BISCAYNE BAY
ECOSYSTEM
RESTORATION
RESERVOIR

A Plan to Help Restore the Bay

Restoring freshwater flow to the Biscayne Bay is essential to ensuring the long-term health of this vital ecosystem.

State of the Bay

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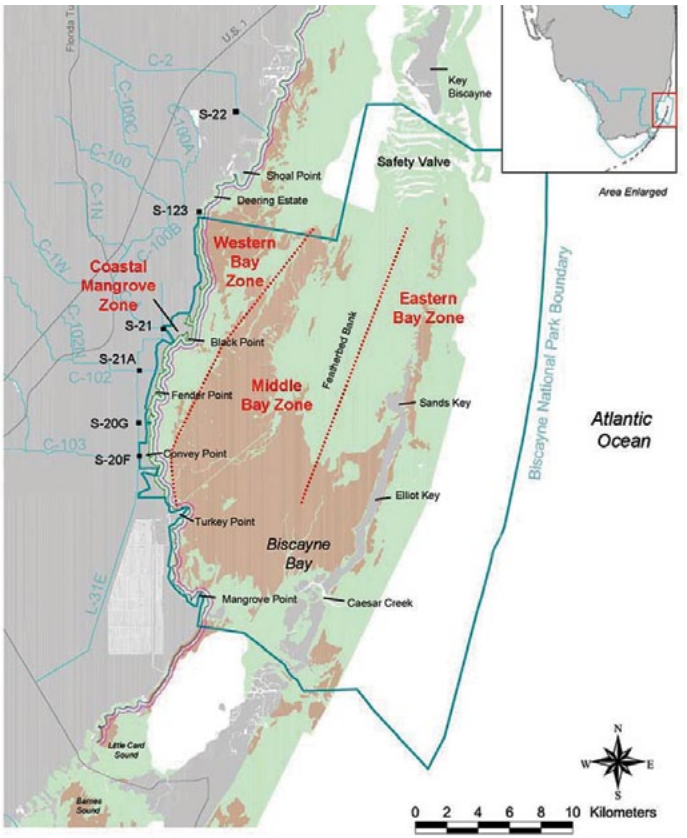
Flood control, development and growing demand for fresh water have reduced the natural flow of fresh water into the Biscayne Bay ecosystem, leading to an unnatural and harmful imbalance between the amount of fresh water and salt water.

This hypersalinity – excess salt concentration – has had a negative effect on the plant and animal life of the bay including reductions of seagrass and habitat for marine organisms that have historically populated the bay ecosystem. Some of the key species that have been harmed and are in need of recovery include widgeongrass, American crocodile, spotted sea trout, mojarras, silver perch, and pink shrimp.

Recovery of these species can only be achieved by the increased flow of clean, fresh water to the ground and surface waters adjacent to the bay.



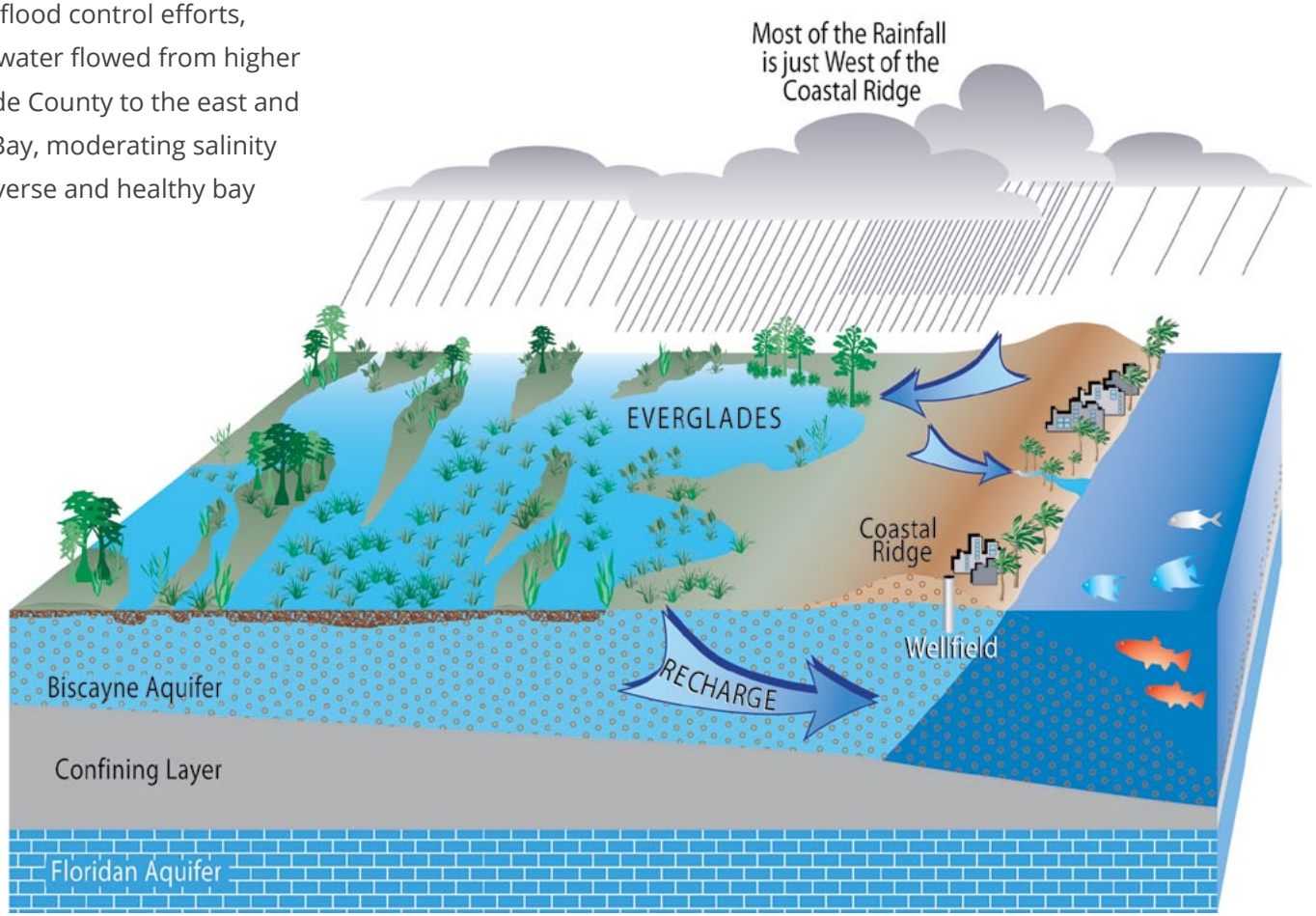
Current Distribution of Vegetation vs. Hard Bottom.

One of the major impacts of the increased salinity in the bay was the loss of seagrass beds and species dependent on the proper mix of fresh water and salt water. A current view of hard bottom (corals, limestone, etc.) vs. seagrass coverage of the bay is depicted in the above graphic.

Pre-Drainage and Current Hydrology Along the Bay

Pre-Drainage

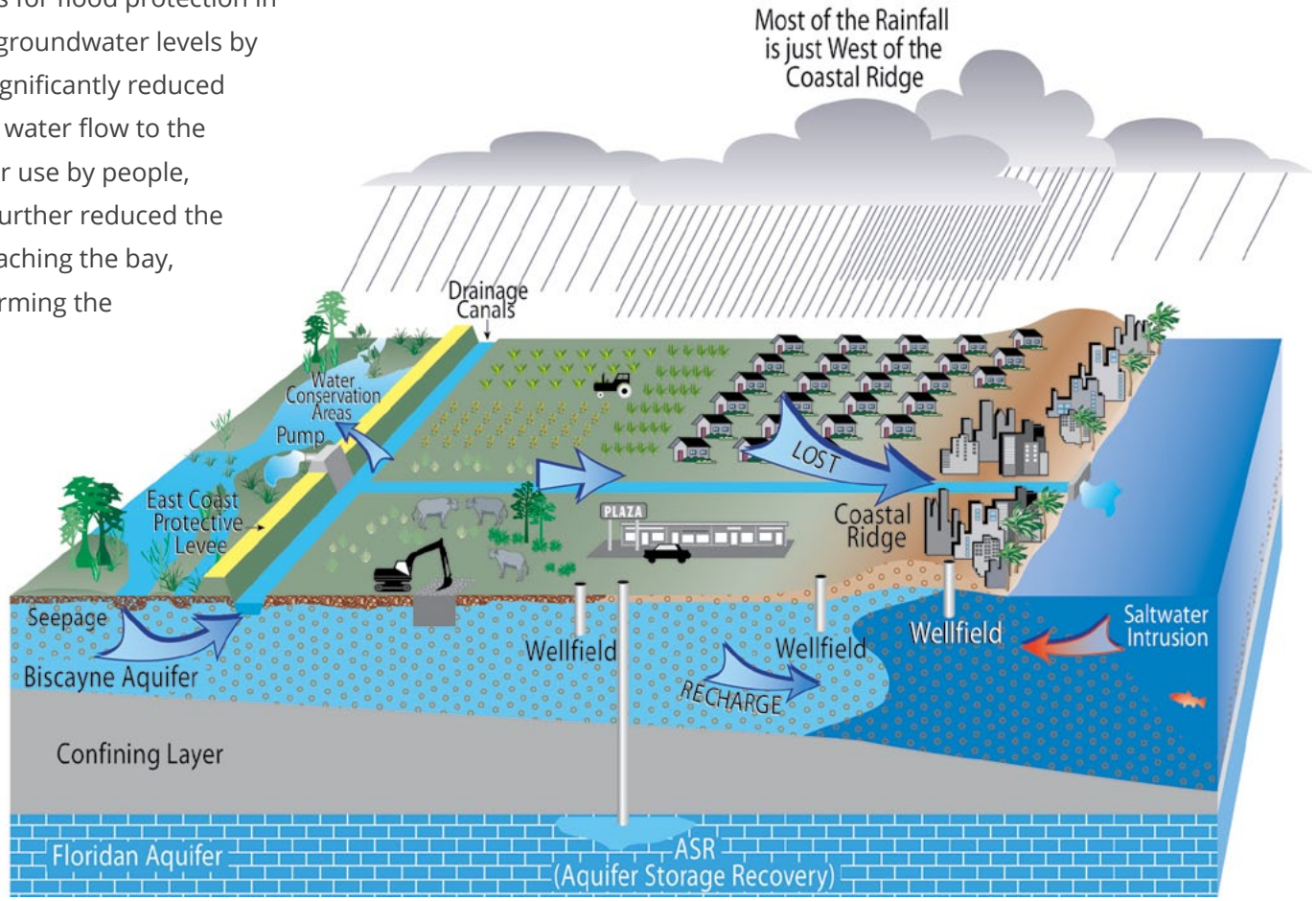
Prior to development and flood control efforts, groundwater and surface water flowed from higher ground in West Miami-Dade County to the east and the wetlands of Biscayne Bay, moderating salinity levels and supporting a diverse and healthy bay ecosystem.



Source: South Florida Water Management District

Current Hydrology

The construction of canals for flood protection in the 1900s lowered these groundwater levels by as much as six feet and significantly reduced groundwater and surface water flow to the bay. Increased fresh water use by people, agriculture and industry further reduced the amount of fresh water reaching the bay, increasing salinity and harming the ecosystem.



Source: South Florida Water Management District

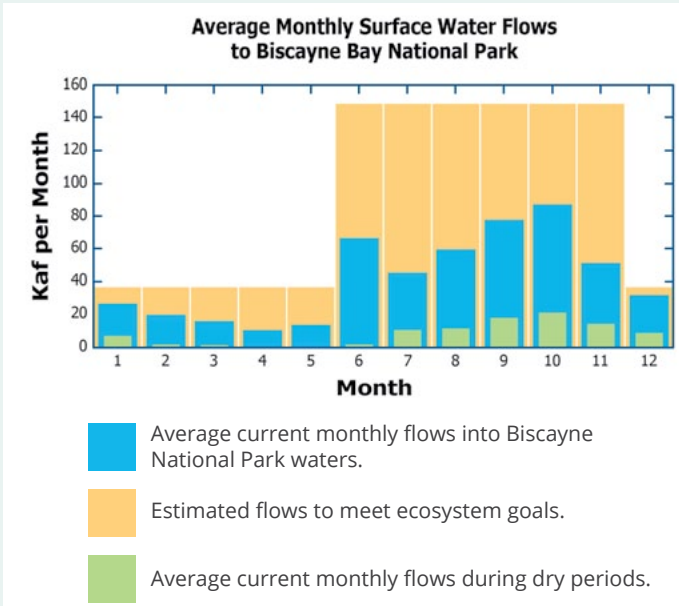
CERP and Bay Restoration

Restoration of the health of Biscayne Bay is an essential part of the Comprehensive Everglades Restoration Plan (CERP), and restoring freshwater flow to the bay is a key component of that plan.

Freshwater Restoration Goals

- The restoration will be demonstrated by an increase in the extent of mixed grass beds of turtle grass (Thallassia), shoal-grass (Halodule) and widgeon grass (Ruppia sp.), an increase in the extent of the moderately brackish conditions (5-20 psu mesohaline) in the bay, and increases in species requiring lower salinity habitat in their life cycle including gold spotted killifish, oysters, shrimp and blue crabs.
- Identify a potential source of clean fresh water available for seasonal releases into the regional canal system for ecosystem restoration of the bay with no impacts to Everglades National Park.
- Provide a source of clean, fresh water, to improve the hydroperiods of wetland systems adjacent to the bay.
- Provide a source of clean fresh water that will offer secondary benefits of combatting sea level rise and providing regional water availability assurances for the bay and Biscayne National Park and Miami-Dade County as required by CERP.
- Provide a source of clean fresh water that is not inconsistent with the concepts envisioned in CERP (WRDA 2000).

Projected Freshwater Needs



Projects Envisioned by CERP to Help Restore the Bay

In 1999, the South Florida Water Management District and U.S. Army Corps of Engineers prepared the "Restudy," which identified five projects with the potential of providing additional fresh water to the bay. However, after further analysis, none of the projects proved economically or technically feasible. Only one project, the Biscayne Bay Coastal Wetlands Plan, had some success, but only Phase I was implemented due to the lack of an additional clean water source. The projects included:

Biscayne Bay Coastal Wetlands Plan

The Biscayne Bay Coastal Wetlands Plan anticipated restoring more natural surface and groundwater flows to Biscayne Bay, coastal wetland and mangrove systems and the Model lands wetlands to the south.

Outcome: *Soon after plan initiation it was determined that there was no identified additional source of fresh water to meet the restoration targets of the bay and surrounding environs. The plan was subsequently divided into two phases. The first phase (being implemented) would use the existing water in the system to provide limited restoration benefits, while the second phase would be put on hold until a reliable freshwater source in both quality and quantity could be identified.*

Bird Drive Recharge Basin

The Bird Drive Recharge Basin is a 2,877-acre area located east of Everglades National Park (ENP) the purpose of which was to capture runoff from the western C-4 Basin and to accept inflows from the West Miami-Dade Wastewater Treatment Plant, if built. This water would then recharge groundwater and reduce seepage from the ENP buffer areas by increasing water table elevations east of Krome Avenue.

Outcome: *Further analysis proved that water could not be stored above ground due to leakage, wetland impacts were unacceptable and Miami-Dade County determined that reuse would not be implemented in this area.*

Projects Envisioned by CERP to Help Restore the Bay

Central Lake Belt

The Central Lake Belt project envisioned storing excess water from the Water Conservation Areas (WCA) and stormwater runoff in rock mines in Central Broward and Miami-Dade Counties, and conveying the water south to the Bird Drive Recharge Basin when conditions allowed.

Outcome: *Further analysis of this concept determined that the mines were dug too deep in the aquifer to hold water without sealing the bottom through liners or concrete. This construction technique and the project were determined to be cost prohibitive.*

L-31N Seepage Management

The L-31 Seepage Management proposal consisted of several components including construction of structures to capture and move more seepage south from C-4, construction of a five mile seepage barrier adjacent to L-31 N to reduce seepage from Everglades National Park (ENP) and installation of a pump station to raise water tables to the east of Krome Avenue.

Outcome: *This project is partially implemented through the construction of a C-4 divide Structure and installation of a few miles of seepage barrier. The project will have limited benefits to the bay, if any, as most seepage collected from C-4 is pumped back into ENP.*

West Miami-Dade Reclaimed Water Treatment Facility (Reuse)

Miami-Dade Reuse was envisioned to use treated wastewater to recharge wetland systems, the groundwater and provide surface water inflows to the bay. The project assumed that 155 cfs of treated and reclaimed wastewater would go the Bird Drive Recharge Basin and 202 cfs of reclaimed wastewater would be used to recharge L-31E canal and the bay.

Outcome: *Further Investigation identified extreme capital costs (in excess of $1 billion), very high annual operating costs and water quality issues associated with discharging reclaimed water into Biscayne National Park, designated as an Outstanding Florida Water. The analysis stated that other sources of water to provide required freshwater flows to southern and central Biscayne Bay should be investigated before pursuing the reuse facility as a source.*

Pilot Project Success

Tests Deliver Fresh Water to Biscayne Bay

In the 2012 – 2013 dry season, two pilot water delivery tests were performed by the South Florida Water Management District. The pilot tests were successful in reducing salinity in the nearshore bay areas and demonstrated that fresh water could be diverted and delivered to the bay using the existing canal infrastructure. Along-shore currents allowed the freshwater discharges to have a longer indirect effect as it traveled up the shoreline and continued to disperse in the estuary.

Before Pilot Project

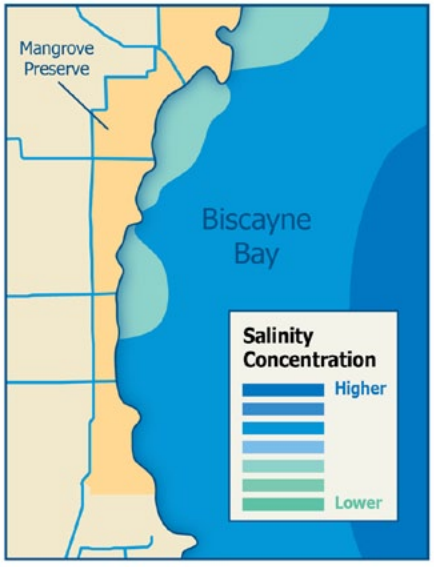


Illustration shows higher (unfavorable) salinity concentrations (blue) in the nearshore area of the bay prior to the pilot project.

After Pilot Project

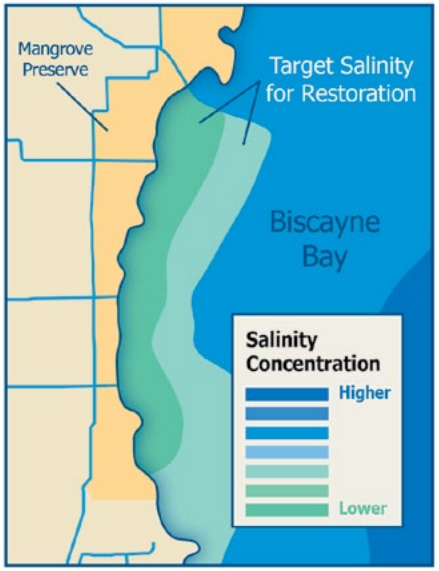
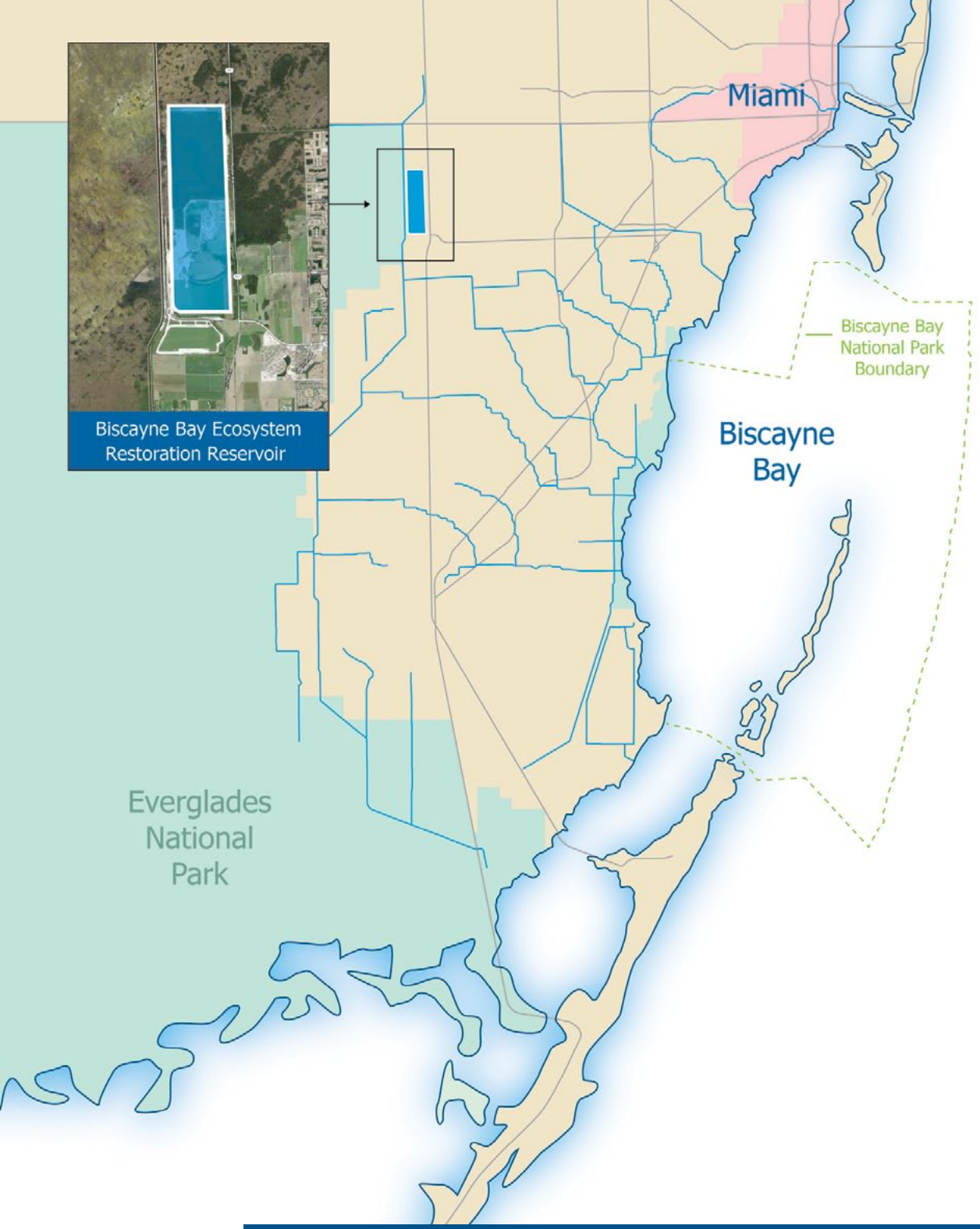


Illustration shows lower (favorable) salinity concentrations (green) in the nearshore area of the bay one month after the pilot project.

The pilot tests suggest that relatively small additional freshwater inflows to the bay can have significant positive effects on salinity concentrations and improve restoration conditions in the bay.

A Proposed Solution



BISCAYNE BAY ECOSYSTEM RESTORATION RESERVOIR

The Biscayne Bay Ecosystem Restoration Reservoir (BBERR) would be developed and implemented using the existing rock mine adjacent to the L-31N canal west of Miami. When completed, the facility will cover a minimum of 1,800 acres and deliver 380,000 acre-feet of fresh water to the bay annually. The reservoir has the potential to ultimately expand to a third phase for a total of 2,400 acres if modeling and performance indicates further improvement in the Biscayne Bay ecosystem.

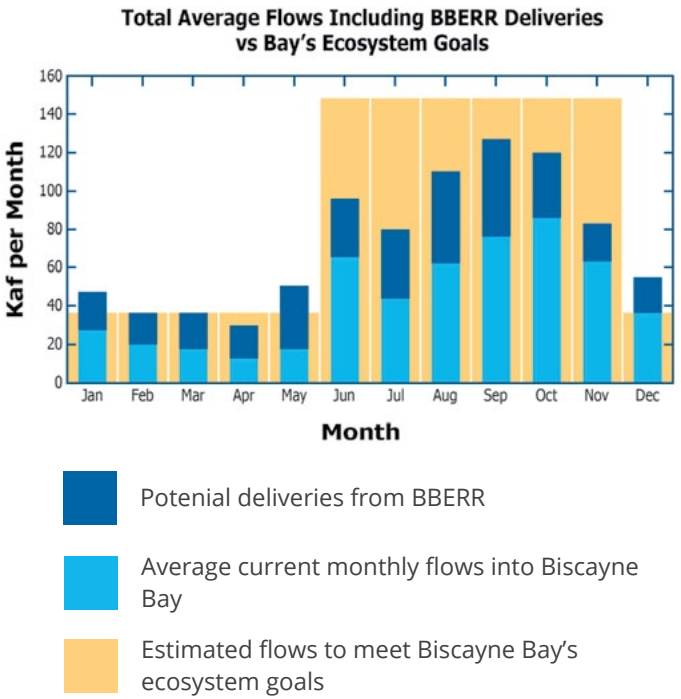
The operation of the reservoir is based on capturing excess water from L-31N during the year and the natural groundwater seepage from Everglades National Park toward Biscayne Bay. Stored water will be released as needed to meet the freshwater needs of the bay through the existing canal systems with minor improvements.

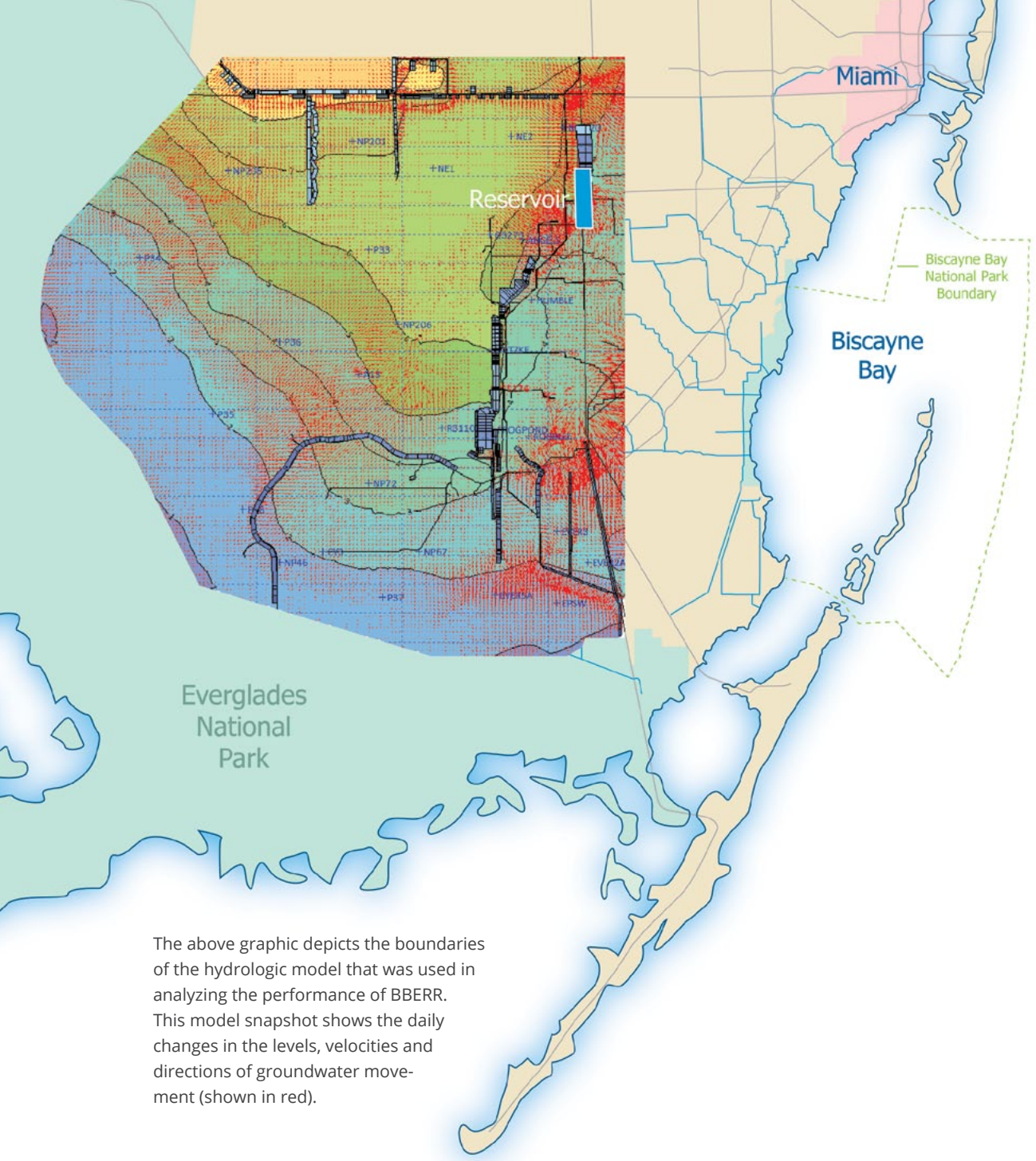
Meeting the Freshwater Needs of the Bay

Supplemental Water Deliveries

When fully constructed, the reservoir can store enough water, without impacts on adjacent lands and ecosystems, and meet 60 percent of the bay's additional freshwater needs. The reservoir can provide virtually all of the bay's dry-season freshwater needs. The water would be conveyed to the bay at the right timing using existing canal systems of the C-100 and C-1 basins and coastal structures.

BBERR can meet approximately 60 percent of Biscayne Bay's additional annual freshwater needs and virtually all of the bay's dry-season freshwater needs.



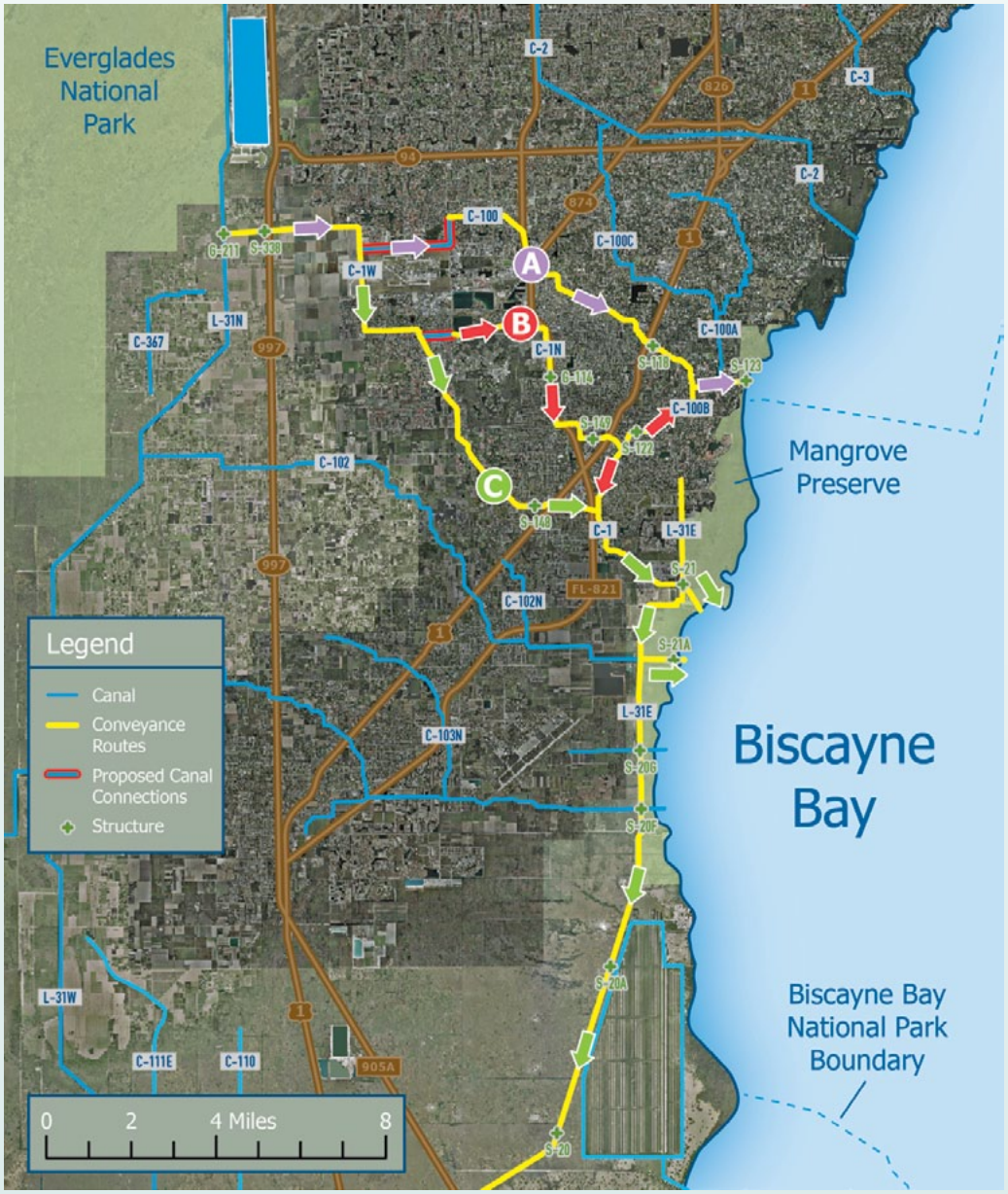


The above graphic depicts the boundaries of the hydrologic model that was used in analyzing the performance of BBERR. This model snapshot shows the daily changes in the levels, velocities and directions of groundwater movement (shown in red).

BBERR Project Analysis and Modeling

Water Flow Model Supports Reservoir Viability

To determine how the reservoir would meet the bay's needs, the BBERR project team used an existing surface water and groundwater model developed for Everglades National Park (ENP). The model was expanded and used to investigate the regional hydrology. The model was used in analyzing the performance and potential effects of the reservoir on ENP, Miami-Dade's West Wellfield and Biscayne Bay. The model revealed that existing groundwater seepage and excess surface water can be stored and delivered to Biscayne Bay to help restore the bay's ecosystem. Additionally, the groundwater loss from ENP in the vicinity of the proposed reservoir will be significantly reduced once construction is completed because a seepage barrier will be built around the entire perimeter of the reservoir; correspondingly, the flooding potential in West Miami-Dade will also be reduced.



Possible Freshwater Delivery Routes

A Route A B Route B C Route C

Delivering Water to the Bay Using Existing Infrastructure

The Proposed Solution Utilizes the Existing Network of Canals

The BBERR evaluation process confirmed what was discovered during the South Florida Water Management District (SFWMD) Pilot Projects in 2012 – the existing network of canals, with minor improvements, is adequate to move fresh water from western Miami-Dade to the bay; these canals include C100, C102, Military Canal and C103 basins. Estimates of the annual flows from these outfalls are based on SFWMD flow records for a 25-year period of record.

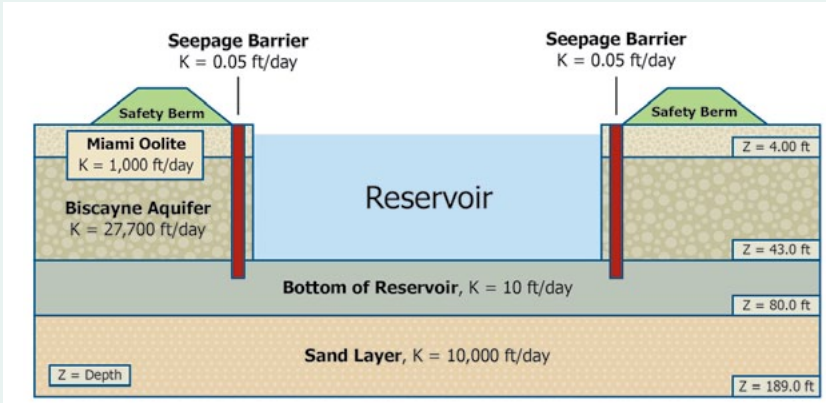
Possible routes (or a combination of routes) to deliver water from reservoir to the Biscayne Bay include:

Route A (within Basin C-100): S-338 to C-1W to C-100 to S-118 to C-100B to S-123

Route B (within Basin C-1): S-338 to C-1W to C-1N to S-149 to S-122 to C-100B/C-1

Route C (within Basin C-1): S-338 to C-1W to S-148 to C-1 to S-21/L-31E

BBERR Required Infrastructure



Seepage Barrier Installation

The reservoir will be about four miles in length and one mile wide when completed. One of the critical components will be the construction of a 50-foot deep and 22-inch wide "slurry wall" that will serve as a seepage barrier. The barrier will surround the reservoir and tie into an existing low-seepage layer to contain the fresh water and eliminate lateral seepage or loss of water from the reservoir.

Pump Stations Inflow and Outflow

The following are recommended:

- One pump station at 300 cfs in order to pump water into the reservoir.
- One pump station with six pumps (150 cfs each) to move water from the reservoir into the canal system to the bay.

Gravity Inflow Structure

It is envisioned that the reservoir will include one gravity spill-way designed at 300 cfs to move water into the reservoir from L-31N when canal surface water levels allow.

Proposed Canal Interconnects

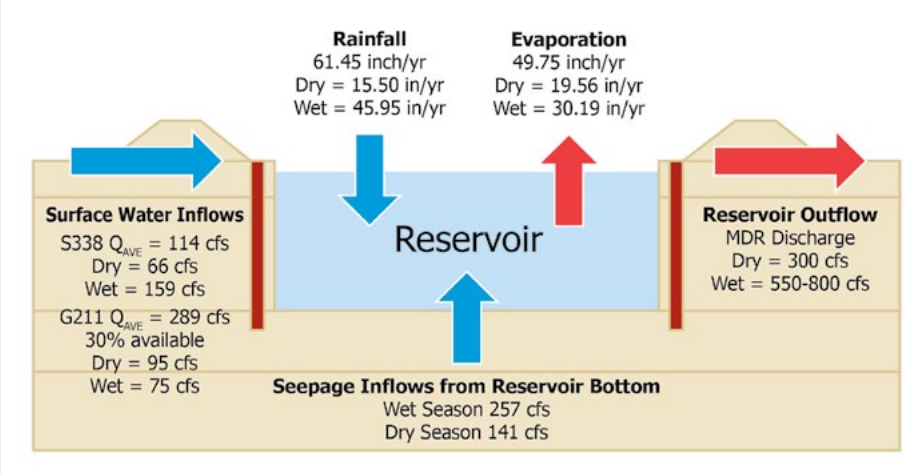
The following connections are envisioned to move fresh water from the reservoir into the existing canal network:

- A new canal on public land on the north side of Tamiami Airport, approximately 10,700-linear foot, and 400-linear foot culverts to connect C-1 W to C-100 N.
- A new canal approximately 3,900-linear foot, and 300-linear foot culvert and approximately 3,500 linear feet of canal improvements to connect canal C-1 W to canal C-1.

Average BBERR Water Budget

The reservoir has a capacity to deliver an average of 338,000 acre-feet of water annually to the bay without having an impact on adjacent land or ecosystems.

The graph below summarizes all of the major inflows and outflows of fresh water to and from the reservoir including rainfall, evaporation, surface water and seepage inflows and the delivery of surface water from the reservoir to the bay.



- During the dry season, an average of 300 cubic feet per second (cfs) can be delivered.
- During the wet season, 550 cfs can be delivered and for two months up to 800 cfs.
- Average withdrawals do not have an effect of more than 0.1 feet on Everglades National Park for 95 percent of the time. This effect will be eliminated during operational optimization.
- There is an additional 1 foot of drawdown at the West Well Field, which will not impact the permitted withdrawals.
- There is reduced seepage to the east in the vicinity of the West Well Field.

Current view of the north end of the proposed Biscayne Bay Ecosystem Restoration Reservoir.

Additional Potential Benefits

The BBERR can help reduce impacts of sea level rise and provide some flood protection benefits.

- The reservoir can assist in better management of stormwater runoff for urban and agricultural areas of South Dade.
- The additional freshwater deliveries can create a freshwater head to maintain the interface between fresh water and salt water to reduce the impact of sea level rise and saltwater intrusion.
- The reservoir can provide regional water availability assurances for Biscayne Bay, Biscayne National Park and Miami-Dade County as required by CERP
- The reservoir can provide some flood protection benefits for C-4 and L-31 N.

BBERR Estimated Project Costs

Implementation of BBERR is anticipated in two phases with a total completion time frame of not later than 2031. Excavation of the first phase is nearly complete and could be implemented earlier depending on funding and support. The second phase is based on the economic market drivers for rock and is currently being excavated.

For cost evaluation of the reservoir and related works, the consultant team developed risk level definitions related to factors of safety calculated on data and information published in 2010. The major construction and administrative categories and their associated costs are described as follows.

Estimated Project Cost

- **Mobilization = $1M**
- **Clearing and Grubbing = $1.8M**
- **Berms and Curtain Walls = $98.9M**
- **Canal Improvements = $1.8M**
- **New Conveyance Canals (connections) = $25.7M**
- **Inflow Gravity Structure = $6.2M**
- **Inflow and Outflow Pump Stations = $27.6M**
- **Contigencies = $40.8M**
- **Construction Costs = $203.8M**
- **Project Administration and Management = $46.9M**
- **Estimated Total Costs = $250.7M**

Conclusions and Next Steps

Conclusions

The reservoir can supply the fresh water needed to help restore Biscayne Bay's ecosystem.

- The reservoir appears to be the only viable option to provide additional clean, fresh water to the bay. BBEER's capital and operating costs are highly favorable compared to the proposed wastewater reuse alternative, the only remaining option under consideration.
- The reservoir can provide water availability assurances as required by CERP for Miami-Dade County, Biscayne Bay, Biscayne National Park and water supply users.
- The reservoir utilizes existing infrastructure to convey fresh water to the bay with minimal improvements.
- The reservoir has favorable geology to eliminate lateral seepage losses and reduce groundwater seepage from Everglades National Park.
- The reservoir can be used to combat sea level rise and salt water intrusion.
- The reservoir can provide flood protection benefits to C-4 and L-31 N.

How Can You Help

You can move Biscayne Bay restoration along by supporting the implementation of the Biscayne Bay Ecosystem Restoration Reservoir.

Local Agencies

Miami-Dade County

Analyze the concept through U.S. Geological Survey (USGS) Model and support the project with State and Federal Agencies.

State Agencies

SFWMD, FDEP, FDAC's, Gov. Office

Dedicate staff to review analysis completed to date, supplement modeling analysis with agency resources, and support adding the project to CERP with the U.S. Army Corps of Engineers (USACE) as part of Biscayne Bay Coastal Wetlands Phase 2.

Federal Agencies

USACE, EPA, DOI, USCG, USGS, NPS

Dedicate staff to review analysis completed to date, supplement modeling analysis with agency resources, and support adding the project to CERP with SFWMD as part of Biscayne Bay Coastal Wetlands Phase 2.

NGO Support

Non-government organizations including National Parks Conservation Association, Tropical Audubon, Everglades Foundation, Friends of the Everglades, National Audubon, The Nature Conservancy, Sierra Club, Tropical Fruits and Vegetables and other interested organizations.

Review concept to date. Support by contacting local, state and federal agencies to voice support for moving project forward either in CERP or as a stand-alone project funded by state and federal agencies. Contact SFWMD Governing Board members and Executive Director in support of the project.

About the Biscayne Bay Ecosystem Restoration Reservoir

Kendall Properties & Investments (KPI), a Florida General Partnership, is the owner of the limestone rock mine that would become the BBERR. KPI has funded the research and analysis of BBERR presented in this publication for consideration by the federal, state, regional and local agencies responsible for the Greater Everglades ecosystem restoration.

Technical and Legal Advisors

Ammon Water Resource Engineering LLC.

Atkins North America, Inc.

GIT Consulting LLC.

Berger Singerman LLP.

Fusionspark Media Inc.

References:

West Miami-Dade Reservoir Feasibility Study, AWRE and Atkins North America, Inc., Ammon Water Resource Engineering (AWRE), April 2013; **West Miami-Dade Reservoir Feasibility Study**, PHASE IIIB1, AWRE, GIT CONSULTING LLC, and Atkins North America, Inc., Ammon Water Resource Engineering (AWRE), April 2013; **Environmental Resource Permit Information Manual**, Regulation Division South Florida Water Management District, 2014; **West Miami-Dade Reservoir Feasibility Study**, Ammon Water Resource Engineering (AWRE) and Atkins North America, Inc., April 2013; Cunningham KJ, Wacker MA, Robinson E, Gefvert CJ, Krupa S (2004b) **Hydrogeology and ground-water flow at Levee 31N**, Miami-Dade County, Florida, July 2003 to May, 2004. US Geological Survey Scientific Investigations Map I-2846.; S.A. Long, A.M. Cook, G.I. Tachiev, V. Villamizar, R. Fennema and F. Miralles-Willhelm: **Analysis of bridge construction as a hydrological restoration technique for Everglades National Park**, FL, USA using hydrological numerical modeling submitted to Water Resources Research, January 2014; **Supplemental Water Deliveries to Biscayne Bay Pilot Project Tests After-Action Report**, SFWMD 2013; **Ecological Targets for Western Biscayne National Park**, Department of the Interior, April 2006; SFNRC 2006:2; **Estimates of Flows To Meet Salinity Targets For Western Biscayne National Park**, Department of the Interior, June 2008; SFNRC 2008:2; **Committee On Independent Scientific Review of Everglades Restoration Projects**, National Academy of Sciences, National Research Council; **South Florida Water Management District Archives Library**

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