Water and its Economic Advantage for Michigan’s Food and Agriculture System

Michigan Commission of Agriculture and Rural Development
September 17th, 2014
Drawing from Recent White Paper

- The Water Cycle
- Water Strategy in Michigan
  - Water Quantity
  - Water Quality
- Water Resource Study – Ottawa County
Water Cycle

\[ R - E = \text{Recharge} + \text{Runoff} \]
Annual Precipitation

I. Annual Precipitation

Avg. Annual Precipitation: 1981 - 2010 (In./Yr.)

- 26 - 28
- 29 - 31
- 32 - 34
- 35 - 37
- 38 - 40
Evapotranspiration

IV. Evapotranspiration

Estimated Evapotranspiration (In./Yr.)
- Green: 14.7 - 20.8
- Light Green: 20.9 - 22.7
- Yellow: 22.8 - 24.6
- Gold: 24.7 - 26.5
- Orange: 26.6 - 29.2
- Red: 29.3 - 38.3
Groundwater Recharge

II. Groundwater Recharge

Estimated Groundwater Recharge (In./Yr.)
- 0 - 4
- 5 - 9
- 10 - 11
- 12 - 13
- 14 - 15
- 16 - 19
Stream Discharge

III. Stream Discharge

Avg. Stream Discharge (cfs)
- 252 - 545
- 546 - 983
- 984 - 1,555
- 1,556 - 2,957
- 2,958 - 6,229
Annual Hydrograph
Water Cycle

Hydrologic Cycle Components:
- Precipitation
- Evaporation
- Infiltration
- Runoff
- Streamflow
- Groundwater (Storage)

Processes:
- Condensation
- Interception
- Evapotranspiration
- Uptake
- Percolation
Water Quantity
Topic Overview

- As Michiganders, we can work together to provide a system that is fair, equitable and assures sustainable water resources.

- Sustainable water management is within the best interests of both water users (e.g., irrigators, industry, municipalities) and the public.
Growing Agricultural Demand for Water

- World’s population is expected to expand from 7 to 9 billion by 2050

- Agricultural industry is growing annually and has significant implications for future water demand considerations

- Water quality impacts in Ottawa County
Passage of Great Lakes Compact and package of bills in 2008 established a new water management process and **Water Withdrawal Assessment Tool (WWAT)**

**WWAT** is a screening tool created and used by the state to evaluate the potential impact of large quantity withdrawals on nearby rivers and streams.

Watersheds that are fully subscribed in the WWAT’s accounting database may convene a local **Water Users Committee** to determine how resources will be shared among users. They are *encouraged* but not mandated.
Effective Governance Structure: Michigan’s Systems

- Water Users Committees can:
  - Evaluate the status of current water resources, water use and trends in water use within a watershed
  - Structure a voluntary agreement among water users to prevent an ARI, but not mandated
- Serious consideration needs to be given to overall effectiveness of committees, including their strength, roles, and limitations
Water Strategy

Water Quantity: Expanding Use of Agricultural Tile Drainage
Effective Governance Structure: Learning from Other States

- Exploring other models, policies, programs and approaches relative to their applicability in Michigan
- Arizona’s “Active Management Areas”
- Nebraska’s Water Resource Areas
Presentation Outline

- The BIG Picture
  - Food
  - Environmental Sustainability
- Example Situations
  - Large Scale
  - Local
- Information Technology (GIS) assistance
  - ELUCID
  - GLWMS
- Working Together
  - Integrated System for Sustainable Ecosystems
Demand

World Population

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>2.5 Billion</td>
</tr>
<tr>
<td>2011</td>
<td>7.0 Billion</td>
</tr>
<tr>
<td>2050</td>
<td>9.2 Billion</td>
</tr>
</tbody>
</table>

Source: United Nations
Water Quality: Saginaw Bay
Water Quality: Lake Erie
Mid-Michigan Water Quality

Mid-Michigan Stream Impairments

Stream Impairments (2012)
- Sedimentation/Siltation
- Phosphorus (Total)
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed High Intensity
- Barren Land (Rock/Sand/Clay)
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Grazing
- Woody Wetlands
- Emergent Herbaceous Wetlands
Mid-Michigan Water Quality

Mid-Michigan Stream Impairments

Stream Impairments (2012)
- Sedimentation/Siltation
- Phosphorus (Total)

High: 302
Low: 176
Solutions

ELUCID
elucid.iwr.msu.edu

The Great Lakes Watershed Management System
www.iwr.msu.edu/glwms
ELUCID

- Environmental Learning Using Computer Interactive Decisions

- Developed through a GLRI project

- Flint River Watershed
Great Lakes Watershed Management System

- Provides baseline non-point source pollution model estimates at field-scales
The ELUCID (Environmental Learning Using Computer Interactive Decisions) tool uses data and modeling results from multiple sources to support natural resource conservation. The common scenarios addressed here include Water Quality, Land Protection, Urban Planning, Stormwater Management and Project Mapping. The manual of the system can be accessed [here](#). The answers to frequently asked questions (FAQ) can be found [here](#). For more information about the system and the upcoming updates, you can visit the [project website](#). You may also email [IWR staff](#) with questions and comments.

- **Generic Entry**
  - **Go to Generic Entry Map**
    The Generic Entry Map allows users to select their own data layers to show on the map. It's intended for conservation technicians in the field. T...

- **Water Quality**
- **Land Protection**
- **Urban Planning**
- **Stormwater Management**
- **Project Mapping**
- **School District**
- **Flint River Watershed Tour**

©Institute of Water Research, Michigan State University
ELUCID - Flint River Watershed

Map Content:
- Flint River Watershed
- Base Maps
- Water Quality Maps
  - Subwatershed
  - Flint Watershed
  - Stream TMCL
  - Waterbody TMCL
  - Impaired Stream
  - Impaired Waterbody
  - Water Quality Assessment Status
  - No Discharge Zones (Stream)
  - No Discharge Zones (Waterbody)
  - Stream
  - Waterbody
  - Water Quality Data SP (mg/l) (DEC)
  - Water Quality Total P (mg/l) (DEC 1)
  - Water Quality Total P (mg/l) (DEC 2)
  - Total P Load (lbs/acre/year) by Subw.

Locations:
- Freeman Drain-Flat River
- Brent Run
- Clark Drain-Flint River
- Gilkey Creek-Flint River
- Crawford Drain-Mistiguiay River
- Cole Creek-Flint River
- West Branch Swartz Creek
- Tower Creek
- Leperian Creek-Flint River
ELUCID - Flint River Watershed

Map Content:
- Ganansaei UDAR Relief (Smoothed)
- Ganansaei UDAR Relief
- Physical Maps
  - Waterfall
  - SSURGO Soil
  - Geology
  - Land Cover 2011
  - OPR
- Hit Sediment/Erosion
  - Resin
  - Watershed-HUC8
  - Sub-watershed-HUC10
  - Sub-watershed-HUC12
  - sediment
    - > 0.1
    - 0.1 - 0.5
    - 0.5 - 1.0
    - 1.0 - 1.5
    - > 1.5
  - erosion
- Cities and Townships
- Roads
- Aerial Photos

[Map of Flint River Watershed with various labeled locations]
ELUCID - Flint River Watershed

Map Content:
- Genesee LiDAR Relief
- Genesee LiDAR Relief
- Physical Maps
- Wetlands
- S3URGO Soil
- Geology
- Land Cover 2011
- DEM
- HiT Sediment/Erosion
  - Resin
  - Watershed-HUC3
  - Sub-watershed-HUC10
  - Sub-watershed-HUC12
  - sediment
    - < 0.1
    - 0.1 - 0.5
    - 0.5 - 1.0
    - 1.0 - 1.5
    - > 1.5
- Cities and Townships
- Roads
- Aerial Photos
ELUCID - Flint River Watershed
ELUCID - Flint River Watershed

Map Content:
- Waterbody
- Water Quality Data (mmpL) (DEQ 2006)
- Water Quality Total P (mmpL) (DEQ 1999)
- Water Quality Total P (mmpL) (DEQ 2003)
- Total P Load (basin) by Subwatershed
- Cattle Counts by Subwatershed
- Septic Systems Counts by Subwatershed
- Total Crop Acreage by Subwatershed
- Sediment by NHIDPlus Catchment (tons)

Options:
- Land Protection Maps
- Physical Maps
- HIT Sediment/Erosion
- Basin
- Watershed-HUC9
- Sub-watershed-HUC16
- Sub-watershed-HUC12

Legend:
- 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- >1.5

Other Options:
- Cities and Townships
- Roads
- Aerial Photos
Great Lakes Watershed Management System (GLWMS) is an on-line tool that allows users to evaluate non-point source (NPS) pollution model estimates at watershed and field scales. The system links two water quality models: High Impact Targeting (HIT) from the Institute of Water Research at Michigan State University, and the Long Term Hydrologic Impact Assessment (L-THIA) from the Purdue University's Department of Agricultural and Biological Engineering. HIT estimates sediment loading from agricultural lands to nearby streams; L-THIA estimates run-off volumes and pollutant loads.

The GLWMS allows users to view HIT and L-THIA estimates at watershed scales, and conduct field scale scenario evaluations of land cover changes or best management practices (BMPs).

The system is currently available for the priority basins of the EPA's Great Lakes Restoration Initiative: the Fox River Basin of Wisconsin, the Saginaw River Basin of Michigan, the Maumee River Basin of Ohio, and the Tennessee River Basin of New York.
Great Lakes Watershed Management System

**Baseline Change Results**

- **Scenario:**
  - Baseline: 6.24 tons/yr
  - Scenario: 2.98 tons/yr
  - Reduction: 3.26 tons/yr

*HIT data to include:*  
- erosion
- sediment
Great Lakes Watershed Management System

**Baseline NPS for Fields**

*report period: Annual*

<table>
<thead>
<tr>
<th>Acreage:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total acres (upland):</td>
<td>77.1 (0.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acres by scenario type:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline NPS</td>
<td>77.1</td>
</tr>
<tr>
<td>Baseline Change</td>
<td>0.0</td>
</tr>
<tr>
<td>Dual Scenario Change</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-point Source Pollution:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HIT sediment loading (tons/yr.):</td>
<td>14.20</td>
</tr>
<tr>
<td>HIT soil erosion (tons/yr.):</td>
<td>75.70</td>
</tr>
<tr>
<td>LTHIA total runoff (acre-ft./yr.):</td>
<td>19.70</td>
</tr>
<tr>
<td>LTHIA total Phosphorus (lbs./yr.):</td>
<td>64.84</td>
</tr>
<tr>
<td>LTHIA total Lead (lbs./yr.):</td>
<td>0.08</td>
</tr>
<tr>
<td>LTHIA total Copper (lbs./yr.):</td>
<td>0.12</td>
</tr>
<tr>
<td>LTHIA total Zinc (lbs./yr.):</td>
<td>0.87</td>
</tr>
</tbody>
</table>
FARM BILL

- REGIONAL CONSERVATION PARTNERSHIP PROGRAM (RCPP)
Irrigation Water Quality Criteria

High concentrations of chloride make groundwater unfit for human consumption and for many agricultural uses and are detrimental to the environment. When salt water is introduced to areas unadjusted to saline conditions, it damages sensitive crops, causes habitat losses, adversely impacts groundwater dependent ecosystems, and contaminates drinking water.

The drinking water recommended standard for chloride is 250 mg/L.

The table below shows irrigation water quality criteria.

<table>
<thead>
<tr>
<th>Chloride</th>
<th>Effect on crops</th>
<th>Susceptible plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mg/L or ppm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>below 70</td>
<td>Safe for most plants</td>
<td>Rhododendron, azalea, blueberry, dry beans</td>
</tr>
<tr>
<td>70–140</td>
<td>Sensitive plants show injury</td>
<td>Onion, mint, carrot, lettuce, pepper, grape, raspberry</td>
</tr>
<tr>
<td>140–350</td>
<td>Moderately sensitive plants show injury</td>
<td>Potato, alfalfa, sudangrass, squash, wheat, sorghum, corn, tomato</td>
</tr>
<tr>
<td>above 350</td>
<td>Can cause severe problems</td>
<td>Sugarbeet, barley, asparagus, cauliflower</td>
</tr>
</tbody>
</table>

Source: Adapted from Ayers and Westcot (1995).
Water Resource Study

- Ottawa County

Areas with Significantly Elevated Chloride Concentrations in Groundwater

This slide shows an overlay of scattered chloride concentration values (point symbols) and their moving window average (continuous color background).

This map is useful in identifying broad trends and patterns in the spatial distribution of chloride concentrations.

Note the chloride concentrations in the following areas are significantly elevated (>100 mg/L):

1. Crockery Township and Northern End of Robinson Township
2. West Allendale Township and East Robinson Twp.
3. Northern part of Blendon Township
4. Northeastern Corner of Olive Township
5. South of Zeeland, especially near the border with Allegan County
6. South of Tallmadge Township (north side of the Grand River Corridor)

mg/L

6/14/2013
Water Resource Study

Ottawa County

Basin-scale Groundwater Dynamics

Basin-scale hydrologic research also suggests that the naturally occurring saline water in the deep formations is inching upward toward the surface, particularly in the lowland areas, or the regional groundwater discharge areas of the state (e.g., Mandle and Westjohn, 1989; Westjohn et al., 1994; Westjohn and Weaver, 1996a, b, c; Holtschlag, 1996, 1997; Gilling et al., 1996; Meissner et al., 1996; Wahrer et al., 1996; Hoaglund et al., 2002).

Computer simulation showed that the Grand River flooding across the Lower Peninsula created both a topographic and water table depression. Model simulations inferred that these areas are likely to be basin-scale groundwater discharge regions, because of the presence of saline groundwater near the land surface in these lowlands.

Steady-state simulations of regional groundwater flow suggest that the presence of saline groundwater in the regional discharge areas results from the upwelling of deep saline groundwater within the regional groundwater flow system. (See also WSO-08400) (Mandle and Westjohn, 1989).

Marshall Formation

Ottawa County is part of the western master discharge zone for the Marshall Formation.
Chloride Contamination in the Saginaw and Ottawa Lowlands

In this slide we visualize Ottawa Lowlands and Saginaw Lowlands in 3D and compare side by side their chloride concentration distribution. The red dots represent wells with chloride concentrations higher than the drinking water standard.

The results clearly show that the two master groundwater discharge areas of deep geological formations stand out in elevated chloride concentrations.

The Saginaw and Ottawa lowlands share the following common characteristics:

- Coastal areas at low elevations in Michigan.
- Master discharge areas of deep geological formations.
- Presence of an extensive surficial clay layer limiting natural recharge to the deep bedrock aquifer.

Saginaw and Ottawa Lowlands are the two master discharge areas of saline groundwater in the Deep Marshall Sandstone Formation.
Water Resource Study

- Ottawa County

Ottawa County Interactive Water Resources Decision Support System
Groundwater Salinity Assessment Map
Summary

- Increasing pressure on agriculture for food
- Water quality issues on a local and large-scale
- Information Technology assistance is available
- Collaboration can help solve existing problems
Questions

- Questions? Contact Dr. Jon Bartholic: bartholi@msu.edu

- Institute of Water Research at Michigan State University: http://www.iwr.msu.edu/