THE PROTECTION & STEWARDSHIP OF CRYSTAL LAKE AND ITS WATERSHED

Presented for:

Hey and Associates, Inc.

January 13, 2016
PROJECT PARTNERS
CRYSTAL LAKE AND ITS WATERSHED

- Crystal Lake – some background
- Implementation and BMP Monitoring
- Lake Condition and Management
- Lippold Project
CRYSTAL LAKE

• Glacial Lake
• High Quality, Mesotrophic
• Over 100,000 Users Annually
CRYSTAL LAKE WATERSHED

- 3,175 acres
- Mostly undeveloped north of lake
- Sewer and water planned
# Crystal Lake Watershed

<table>
<thead>
<tr>
<th>Name</th>
<th>Drainage Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lippold Watershed</td>
<td>2,400</td>
</tr>
<tr>
<td>Cove Pond and Woodland Wetland</td>
<td>640</td>
</tr>
<tr>
<td>Direct Drainage Area</td>
<td>190</td>
</tr>
<tr>
<td>Lake Surface Area</td>
<td>233</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,463</strong></td>
</tr>
</tbody>
</table>

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## Lake Bathymetry

<table>
<thead>
<tr>
<th>Parameter (units)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Surface Area (acres)</td>
<td>233.2</td>
</tr>
<tr>
<td>Maximum Depth (ft)</td>
<td>40</td>
</tr>
<tr>
<td>Mean Depth (feet)</td>
<td>14.7</td>
</tr>
<tr>
<td>Area Deeper than 10 Feet (%)</td>
<td>54%</td>
</tr>
</tbody>
</table>
CRYSTAL LAKE WATERSHED SOILS

- Mostly HSG B
- Infiltration Rate > 20 in/hr below 5 feet
**Geologic Cross-section of the Crystal Lake Area**

North

South

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Crystal Drainage District and Drainage Tiles

- Built in 1917
- Covers 1,300 acres
- About 5 feet deep
CRYSTAL LAKE WATER BUDGET

Crystal Lake Inflow (ac-ft)

- Lippold (Tile): 44.4%
- Cove Pond: 16.2%
- Precipitation on Lake: 17.2%
- Groundwater: 17.1%
- Direct Surface Runoff: 5.2%
Protect the quantity and quality of water reaching the lake

- No reduction in quantity of water reaching the lake
- Quality of water reaching lake is no worse than quality of water in the lake
- Protect quality of the groundwater in aquifer
- Ensure stormwater infiltration designs are sustainable
- Provide mechanism for long-term maintenance
**Development Issues**

- Shift in water budget from groundwater to surface water by storm sewers
- Urban runoff pollutants especially phosphorus (in-lake target < 0.02 mg/l)
- Increased volume of stormwater to be managed
- Most groundwater enters a 90-year old tile system that needs maintenance
- Stormwater management systems must be properly built and maintained
Regulations Review Initiated in 2005

Historical Regulations

- 1975 Management Plan had many far-sighted recommendations which led to Crystal Lake Stormwater Ordinance
- Impervious area greater than 20% not allowed

Updated Approach

- Enhanced technical criteria for stormwater management
- No longer rely solely on impervious surface reduction to accomplish lake protection objectives
CITY OF CRYSTAL LAKE
Crystal Lake Watershed Stormwater Management Design Manual

Prepared by:
Hey and Associates, Inc.

November 6, 2007
Seven Step Process in Design Manual

1. Pollutant Source Control Plan
2. Runoff Reduction Evaluation
3. Separate Design Sizing Criteria
   - Permeable Pavement
   - Grass Swale
4. Underdrains
5. Energy Dissipator
6. Wet Basin
   - 2-Year 24-Hour Live Storage
7. Infiltration Basin
   - At least 100-Year 24-Hour Live Storage

- Construction Quality Control
- Perpetual Monitoring and Maintenance
SITE EVALUATION AND SCREENING

- Assess Infiltration Requirements
- Evaluate Infiltration Feasibility Screening
  Soil Boring
  Field Infiltration Rate Tests
- Define Other Development Constraints
  Floodprone Areas (onsite and downstream)
  Wetlands
  Other Code Requirements
Step 1: Source Control

- Phosphorus ban in the watershed
- Herbicide and pesticide limitations
- Minimized use of road salt
- New developments required to submit annual usage plans
1. Minimize site impervious surfaces
2. Route impervious to pervious areas prior to BMPs
   • Rain gardens
   • Filter Strips
   • Bio-retention
   • Swales to replace storm sewers
   • Permeable pavement
Reduce Effective Imperviousness

Rain Garden

Vegetated Swale

Permeable Pavement

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Step 4: Water Quality Treatment Practices

- Reduce annual average total phosphorus to <0.10 mg/l prior to infiltration basin
  1. Wet detention
  2. Wetland detention
  3. Bio-retention

- BMPs also effective for nitrogen, metals and organics
Pre-Treatment Best Management Practices

Wet Detention

Bio-retention

Wetland Detention

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**STEP 5: INFILTRATION BASINS**

- **Infiltration requirements**

  1. Require field infiltration testing and a soil evaluation report
  2. Infiltrate > 90% of annual runoff volume
  3. Gravity discharge only for events > 2-year, 24-hour recurrence
  4. Require filtration through engineered soils and vegetation prior to infiltration
  5. Maintain four foot separation from basin bottom and groundwater
  6. Require setbacks from wells
  7. Increase groundwater flow to lake
  8. 50 foot separation from existing farm tiles and no new connections
  9. No Class V Injection Wells
Steps 6 and 7: Construction and Monitoring/Maintenance

- Evaluation and critique of the draft design manual at public meetings.
- Led to request to develop an implementation program.
Implementation Plan

• Provides more detail on how watershed regulations would be executed by City.

• Gives specific details on responsibilities of developers, property owners and City.
IMPLEMENTATION PLAN

- Regulation
- Education
- Monitoring
- Tracking

- Inspections
- Maintenance
- Enforcement
- Funding
REGULATION

Ensure the goal of protecting the quality and quantity of water reaching Crystal Lake is achieved and maintained in perpetuity.
Creation of a brochure for stakeholders, developers and potential land purchasers:

- Explanation of importance and function of watershed and relationship to lake.
- Map showing area.
- Adverse impacts of fertilizers, pesticides, herbicides, phosphorus and sodium chloride.
- Overview of types of Best Management Practices that can be utilized.

Available on City website at [www.crystallake.org](http://www.crystallake.org), Departments, Engineering, Crystal Lake Watershed
CITY MONITORING

- Installed six new wells throughout watershed area.
- Expanded the current monitoring program to include groundwater quality.
- Tile line flow monitoring.
- Analyze priority pollutants once a year.
- Completed by in-house Public Works staff.

Main purpose is to establish baseline data.
Development Monitoring

Developers also have responsibilities on their site as defined in the Design Manual:

- Monitoring ports on tile lines entering and leaving their property;
- Monitoring wells upgradient and downgradient points on their property; and
- Monitoring port in their infiltration basins.
Currently utilize existing system but this may be expanded as the program gets larger with more development.

Four properties currently redeveloped with one more in the near future.
INSPECTIONS

During construction:
• Completed by City Engineering inspectors

After construction:
• Completed by City hired consultant firm
Perpetual maintenance to ensure system is functioning as designed.

Routine maintenance completed by City hired consultant.

Large scale maintenance completed by City hired contractor.
INSPECTION AND MAINTENANCE

Ownership and Maintenance Responsibilities of Stormwater Facilities:

• Residential – City with cost assessed to homeowners via Special Service Area tax.

• Non-Residential – City has inspection and enforcement responsibilities to perform proper maintenance of the facilities. Cost paid via owner with an annual deposit to the City. Platted stormwater easement area and agreement.
City’s authority and regulatory powers are provided in the existing Codes to provide enforcement to remedy any circumstances of non-compliance.

Currently funded by City using existing staff but may need to be re-evaluated as development and program grow.
MONTHLY SITE INSPECTIONS

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MONTHLY SITE INSPECTIONS
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Quarterly Groundwater Sampling

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CRYSTAL LAKE WATERSHED
Lake & Lake Management

- Lake Levels/Hydrology Monitoring
- Water Quality
- Aquatic Vegetation Management
- Exotic Species
- Lippold Park Wetland Enhancements
- Question and Answer
HYDROLOGY MONITORING

- Water Budget
  Inputs – Outputs = Change in lake level

- Where does Crystal Lake get its water and where does it go?
CLPD SURFACE RUNOFF AND TILE FLOW MONITORING
CLPD GROUNDWATER MONITORING WELLS
Lake Levels

Stilling Well

Staff Gauge
CRYSTAL LAKE MEASURED LAKE LEVEL

Crystal Lake Measured Lake Level

Lake Stage


885.00 886.00 887.00 888.00 889.00 890.00 891.00 892.00 893.00

890.9 NWL

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HYDROLOGY (2015 WATER INPUTS)

- Precipitation Runoff: 20%
- Groundwater: 17%
- Cove Pond: 9%
- Lippold: 51%
- Lake Surface: 3%
HYDROLOGY (2015 WATER OUTPUTS)

- Losses: 64%
- Evaporation: 24%
- Groundwater: 11%
- Surface: 1%

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Crystal Lake Pollutant Sources

- Phosphorus inputs to the lake are most important
- Principal inputs are Lippold and Cove Pond
City of Crystal Lake Water Quality Monitoring Sites

City Sampling Locations:
A. Lake
B. Crystal Creek
C. Sod
D. Lippold Park Eff.
E. Lippold Park Inf.
F. Lippold Park West
G. Lippold Park Center
H. Lippold Park East
I. Cove Pond Infl.
J. Cove Pond Eff.
Lake Sampling Locations

West Bay

Mid-Lake
In-Lake Water Quality Monitoring Results

- Temperature
- Dissolved Oxygen
- Phosphorus
- Clarity (Secchi Disk)
- Algae (Chlorophyll a)
**Nutrient / Clarity Relationships**

Total Phosphorus

Algae (Chlorophyll a)

Water Clarity (Secchi Disk)
Total Phosphorus Inputs: 2015

- Honesuckle: 59%
- Dry Fallout: 20%
- Direct Runoff: 7%
- Groundwater: 3%
- Cove Pond: 7%
- Precipitation: 4%
TOTAL PHOSPHORUS INPUTS: 2005 TO 2015

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**Monitoring Results: Chlorophyll a**

- Chlorophyll a results consistently show algae at less than 1 ug per liter of lake water

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MONITORING RESULTS: SECCHI DISK

Annual Secchi Transparency (Average, Maximum, & Minimum)
Representative Site Only

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Monitoring Results 2015: Carlson Trophic State Index (TSI)

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What Do TSI Results Mean?

- Crystal Lake is Mesotrophic
  - Water is relatively clear
  - Moderately productive
  - Hypolimnion is anoxic in summer
    - Free of oxygen below the thermocline

- Conclusion is that the lake continues to be in excellent health
TSI COMPARISONS (OTHER REGIONAL LAKES)

- Crystal Lake
- Fox Lake (IL)
- Lake Zurich (IL)
- Lake Beulah (WI)
- Lake Delavan (WI)
- Green Lake (WI)
- Pleasant Lake (WI)

TSI Value

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AQUATIC PLANTS
## Aquatic Plant Statistics by Year

<table>
<thead>
<tr>
<th>Year</th>
<th># Species Lake-wide</th>
<th># Native Species Lake-wide</th>
<th>Overall Frequency Occurrence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>10</td>
<td>7</td>
<td>88.4</td>
</tr>
<tr>
<td>2007</td>
<td>14</td>
<td>11</td>
<td>94.7</td>
</tr>
<tr>
<td>2008</td>
<td>14</td>
<td>7</td>
<td>90.1</td>
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<td>2009</td>
<td>9</td>
<td>5</td>
<td>93.5</td>
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<tr>
<td>2010</td>
<td>11</td>
<td>7</td>
<td>82.9</td>
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<td>2011</td>
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<td>10</td>
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<td>2012</td>
<td>8</td>
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<td>8</td>
<td>96.8</td>
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<td>11</td>
<td>8</td>
<td>96.9</td>
</tr>
<tr>
<td>2015</td>
<td>11</td>
<td>8</td>
<td>97.0</td>
</tr>
</tbody>
</table>
Aquatic Plant Density 2014-2015

2014

Total Plant Density Sept. 2014 Sampling

2015

Total Plant Density September 2015 Sampling

Plant Density Key
- 5 - Dense
- 4 - Abundant
- 3 - Medium
- 2 - Scarce
- 1 - Rare
- 0 - Not Present
Native Plant Density September 2015

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MILFOIL PLANT DENSITY JUNE 2015 AND SEPTEMBER 2015

June 2015

September 2015

Plant Density Key
- 5 - Dense
- 4 - Abundant
- 3 - Medium
- 2 - Scarce
- 1 - Rare
- 0 - Not Present

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**Zebra Mussels**

- Zebra mussels were found in Crystal Lake in 2007.
  - Attached to aquatic plants, rocks, and native mussels on lake bottom
  - Decline in numbers since the peak in 2009 has leveled off
  - Can see a correlation between mussel population and lake clarity (secchi depth)
Vegetation Types

Native

Non-native
**Hybrid Watermilfoil**

- Hybrid Watermilfoil
  - Samples taken at from West Bay and the north side at Mid-lake
  - Sent in for genetic testing...Positive results
  - Adjusted product application rates for effective control
BEACH TREATMENT LOCATIONS

- West Beach
- Main Beach

Site 1: 3.0 ac/3’ avg depth
Site 2: .10 ac/3’ avg depth

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TREATMENT OF NON-NATIVE SPECIES (MILFOIL)

Site 1
Site 2
Site 3
Site 4
Past Harvesting in West Bay

- Not performed this year
LIPPOLD PARK POND PROJECT

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Lippold Park Pond Project