Use of Wetlands for Stormwater and Wastewater Treatment

Speakers
Jim Bays/ CH2M HILL
Larry Schwartz/ SFWMD
Chris Keller/Wetland Solutions Inc.

Florida Chamber's
2014 Environmental Permitting Short Course
Marco Island Florida
July 24-25 2014
Topic Briefings

✔ Treatment Wetlands
  ✔ Jim Bays/CH2M HILL
✔ Stormwater Wetlands
  ✔ Chris Keller/Wetland Solutions Inc.
✔ Wetland Application Rule and Everglades Science Plan Overview
  ✔ Larry Schwartz/SFWMD

✔ Q&A

Copies of presentations on Conference Web Site
Treatment Wetlands

- Design Overview
  - Ecological Basis
  - Sizing
  - Hydrology and Hydraulics
  - Planting Design
  - Public Use
  - Operation and Maintenance

- Selected Case Histories and New Applications
Florida 46% Historic Wetland Loss in Response to Population Growth

Wetland Acres

- 1780s: 20,325,013
- 1980s: 11,038,200
- 70s-80s: -260,000

http://www.epa.gov/owow/wetlands/vital/epa_media/usa.gif
Legislation Counters Wetland Losses Using Effluent and Stormwater As Wetland Water Source

- Experimental Exemption for Wastewater Recycling 1979
- Warren Henderson Act 1984 (ERP)
- Wetlands Application Rule 1986
- Everglades Forever Act 1994
- Reuse Rule 1989 (last update 2007)
  - 10 systems, 33.4 mgd, 5440 acres (FDEP 2014)

Map of Wastewater Wetlands in Florida
[Approximate Locations]
REVISED 2007

Map of Wastewater Wetlands in Florida
[Approximate Locations]
REVISED 2007

- 1 Bayou Marcus
- 2 Rice Creek
- 3 St. John's County SR16
- 4 Blacks Ford
- 5 Hurlbut Field
- 6 Apalachicola
- 7 Boot Wetland
- 8 Jasper
- 9 Monticello
- 10 OCESA
- 11 Orlando Easterly Wetlands
- 12 Blue Heron
- 13 Yulee
- 14 South Central Regional
- 15 Yankee Lakes, Seminole
- 16 Hilliard
- 17 Waldo Wetlands
- 18 East Central Regional
- 19 Indian River
- 20 Leesburg
- 21 Wakodahatchee & Green Cay Wetlands
- 22 Northwood
- 23 Deer Park Wetlands
- 24 Petro Truckstop
- 25 Spencer
- 26 Pace Wetland
- 27 Lakeland, Glendale
- 28 Ft. Meade
- 29 Glades County
- 30 Port of the Islands South
- 31 Orange County Northwest
- 32 High Springs Commercial Park

Color Key
Natural Wetlands
Man-made Wetlands
Combination of Natural and Man-made

http://www.dep.state.fl.us/water/wastewater/dom/wetmap.htm
Wetlands for Water Treatment: Florida Origins and History

- **1970s**
  - Center for Wetlands (Odum)
  - Houghton L MI (Kadlec)

- **1980s**
  - Arcata Marsh CA
  - 1984 – Henderson Act
  - 1986 – Wetlands Application Rule
  - 1987 – Lakeland, Orlando

- **1990s**
  - EPA: TW Data Base
  - SFWMD: EFA, ENRP
  - SJRWMD: L Apopka Flow-way
  - SWFWMD: Rushton research

- **2000s –Implementation**
Definitions

Wetland:
- An ecosystem characterized by extended periods of saturation, resulting in hydric soils and dominated by vegetation adapted to such conditions

Constructed wetland:
- a manmade system designed to replicate the physical and ecological components of a natural wetland ecosystem

Treatment wetland:
- a natural or constructed wetland system engineered to reduce contaminants from water
Natural Wetlands for Treatment

Distribution Pipe

Outflow

Poinciana 1984

Blacksford Swamp 1999

Carolina Bays SC 1987

West Palm Beach 2004
Surface Flow Constructed Wetlands

Wakodahatchee 1996

Viera 2004

Orlando 1987
Other Natural Treatment Systems

Floating Aquatic Plant Systems
- Water Hyacinth

Periphyton/SAV
- PSTA

Floating Islands International

BeeMats

Floating Wetland Islands

Hydromentia
Wetlands Affect Water Quality Naturally

- N, BOD, Volatile Organics, Selenium
- Volatilization

- Nitrification / Denitrification
  - NO₃, NH₃

- Plant Uptake & Storage
  - Metals, N, P

- Annual Growth Cycle

- Sedimentation
  - TSS, Adsorbed Contaminants

- Precipitation
  - P, Metals

- Decomposition
  - Adsorbed Contaminants

- Burial & Soil Storage
  - ON, NH₃, P, Metals, Organics
  - Diffusion

Surface Water
Detritus
Sediments
Steady Progress in Treatment Wetlands Design


Annual South Florida Environmental Report

1990  2000  2010
A Preliminary Water Balance Is Needed to Ensure Adequate Water to Maintain Wetlands

Pumped or Gravity Inflow

Use vegetative indicators to establish target SHWL, NP elevations

Infiltration can be a planning objective
Compartments in Treatment Wetlands Aid System Hydraulics and Performance

- Inlet Distribution Zones
- Shallow Emergent Marsh
- Outlet Control Structures
- Cells in Series
- Parallel Flow Paths
- Deep Zones
- Habitat Islands
Effluent Treatment Wetland: Pretreatment Requirements
Surface Water/Stormwater Wetland: Pretreatment Requirements

- Runoff and Load Generation
  - Source Controls
  - Public Education
  - Erosion Control
  - Roof Runoff
  - Florida Yards
  - LID

- Conveyance and Pretreatment
  - Swales
  - Catch Basins
  - Filter Inlets
  - Oil/water Separators

- Additional Treatment and Attenuation
  - Storage Tank
  - Sediment Sump
  - Alum

- Final Treatment and Attenuation
  - Retention
  - Detention
  - Wetlands
  - Alum

Additional Pretreatment
- Runoff and Load Generation
- Conveyance and Pretreatment
- Additional Treatment and Attenuation
- Final Treatment and Attenuation

http://www.co.broward.fl.us/Stormwater/
General Performance Results Set General Expectations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Removal Efficiency</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>50 – 90%</td>
<td>2 – 10 mg/L</td>
</tr>
<tr>
<td>TSS</td>
<td>50 – 90%</td>
<td>2 – 10 mg/L</td>
</tr>
<tr>
<td>TN</td>
<td>40 – 90%</td>
<td>1 – 3 mg/L</td>
</tr>
<tr>
<td>TP</td>
<td>10 – 90%</td>
<td>&lt;1 mg/L</td>
</tr>
<tr>
<td>Fecal Coliforms</td>
<td>80 – 99%</td>
<td>&lt;100 – 1,000 col/100 mL</td>
</tr>
<tr>
<td>Metals</td>
<td>50 – 90%</td>
<td>Below Detection</td>
</tr>
</tbody>
</table>

*Removal efficiencies and effluent concentrations are very dependent upon influent concentration and hydraulic loading rate.*
Loading Coordinate Graph Establishes, Confirms Performance

The graph shows the relationship between TP effluent concentration (mg/L) and TP influent loading (kg/ha/d). The data points are categorized by source: Livestock, Industrial, Municipal, Other, and Stormwater. The graph includes specific points labeled as Orlando, Nat, HA, STAs, and Wakodahatchee. The line of best fit is represented by the equation $y = 2.0126x^{0.8523}$ with a $R^2 = 0.8098$. The graph also highlights areas corresponding to Freedom Park.
Wetland Treatment Performance Described by First-order Model

\[ Q \frac{dC}{dA} = -k(C - C^*) \]

Calibrate \( k \) by pollutant

Kadlec and Knight (1996)

**First-order treatment model**

\[
\left( \frac{C - C^*}{C_i - C^*} \right) = \frac{1}{(1 + k/Pq)^P}
\]

Example Wetland Performance

**Wetland Area**

\( C_{out}/C_{in} \)

0

1

**Graph**

- \( Q \) 1.2 mgd
- \( A \) 42 ac
- \( k \) 19 m/y
- \( C_i \) 430 ug/L
- \( C_o \) 80 ug/L TP
Orlando Wetlands Park FL: AWT Wetland Milestone

<table>
<thead>
<tr>
<th>In (mg/L)</th>
<th>Out (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN</td>
<td>2.4</td>
</tr>
<tr>
<td>TP</td>
<td>0.28</td>
</tr>
<tr>
<td>BOD</td>
<td>1.5</td>
</tr>
<tr>
<td>TSS</td>
<td>&lt;1.0</td>
</tr>
</tbody>
</table>

1,220 ac
12 cells
3 flow paths
20 mgd
>30 d HRT
Orlando Wetlands Meet Proposed Numeric Nutrient Criteria

Source: Sees, 2005
Install and Manage Vegetation for Biomass, Diversity, Aesthetics, Flow

- Thalia, Pontederia, Eleocharis, Sagittaria, Cladium
  - Emergent marsh
- Deep zone
  - Nymphaea, SAV
Treatment Wetlands Operations: Track Performance and Monitor Flow

- **Water Quality**
  - Monitoring
  - Constituent Loading

- **Hydraulic Operation**
  - Water Level and Flow Control
  - Flow Path Rotation

- **Vegetation Management**
  - Aesthetics and Exotics
  - Replacement for Hydraulics, Performance, Herbivory
  - Harvesting? No

- **Control of Nuisance Conditions**
Sediment Removal FAQ

An Uncommon Practice

- Decades of Storage
- Slow Accretion Rate
  - 0.1 – 0.5 in/yr
  - Near inlet
  - Build in storage in deep zones
  - Water level adjustment
- Stormwater Considerations
  - 5 – 10 year cycle: clean out forebay/inlet deep zone

Orlando Wetlands (2002-03)

- Disposed on-site
- 160,000 bulrush installed
- Areal efficiency increased from 0.34 to 0.74.

- Initial cells (59 ha)
- Vegetation, sediments, organic debris
- 130,000 m³

Source: Sees (2005)
Public Recreational Use Can Exceed Expectations

- Parking lot expanded from 10 to 50 in first year; still low.
- Available records indicate visitors increased from 165 in 1997 to conservatively 125,000 per year.
- Dec, Jan, Feb: 600 people per day.
- Birders, photographers, fitness walkers, and multi-generational groups.
- Featured in local and national media.
- Google “Wakodahatchee”:
  - 50 in 2004
  - 510 in 2013
Capital Cost Considerations

Source: Kadlec & Wallace (2009)

- $40,000/ac
- ~$100,000/ac

Source: Kadlec & Wallace (2009)
Everglades Construction Project: World’s Largest Treatment Wetlands

- 57,000 ac STA area
- 1,727 MT TP retained since 1994
- 74% TP Reduction
- FWM TP outflow 21 ppb
- WY 2013
  - 1,060,000 ac-ft treated
  - 84% TP Reduction
  - FWM TP outflow 21 ppb
  - 166 MT

Sources: SFER 2014
Freedom Park, Naples: Stormwater Treatment, Restoration, Recreation
Treatment Wetlands Sustain Native Diversity

- 50-ac: since 2009
- 200 Million Gallons of SW Flow into Naples Bay Treated per Year
- Nitrogen Reduced By 39% to 0.8 mg/L (background)
- Phosphorus Reduced By 82% to 30 ppb (nr. backgr.)
- Metal Concentrations Reduced to Background Levels
- Critical Component of County’s Stormwater Improvement Plan
Floating Wetland Islands: A Strategy for Nitrogen Reduction in Reclaimed Water

FWIs: After 1.5 years

Presence of Islands Improved
TN Reduction

- 45%
- 62%
- 30%

Total Nitrogen (mg/L)

CH2M HILL
Enhanced Wetlands ("Intensification") and System Integration Can Help Meet TMDLs

**Forced Bed Aeration**

- Air Header
- Air Line
- Air Line Connection
- Aeration Header
- Liner
- Mulch Layer
- Gravel Bed

**Integrated Media Filtration**

**Alligator Creek Treatment Train:**
1. Flow diversion (pump)
2. Forebay settling
3. Wetland treatment (2 cells)
4. Downflow gravel filtration
5. Upflow media adsorption
6. Re-aeration
7. Recirculation

- Bioreactors (Wood chip)

Wanielista & Flint 2012
Wetlands for Water Treatment: Perspective

- Versatile
  - Mass removal, concentration
  - New applications
- Passive, low energy, low O&M, stores nutrients
- Well-understood, good record
- Conserves land, creates habitat

Freedom Park, Naples FL

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