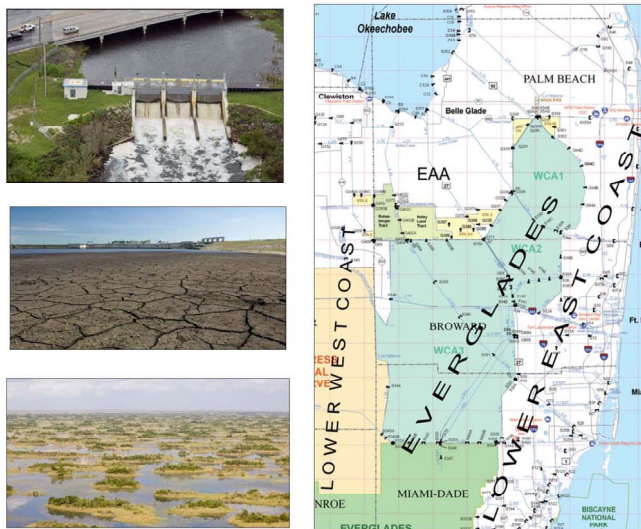


# Water Quality and Biological Resources in Everglades Canals

Joel VanArman and Kevin VanArman

## Introduction

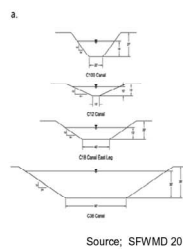
- A system-wide analysis of the primary canal system was conducted by the author as a contractor to the South Florida Water Management District.
- The canal-based water management system in South Florida has developed over the past 130 years. The federal project that exists today was authorized by Congress in 1949 and consists of more than 500 water control structures, 60 pump stations and 2900 km of canals within a 44,000 km<sup>2</sup> watershed.
- Canals in the Everglades were initially constructed to lower water levels in Lake Okeechobee, drain Everglades wetlands for development, and facilitate navigational access. They are not natural water bodies and are operated and maintained to prevent or minimize growth of organisms that may impede primary water delivery functions.
- Due to their design, construction and maintenance, and interactions with local soils and groundwater conditions, canals have intrinsic water quality issues, which may include elevated concentrations of nutrients. Studies indicate that nutrient concentrations *per se* show little relationship to the quality or diversity of biological communities in canals.
- Today canals play an essential role in sustaining the existing Everglades. Effective management and operation of the Everglades canal system will be required in the future to achieve restoration



## Methods

Historical accounts, literature, SFWMD and USACE reports and data were reviewed to compile a history of the construction of District canals. SFWMD operational manuals and recent survey data provided descriptions of canal designs, operational and maintenance history and procedures. Water quality data were compiled from the SFWMD DBHYDRO Database and analyzed to determine average concentrations at key stations, for individual canals, and by District sub-regions. A survey of scientific literature was conducted to identify biological studies conducted in canal systems of South Florida and studies in other areas that related to relationships between nutrients in the water column and associated biological resources in canals. Some additional literature related to biological resources in streams was also examined. Requests were sent to other Florida State and regional agencies, federal agencies, and to local entities (primarily counties) for information related to these topics. Biological information from all of these sources was then reviewed to identify apparent patterns and trends, and relationships to the water quality data.

### Typical Canal Cross-Sections



Source: SFWMD 2010



Deliver Water for Urban Communities

Remove Excess Flood Waters

## Results and Discussion

### History.

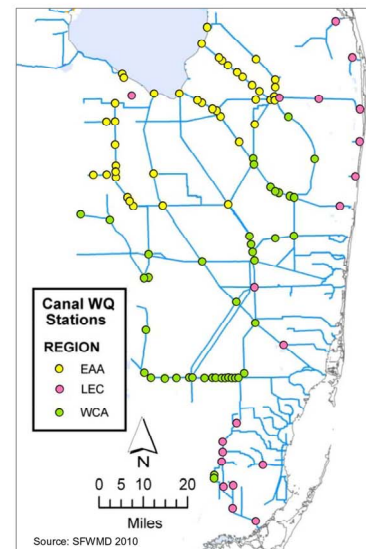
- Construction of canals through the Everglades began in the early 1900's. Most of the features of the present system were completed by 1980.
- Canals were primarily constructed to meet human needs for drainage, water supply, flood control and navigation.
- Many canals (especially coastal canals) were constructed along existing water courses (streams, rivers and creeks. Most of the major canals through the Everglades, although they sometimes followed natural depressions in the landscape, were dredged as deep channels through shallow wetlands, often penetrating below surface waters to connect with underlying surficial aquifers.
- Canals were designed, constructed operated or maintained to provide habitat for aquatic organisms, although many species flourish in these unique habitats.
- Today, the EAA and the EPA both occupy areas that were historically Everglades landscapes. The primary difference is that historically the EAA contained two major landscapes that do not exist, or only exist as remnants) today – Custard Apple Swamp and Sawgrass Plains.

### Diversity.

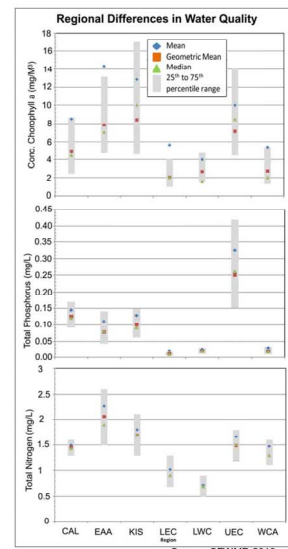
- District canals differ greatly in their design and operation, depending primarily on their intended function, adjacent land use, and development within the basin. Water quality in canals is affected by tributary

### Water Quality.

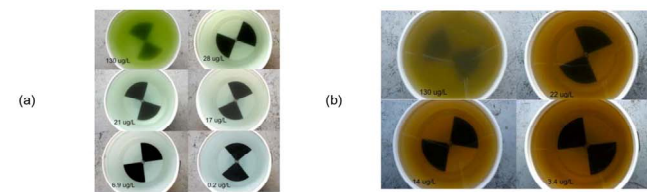
- Water quality varies greatly among regions of the SFWMD, individual canals within regions, and sections of the same canal.
- Nutrient levels tend to be higher at inland and upstream sites, but there also is considerable variation in nutrient concentrations over space and time.
- Canal phosphorus concentrations span an order of magnitude and vary based on intensity of adjacent land use and nature of inflow sources
- The variability of phosphorus concentrations tends to be much higher than that for nitrogen and the two constituents do not correspond closely..
- Chlorophyll a concentrations are higher in canals than in natural streams but not particularly higher than other open bodies of water such as ponds and lakes.
- Despite large uncertainty and lack of information, many District canals are currently listed by FDEP as impaired.



Source: SFWMD 2010

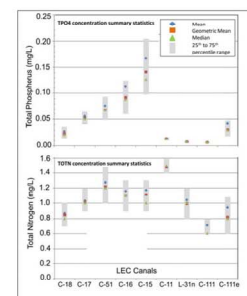


Source: SFWMD 2010

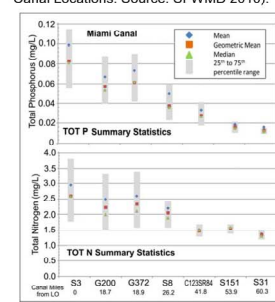


Effects of Adding Microalgae to De-ionized water (a) and naturally colored water (158 PCU) from the Miami Canal. (Source: DB Environmental, 2010)

Nutrient Concentrations in Different LEC Canals. (Source: SFWMD 2010)

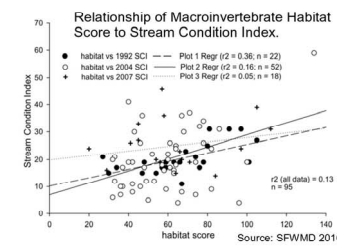


Nutrient Concentrations at Different Miami Canal Locations. (Source: SFWMD 2010).



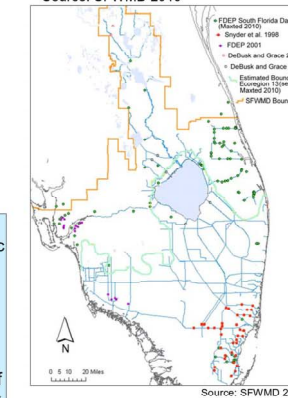
## Biological Resources.

- Because canals are artificial (man-made) water bodies, and because they are disturbed on a regular basis by required operation and maintenance activities, canals provide less stable and predictable environments than other flowing waters.
- Canals provide marginal/stressed habitat for many aquatic species. Communities tend to have lower species diversity and richness than streams. The species present tend to be indicative of stressed conditions, including many exotic and nuisance species.
- Canals contain a diverse community of macroinvertebrates. The quality of macroinvertebrate assemblages seems to primarily depend on canal physical features, particularly canal bank composition, aquatic vegetation), adjacent land uses, and connectivity to wetlands. Evidence suggests that the Stream Condition Index, used by FDEP to assess impairment, is not an appropriate indicator of conditions in canals. The highly variable nutrients levels in canals show no apparent relationship to quality of macroinvertebrate communities.



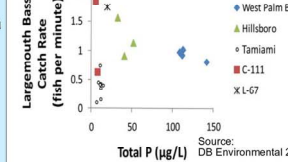
Source: SFWMD 2010

Macroinvertebrate Sampling Programs in South Florida Canals and Waterways. (Source: SFWMD 2010)



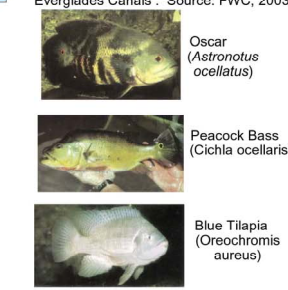
Source: SFWMD 2010

- Fish communities in canals are dominated by large predatory and exotic species.
- Many canals support important recreational fisheries for exotic species such as tilapia, oscar, and peacock bass.
- Canals provide a pathway for spread of exotic species, provide refugia for many species during droughts and thermal refugia during cold events. Canals are a source for recolonizing wetlands when favorable conditions return.
- Large alligators tend to live in canals, although survival of young alligators is greater in marshes. Also, alligators in canals tend to be isolated from marsh alligators.



Source: DB Environmental 2010

Exotic Fishes Commonly Caught in Everglades Canals. Source: FWC, 2003



## Conclusions and Recommendations

- The canal system in South Florida was originally built for flood control, drainage, and navigation and was later enhanced to provide water to sustain human and natural communities.
- Canals provide habitat for many plants and animals including species used for food and recreation. These resources are significant, but are secondary in importance to the primary use of canals for conveyance.
- Scientific studies of plant and animal communities in Everglades canals and relationships to water quality are lacking. Improved methods, consistent approaches and monitoring are needed; water quality and biological monitoring need to occur synoptically
- South Florida includes multiple subregions that have different topographic, geological, soil, hydrologic and ecological features. These differences need to be considered in the development of water quality criteria for canals. Different ecoregions may require different reference sites and measurements, water quality criteria and standards for biological indexes.
- Canals cannot be accurately characterized as streams, lakes or reservoirs. Separate canal condition indices and reference conditions need to be considered to address these differences.
- Canals serve critical functions for protection of lives, property, public health and safety. Exceedances of canal water quality criteria cannot compromise the need to move water to meet these functions.
- Water quality in canals is influenced by the upstream source of water, surface runoff and groundwater seepage. Different criteria may need to be developed and applied during periods when canals are flowing vs. periods when water is not moving.
- Determine what constitutes appropriated designated uses for different types of canals and how Class III water quality standards relate these uses.
- Develop improved design criteria for canals – in terms of construction of new canals and retrofitting of older canals – to improve side- slope (height/width) ratios; incorporate shallow shelves to enhance growth of littoral zone vegetation; and improve connection to adjacent wetlands.
- The ability of canal organisms and sediments to remove nutrients from the water column needs to be studied further.
- Canals are conduits for water movement. Resources in the canals should be protected by establishing criteria for upstream water sources and controlling quality of runoff by BMPs. Downstream water bodies should be protected from excessive nutrients by establishing appropriate concentrations and loadings from the entire watershed through the TMDL process.



## Acknowledgements

Kevin VanArman provided the original format and layout for this presentation. The SFWMD (2010) Canal Study report was the primary basis for this poster. This report was prepared by the Canal Science Inventory Workgroup led by Kevin Carter. Garth Redfield provided overall science direction. Scott Huebner compiled and summarized water quality data with support from Nenad Ircanin and Lucia Baldwin and Steven Hill. Sue Newman, Mac Kobza, and Lawrence Glenn compiled information on wildlife including fish, alligators, and birds. John Maxted compiled data on macroinvertebrate communities in canals and prepared summaries and a reanalysis of key data. Cled Weldon, Sally Kennedy, Matahel Ansar, Adnan Mirza, and Lucine Dadian provided information on the operation, management design, and construction of canals. Chris Petit provided legal guidance.

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