Development of an Integrated Strategy for Meeting Dissolved Oxygen Standards Proposed for the Chicago Area Waterway System (CAWS)

David Zenz
MWRDGC Monitoring and Research Seminar Series
October 30, 2009
Presentation Overview

- Study Objectives & Waterway System Overview
  - IEPA Proposed DO Standards
  - General Study Approach
  - Long List Evaluation of Technologies
  - Short List Evaluation of Technologies
  - Cost Estimate
Determine the Technologies and Costs to Meet New Proposed IEPA Dissolved Oxygen (DO) Water Quality Standards for the Chicago Area Waterway System (CAWS)
Presentation Overview

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IEPA Proposed DO Standards

Aquatic Life Use “A” Waters

March through July
5.0 mg/l minimum at all times

August through February
4.0 mg/l daily minimum averaged over 7 days
3.5 mg/l minimum at all times

Aquatic Life Use “B” Waters

Year Round
4.0 mg/l daily minimum averaged over 7 days
3.5 mg/l minimum at all times

NSC
UNBCR
Cal-Sag
LCRN
Lower Calumet
Grand Calumet

LNBCR
Chicago River
SBCR
Bubbly Creek
CSSC
Upper Calumet
## IEPA Existing vs. Proposed DO Standards

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<th>Existing</th>
<th>Proposed</th>
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March through July / August through February
Presentation Overview

- Study Objectives & Waterway System Overview
- IEPA Proposed DO Standards

General Study Approach

- Long List Evaluation of Technologies
- Short List Evaluation of Technologies
- Cost Estimate
General Study Approach

- Develop Long List of potential options
- Develop Short List of potential options
- Consensus decision on final mix of options to meet proposed IEPA standards for
  - 90% Compliance with Standards
  - 100% Compliance with Standards
- Prepare detailed cost estimate
Presentation Overview

- Study Objectives & Waterway System Overview
- IEPA Proposed DO Standards
- General Study Approach

Long List Evaluation of Technologies

- Short List Evaluation of Technologies
- Cost Estimate
- Directly or indirectly increase CAWS DO to achieve IEPA proposed standards
- Have reliable cost data available
- Have a history of successful application, preferably in CAWS setting
Previously agreed upon Long List supplemental aeration technologies

- U-Tube
- Porous Ceramic Diffusers (Blower on Shore)
- Jet Aeration (Venturi Aeration System)
- Sidestream Elevated Pool Aeration (SEPA)

Previously recommended flow augmentation alternatives

- Aerated flow augmentation for UNSC
- Flow augmentation with supplemental aeration for Bubbly Creek
U-Tube (HPO)

HPO

Aeration Pump

U-Tube

PVC Pipe

Casing

Cap

Depth ~ 100 ft

Channel

Channel Bottom

Diffuser Pipe

Stockton, CA

HPO Tank
Porous Ceramic Diffusers

BLOWER HOUSE

WATER SURFACE

TOP OF SHEET PILING

DIFFUSER

DIFFUSER

CHANNEL BOTTOM

Sanitaire Ceramic Diffuser
Porous Ceramic Diffusers

Webster Avenue
Aeration Station
Jet Aerator

AIR INLET
(from blower)

PUMP
Supplemental Aeration

Presented to District by Others
- Coherent Water Resonator
- Venturi Oxygenator
- Stainless Steel Fine Bubble Disk Aeration

Technologies Suggested by AECOM
- Constructed Urban Waterfalls
- Barge Mounted Aeration

Sediment Treatment
- Capping
- Chemical Treatment
- Stabilization

Bubbly Creek CSO Diversion
- RAPS and Bubbly Creek CSOs to CSSC

Waterway Relocation
- Relocate Wilmette Pump Station
Presented to the District by Others

- Coherent Water Resonator
  Rejected due to:
  - Safety of electromagnetic waves unknown
  - Lack of full-scale application

- Venturi Oxygenator
  Rejected due to:
  - Cooling water discharges to CAWS are relatively small
  - Private sector approval required

- Stainless Steel Fine Bubble Disk Aeration
  Conditionally Rejected:
  - AECOM may consider as cost-effective alternative to ceramic diffuser aeration
Technologies Suggested by AECOM

- Constructed Urban Waterfalls
- Barge Mounted Aeration
- Architecturally significant constructed urban waterfalls could be used for oxygenation
- Have been applied in visible, high traffic areas
- Examples in New York and Canada were constructed for aesthetics, not for oxygenation
**Constructed Urban Waterfalls**

- New York City, New York
- 4 constructed
- $15 million construction cost

Image Source: flickr member bly2k
## Constructed Urban Waterfalls

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>- Directly increases D.O.</td>
<td>- Aeration efficiency is not known</td>
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<td>- Low construction cost</td>
<td>- Application as supplemental aeration has not been demonstrated</td>
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<td>- Emphasizes waterways within the architectural and artistic vision of urban areas</td>
<td>- Excessive height and spray may be required to reach desired level of performance</td>
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<td>- Potential tourism revenue generated</td>
<td>- Spray may impact river and shoreline users, such as:</td>
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<td>- NYC estimates $55M in Summer 2008</td>
<td>- Odor</td>
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<td></td>
<td>- Navigation</td>
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<td>- Spray contact</td>
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<td>- Winter operation difficulties</td>
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REJECTED
Barge Mounted Aeration

- River barge could inject $O_2$ into river via hydraulically operated diffuser lowered into water
- Water could be withdrawn from the river, oxygenated on-board the barge, and returned to the river
- Barge could also be fitted with surface aerators
- Barge would be moved to high oxygen demand areas
- Typically operated in wide, navigable waterways
Barge Mounted Aeration

- Shanghai, China
- $O_2$ generator on board
- 10,000 lbs $O_2$ per day

Image Source: Environmental Science & Engineering Magazine
# Barge Mounted Aeration

## Advantages
- Directly increases D.O.
- Demonstrated technology in CAWS type settings
- Cost data available
  - Can be brought to low DO waterways reaches as needed
  - Mobile with no permanent equipment required on land
  - Could be contractor operated
  - Research value for sampling and monitoring

## Disadvantages
- May negatively impact waterway traffic
  - May require multiple barges
  - High O&M costs
    - Labor
    - Fuel
    - Maintenance
  - Complex operations

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**Accepted Conditionally for Applicable Waterways**
Non-Aeration Technologies Considered

- Sediment Treatment
  - Capping
  - Chemical Treatment
  - Stabilization
  - On-Site Sediment Management

- Bubbly Creek CSO Diversion
  - RAPS and Bubbly Creek CSOs to SBCR

- Waterway Relocation
  - Wilmette Pumping Station Relocation

- Other Technologies
  - Aquatic vegetation
  - Micropore membrane aeration
  - Phytoremediation
  - Biological Additives
Sediment Treatment Technologies

- Capping
- Chemical Treatment
- Stabilization
- On-site Sediment Management
Sediment Capping

- Material is placed over contaminated sediment
- “Passive” materials, such as sand, are used solely to reduce contact with the water column
- “Active” materials can be used to bind or degrade heavy metals, PAHs, VOCs, PCBs, and other contaminants

### Capping Materials

- Clean sediments
- Sand
- Gravel
- AquaBlock®
- Geotextile mats

- Coke Breeze
- Apatite
- Granular Activated Carbon (GAC)
- Clay
- Nitrate, etc.
### Advantages

- Indirectly increases D.O.
- Record and history of application, including USEPA and USACE
  - Both S.O.D. and pollutant leaching are significantly reduced
  - “Active” capping may reduce contaminants in existing sediment
- Can provide clean surface substrate for recolonization of aquatic organisms
- Minimal impact on surrounding areas

### Disadvantages

- Benefits negated by future sediment deposition from CSO events
- Does not directly increase D.O.
- Testing needed for reliable cost estimate
- Leaves contaminated sediments in place
- Reduces water depth
- Long-term monitoring and maintenance
- Factors increase costs / reduce feasibility:
  - Fine sediments
  - High velocities
  - Ice jams
  - Freeze/thaw
  - Debris laden sediment
  - High gas production
  - Irregular channel bottom
Sediment Treatment Technologies

- Capping
  Conditionally accepted pending study by Dr. Melching using DuFlow model

- Chemical Treatment

- Stabilization

- On-site Sediment Management

Rejected Due to:
- Lack of cost data
- Lack of application in CAWS type systems
- Benefits negated by future CSO sediment deposition
- On-site sediment management requires sediment removal
Non-Aeration Technologies Considered

- Sediment Treatment
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- Other Technologies
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  - Biological Additives
- Discharge from RAPS and Bubbly Creek CSOs could be diverted to CSSC
- Provides an opportunity for a mixed-use flow augmentation tunnel
- Rejected
  - Expensive
  - Moves problem downstream
Waterway Diversion

- Relocate CAWS-Lake boundary to just upstream of NSWRP outfall
- ~4 miles of UNSC becomes part of Lake Michigan
- UNSC CSOs must be diverted to LNSC
- Rejected
  - Expensive
  - Negatively impacts Lake Michigan
Other Technologies

- Aquatic vegetation
- Micropore membrane aeration
- Phytoremediation
- Biological Additives

Rejected due to:

- Limited performance and cost information is available
- Untested in CAWS type system
- Feasibility and applicability is questionable without further research
 Alternatives Selected During Long List Workshop

- **Flow Augmentation**
  - Bubbly Creek (for SBCR)

- **Aerated Flow Augmentation**
  - Upper NSC

- **Supplemental Aeration**
  - U-Tubes
  - Porous Ceramic Diffusers
  - Jet Aeration
  - SEPA
  - Barge Mounted

- **Sediment Oxygen Demand Control**
  - Sediment Capping
    Evaluated by Dr. Melching using DUFLOW model
Findings from DUFLOW Model

- Reducing SOD can improve DO compliance during dry weather periods
- Reducing SOD has little effect on the very low DO resulting from storms and CSOs
- SOD reduction would not substantially reduce the size of aeration stations needed to achieve 100% compliance.

REJECTED
100% compliance with IEPA proposed standards may require:

- Supplemental aeration of UNSC
- Aerated Flow Augmentation of Little Calumet River upstream of Calumet WRP
- Aeration of Chicago River during stagnant conditions

For Aerated Flow Augmentation consider:

- Venturi Aerator
- Speece Cones
The following force-main aeration technologies were accepted for inclusion on the Long List:

- U-Tube (HPO)
- Venturi (HPO)
- Speece Cone (HPO)
## Short List Evaluation Technology Matrix

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# Short List Evaluation Matrix Summary

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(1) Decisions made at Short List Workshop on 8/21/2008
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(1) Decisions made at Short List Workshop on 8/21/2008
Project Status

- Short List of DO enhancement alternatives by waterway segment are completed
  - 90% compliance
  - 100% compliance

- DUFLOW modeling to determine location and sizing of DO enhancement alternatives not finalized

- Therefore detailed cost estimate has not been done

- “Rough cut” cost estimate to meet IEPA proposed DO standards has been presented at IPCB hearings
100% Compliance “Rough Cut” Cost Estimate Assumptions

- Supplemental Aeration and / or Flow Augmentation Only
- Order of magnitude estimate
- Ceramic diffusers with blowers on shore
- U-Tube aeration of augmented flow
- Sizing of aeration and augmented flow amounts based upon preliminary modeling
- Existing aeration stations at full firm capacity
- Inflation corrected costs derived from previous AECOM study for UAA

- Operating costs based upon:
  - 1 month full capacity
  - 7 months half capacity
  - 4 months out-of-service
Aeration Station Locations

- **Existing Aeration Station**
- **Proposed Aeration Station**

*All Stations 80 grams/sec unless noted*
Total Capital Cost: $524,800,000
Total Annual Cost: $6,870,000
Total Present Worth: $656,600,000
Current Activities

- District has developed its recommended CAWS DO standards
- DUFLOW modeling of supplemental aeration / flow augmentation necessary to meet District recommended standards is underway
- After modeling completion, AECOM to develop order of magnitude costs to meet District recommended DO standards
Future Activities

- Modeling of supplemental aeration / flow augmentation necessary to meet IEPA standards using updated Marquette model
- Based upon modeling, detailed cost estimate for meeting IEPA standards will be developed