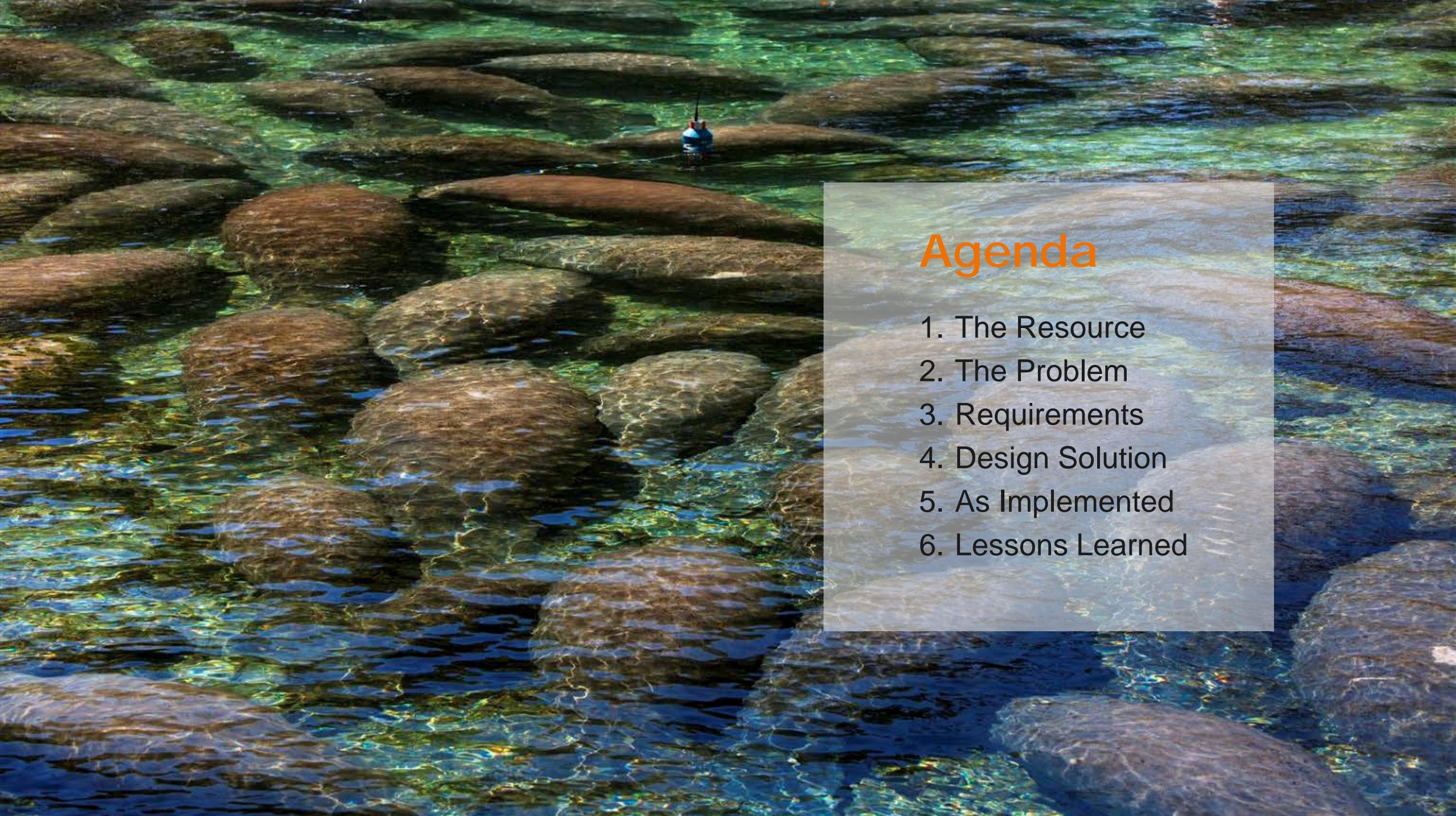




**NCER 2018**  
**Ecosystem Restoration as a  
Tool for Enhancing Resiliency**

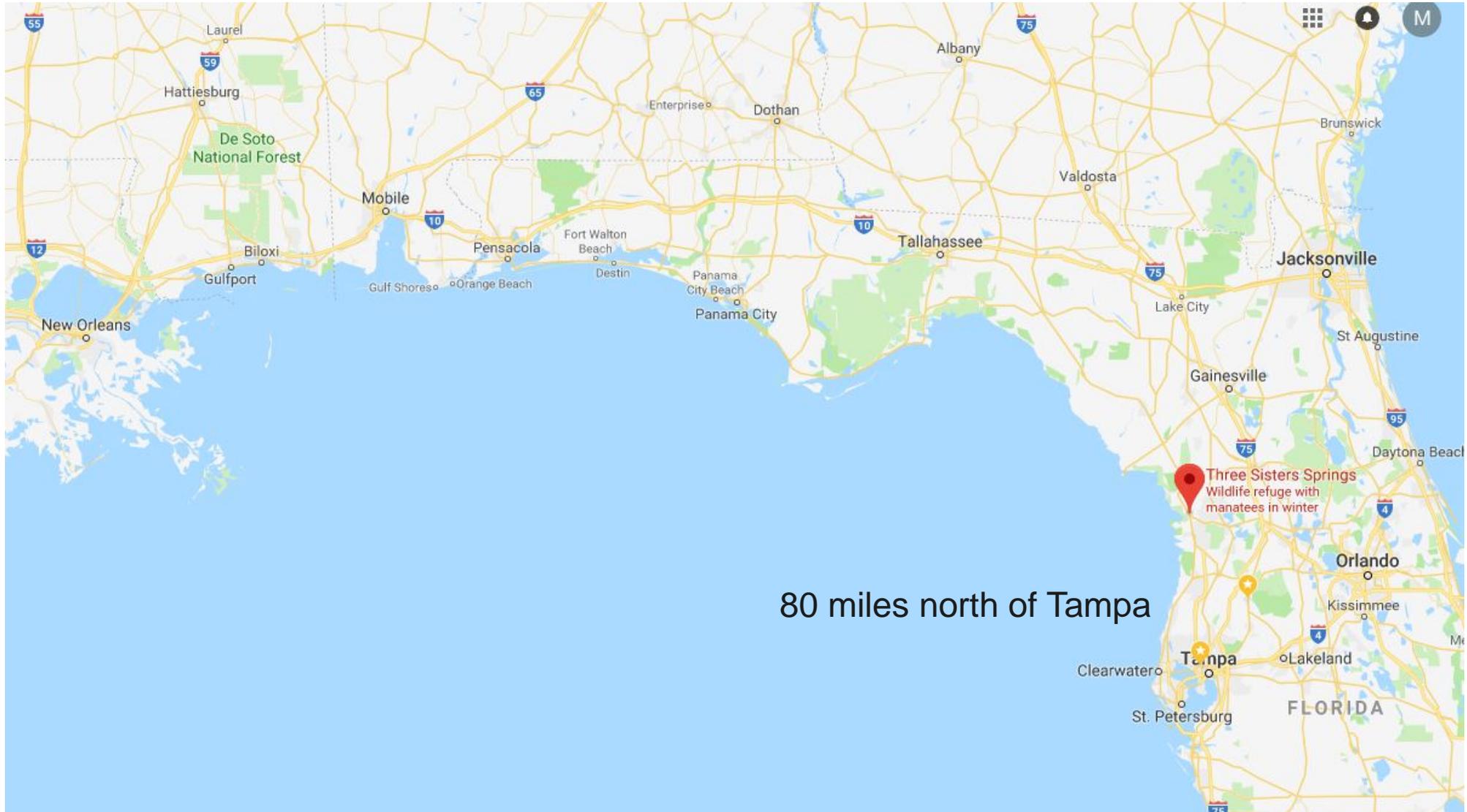
Planning and designing  
resilient shoreline  
stabilization solutions:  
Three Sisters Springs



## Agenda

1. The Resource
2. The Problem
3. Requirements
4. Design Solution
5. As Implemented
6. Lessons Learned

# The Resource



# The Resource



Crystal River,  
including  
Kings Bay  
Outstanding...

Crystal Bay

Crystal River  
Archaeological State Park

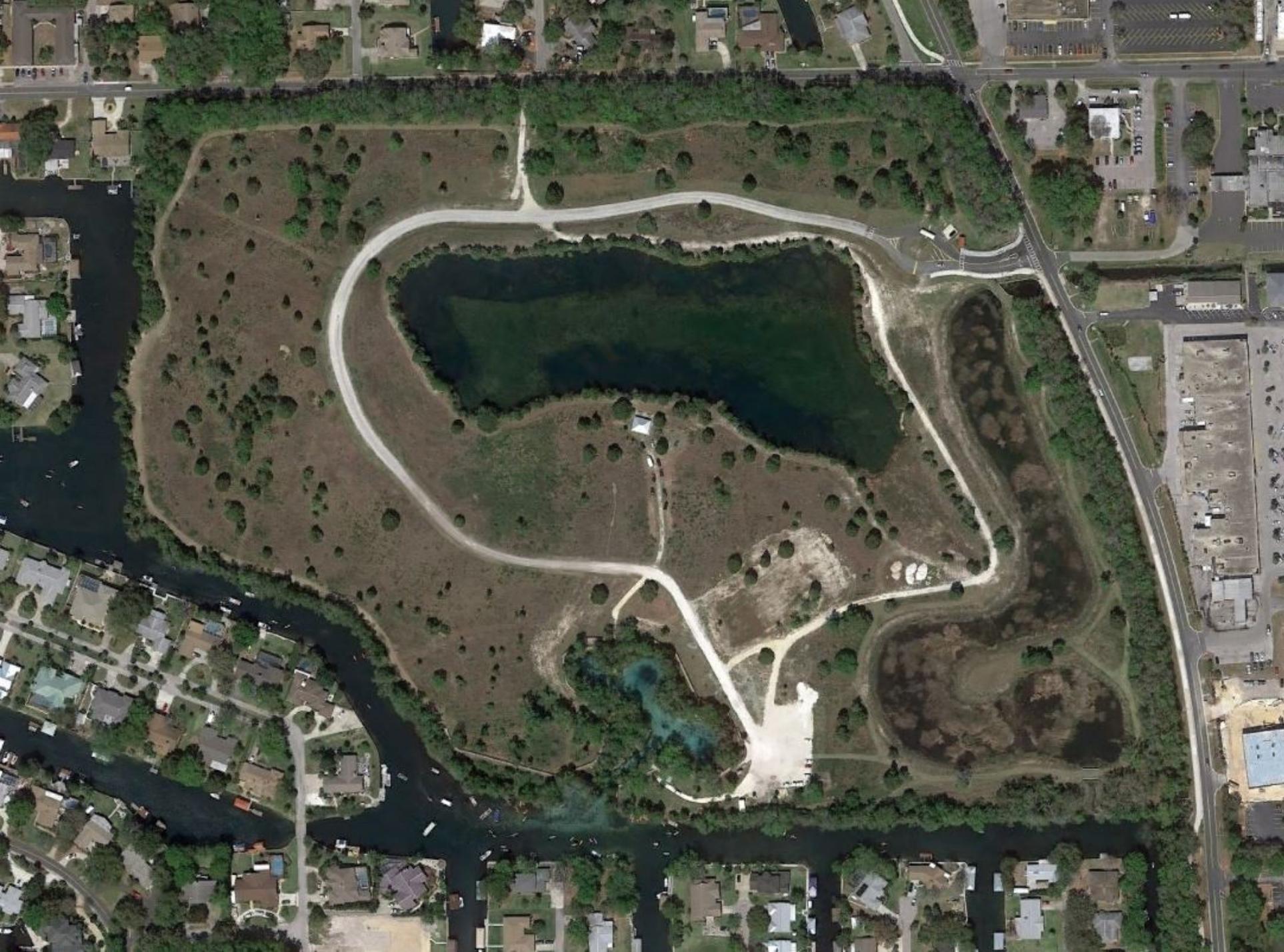
Crystal River

Crystal Lodge  
Dive Center

Three Sisters Springs  
Wildlife refuge with  
manatees in winter

Crystal River  
Preserve  
State Park

Stoney-Lane  
Outstanding



## The Resource

57 acre parcel of land previously cleared and filled for development

- 3 main springs/20 spring vents
- 20 mgd flows



The Resource

# The Resource

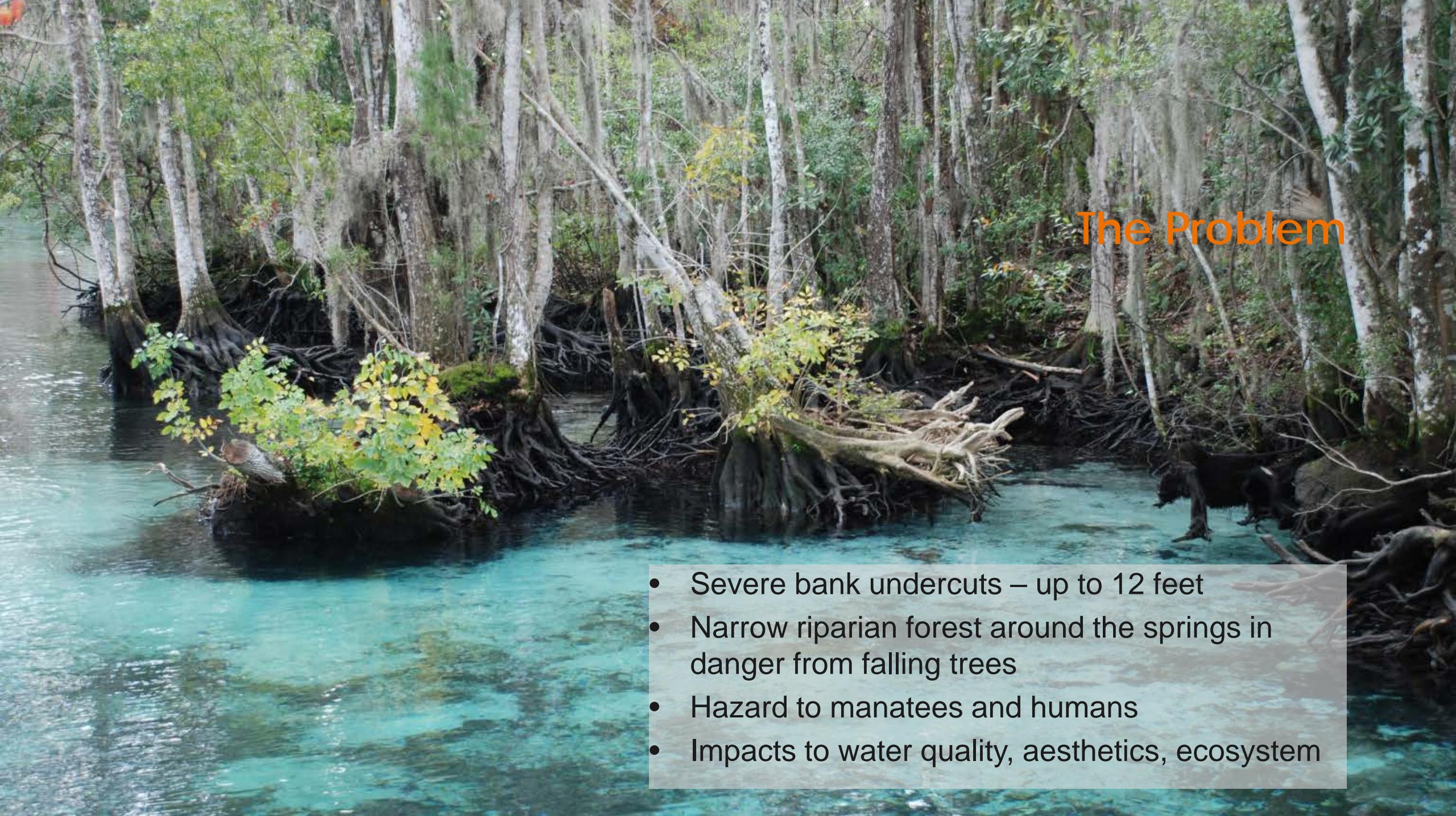
- Has become one of the most significant manatee cold weather refuges – 72 degrees year round
- Up to 300 manatees seek refuge during cold winter days
- Popular tourist attraction –
  - 43 commercial special use permits
  - 50+ unpermitted operators





## The Problem

- High manatee concentrations during winter months – 70 per day
- Heavy use by visitors 250,000 per year



## The Problem

- Severe bank undercuts – up to 12 feet
- Narrow riparian forest around the springs in danger from falling trees
- Hazard to manatees and humans
- Impacts to water quality, aesthetics, ecosystem



Why?

# Stakeholders

- Owned by SWFWMD/City of Crystal River
- Managed by USFWS - Crystal River NWR
- Florida Fish & Wildlife Commission
- Friends of Crystal River NWR
- Commercial Dive/Kayak Operators
- Residents

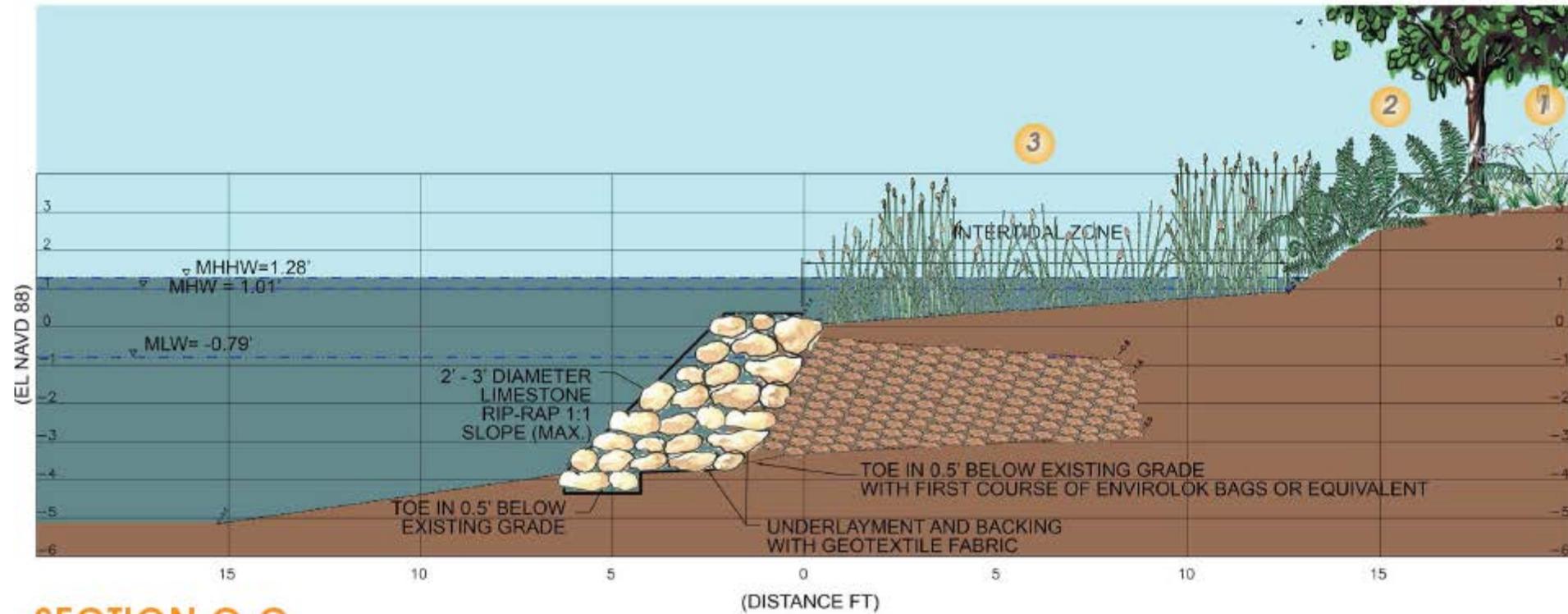


# Requirements

- Long term, resilient solution
- Resistant to manatee and human impacts
- Preserves the remnant riparian canopy
- No adverse impacts to water quality
- Naturalized appearance
- Minimize footprint in springs/1:1 or steeper slope
- Safe to manatees and humans
- Constructible within budget



# Design Solution



## SECTION C-C

SCALE: 3/8" = 1'-0"

## Design Solution

- Fill undercuts with a non-fibrous earth-filled bag
  - Reduce migration of earth
  - Minimize impacts to water quality
  - Provide a medium for tree roots to regrow

## Design Solution



- Face slope with large, stacked limestone boulders
  - Natural, local material
  - Consistent appearance with previous efforts
  - Heavy enough to resist manatee affections
  - Discourages disembarking by kayakers/swimmers



Fill in the voids with filter stone  
minimize movement/settling  
improve stability

Remove invasive species

Plant endemic vegetation in exposed earthen bags  
appropriate to ecological community

**Design Solution**

## As Designed

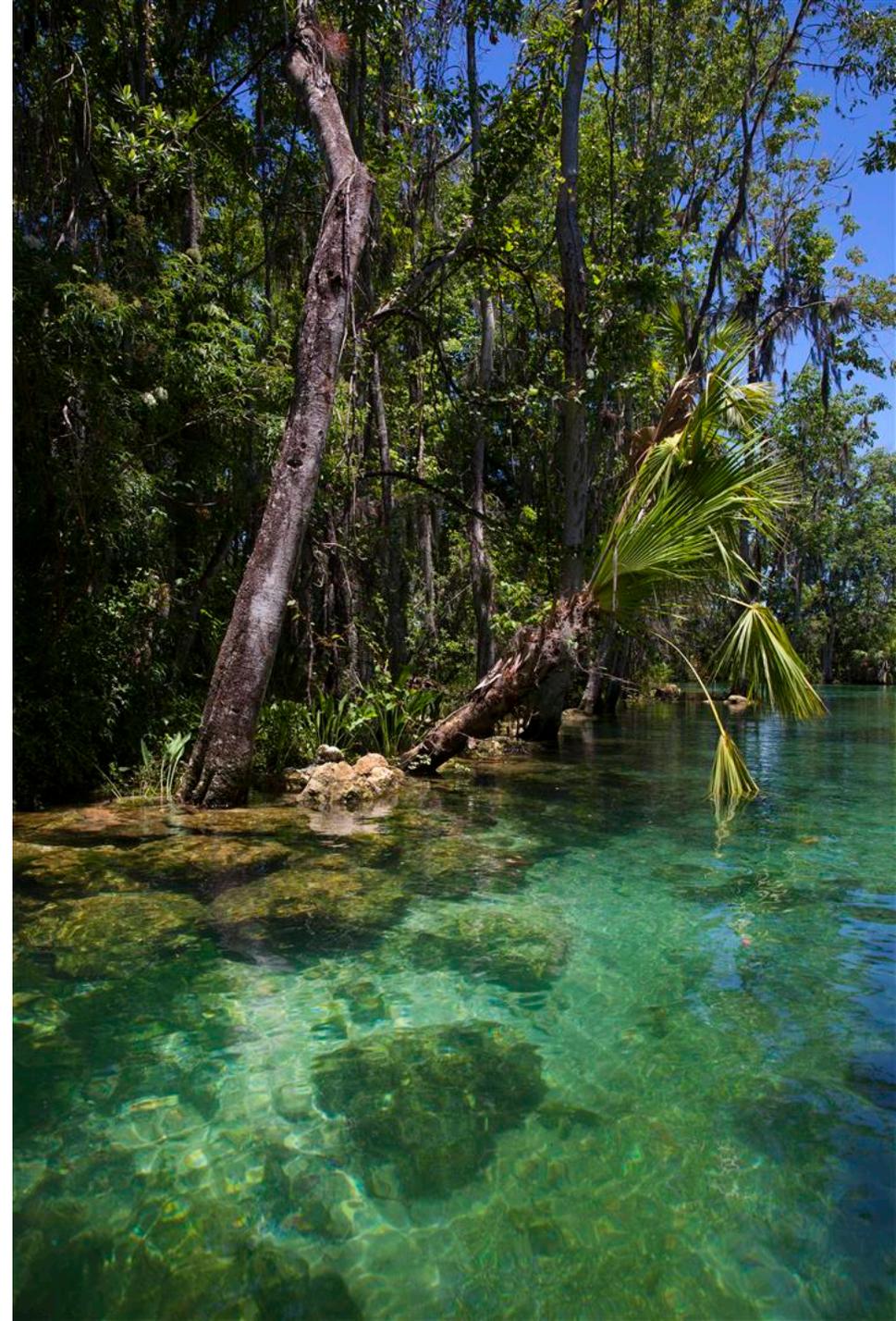
- 4400 filled Envirolok™ bags (250 cy)
- 1540 tons of limestone boulders
- 230 cubic yards of filter stone
- 3868 plants installed
- OPC \$644,500 for 1200 linear feet
- \$537.08/lf

## As Implemented

- 7300 bags installed (6400 Envirolok™)
- 1500 tons of limestone boulders
- 88 cubic yards of filter stone
- 3868 plants installed
- \$497,850 for 1200 linear feet
- \$414.87/lf

## Lessons Learned

- Proprietary non-fibrous bags cost 5x as much as a burlap sack
- Pea gravel is difficult to keep in place
- Limestone boulders look natural and haven't been dislodged after two seasons of record-breaking visitor use and manatee refuge



Questions?

