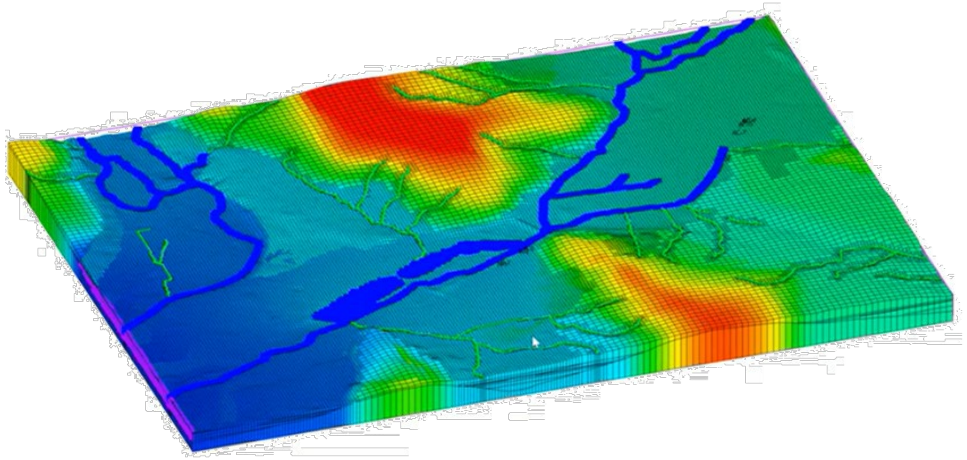
Uses/Benefits:

- Operations planning
- Dewatering design
- Evaluating design alternatives
- Water withdrawal planning
- Permitting
- Natural resource evaluation
- Estimating future conditions
- Process optimization
- Equipment selection optimization
- Evaluating complex geology
- Contaminant fate and transport

Building a Groundwater Model





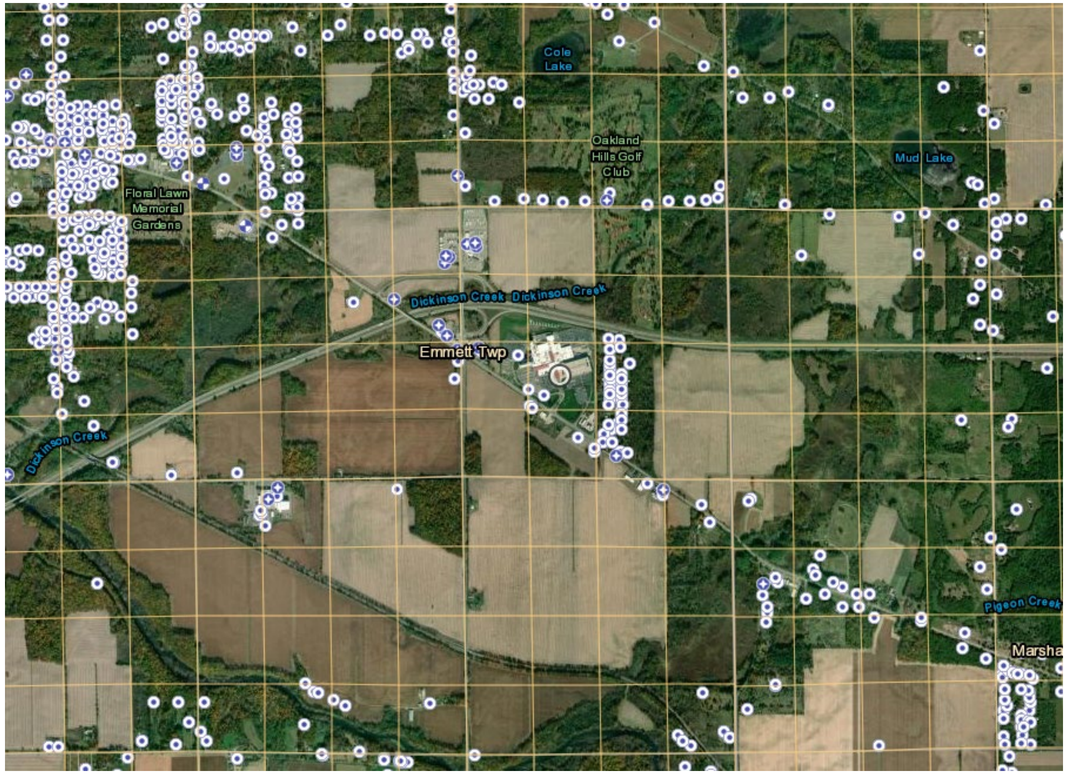


Source: Haley & Aldrich

Model Inputs and Data Sources

Input	Potential Data Source(s)
Surface topography	Digital elevation models, aerial survey
Geology	EGLE well logs, published data, test borings
Aquifer properties (conductivity, specific yield, etc.)	Aquifer testing, published data, calculated by model
Precipitation/Evaporation	Weather stations, published datasets
Surface water (streams, lakes, etc.)	USGS topo maps, FEMA flood mapping data
Groundwater elevation	Monitoring wells, published datasets, EGLE well logs
Current/planned water withdrawal	Operations plans, EGLE well logs

Data Source: EGLE Well Logs



EGLE Water Well Viewer

Water Well And Pump Record

Completion is required under authority of Part 127 Act 368 PA 1978.
Failure to comply is a misdemeanor.

Import ID:

Tax No: | **Permit No:** | **County:** Calhoun | **Township:** Emmett

Town/Range: 02S 07W | **Section:** 13 | **Well Status:** Active | **WSSN:** | **Source ID/Well No:**

Well ID: 13000007801

Elevation:

Latitude: 42.297294

Longitude: -85.077586

Method of Collection: GPS Std Positioning Svc SA Off

Distance and Direction from Road Intersection:
1/4 MILE EAST OF 11 MILE RD 1/8 MILE NORTH OF E MICHIGAN AVE

Well Owner: FIRE KEEPERS CASINO

Well Address:
11177 E MICHIGAN AVE
BATTLE CREEK, MI 49014

Owner Address:
11177 E MICHIGAN AVE
BATTLE CREEK, MI 49014

Drilling Method: Rotary
Well Depth: 120.00 ft. **Well Use:** Irrigation
Well Type: New **Date Completed:** 7/11/2013

Casing Type: PVC plastic **Height:** 2.00 ft. above grade
Casing Joint: Solvent welded/glued
Casing Fitting: Shale packer/trap

Diameter: 6.25 in. to 31.00 ft. depth SDR: 21.00

Borehole: 10.58 in. to 31.00 ft. depth
6.00 in. to 120.00 ft. depth

Static Water Level: 18.00 ft. Below Grade
Well Yield Test: **Yield Test Method:** Air
Pumping level 30.00 ft. after 2.00 hrs. at 150 GPM

Screen Installed: No **Intake:** Bedrock Well

Pump Installed: Yes **Pump Installation Only:** No
Pump Installation Date: 7/26/2013 **HP:** 10.00
Manufacturer: A.Y. McDonald **Pump Type:** Submersible
Model Number: 5150S10HP66 **Pump Capacity:** 150 GPM
Drop Pipe Length: 42.00 ft. **Pump Voltage:** 460
Drop Pipe Diameter: 3.00 in. **Drilling Record ID:**
Draw Down Seal Used: No

Pressure Tank Installed: No
Pressure Relief Valve Installed: No

Formation Description	Thickness	Depth to Bottom
Gravel & Stones Coarse	6.00	6.00
Gravel & Sand Coarse	14.00	20.00
Sand	10.00	30.00
Sandstone Broken	1.00	31.00
Sandstone Water Bearing	89.00	120.00

Aquifer Testing

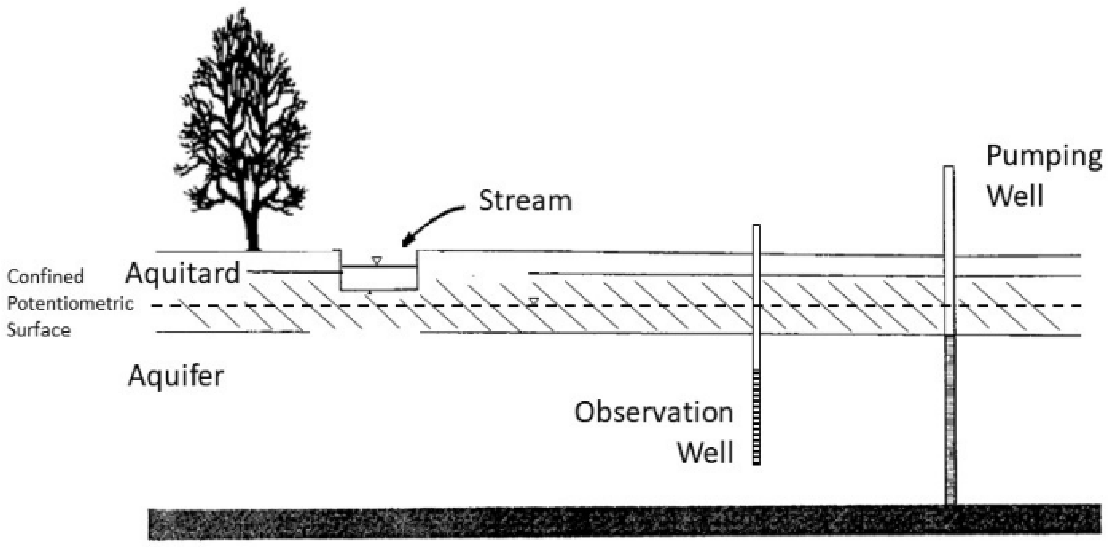
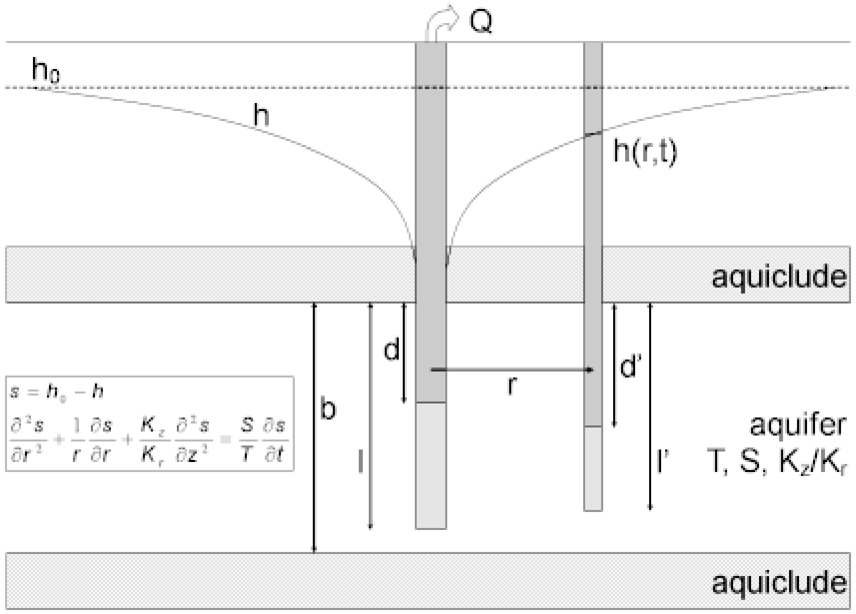
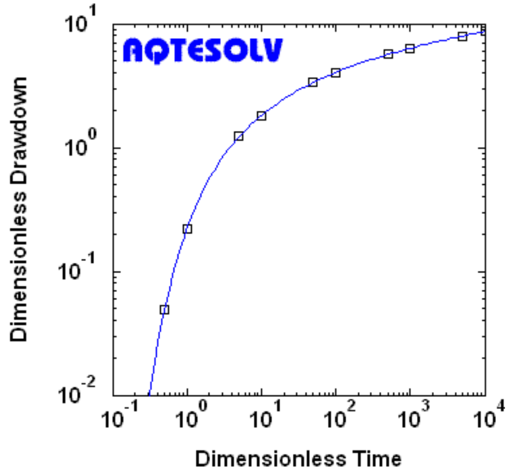


Figure modified from Unsteady Stream Deplection when Pumping from Semiconfined Aquifer, Figure 1, by Bruce Hunt, 2003

Source: EGLE Aquifer Performance Test Guidance



Source: Aqtesolv.com



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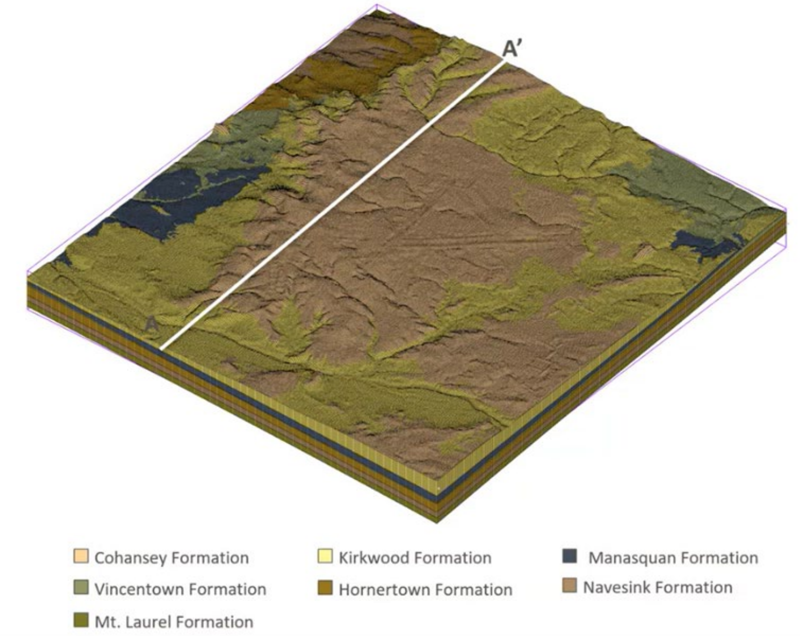
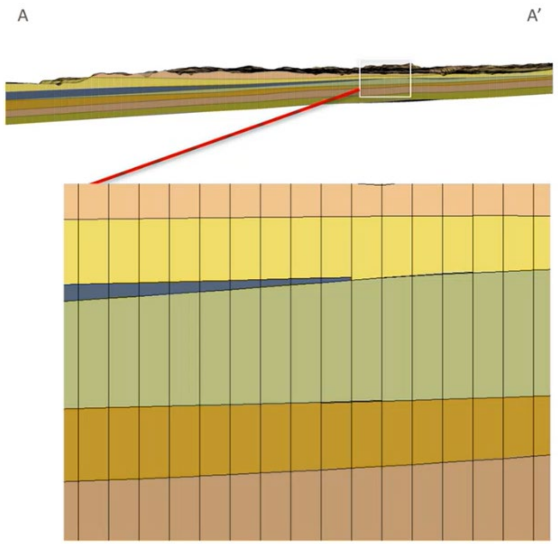
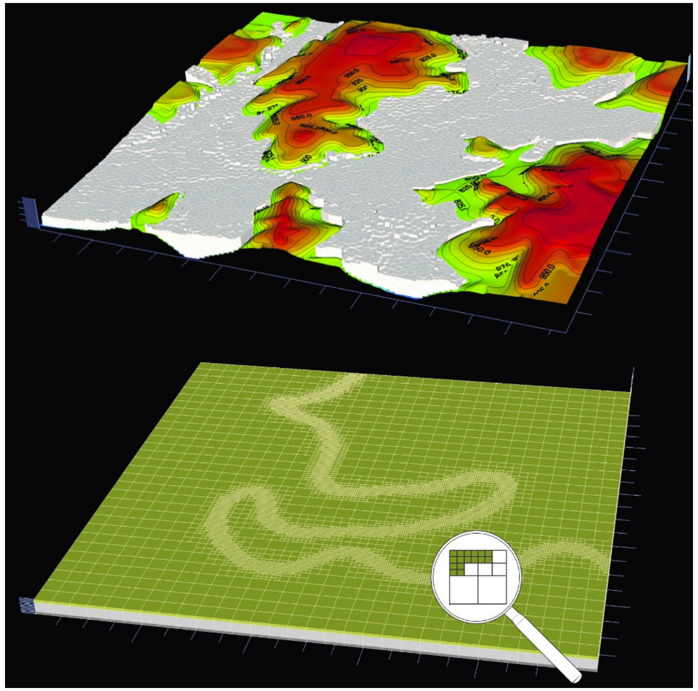
New Modeling Tool: Unstructured Grids



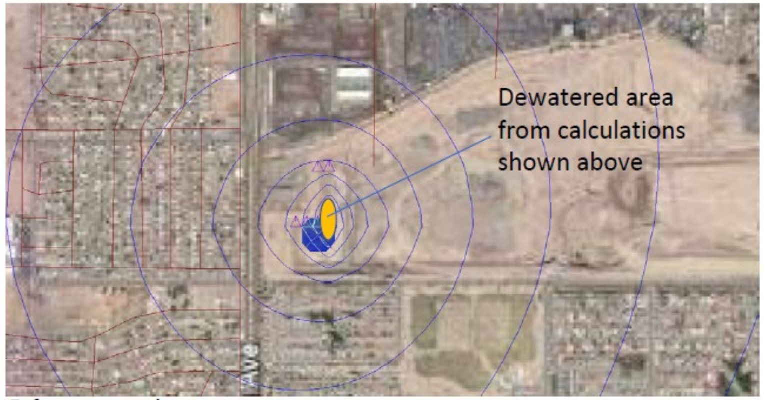




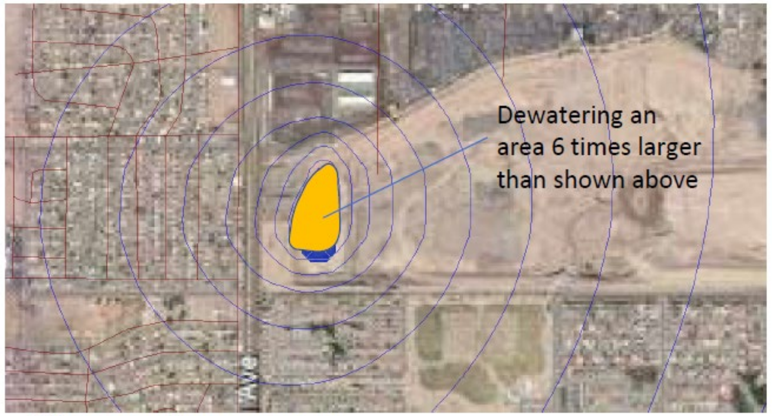
Source: Haley & Aldrich

Source: Haley & Aldrich/DoD Environmental Security Technology Certification Program

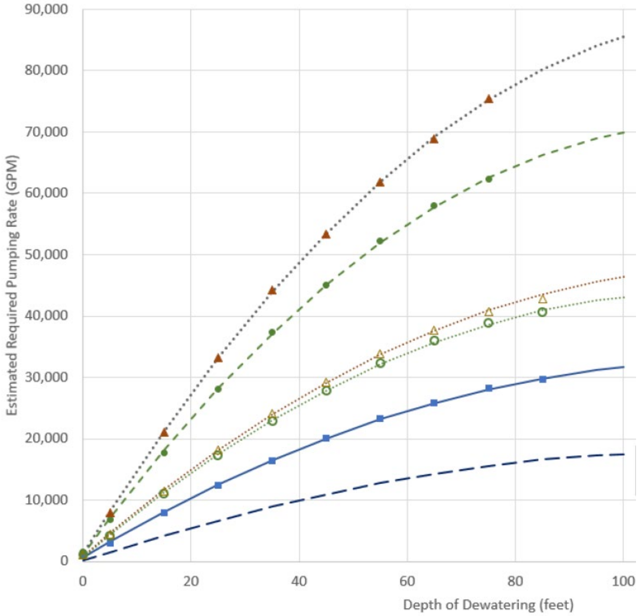
Groundwater Modeling for Aggregate Mine Dewatering

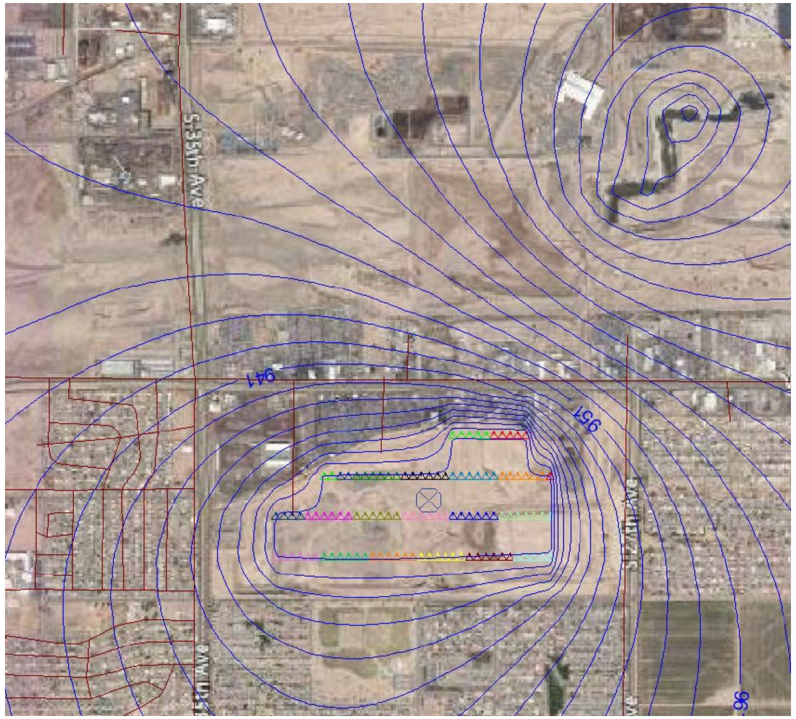


5-foot groundwater contours



5-foot groundwater contours





Optimization of mine dewatering

Source: Haley & Aldrich

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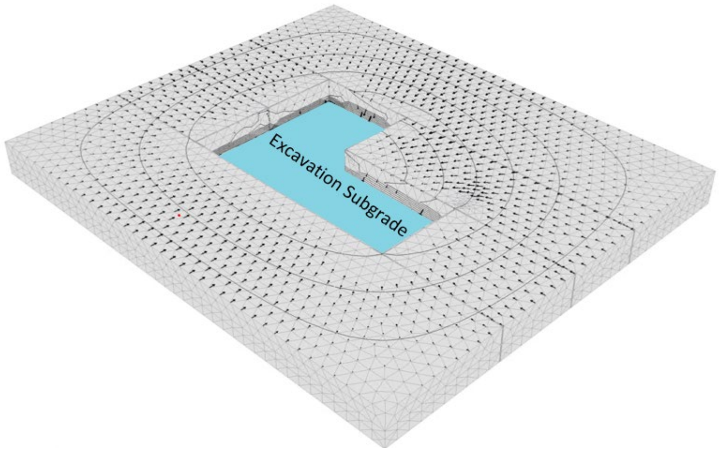
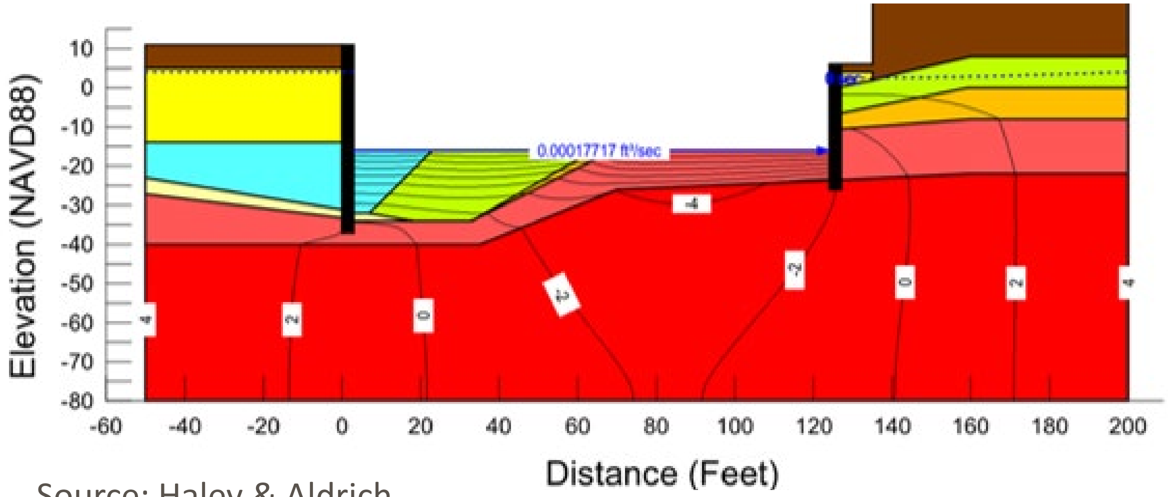
Groundwater Modeling for Engineering Design





Construction dewatering model

Source: Haley & Aldrich

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Groundwater Modeling for Permitting

EGLE

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION

WATER WITHDRAWAL PERMIT APPLICATION INSTRUCTIONS

WHO MUST APPLY FOR A WATER WITDHRAWAL PERMIT?

Part 327, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, requires a person who proposes to make a new or increased water withdrawal from the waters of the state that meets any of the following conditions to apply for a permit prior to making the withdrawal:

(a) More than 2,000,000 gallons per day in total cumulative withdrawal capacity utilizing a common distribution system. Includes withdrawals from groundwater, inland surface water, and the Great Lakes and connecting waterways.
(b) A Zone C withdrawal as determined by a site-specific review of more than 1,000,000 gallons per day capacity utilizing a common distribution system.
(c) A transfer from the watershed of one Great Lake to that of another Great Lake of more than 100,000 gallons per day average over any 90-day period.

Water Resources Division
Hydrogeological Investigations Administrative Checklist for Lake Creation Projects

EGLE

This checklist is for the Department of Environment, Great Lakes, and Energy (EGLE) internal use in determining if a Hydrogeologic Investigation for a proposed lake creation project is complete under Part 301, Inland Lakes and Streams; Part 303, Wetlands Protection; or Part 327, Great Lakes Preservation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).

EGLE

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION

GROUNDWATER MODELS AND FILES REQUIRED FOR WATER USE ASSESSMENT UNIT GROUNDWATER MODEL REVIEWS

Groundwater Modeling for Permitting

- Hydrogeology evaluation required for EGLE permits:
  - Surface or groundwater withdrawal >100,000 gpd (70 gpm pump capacity) (Part 327, Great Lakes Preservation)
  - Surface or groundwater withdrawal > 2 mgd (1,389 gpm pump capacity) (Part 327, Great Lakes Preservation)
  - Creation of inland lake ≥ 5 acres (Part 301, Inland Lakes and Streams)
  - Impact of lake creation on regulated wetlands (Part 303, Wetlands Protection)

Water Withdrawal Permits (Part 327)

- Large quantity surface or groundwater withdrawal:
  - >100,000 gpd (70 gpm pump capacity) – registration required
  - >2 mgd (1,389 gpm pump capacity) – permit required
- Required hydrogeology evaluation for water withdrawal permit:
  - Evaluate potential effects of the proposed withdrawal on neighboring water wells, wetlands, and inland lakes or streams

Inland Lakes and Streams Permits (Part 301)

- Creation of inland lake ≥ 5 acres (includes excavation of gravel pits)
- EGLE draft hydrogeology guidance updated December 2023
- Required hydrogeology evaluation includes:
  - Groundwater elevation change predictions for all resources (wetland, lake, stream, or well) within 1,000 feet of the lake boundary
  - Phases to evaluate: early excavation, late excavation, and long-term (reclamation)
  - Effects to evaluate: seepage/material removal, hydraulic gradient flattening, increased evaporation

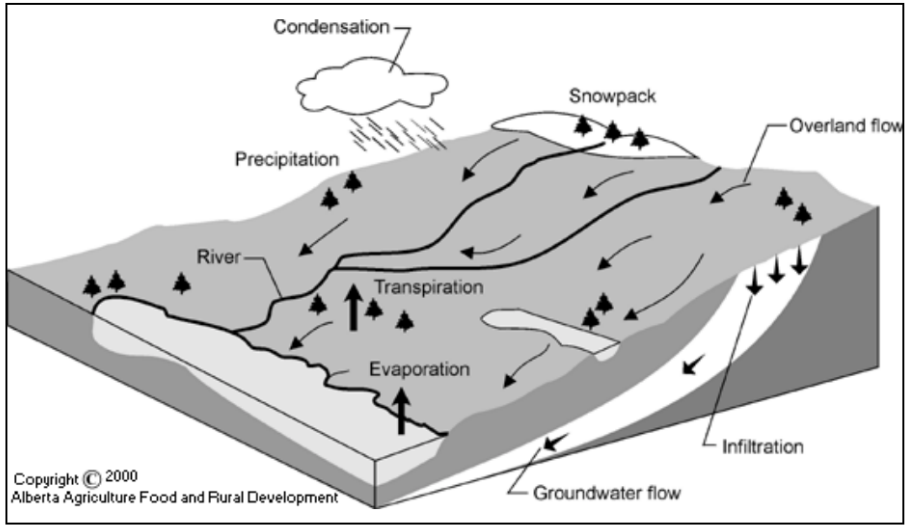


Figure 1 - Components of the hydrologic cycle

Inland Lakes and Streams Permits (Part 301)

- EGLE hydrogeology evaluation requirements (updated December 2023):

Water Resources Division
Hydrogeological Investigations Administrative Checklist for Lake Creation Projects

EGLE

Site Hydrologic Conditions	Solution Type	Solution Examples
Unconfined homogeneous aquifer	Analytic	Theis for unconfined settings
Confined homogeneous aquifer	Analytic	Theis for confined settings
Confined or unconfined heterogeneous aquifer	Numeric	MODFLOW
Any proposed lake greater than 200 acres in size.	Numeric	MODFLOW

If a numeric model is used, the model files are required for the report to be reviewed.

7. **Parameter Calculation Sheets and Raw Data** – Step-by-step calculations, references, and raw data, as appropriate, for each parameter used in the groundwater change predictions should be included in the report for, at a minimum, the following parameters:
   a. Precipitation Rate
   b. Evaporation Rate
   c. Hydraulic Conductivity
   d. Storativity or Specific Yield
   e. Porosity
   f. Stream Bed Conductance
   g. Aquifer Thickness
   h. Groundwater Gradient
   i. Groundwater Flow Rate used in Analytical Approximation
   j. Excavation Rate

Inland Lakes and Streams Permits (Part 301)

- Geological complexity:

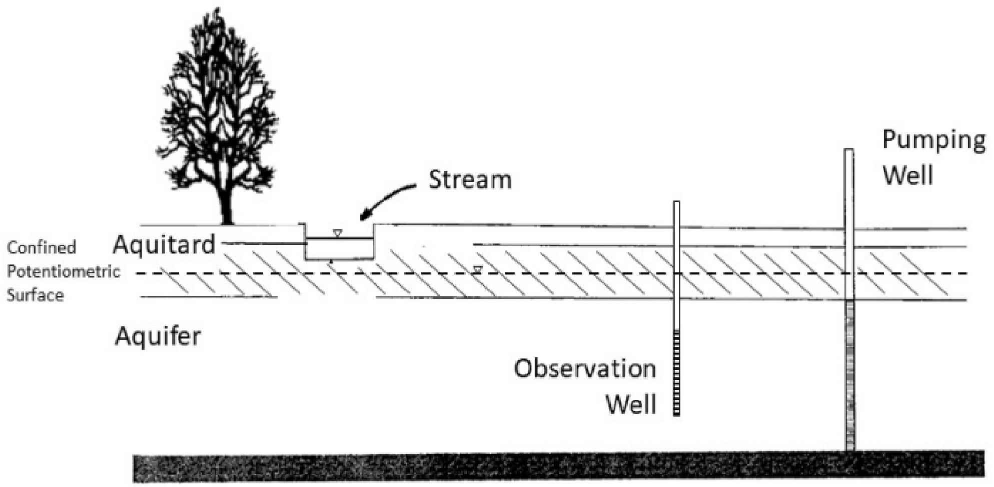
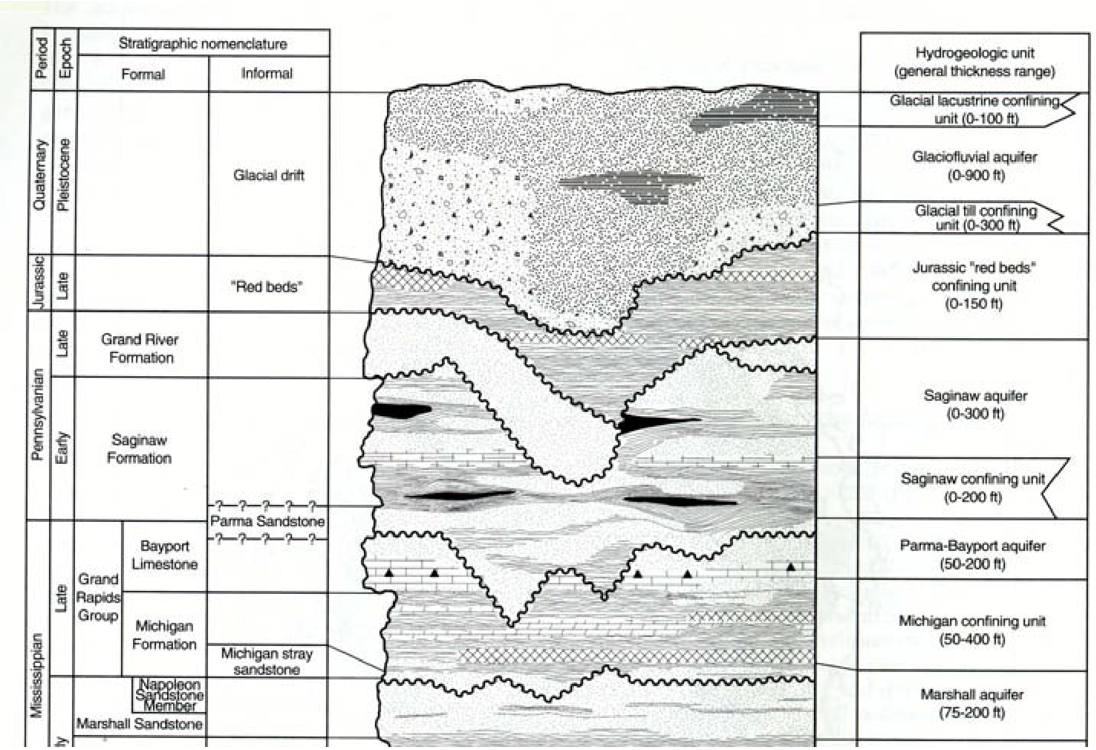


Figure modified from Unsteady Stream Deplection when Pumping from Semiconfined Aquifer, Figure 1, by Bruce Hunt, 2003

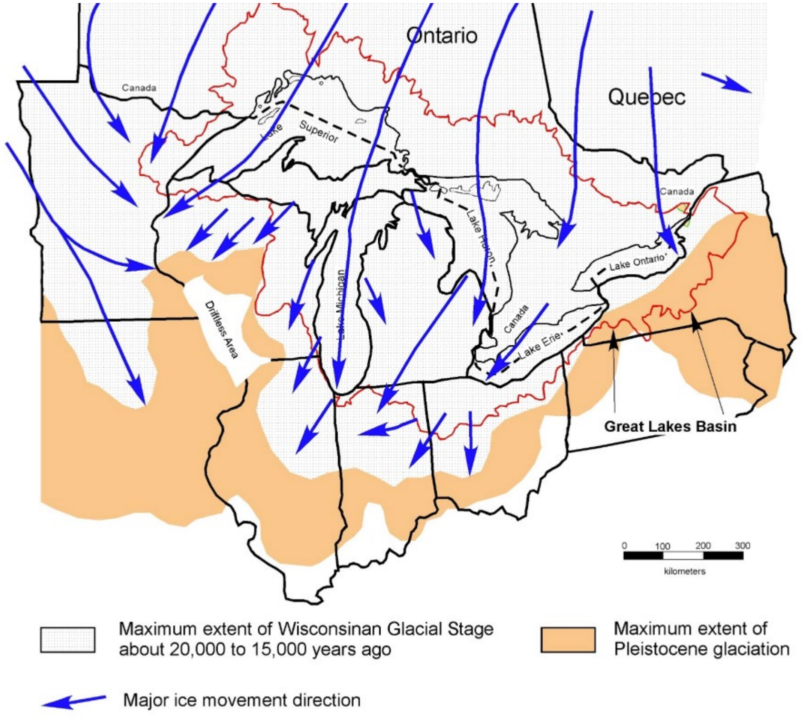
Homogeneous



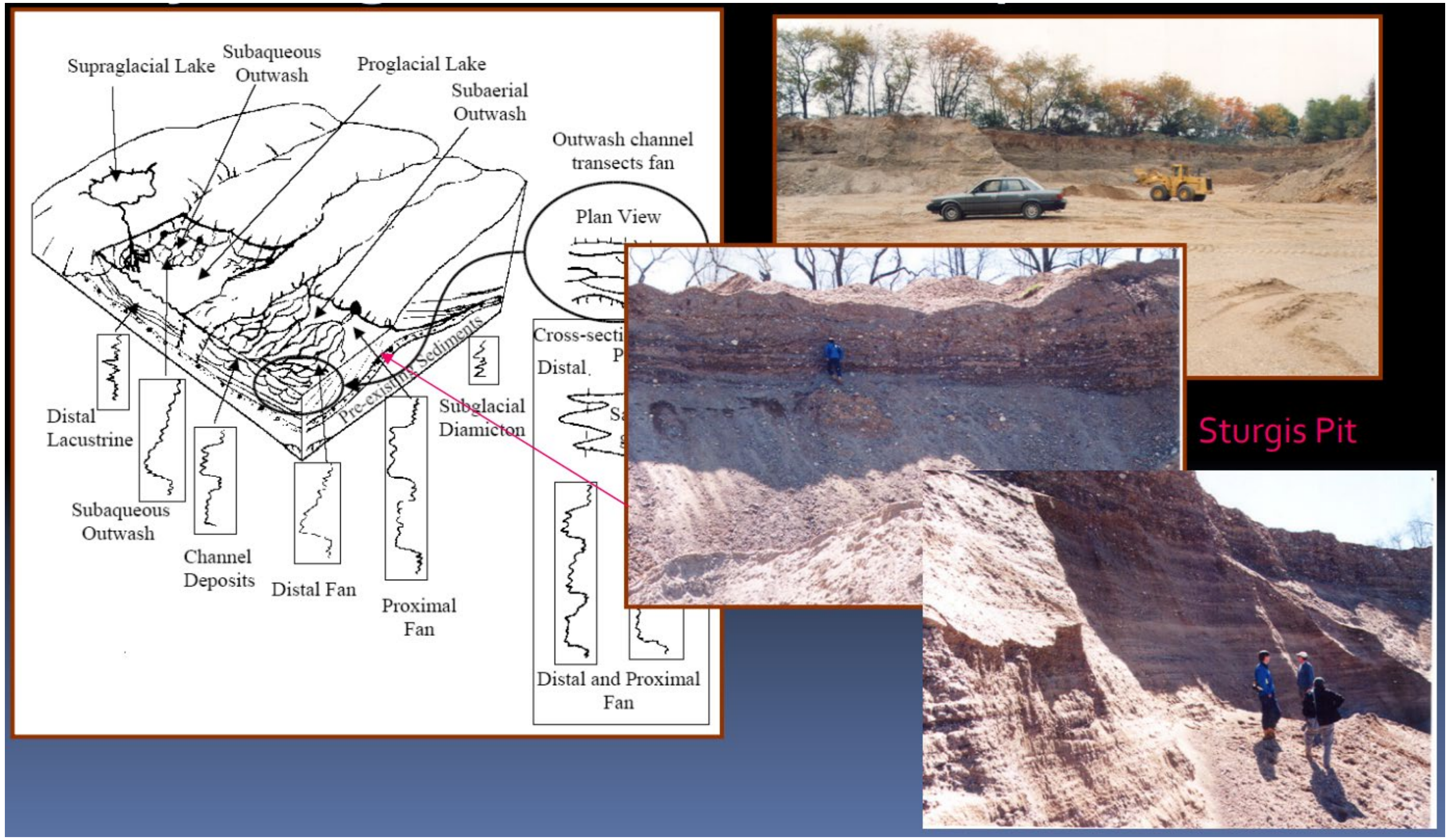
Source: USGS, 1998, Hydrogeologic Framework of the Michigan Basin Regional Aquifer System

Heterogeneous

Sources of Geological Complexity (and Aggregate)



Source: Bornhorst, 2016, An Overview of the Geology of the Great Lakes Basin



Pleistocene Glaciation

Source: Kehew, A., Michigan Geological Survey, 3-D Geologic Mapping for Hydrogeologic Applications, swmpc.org

Questions?

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