Stormwater ponds: Research and management

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“If you moved to Florida since 1880, you’re part of the problem,” said Reynolds at the Army Corps. "If you’ve eaten food you didn’t grow yourself, you’re part of the problem. If you’ve used the bathroom in the last 24 hours, you’re part of the problem. If you’ve driven on a road or lived anywhere there’s concrete or shopped in a store, you’re part of the problem,” she said. “So we’re all part of the problem.”
We are all part of a larger system:

“Getting the water right”

**TIMING**

+ **QUALITY**
STAs mandated by the Everglades Forever Act (EFA), section 373.4595, FL statutes

- Reduce TP concentration in surface runoff prior to discharging in the Everglades Protection Area
- Managed by SFWMD
- Total area is ~ 68,000 acres (57,000 effective)
- Treated over 4.8 trillion gallons and retained 1,874 t of P (75% load reduction)
- Average flow-weighed mean = 34µg/L (as low as 21µ/L in 2014)

Stormwater Treatment Areas: a green technology to clean water
Exposed limerock

Inflow with high phosphorus Concentration (200 µg L⁻¹)

Dense beds of Typha

Rooted SAV

Outflow with low phosphorus Concentration 25-50 µg L⁻¹

Exposed limerock

Stormwater Treatment Areas: a green technology to clean water
Exposed limerock

Inflow with high phosphorus Concentration (25-50 µg L⁻¹)

Additional treatment cell

Periphyton

Outflow with low phosphorus Concentration 30-15 µg L⁻¹
Stormwater ponds: a green technology to clean & regulate water
PRE-URBANIZATION
PRE-URBANIZATION
PRE-URBANIZATION

Filtration, Nutrients Uptake

Aquifer
POST-URBANIZATION

FRESHWATER, NUTRIENTS, METALS, DUST
FRESHWATER, NUTRIENTS, METALS, DUST

STORMWATER POND

FRESHWATER, NUTRIENTS, METALS, DUST

RECHARGE AQUIFER

80% CLEAN FRESHWATER
Stormwater Treatment Areas: a green technology to clean water

Chapter 62-40 of the Florida Administrative Code

Stormwater runoff to be slowed down in order to:

- prevent erosion
- allow siltation/sedimentation prior to reaching natural hydrosystems,
- promote soil filtration over adequate soils and thus permitting
- pollutant removal
- let the aquifer recharge to ultimately protect the delicate floral and faunal balances of the downstream coasts.

Through Chapter 62-40, stormwater pollutants to be reduced by 80% with respect to the State Water Quality Standards and changed to 95% reduction when such stormwater emptied into an Outstanding Florida Waterway (OFW).
Removal of at least 80% of pollutant load for class III and 95% removal for class I and class II waters. (Livingston 1993). Reduction:

- Total Suspended Solids (TSS) = 75 to 85%
- Total Nitrogen (TN) = 37 to 60%
- Total Phosphorus (TP) = 59 to 85%
- Metals = 40 to 80%

Slow down water runoffs to the sea and rivers thus mimicking the original hydro-patterns (infiltration during the dry season & deliveries during the rainy months)
Stormwater Treatment Areas: a green technology to clean water

Wet vs. Dry ponds

Dry pond
Stormwater Treatment Areas: a green technology to clean water

Wet vs. Dry ponds

Wet pond
Stormwater Treatment Areas: a green technology to clean water

Higher density next to the coasts, and on islands: They track the people

Collier County

3837 in 2013, 4220 (10% more) in 2018

7632 in 2013, 8400 (?) in 2018
Stormwater Treatment Areas: a green technology to clean water

Higher density next to the coasts, and on islands: They track the people

Collier County

3837 in 2013, 4220 (10% more) in 2018

7632 in 2013, 8400 (?) in 2018

Number of wet urban ponds in Lee County from 1961 to 2013
Stormwater Treatment Areas: a green technology to clean water

Lee County:
22.1 sq miles total planar area
average size: 1.8 acres, 1.8% of the County

Collier County:
17.6 sq miles total planar area
average size: 2.9 acres, 0.8% of the County
1.5 times the planar area of the Caloosahatchee River S. of Franklin Lock
Stormwater Treatment Areas: a green technology to clean water

The good algae: Periphyton
The periphyton:

- Is the base of the food chain
- Provides with most oxygen in the water column
- Arbors beneficial bacteria and invertebrates
- Disappears when the temperature is low (but especially grows during the rainy season)
- Does not release much nutrients when it decays
- Does not create odors when it decays likely because of its high calcium carbonate (chalk) content.
- When it decomposes, it creates a “slab” of limestone which isolates the lake bed. This is mostly inorganic calcium carbonate or chalk (low sediment built up).
- Can lock phosphorus as it dries up. Limestone is a trap for phosphorus.
- Can remove nitrogen through denitrifying bacteria
The misuse of ponds:

• People want wet retention/detention ponds: “Lakes” for the view

• But, open water is NOT a good way to sequester nutrients

• All efforts to limit nutrient loading into wet ponds should be made

• Dry ponds (i.e. wetlands) should be preferred as a more efficient water treatment
Pond misused

Folks want lakes, lake front view, no view obstruction, green lawns, clear water:
Pond misused

Folks want lakes, lake front view, no view obstruction, green lawns, clear water:

9% added value when
On lake view.
Pond misused

Folks want lakes, lake front view, no view obstruction, green lawns, clear water:
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Folks want lakes, lake front view, no view obstruction, green lawns, clear water:
Pond misused

Eutrophication
Pond misused
Top 5 poorest ponds (AMEC, 2011)

<table>
<thead>
<tr>
<th>LAKE</th>
<th>POLLUTANTS OF CONCERN</th>
<th>POLLUTANT REMOVAL EFFICIENCIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Lake (#9)</td>
<td>TN, TP</td>
<td>TN = -123%, TP = -192%, TSS = 27%</td>
</tr>
<tr>
<td>Lois Selfon (#31)</td>
<td>TN, TP, Fecal Coliform</td>
<td>TN = -3%, TP = 27%</td>
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<tr>
<td>Alligator Lake (#10)</td>
<td>TN, TP, TSS</td>
<td>TN = -18%, TP = 13%, TSS = -200%</td>
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<tr>
<td>Swan Lake (#2)</td>
<td>Copper, Fecal Coliform</td>
<td>TN = 47%, TP = 69%, Copper = -292%</td>
</tr>
<tr>
<td>Half Moon Lake (#24)</td>
<td>TN, TP</td>
<td>TN = -139%, TP = -363%</td>
</tr>
</tbody>
</table>

Pond misused
Pond misused

- South Naples (3 ponds, 1 community)
- City of Naples (2 ponds)
- North Naples (18 ponds, 3 communities)
- Estero/Bonita Springs (11 ponds)
- FGCU ponds (1 pond)
- Sanibel islands (8 ponds)
- Burnt Store Lakes (11 ponds)
Consequences of pond misused

Average Trophic status index

Ponds:
- Village Walk
- Longshore Lake
- Lake Manor
- Spring Lake
- Pelican landing E1
- Pelican landing C4
- Pelican landing D14
- Pelican landing E7
- Pelican landing E5
- Pelican landing E11
- Pelican landing D4
- Pelican landing B4
- Pelican landing A8
- Pelican landing A2
- Pelican landing A13
- Carlton Lakes 1
- Carlton Lakes 2
- Carlton Lakes 3
- Carlton Lakes 4
- Carlton Lakes 5
- Carlton Lakes 6
- Carlton Lakes 7
- Carlton Lakes 8
- Carlton Lakes 9
- Carlton Lakes 10
- Carlton Lakes 11
- Carlton Lakes 12
- Carlton Lakes 13
- Carlton Lakes 14
- Carlton Lakes 15
- Carlton Lakes 16
- Little Harbour North
- Little Harbour Center
- Little Harbour South
- Burnt Store Lakes 1
- Burnt Store Lakes 2
- Burnt Store Lakes 3
- Burnt Store Lakes 4
- Burnt Store Lakes 5
- Burnt Store Lakes 6
- Burnt Store Lakes 7
- Burnt Store Lakes 8
- Burnt Store Lakes 9
- Burnt Store Lakes 10
- Burnt Store Lakes 11

Trophic status:
- oligo
- oligo+
- meso
- eu
- eu+
- hypereu
- hypereu+
Consequences of pond misused

Pelican Landing
2,365 acres
91 wet ponds (216 acres)

4,000 homes
~300,000 sf of retail space 475,000 sf of office space
750 hotel/motel rooms
50,000 sf conference center
65 wet boat slips
150 dry boat storage spaces, and recreational amenities (e.g. 24 tennis courts, 77 holes golf courses, canoe/kayak parks, boat ramp and a beach park).
~143 acres of upland habitat preserve
678 acres of salt and fw marshes
162 acres of public & private rights-of-way
3 acres of off site parking, 6 acres of utilities
Pond misused
Consequences of pond misuse

Pollution export
Consequences of pond misused

Muck accumulation
Consequences of pond misused

Muck accumulation
Consequences of pond misused

Muck accumulation
Possible unexpected effects of ponds

Groundwater discharge

STORMWATER POND

FRESHWATER, NUTRIENTS, METALS, DUST

80% CLEAN FRESHWATER
RECHARGE AQUIFER

RECHARGE AQUIFER

?
Possible unexpected effects of ponds

Great hydraulic conductivity (2013)

Groundwater discharge
Possible unexpected effects of ponds

Groundwater discharge

![Map and chart showing groundwater discharge and possible effects.]

Legend:
- Urbanized campus
- Pinelands + wetlands
- Lakes
- FGCU
- Lake Miromar
- Lake Como
- Solar field
- Pond studied
- Golf courses/houses
- Agriculture
- Paved road
- Campus limits

Water flux density (L/m²/d):

<table>
<thead>
<tr>
<th>Month</th>
<th>Flow Rate (L/m²/d)</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>03/13</td>
<td>1413</td>
<td>0.20%</td>
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<tr>
<td>04/13</td>
<td>3887</td>
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<tr>
<td>05/13</td>
<td>2202</td>
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<tr>
<td>06/13</td>
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<td>07/13</td>
<td>334</td>
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<tr>
<td>08/13</td>
<td>-312</td>
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<td>09/13</td>
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<tr>
<td>10/13</td>
<td>650</td>
<td>0.09%</td>
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<tr>
<td>11/13</td>
<td>433</td>
<td>0.06%</td>
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<tr>
<td>12/13</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>01/14</td>
<td>6145</td>
<td>0.89%</td>
</tr>
<tr>
<td>02/14</td>
<td>-655</td>
<td>-0.09%</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Months:
Possible unexpected effects of ponds

Groundwater discharge
Possible unexpected effects of ponds
Possible unexpected effects of ponds

Groundwater discharge

232 pounds Phosphorus /year

Phosphorus comes mainly From groundwater. ➔ Water conc. 51ppb
Possible unexpected effects of ponds

Groundwater discharge

Groundwater Seepage

15.2 pounds Nitrogen/year
Fixing ponds

- Chemicals
- Dyeing
- Mixing
- Dredging (e.g. Lake Manor)
- Phytoremediation (Artificial Floating Islands)
- H₂O₂
- Bacteria and enzymes
Fixing ponds

- Chemicals
- Dyeing
- **Mixing**
- Dredging (e.g. Lake Manor)
- Phytoremediation (Artificial Floating Islands)
- $\text{H}_2\text{O}_2$
- Bacteria and enzymes
Fixing ponds

➢ **aeration**

Water surface

O2 dissolves into water

Temp is reduced

Convection cells are created so that the water is not stratified

P is locked into the sediment since DO is present

**Nutrients are released**

Aerobic respiration of the muck

**C(H2O) + O2aq → CO2 + H2O**

Limitation of anaerobic bacteria mediated reactions in the sediment (redox is increased)

Algae circle thru the water thus lowering their growth
Aerator efficiency: *seems* limited
Fixing ponds

- Chemicals
- Dyeing
- Mixing
- Dredging (e.g. Lake Manor)
- Phytoremediation (Artificial Floating Islands)
- $\text{H}_2\text{O}_2$
- Bacteria and enzymes
Fixing ponds

Lake Manor (pre dredging, 2013)
Fixing ponds

Lake Manor (pre dredging, 2013)
The 4-acre lake was just under $1,000,000.
Fixing ponds

- Chemicals
- Dyeing
- Mixing
- Dredging (e.g. Lake Manor)
- **Phytoremediation**
- $\text{H}_2\text{O}_2$
- Bacteria and enzymes
Fixing ponds

Found:

- Oxygenate the water with the plants roots
- Harbor beneficial bacteria
- Did not harbor zooplankton (but forage fishes)
- Roots had allelochemicals which controlled algae

Fixing ponds
Fixing ponds
Fixing ponds
Fixing ponds

• Chemicals
• Dyeing
• Mixing
• Dredging (e.g. Lake Manor)
• Phytoremediation (Artificial Floating Islands)
• $\text{H}_2\text{O}_2$
• Bacteria and enzymes
Using ponds as a tool to teach about water quality: Environmental Education


Project FLOW: Future Leaders of Water Quality; Enhancing Local Water Quality Through Environmental Stewardship

"These are going to be the citizens that grow up in Southwest Florida and maybe will live here in Southwest Florida and will be making decisions about policies that are going to impact us in the future," said Molly Nation, a professor of environmental education at FGCU.
Using ponds as a tool to teach about water quality: Environmental Education

• All school in Lee County have a stormwater pond
• Pond as hand on material to learn about:
  • Curriculum
  • Water quality
  • Watershed
  • Nutrient limitation/ eutrophication
  • Living shoreline benefits
  • Phytoremediation
  • And more...

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Acknowledgements