Reasons for GW Monitoring

- Water Availability/Water Supply
- Conflict Resolution
- Drought Warning
- Diversion of Great Lakes Water by GW Pumping
- Water Quality in the Nearshore Zone
Public Supply, 2001 - 2004 Stress Period.
Blue - glacial wells, Brown - bedrock wells, 7600 total
GW Monitoring for Lake Michigan Basin
Aspects of the GW Flow System

- Understand monitoring data with respect to the gw flow system
- Most areas will need to have deep and shallow monitoring wells – bedrock and glacial deposits
- Karst and fractured-rock aquifers are a special case
Figure 7. Distribution of dissolved chloride in ground water from the Marshall aquifer, Upper Peninsula of Michigan.
Ground-Water Divides

A

Natural conditions
Stream
Ground-water divide
Water table
Confining unit

B

Affected by pumping
Stream
Ground-water divide
Water table
Confining unit
Lake

High-capacity pumping well
Circle areas proportional to pumping rate (cubic ft/day) with 100,000 as the reference.
Circle areas proportional to pumping rate (cubic ft/day)

2000 - 2010
Ground-Water/Surface-Water Interaction

- Nearly 80 percent of discharge to Lake Michigan originates as ground water.
- How does gw pumping affect ecosystems dependent on gw discharge to streams?
- Important for water-quality issues such as non-point source.
Importance of Old GW Level Data

- Lots of GW level data starting in the 1930’s
- Many sites discontinued in the 1970’s and 1980’s
- Water-level data to identify hydraulic properties – days to months
- Water-level data to address long-term gw development – years to decades
<table>
<thead>
<tr>
<th>Date</th>
<th>Hour</th>
<th>Depth to Water</th>
<th>Elev. of Water Surface</th>
<th>Meas. St.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 31</td>
<td>12:00</td>
<td>30.6</td>
<td>33.12</td>
<td>32.00</td>
<td>-1.38</td>
</tr>
<tr>
<td>Feb. 17</td>
<td>11:39</td>
<td>31.3</td>
<td>33.86</td>
<td>33.00</td>
<td>-1.84</td>
</tr>
<tr>
<td>Mar. 29</td>
<td>3:00</td>
<td>30.4</td>
<td>32.96</td>
<td>32.00</td>
<td>-1.64</td>
</tr>
<tr>
<td>Apr. 27</td>
<td>11:15</td>
<td>30.5</td>
<td>33.05</td>
<td>33.00</td>
<td>-2.45</td>
</tr>
<tr>
<td>May 29</td>
<td>3:50</td>
<td>32.4</td>
<td>34.69</td>
<td>33.00</td>
<td>-0.51</td>
</tr>
<tr>
<td>Jun. 11</td>
<td>3:12</td>
<td>32.6</td>
<td>35.10</td>
<td>35.00</td>
<td>-3.50</td>
</tr>
<tr>
<td>Jul. 27</td>
<td>4:30</td>
<td>34.8</td>
<td>36.13</td>
<td>37.00</td>
<td>-2.87</td>
</tr>
<tr>
<td>Aug. 13</td>
<td>10:55</td>
<td>38.2</td>
<td>39.65</td>
<td>35.00</td>
<td>-1.82</td>
</tr>
<tr>
<td>Sep. 26</td>
<td>12:16</td>
<td>39.5</td>
<td>39.3</td>
<td>36.00</td>
<td>-2.18</td>
</tr>
<tr>
<td>Oct. 30</td>
<td>12:30</td>
<td>32.7</td>
<td>32.20</td>
<td>35.00</td>
<td>-2.80</td>
</tr>
<tr>
<td>Nov. 27</td>
<td>1:35</td>
<td>32.35</td>
<td>31.85</td>
<td>SCH</td>
<td>34.00</td>
</tr>
</tbody>
</table>
GW Monitoring for Lake Michigan Basin
Monitoring Principles

- First and foremost, a collaborative process is required
- Organize so that the same data can be analyzed for both local and regional purposes
GW Monitoring for Lake Michigan Basin Monitoring Areas

- Areas with large withdrawals
- Areas not effected by withdrawals (for drought and climate studies)
- Areas to be developed
- Areas with important amounts of recharge
GW Management Decisions

- Most are made at the State or local level
- Effective monitoring must involve these units of government
- However, gw issues are becoming more regional
Geologic Maps
WelLogic Lithology
Aquifer Tests

Ground-Water Inventory and Map

Hydrogeology
Mapping
Geostatistics
Geographic Database

RASA Studies
Local Studies

125 years of science for America
Michigan State University
Ground-water Management Areas

- Centered on Waukesha and Brown County
- Areas of significant drawdowns and over-pumping
- Water quality problems (arsenic, radium, salinity)
- Need for a coordinated management strategy
Monitoring Adapted to Degree of Confinement

- **Unconfined**
  - Gravity drainage
  - Less water-level change
  - Cannot effectively use entire saturated thickness

- **Confined**
  - Aquifer compression and water expansion
  - Hydraulic pressure reduced
  - Pumping same quantity of water produces larger water-level declines than unconfined aquifers
Ground-Water Monitoring and Ground-Water-Flow Models

- Used to indicate the status and trends of ground-water availability
- Relate regional modeling simulations to sub-regional scale model simulations
- Climate variability and effects of climate change on recharge and shallow flow systems
- Iterative process – monitoring improves model and vice versa
- Model provides a logical way to evaluate the GW monitoring network
Lake Michigan Basin Model Domain
Lake Michigan (values in cubic feet per second)

- Precipitation on lake: 53,000 ft³/s
- Direct surface-water runoff: 8,800 ft³/s
- Ground-water discharge to streams entering the lake: 32,000 ft³/s
- Direct ground-water discharge to the lake: 2,700 ft³/s
- Diversions into Lake Michigan: 50 ft³/s
- Return flows from water users: 6,000 ft³/s
- Evaporation from the lake: 41,000 ft³/s
- Outflow to Lake Huron: 52,000 ft³/s
- Ground-water withdrawals from within the basin: 7,500 ft³/s
- Surface-water withdrawals from within the basin: 2,100 ft³/s

a Return flow is reduced by 3,200 ft³/s that is diverted out of the basin at Chicago, Ill.
b Withdrawals for power plant cooling not included
Nitrate Concentrations in Michigan

Source: MDEQ WaterChem Database, 1983-2003 samples
Opportunities to promote regional Ground-Water Monitoring in the Lake Michigan Basin

- Annex to the Great Lakes Charter
- Great Lakes Regional Collaboration
- LaMP Process
- SOLEC
The Great Lakes
An International Treasure