Application of the MIKE Marsh Model of Everglades National Park to Evaluate Restoration Alternatives

Kiren Bahm¹ and Amy M. Cook²
Robert J. Fennema¹, Georgio I. Tachiev², Kevin Kotun¹

¹National Park Service, Homestead, FL, USA
²GIT Consulting, Coral Gables, FL, USA

2016 National Conference on Ecosystem Restoration
Flow Patterns of the Everglades

Historical
Flow Patterns of the Everglades

Historical

Current
Flow Patterns of the Everglades

Historical

Current

Future

National Park Service
Everglades National Park

GIT CONSULTING LLC
Civil • Water • Environment • GIS
Flow Patterns of the Everglades

Desired state of conservation:

“On average, a total annual volume of water should be delivered to NESRS of **550 thousand acre-feet** (acre-feet) with a range of 200 to 900 thousand acre-ft during years of below- and above-average rainfall, respectively.”

Problem statement

How can we **increase flow** into Northeast Shark River Slough (NESRS)?
Problem statement

How can we **increase flow** into Northeast Shark River Slough (NESRS)?
Problem statement

How can we **increase flow** into Northeast Shark River Slough (NESRS)?
Problem statement

How can we **increase flow** into Northeast Shark River Slough (NESRS)?
Problem statement

Water budget calculations for transects in NESRS show:

- **237** Kaf/yr flows into ENP at Tamiami Trail
- **52** Kaf/yr flows further into NESRS
- **197** Kaf/yr is immediately lost out of the Park to the east.
- Remainder accounted for by rainfall and ET

21% retained
79% lost
Problem statement

Why is this happening?

• Maintaining low canal stages to the east, which draws water out of the park where stages are higher

• Not enough north-to south gradient to drive higher flow volumes down the slough
Problem statement

Restoration components modeled are:

- High Canal Stage
- Low Canal Stage
- High Stage in Slough
Problem statement

Restoration components modeled are:

- **Increased canal stage** in L29 to provide a greater gradient for flow
Problem statement

Restoration components modeled are:

- **Increased canal stage** in L29 to provide a greater gradient for flow
  - requires construction of **bridges** along roadway and removal of roadbed
Problem statement

Restoration components modeled are:

- **Increased canal stage** in L29 to provide a greater gradient for flow
  - requires construction of **bridges** along roadway and removal of roadbed

- Installation of a seepage **barrier** to reduce losses to the East

---

**Bridges**

**Increased Canal Stage**

**High Stage in Slough**

**Low Canal Stage**

**Seepage Barrier**
MIKE Marsh Model of Everglades National Park (M3ENP)

- 400 meter finite difference, square grid
- 1250 mi² domain, 120 mi canals
- 2D Overland/Sheet Flow
- 1D Unsaturated Zone Flow
- 3D Saturated Zone flow
- 1D channel flow
What makes M3ENP unique?
What makes M3ENP unique?

- Uses MIKE SHE/MIKE11 software
- 400x400 meter grid resolution
- 3 saturated zone layers
- 27 unsaturated zone layers
- Ability to simulate **highly localized effects**
  - detention areas
  - bridges
  - seepage barriers
  - groundwater flow around structures
M3ENP Scenarios

- Tamiami Trail bridges and roadbed removal
  - No bridges / Two bridges
M3ENP Scenarios

- **Tamiami Trail bridges** and roadbed removal
  - No bridges / Two bridges
- **Raising canal stages** in L29
  - 7.5 ft / 8.5 ft NGVD maximum stage
M3ENP Scenarios

• **Tamiami Trail bridges** and roadbed removal
  – No bridges / Two bridges

• **Raising canal stages** in L29
  – 7.5 ft / 8.5 ft NGVD maximum stage

• **Seepage barrier** between the Park and L31N canal
  – No barrier / 5 mile barrier
M3ENP Scenarios

- **Tamiami Trail bridges** and roadbed removal
  - No bridges / Two bridges
- **Raising canal stages** in L29
  - 7.5 ft / 8.5 ft NGVD maximum stage
- **Seepage barrier** between the Park and L31N canal
  - No barrier / 5 mile barrier
- **Combined effects** of all above components
  - Base / Two bridges, 8.5 maximum stage, and 5-mile seepage barrier
M3ENP Scenarios

- **Tamiami Trail bridges** and roadbed removal
  - No bridges / Two bridges
- **Raising canal stages** in L29
  - 7.5 ft / 8.5 ft NGVD maximum stage
- **Seepage barrier** between the Park and L31N canal
  - No barrier / 5 mile barrier
- **Combined effects** of all above components
  - Base / Two bridges, 8.5 maximum stage, and 5-mile seepage barrier

*Coming up at 11:40 Fahmida Khatun will discuss more details!*
Why do we need bridges?

- To allow us to raise canal stages in L29
- To allow more sheet flow, less point-source flow

- **Common perception:** the bridges are being built because Tamiami Trail is blocking flow to the park
- **In reality:** the canal level cannot be raised without risking damage to the existing roadbed
Why do we need bridges?

Groundbreaking in 2016

Completed in 2013

2.6 Mile Bridge
C42, C44, C45, C46, C47, C48, L-29, C50, C51, C52, C53, C54, C55, C56, C57, C58, C59

1 Mile Bridge

Culverts remain under the roadway at non-bridged locations
Why do we need bridges?

Transect Flow

<table>
<thead>
<tr>
<th></th>
<th>Base</th>
<th>Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>-197</td>
<td>-203</td>
</tr>
<tr>
<td>Kaf/yr</td>
<td>237</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>64</td>
</tr>
</tbody>
</table>

(Average Kaf/yr)
Why do we need bridges?

Effects of adding Tamiami Trail bridges:
- Available flow into the Park increases 8%
- Losses out of the Park increase 3%
- Flow to NESRS increases 22%
Why do we need bridges?

Effects of adding Tamiami Trail bridges:

- Available flow into the Park increases 8%
- Losses out of the Park increase 3%
- Flow to NESRS increases 22%

24% retained
76% lost
Why raise canal stage?

- To produce a steeper gradient to move more water into the park
- To increase cross-sectional flow area
Why raise canal stage?

Increasing L29 canal stage to a maximum of 8.5 ft:

- Increases inflows to the Park by 71%
- Increases seepage out of the Park by 29%
- Increases flow to NESRS by 212%

39% retained
61% lost
Why Add a Seepage Barrier?

- To mitigate for groundwater losses into the L31N canal.
- Increasing stages in NESRS also increases losses

- 35 feet deep
- 2 miles built
- 3 miles under construction
Why Add a Seepage Barrier?

Adding the 5-mile L31N Seepage Barrier:

- Decreases available flow to the Park by 9%
- Decreases seepage out of the Park by 22%
- Increases flow to NESRS by 40%

32% retained
68% lost
Adding the bridges, seepage barrier, and raising canal stages:

- Increases available flow to the Park by 59%
- Decreases seepage out of the Park by 2%
- Increases flow to NESRS by 270%

50% retained
50% lost
The **independent** effects of the components provided benefits to the Park, most notably **increasing stages** in the L29 canal.
The **independent** effects of the components provided benefits to the Park, most notably increasing stages in the L29 canal.

The **combined** effects of these three components will result in significantly higher flows into the park, while mitigating for seepage losses.
The Takeaway

- The **target** for restoration of flows to NESRS is **550 Kaf/yr**

- Implementation of all three components will increase flows along the northeastern boundary of ENP to **370 Kaf/yr**

- **195 Kaf/yr** will be retained in Shark River Slough

- This represents a **significant step** towards achieving our restoration goals
Acknowledgements

Robert J. Fennema, PhD (ENP)
Georgio I. Tachiev, PhD, PE (GIT Consulting)
Kevin Kotun, PE (ENP)
Stephanie Long, PE, PhD
Leonard Pearlstine, PhD (ENP)
Janice Parsons (ENP)
Thank You