SUNSET ACRES CASE STUDY
Tavernier, Florida

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MACTEC

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1.0 INTRODUCTION

As part of the Monroe County Residential Canal Inventory and Assessment, MACTEC Engineering and Consulting, Inc. (MACTEC E&C), formerly Law Engineering and Environmental Services, Inc., conducted a case study of a canal system that recently underwent modifications, including being permanently opened (connected) to Florida Bay. This canal system is located in the subdivision of Sunset Acres on Key Largo, Monroe County, Florida.

The purpose of the case study was to evaluate the water quality in the canal after modifications were completed. Historic water quality data, collected for approximately a decade, were compiled for comparison to water quality data collected since the connection to Florida Bay. The water quality data were compared to state water quality parameters, where applicable, and to ambient water quality data for Florida Bay. Additionally, water quality data were collected by MACTEC E&C on an approximately quarterly basis for one year (2002-2003) to provide additional data for evaluation of post-modifications changes. Canal bottom sediment samples were also collected to evaluate if accumulated debris was providing a continued organic load to the canal system.

The case study also included a review of the canal configuration and physical attributes, such as depth, geometry, length, geology and flushing rates, as these attributes can affect the water quality of canals (Kruczynski, 1999), and of historical literature regarding water quality in similar canals.

2.0 SITE DESCRIPTION

Sunset Acres is located in the town of Tavernier, an unincorporated community on Key Largo in Monroe County in the Florida Keys. The Florida Keys stretch from the southeast tip of Florida, bearing first south and then west toward the Gulf of Mexico (**Figure 1**). Generally, the Keys are described in literature, and depicted on maps, as beginning in Key Largo in the north and ending at Key West to the south, a distance of approximately 100 miles (160 km). Based on physical attributes such as geography, geology, hydrology and biology, the Florida Keys are divided into three areas (**Figure 2**):

- Upper Keys - Key Largo to Upper Matecumbe Key
- Middle Keys - Upper Matecumbe Key to the 7 Mile Bridge,
- Lower Keys – 7 Mile Bridge to Key West

Tavernier is located in the Upper Keys.

One of the characteristics delineating the three areas is their geology. The uppermost bedrock of the Keys is limestone, of which two different types are found at the surface – either Key Largo Limestone or Miami Oolite. In the Upper and Middle Keys, the Key Largo limestone is the surficial formation. The Key Largo limestone is comprised primarily of fossilized coral cemented in place (*in situ*) with calcite interspersed with fragmented remains of marine life such as bryozoans and mollusc shells. In the Lower Keys, although the Key Largo limestone is present, it is overlain by the Miami Oolite, which consists of egg-shaped limestone particles cemented together. Underlying these formations are additional marine sediments ranging in thickness from 3,000 to 14,000 feet (900 to 4000 m), which are the record of carbonate deposition in the area of the Keys since the Jurassic (DPC, 1973; Chiappone, 1996).

The physiography of the Upper and Middle Keys differs from that of the Lower Keys as well, in that the islands are elongated northeast to southwest, rather than northwest to southeast, respectively. To the south of the Keys is the Atlantic Ocean and to the north is Florida Bay. Florida Bay is a relatively large embayment of approximately 1120 miles^2 (1800 km^2) that is bordered by the Florida mainland to the north, the Keys to the east and south and the Gulf of Mexico to the west. In the Upper Keys, the exchange of water between the bay and the ocean is minimal due to the limited connection between Florida Bay and the Atlantic Ocean and the relatively shallow depth of the bay with a large number of mud banks and small lakes. As a

result, the tide on the bay side is generally less than six inches. The Lower Keys have a somewhat better tidal exchange, but it is still relatively low. The Middle Keys, however, are characterized by wide channels that allow for better circulation between Florida Bay and the Atlantic Ocean (EPA, 1984; EPA, 1999; Chiappone, 1996).

Sunset Acres is located on the Florida Bay side of Tavernier (**Figure 3**). The community of Sunset Acres consists of 80 residential lots, 61 of which front the canal system. The canal system consists of four adjoining legs (**Figure 4**). There are three, parallel east-west legs (Canals number 1 - 3) that range from approximately 350 to 500 ft (105 to 150 m) long. These three legs dead end at their east end and empty into a perpendicular perimeter channel (Canal number 4) that is approximately 600 ft (180 m) long. For the most part, the canals are seawalled.

3.0 SITE HISTORY

Prior to development, Sunset Acres consisted of black mangrove dominated wetlands and limestone outcroppings (Rio Palenque Research Corporation, 1979). Much of the shoreline of Key Largo and the Upper Keys was mangrove-dominated wetlands prior to development. The ocean side of the Upper Keys was predominantly red mangroves on rocky substrate, however, the bay side of the upper Keys included black mangrove-dominated wetlands on thicker peat and soft sediment substrate. As the Florida Key's population expanded, the mangrove areas were filled to create land for development, predominantly on the soft sediments of the bay side. A common construction technique used in coastal areas was dredge and fill, where drag lines with large clam shell devices operated by large cranes and mechanized pulley systems were dragged across the substrate to collect the "fill" used to build up the land for development. Much of the Upper Keys lacked natural harbors, and nearshore waters were too shallow to navigate with recreational boats, thus canals provided both the access and space needed to accommodate the boating recreation (e.g. diving, fishing) that fueled development of the Upper Keys. In addition, canals were popular because they provided the material for raising the land elevation above sea level, and met the desire for waterfront property in the Keys. Between 1970 and 1980, the population in the Keys increased by approximately 10,000 inhabitants. It was during this time that the community of Sunset Acres was developed. By 1991, over 40 percent of the mangrove habitat in south Key Largo was filled for development (Barada and Partington, 1977; Lott et al, 1996).

In 1970, a permit (#253.03-171) was issued to the developer of what was to become Sunset Acres by the Internal Improvement Trust Fund and authorized by the Florida Department of Pollution Control, predecessor to the present Florida Department of Environmental Protection (DEP). The permit authorized the developer to dredge the following:

- Three channels (canals) 100 ft long x 50 ft wide x 5 ft deep (30 x 15 x 1.5 m)
- One perimeter channel (connecting canal) 50 ft long x 30 ft wide x 5 ft deep (15 x 10 x 1.5 m)
- One access channel in Florida Bay of 150 ft long x 50 ft wide x 5 ft deep (45 x 15 x 1.5 m) (Note - This channel would act as a corridor through the shallow nearshore Florida Bay waters adjacent to the proposed development. Without this channel, boat traffic would inevitably cut lanes through the existing shallow waters and seagrass beds. This channel would direct boat traffic along a specific corridor to deeper water offshore.)

Residential lots would line the canals, and the access channel would provide boats access to Florida Bay.

Before Sunset Acres was developed, however, ownership of the property changed hands and the permit was subsequently revised to be a landlocked canal system dredged from uplands with no bay access. It allowed the canals to be dredged and the access channel in Florida Bay to be dredged, but the permit did not allow the canals to be connected to the access channel. The canals were separated from the access channel in Florida Bay by a berm.

In 1973, the canal system was dredged as a landlocked system, per the existing permit. However, the dimensions of the canals, in particular the depth, were apparently increased (based on subsequent measurements and correspondence). The finished canal system consisted of:

- Three channels between 350 and 500 ft long x 50 ft wide x 15 to 20 feet deep (105 – 150 x 15 x 5 – 6 m)
- One perimeter channel 595 ft long x 30 ft wide x 15 to 20 ft deep (180 x 9 x 5 – 6 m)

In addition, the access channel, although still permitted, was not dredged.

In 1974 the Internal Improvement Trust Fund allowed indirect access to Florida Bay by permitting (#44-39-2514E):

- Dredging of one access channel 580 ft long x 50 ft wide x 5 ft deep (177 x 15 x 1.5 m) in Florida Bay
- Construction of a boat lift platform, to lift boats from the landlocked canal into the access channel in Florida Bay.

The access channel was dredged, but the boat lift was never constructed. This meant that there was no boat access, either directly (ex: cut through berm) or indirectly (ex: boat lift). A berm was still in place that separated the canals from the access channel.

In 1974, a sewer plant, operated by the homeowners was put into service. Its permit is renewed every 5 years by DEP.

In 1979 a permit application (#44-16735-5E) was submitted to allow removal of an earthen plug in order to connect the landlocked canal system to Florida Bay. Also in 1979 an artificially-induced break occurred in the berm. The break was reportedly enlarged in 1980, but subsequently replugged.

In 1980 the permit was denied by DEP.

In 1981 a storm-related break occurred in the berm.

In 1988, the US Army Corps of Engineers (USACE) sent a Notice of Violation (NOV) to Sunset Acres informing the community that the break in the berm was not permitted and would have to be repaired. The matter was taken to court, and in 1989 the USACE repaired (plugged) the berm.

According to a 1990 letter from Sunset Acres homeowners addressed to then Florida Governor Bob Martinez, during the time the berm was open, homes were sold to persons who were not informed "of any violation or indication that access to the bay would be closed". The letter stated that although the developer entered into an agreement with the USACE to plug the berm and pay a fine, this information was never provided to the homeowners. When the homeowners learned of the NOV, they retained engineers and lawyers to work with the regulatory agencies to obtain the necessary permits to permanently and legally open the berm to allow direct boat access to Florida Bay (DEP, 2001).

In May 1989, Sunset Acres installed an aeration system to improve the water quality in the canal. A discussion of water quality issues and the results of several years of water quality data from the Sunset Acres canals are presented below in Sections 4.0 and 5.0.

Later in 1989, during an inspection by DEP, four culverts were discovered in the berm. The culverts, which connected the perimeter canal to Florida Bay, reportedly appeared to be relatively new. A letter was sent by DEP to Sunset Acres notifying them that as a result of the four unpermitted culverts installed in the berm, the aeration system required a permit, because the canal was now connected to the bay. The DEP letter stated that installation of the aeration system could cause resuspension of heavy metals from canal sediments, which in turn could result in degradation of Florida Bay (which had been designated an Outstanding Florida Water, see discussion below).

In 1991, a portion of the berm was again washed away in a storm, re-connecting the canal system to Florida Bay.

In 1997, after many proposals, negotiations, studies and revisions to proposals, the DEP and USACE issued a permit to shoal (backfill) the canals to a depth of 6 feet, and unplug the berm to allow a permanent connection to Florida Bay. The permit required the use of clean limerock fill free of organic debris.

In August 1998, the permitted work was completed. Monroe County issued a permit requiring the community to monitor the canal and adjacent waters in Florida Bay for one year.

4.0 WATER QUALITY

Regulatory concerns in regard to allowing the connection of the Sunset Acres canal system to Florida Bay centered on the question of water quality. Florida Bay is classified as a Class III water under Chapter 62-302, Florida Administrative Code (FAC). Class III waters are defined as waters used for recreation and the propagation and maintenance of healthy, well-balanced populations of fish and wildlife. Under Chapter 62-302, FAC, certain water quality criteria must be maintained. In addition, Florida Bay is afforded special protection due to its designation as an Outstanding Florida Water (OFW) and its inclusion in the Florida Keys National Marine Sanctuary (FKNMS). As a result, the state has the responsibility to 1) ensure that the Class III Water Quality Standards will be maintained, 2) look at cumulative impacts, 3) ensure that the OFW will not be degraded, and 4) protect the public's interest.

It was then, within these mandates to protect the water quality of Florida Bay, that the permit application and ensuing negotiations were conducted. Although it is large (over 1100 miles^2 /1800 km^2), the bay is relatively shallow. Its bottom is not flat, but rather is a unique system of shallow bays that are less than 10 ft (3 m) deep and are separated by mud banks that are typically covered by seagrasses and algae, the predominant bottom cover of the bay. In northeastern Florida Bay, including the vicinity of Sunset Acres, where there is limited opportunity for exchange of oceanic waters, fish species abundance and diversity is lower in comparison with other parts of the bay. However, seagrass communities are recognized as providing habitat for juvenile and sub-adult stages of fish, including important sport and recreational species such as red drum, spotted seatrout and gray snapper. Seagrass communities, in general are recognized as important nursery and spawning grounds for marine life (Barada and Parrington, 1972; Chiappone and Sluka, 1996; Kruczynski, 1999).

While the definition of water quality can be subjective (ex: clear water, non-offensive odors), there are a number of parameters that can be measured objectively. Typical water quality parameters include nutrients, salinity, temperature, dissolved oxygen, pH, and solids, both organic (plant detritus) and inorganic (minerals). A discussion of these parameters relative to this case study follows:

Biological Oxygen Demand (BOD) – This parameter is important in the vertical profiling of canals. The narrow configuration of canals prevents vertical mixing by wind. Wind mixing of shallow waters occurs in all the nearshore or shallow areas of Florida Bay and the Keys. In canals, the input of particulate organics stimulates the microbial degradation of organic matter (i.e., leaves, fish heads, plankton). This microbial action rapidly strips the oxygen content of water and leads to a shift from "aerobic" (with oxygen) to "anaerobic" (without oxygen) respiration. The common metabolic end products of anaerobic respiration include methane (a "sewage smell") and hydrogen sulfide (a "rotten egg smell"), common in muds of mangroves. In addition, the shift to anoxic (anaerobic) conditions produces high turbidity, which reduces light penetration through the water column, thus the conditions are amplified once initiated (Sealey, 2001). Hydrogen sulfide is toxic to fish, and all of these end products create undesirable water quality conditions for homeowners such as offensive odor and poor water clarity.

Salinity and temperature – Salinity and temperature vary widely in the bay due to its shallow depths and the seasonal influxes of freshwater to the bay from the Florida mainland. In a summary of a number of studies conducted in Florida Bay and compiled for The Nature Conservancy, salinity and temperature ranged from 2 to 70 parts per thousand (ppt) and from 9 to 40° C, respectively. In the vicinity of Sunset Acres, salinity is generally between 30 and 40 ppt; however, it can become higher, especially in the summer when evaporation rates exceed freshwater recharge and the bay is considered a negative estuary. For comparison, salinity in offshore waters, such as the Atlantic Ocean, is generally 36 to 37 ppt. Salinities of nearshore waters are generally higher, ranging between 36.5 and 42 ppt. Water temperature is dependent upon the weather and the variability is a result of circulation patterns, cold fronts, wind speeds and air temperatures (Chiappone, 1996). In canals with poor circulation, the water tends to be stratified because denser waters sink. Therefore, the water at the bottom of the canal tends to be colder and more saline than the surface water.

Nutrients - The source of nutrients in Florida Bay and canals in Monroe County is a cause of much debate and study. While nutrients are essential for the healthy functioning of plants and animals, excessive levels can be detrimental. It has been documented that nutrients such as nitrogen and phosphorus have increased over the years in Florida Bay to such an extent that eutrophication occurred, i.e. excess nutrient levels exist. However, because nutrient data were not collected before canal modification, the effect of nutrients on water quality in the canal and adjacent waters will not be analyzed in this study.

Dissolved oxygen – Dissolved oxygen (DO), an important component in determining the quality of tropical marine habitats, is a function of both advective and biological processes. The primary factors affecting the distribution of DO in seawater are: 1) mixture of atmospheric oxygen with surface water, 2) biological production by plants via photosynthesis (daylight hours only), 3) biological use in respiration and oxidation of plant materials and 4) sinking of colder waters rich in oxygen (Lapointe and Clark, 1992; Chiappone, 1996). The configuration of deep canals (i.e. those over approximately 5 – 7 ft (1.5 - 2 m) deep) has direct bearing on some of these factors. Following is a brief discussion of each of these factors as they relate to canals in the Keys, particularly those with a configuration similar to that of the Sunset Acres canals:

- *Mixture of atmospheric oxygen with surface water* – Mixing is inhibited in canal systems such as Sunset Acres due to lack of circulation (Rio Palenque, 1979), thus this mixture would most likely only occur in the near surface waters. Because the canals are relatively deep (generally over 15 ft/5 m) in

comparison to Florida Bay (less than 5 ft/1.5 m) and the tidal fluctuation in the Bay is less than 1 foot (0.3 m) (DEP, 2001), there is no energy or force to induce circulation in canals, other than wind. A hydrographic study of the Sunset Acres canal system conducted in 1991 calculated that wind may contribute to circulation based on prevailing wind direction (from east) and orientation of the Sunset Acres canals (east - west) (DEP, 2001). However, a circulation study of the Sunset Acres canal system using dye tracers conducted in 1984 indicated that limited vertical mixing occurred within the canal system (USEPA, 1984). Poor circulation contributes to a phenomena commonly observed in deep canals called stratification, i.e., DO concentrations are stratified in the water column. As has been observed in the Sunset Acres canals, the DO level is higher in samples collected at or near the surface than in samples collected at or near the bottom.

- *Biological production by plants (photosynthesis)* – Canals generally have a box-like construction that prevents the penetration of adequate light necessary to promote oxygen-producing plant life, especially on the canal bottom. Additionally, samples and observations of Sunset Acres and similar canal substrates indicate the presence of silt and finer sediments in canals as opposed to coarser sediments (sand and shell fragments) found in adjacent nearshore Florida Bay. The fine sediments, and elevated organic matter (see next bullet) also limit development of a diverse benthic macroinvertebrate community. Biological studies conducted at Sunset Acres and similar canals generally indicate that biodiversity is lower in canals as compared to adjacent ambient waters (USEPA; 1984; Barada and Partington, 1977; Rio Palenque, 1979; DEP, 2001).

- *Biological use* – Dead plant materials accumulate in the bottom of canals. Studies have found elevated organic matter in canal sediments. Degradation of this material tends to deplete available oxygen(USEPA; 1984; Barada and Partington, 1977; Rio Palenque, 1979).

- *Sinking of colder waters* – During cold spells, the surface water becomes cooler. If the water becomes colder, and therefore heavier, than the water lower in the water column, it will sink, thus mixing surface and bottom waters.

Thus, due to a combination of configuration and geographic location, the primary factors that affect the distribution of DO have limited benefit in Keys canals. Atmospheric mixing and biological production occur at or near the surface only, biological use exceeds production, and sinking of colder waters would not be expected to occur often in South Florida. The result is that the DO concentration in canals, except at the surface, is generally lower than the 4.0 milligrams/Liter (mg/L) regulatory standard in Chapter 62-302, FAC. This is further exacerbated by elevated temperatures and salinity, both of which decrease DO and are common conditions in Florida Bay and adjoining canals.

pH – pH is generally in equilibrium with the atmosphere in oceanic water at roughly 8.2. Variances in pH can affect the toxicity or precipitation of certain metals. Reduced pH levels, found in certain affected waters, can be toxic to fish.

Solids – Solids are an important consideration in canal systems because stormwater runoff containing plant debris, solid waste, soil, and other solids tends to accumulate in canals. Such accumulation can affect turbidity, light penetration and BOD, as described above.

In 1980, following denial of the permit application to open the Sunset Acres canal system to Florida Bay, the consultants for Sunset Acres began exploring options for modifications of the existing canal to address water quality concerns, and enhance the probability of eventual approval of a connection to Florida Bay.

In the late 1980s, the community began collecting water quality data in preparation for installing an aeration device to improve the DO levels in the canal through oxygenation. Basically, in an aeration system, a stream of small air bubbles rises through the water column from perforated pipes laid along the canal bottom. This adds oxygen to, and provides some vertical mixing (by displacement) in the water column. The sample locations used to collect the water quality data are shown on **Figure 5**. Note that samples have been collected by a number of different agencies and other entities since 1979, and each set of sampling data used its own unique sample numbering system. Each of these systems started with sample number 1 and continued sequentially, with the final number representing the number of sample locations or stations. Therefore, what is Station 1 for the Sunset Acres community sample data, is not necessarily the same location as Station 1 for DEP's sample data. A master list of sample numbers by sampling event and their corresponding map number (on **Figure 5**) is provided on **Table 1**.

MACTEC E&C performed a one-year monitoring study (4 sampling events) from April 2002 to April 2003. Monitoring included the measurement of salinity, turbidity, temperature, and dissolved oxygen (DO) parameters from 3 depths in the canal system at the end of each of the 3 canal legs, at the canal mouth and in the bay just outside of the canal system. A Field Sampling Plan was prepared and followed to ensure that approved and consistent protocols were followed. The Field Sampling Plan is included in the attached CD. Samples were collected in the morning, preferably on falling tides, to assess the worst case conditions, particularly for DO. Comparable samples were collected in the afternoon. Samples were collected approximately quarterly.

Additionally, sediment cores were collected from the canal bottoms at the end of each canal leg. The samples were dried, sieved, separated by grain size and then muffled to determine the total organic content at the University of Miami. This was done to determine the residual organic load that may still be affecting the water quality.

When studying the water quality of the Sunset Acres canal system, it is important to keep in mind several features (Sealy, 2001):

1) The entire development was constructed on fill, and in particular fill that was likely high in organic content (mangrove peat).

2) The canal system was "leaky" with an unconsolidated rocky jetty along the western face of the perimeter canal (i.e., adjacent to Florida Bay).

3) Water quality sampling (discussed further below) throughout the history of Sunset Acres was sporadic and only partially characterized the variability of key parameters. Both homeowners and regulators, for different reasons, focused on DO.

5.0 WATER QUALITY DATA SUMMARY AND COMPARISON

In this section, water quality data, collected before and after the permitted modifications were made to the canal and berm, will be compared. Water quality data was collected by various entities between 1979 and 2003. The data are compiled in the table provided in **Appendix A**. The raw data, i.e. the report or document from which the data were obtained, are provided in **Appendix B**. A summary of the data providing collection dates, the entity for whom the data were collected, the document from which the data was obtained and the parameters that were collected is provided in **Table 2**.

The following evaluation is divided into two sections. The first section will provide a comparison of water quality data collected before and after installation of the aeration system. This discussion will be followed by an evaluation of the water quality data collected before and after the berm at Sunset Acres was permanently unplugged to allow access to Florida Bay.

5.1 COMPARISON OF WATER QUALITY PARAMETERS BEFORE/AFTER AERATION SYSTEM INSTALLATION

In May 1989, an aeration system was installed in the canal system of Sunset Acres at the request of, and through funds provided by, the homeowners in the community. A copy of the specifications and layout (drawing) are provided in **Appendix C**. Aeration in canals treats a symptom of high BOD which is low DO. Aeration does not treat the source of the problem which is excess organic material accumulating in the bottom of the canal. Aeration is a method of shifting the canal back to aerobic respiration, which ideally would allow microbes (bacteria, blue-green algae) to process organic matter with oxygen, thus avoiding unpleasant end-products of anaerobic respiration (odor, cloudy water). Aeration can be designed to prevent stratification and maintain DO levels to some threshold, but organic input into the canal system can at some point exceed the system's ability to maintain aerobic conditions and most aerated canals still develop anoxic sediments. There is some concern as well that, because aeration facilitates some circulation within the water column, it may cause degradation of adjacent ambient waters by exporting organic matter that would normally accumulate within the canal, out of the canal system (Sealey, 2001).

To evaluate the effectiveness of the aeration system, DO, temperature and salinity were measured before and after the system was installed. Samples were generally collected at three depths: surface, mid-depth and bottom (generally collected one foot from the bottom of the canal). The samples were analyzed in the field for temperature (° C), DO (mg/L), and salinity (ppt). Some samples were also analyzed for turbidity (nephelometric turbidity units (NTU)). Samples were collected from five locations in the canals and one location in Florida Bay. The sampling results are provided in **Table 3** and the sampling locations are shown on **Figure 5**. Note that due to changes in sampling personnel, the sample nomenclature changed over the course of sampling. In **Table 3** the Station Number refers to the sample location as reported at the time the sample was collected and the Sample Location corresponds to the location on **Figure 5**.

A total of nine sampling events are being used to evaluate the effectiveness of the aeration system - three sets of samples collected prior to the system being installed and six sets of samples collected after installation. The three sampling events that occurred prior to installation of the aeration system were collected on October 11, 1988, April 24, 1989, and May 11, 1989. Although samples were collected for approximately 10 years following installation of the aeration system, in an attempt to isolate noted changes to a single variable (i.e., installation of the aeration system), only the six sampling events that occurred in 1989 immediately after the installation are being used for this comparison. The post-aeration installation samples were collected on May 17, May 18, July 10, August 20, September 10, and September 18, 1989. There was a seventh sampling event that occurred in December of 1989, but samples were only collected at mid-depth, and therefore are not comparable to the other sets being evaluated. Following the December 1989 event, samples were not collected again until 1991.

As can be seen from the sample results provided in **Table 3**, samples collected prior to the aeration system being installed generally exhibit stratification, i.e. the water quality parameters change with depth. As discussed earlier in Section 4.0, stratification is common in canals due to poor circulation caused by their configuration. This is further exacerbated in canals adjacent to shallow open waters. Typically in canals with poor circulation, DO and temperature decrease with depth, while salinity increases. Factors, which generally indicate stratification, are as follows:

- DO concentrations are highest at the surface where the canal water is able to obtain oxygen from the atmosphere. Because there is little energy to promote mixing, the DO obtained from the atmosphere is not distributed throughout the water column.

- Plants growing on the substrate of marine waters typically manufacture oxygen through photosynthesis, but because light penetration is limited, there is little or no plant life at the bottom of canals. In addition, organic materials tend to accumulate at the bottom of canals and increase the BOD.

- The colder the water, the denser; this causes cold water to sink, and with no mechanism for mixing, the cold water settles near the bottom.

- The more saline the water, the denser; this causes salinity to increase with depth and settle like colder water.

The sample results indicate that stratification was occurring in the Sunset Acres canal. For example, as shown in **Table A** below, in the May 11, 1989 samples, the DO concentration in the surface samples obtained from the canal ranged from 3.0 to 4.0 mg/L, whereas the concentrations of the mid-depth samples ranged from 1.1 to 3.4 mg/L. The mid-depth samples were between 0.1 and 1.9 mg/L lower than the surface samples at each sample location. The decrease in the DO concentration was more pronounced in the bottom sample, where DO concentrations ranged from 0.2 to 0.4 mg/L, a decrease of between 2.8 and 3.6 mg/L. During the same sampling event, the DO concentration of the Florida Bay samples were 5.8 mg/L at both the surface and the bottom.

TABLE A: MAY 11, 1989 DO CONCENTRATIONS (MG/L):

Sample Location	Surface Sample	Mid-depth Sample	Bottom Sample	Difference Between Surface and Mid-depth DO Concentrations	Difference Between Surface and Bottom DO Concentrations
Station 1	3.0	1.3	0.4	1.7	2.6
Station 2	3.5	3.4	0.4	0.1	3.1
Station 3	3.0	1.1	0.2	1.9	2.8
Station 4	4.0	3.0	0.4	1.0	3.6
Station 5	4.0	3.5	0.3	0.5	3.7
Florida Bay	5.8	Not collected	5.8	-	0

Also evident in the May 11 sampling results was the stratification of the temperature and salinity measurements. Temperature decreased about 0.5° C between the surface and mid-depth and approximately 1.0 ° C in the bottom sample, while salinity increased approximately 0.5 ppt with each successive sampling depth.

Following installation of the aeration system, stratification still was evident, but less pronounced. Using May 18, 1989 as an example, the DO in the surface samples from the canal ranged from 5.4 to 5.8 mg/L (**Table B**). The mid-depth samples were very close, ranging from 5.1 to 5.8 mg/L. The difference between the surface and mid-depth samples, ranging between 0 and 0.3 mg/L, indicated little stratification between these depths. The DO concentrations for the bottom samples ranged from 3.4 to 4.4 mg/L, a decrease of between 1.0 and 2.4 mg/L, which is relatively small compared to the differences in the pre-aeration samples. During the same sampling event, the DO concentration of the control sample in Florida Bay was 8.0 mg/L at both the surface and the bottom.

TABLE B: MAY 18, 1989 DO CONCENTRATIONS (MG/L)

Sample Location	Surface Sample	Mid-depth Sample	Bottom Sample	Difference Between Surface and Mid-depth DO Concentrations	Difference Between Surface and Bottom DO Concentrations
Station 1	5.5	5.4	3.8	0.1	1.7
Station 2	5.7	5.4	4.4	0.3	1.3
Station 3	5.4	5.1	4.4	0.3	1.0
Station 4	5.8	5.5	3.4	0.3	2.4
Station 5	5.8	5.8	3.8	0	2.0
Florida Bay	8.0	Not collected	8.0	-	0

Improvement was also evident in the May 18 salinity sampling results - the salinities remained at approximately the same concentration throughout the water column. Temperature, however, still showed a decrease of about 0.5° C between the surface and mid-depth and approximately 1.0° C in the bottom sample.

The average DO concentrations for the nine pre and post-aeration sampling events were plotted to evaluate potential trend development. The results are plotted on **Chart 1**, which includes the following four sets of data:

- DO in Florida Bay before the aeration system was installed (the average of the DO concentrations for each depth for bay samples collected during three events from October 11, 1988 to and including May 11, 1989).

- DO in Florida Bay after the aeration system was installed (the average of the DO concentrations for each depth for bay samples collected during seven events from May 17, 1989 to and including September 18, 1989).

- DO in the canal before the aeration system was installed (the average of the DO concentrations for each depth for canal samples collected during three events from October 11, 1988 to and including May 11, 1989).

- DO in the canal after the aeration system was installed (the average of the DO concentrations for each depth for canal samples collected during seven events from May 17, 1989 to and including September 18, 1989).

A few trends in the DO concentrations are evident on **Chart 1**:

- Florida Bay concentrations do not exhibit stratification – i.e., the lines are flat. This is true for the bay samples both before and after the aeration system was installed.

- Florida Bay concentrations are higher than the canal concentrations both before and after the aeration system was installed.

- The concentrations in both the canal and Florida Bay increased following installation of the aeration system; however, the increase in the middle and bottom sample of the canal is of greater magnitude (approximately 4.0 mg/L and 3.5 mg/L, respectively) than the overall increase in the before and after aeration system installation of the bay samples (approximately 2.0 mg/L). This indicates the increase in the mid-depth and bottom canal samples are not just reflective of an apparent overall increase in DO, but of an improvement after the aeration system was installed.

- The canal concentrations still exhibit stratification after the aeration system was installed, but the difference between the surface and bottom sample is less after the aeration system was installed (approximately 1.5 mg/L) than before the installation (approximately 3.0 mg/L).

As sampling continued through 1989, the DO concentrations remained above pre-aeration levels. Although the DO concentrations continued to exhibit stratification in the bottom sample, concentrations below the state criteria of 4.0 mg/L were infrequent. The occurrence of DO concentrations below the regulatory criteria were recorded in the samples collected at the dead end of Canals #1 and 3, and in the perimeter canal locations that are not adjacent to the flushing channels. The low DO concentrations (i.e., below 4.0 mg/L) always occurred in the bottom sample.

5.2 COMPARISON OF WATER QUALITY PARAMETERS BEFORE/AFTER MODIFICATIONS TO OPEN CANAL TO FLORIDA BAY

In 1997, Monroe County, FDEP and USACE granted Sunset Acres a permit to permanently remove a portion of the berm to allow access from the Sunset Acres canal to Florida Bay.

Pertinent conditions of the permits included:

- Backfill existing residential canal system to an average depth of no greater than
- 6 feet below mean low water.
- Plug existing culverts.
- Construct and maintain a plug isolating canal system from Florida Bay for the duration of the shoaling operations.
- Submit a bathymetric survey at completion of shoaling operation.
- Following approval of the shoaling operation, remove the plug and open the canal system to Florida Bay.
- Work to be completed before January 2000.

In addition, Monroe County required Sunset Acres to implement a water quality monitoring plan containing the following provisions:

- Parameters to be collected included: time of day, water depth, temperature, DO, electric conductivity, pH, turbidity and salinity.
- Data to be collected beginning on the day the plug is removed.
- Data to be collected from five locations in Sunset Acres, one location in Florida Bay and five locations in Hammer Point Subdivision (for comparison).
- Data to be collected from two depths at each location: one foot below the surface and one foot from the bottom.

The first sampling event occurred on August 4, 1998. Sampling continued monthly until August 18, 1999. Four additional sampling events were performed by MACTEC E&C between April 2002 and April 2003 as part of the Monroe County Residential Canal Assessment and Inventory.

The issuance of the permits was the culmination of almost 20 years of negotiations by the Sunset Acres homeowners to obtain access to Florida Bay. Throughout this time, water quality data were intermittently collected by various entities. The only parameter consistently collected throughout this period was DO; however, other parameters were collected intermittently. A summary of the data collected, dates of collection, and the entity for whom data were collected is provided in **Table 2**.

Because DO was the only data consistently collected, it will be the focus of the discussion in this section evaluating the water quality in Sunset Acres canal system before and after the permit modifications were implemented. However, interpretation of DO values requires some information on temperature and salinity conditions in the canal at the time of sampling.

As noted in the previous discussion, the water quality parameters in the canal system exhibited stratification. A comparison of surface vs. bottom DO concentrations before and after the canal was backfilled in August of 1998 is provided in **Charts 2** and **3**, respectively. This is typical for narrow deep canals that are plugged or have a shallow sill- the vertical walls of the canals prevent wind mixing, and there is not mechanism for bottom water exchange.

Chart 2 compares the surface and bottom DO concentrations before the canal was backfilled. As illustrated in this chart, the DO concentrations for the bottom sample, while mimicking the surface sample, show a wide range in the concentrations, sometimes as much as 3 or more mg/L lower than the surface sample. However, in **Chart 3**, which compares the surface and bottom concentrations after the canal was backfilled, the variations are generally 1.0 mg/L or less. This indicates that both more exchange of water is likely occurring throughout the canal system, and more mixing vertically with shallower depths throughout the canal, although there is still some stratification. The only source of DO is mixing with the atmosphere, with some photosynthetic contribution depending on the biomass of algae or photosynthetic microbes. Indications include: 1) the canal is much shallower, shallow waters would require less wind energy for vertical mixing, and 2) the improvement was immediately noticeable and benefits from photosynthesis depend on the photosynthetic flora in place (no seagrass recorded on the bottom of the canal, and little macroalgae on the sides).

A comparison of DO concentrations in the canal and adjacent bay before and after the 1998 modifications is provided in **Charts 4** and **5**, respectively. **Chart 4** illustrates the natural vertical mixing of the water column in adjacent bay waters (e.g. similar surface and bottom DO concentrations), as opposed to a highly-stratified and deeper water column in the narrow canal (e.g. lower bottom DO concentrations). **Chart 4** also illustrates the impact of storm and weather events on the coastal ecology, the canal and bay data are distinct and different, with the exception of one event in August 1995. Very hot tropical summer weather can drive DO of the natural system to levels approaching the canal DO. After modifications, there are fewer differences

between canal and adjacent bay waters (**Chart 5),** indicating greater circulation through the canal system**.** The DO concentrations improved overall in the canals with increased water movement.

The DO concentrations were then compared over the 20-year span in which the data were collected. On **Chart 6A**, the DO concentrations in the surface samples of the canal and of the adjacent bay are plotted with a trendline. The apparent trend is a decrease in the DO concentrations in both the bay and the canal over time. The overall drop in DO for both the adjacent bay and canal is an indication of the chronic eutrophication of nearshore waters in the Florida Keys. The consistently lower DO in the canals is indicative of the higher BOD of the restricted system. In an attempt to evaluate whether this trend was long-term, on **Chart 6B** only the sampling data collected prior to the 1998 modifications were plotted. Here the trend indicates the DO concentration of the bay surface samples increased slightly, while that of the canal decreased. This suggests that the downward trend in the DO concentration of the surface sample in the bay occurred after the 1998 modifications. Even if this data set is small, the eutrophication of the adjacent bay water appears as a consistent trend since 1998.

On **Chart 7A**, the DO concentrations of the bottom samples of these water bodies are plotted. The trendlines through these data show two different patterns. Overall, the bottom waters experience greater intra-annual variability and lower extremes (near anoxia). While the DO concentrations in the adjacent bay waters appear to be decreasing (eutrophication), the canal DO concentrations slightly increased (improved circulation). Again, the DO concentrations were replotted using only the data collected prior to the 1998 modifications (**Chart 7B**). This chart shows very little difference in bottom DO concentrations for both bay and canal waters prior to 1998.

5.3 SEDIMENT QUALITY AFTER MODIFICATIONS TO OPEN CANAL TO FLORIDA BAY

Sediment cores, approximately 8.5 -10.5 inches (22 to 27 cm) long, were collected from the canal bottom at each sampling station (**Figure 5**), then frozen for analysis of total organic content. The cores were collected in 2-nch diameter plastic pipes, frozen, and brought to the University of Miami for analysis. The frozen cores were sliced into sections. The sections were placed in crucibles in a drying oven set at 60° C for up to 48 hours or until dry weight stabilized. There was no evidence of stratification and the grain size was uniformly small mud-clay material with some shell fragments or rubble (less than 0.125 mm). Grain size was not retained by 0.125 mm

sieve, indicating very fine mud-clays. Less than 1% of dry weight of sediment was larger grain size. Sediment samples were discolored black, with a strong methane odor, and a very sticky consistency, suggesting high organic content. There was no evidence of clean limerock backfill material at any of the sediment sampling stations.

Smaller samples of dried sediments were put into crucibles, and placed in a muffle furnace at 555 ° C to burn all organic matter. Samples remained in muffle furnace for 3 hours, were cooled, and re-weighed to determine percent organics in the sediment. All samples were weighed on a top-loading analytical scale to 0.01 grams. Crucible weights have already been subtracted from sample weights.

The results showed that these sediments contained an organic content ranging from 2.8% to 6.1% of the dry weight (**Table 4)**. These would be considered relatively high organic content typically seen in sediments collected from canal bottoms or from a coastal wetland system. These values are one to two orders of magnitude higher than offshore sediment samples. The very fine grain size in the samples is also consistent with sediments found in mangrove wetlands. The high organic matter suggests loading of nutrients/particulate organic material from the adjacent land and accumulation on the canal floor. Sediments are likely resuspended and disturbed by wind or boats in the canal, thus remain unstratified, flocculent and likely support a robust anoxic microbial community. Bottom DO measurements are likely near zero. DO measurement made by oxygen electrodes are subject to error in hypoxic environments with hydrogen sulfide (thus not true “0” DO measurements would be recorded).

High water contents reflect the flocculent nature of the sediments (soft and "oozy" on the bottom). Small grain size would support higher surface area for microbes and trapping POM, and higher volume of pore water. The nature of the sediments make them likely contributors to the chronic poor water quality in this canal system. The sediments collected in this sampling do not indicate a coarse grain or sand fill as prescribed by the back-fill permit. **Appendix B** contains the complete laboratory spreadsheets.

6.0 CONCLUSIONS AND RECOMMENDATIONS

While there is sufficient data to make some overall conclusions about the Sunset Acres canal, the picture is not complete. The only data set of sufficient duration is that of DO, which by itself can be used as a good indicator of water quality and is a critical component in maintaining a healthy ecosystem and supporting marine life. When DO levels fall below 4.0 mg/L, certain marine species experience distress, and levels below 1.0 mg/L are fatal to some species. Therefore, low DO levels, even if it only occurs sporadically, can have detrimental effects on the marine environment (DPC, 1973).

The DO data for Sunset Acres indicate that DO concentrations in the canal when the data were first collected were frequently below the state regulatory criteria of 4.0 mg/L (**Chart 4**). While DO showed some improvement after an aeration system was installed (i.e., higher DO concentrations in both surface and bottom samples, and less variability between surface and bottom concentrations as depicted on **Chart 1**), stratification and DO concentrations below the regulatory criteria still occurred (as shown on **Chart 2**). The DO concentrations after the 1998 modifications exhibited some stratification, but the incidences were sporadic and minimal, indicating that the water column is in better equilibrium and more closely resembles open water conditions (**Chart 3**). As depicted on **Chart 5**, the DO concentrations in the canal were still below that of the bay and usually below the state criteria.

The DO concentrations of the surface samples in both the bay and the canal show a decreasing trend when the available data is plotted (1979 through 2003, **Chart 6A**). When only the data prior to the 1998 modifications are plotted (**Chart 6B**), however, the bay DO concentrations at the surface appear to increase slightly, although the canal surface samples still indicate a downward trend. However, in **Chart 3**, which compares the surface and bottom concentrations after the canal was backfilled, the variations are generally 1.0 mg/L or less. This indicates that there is more mixing since the canal was backfilled, although there is still some stratification.

The DO concentrations of the bottom samples tell a different story. When the reviewed data is plotted (**Chart 7A**), the bottom samples from the bay show the same downward trend as the surface samples, but the bottom samples from the canal appear to be improving. When only the

data collected prior to the 1998 modifications is plotted (**Chart 7B**), the DO concentrations of both the bay and the canal appear to be improving.

The cause of the apparent decrease in DO concentrations of the surface samples after the 1998 modifications is not known. As has been stated earlier, dissolved oxygen concentrations in seawater are extremely dependent on temperature – any assessment of year-to-year variability in DO has to be accompanied by an assessment of year-to-year temperature records. 1998 was an El Nino-Southern Oscillation year, with record high temperatures in the Florida Keys (and recorded coral bleaching events). This year would produce extremely low DO values even in natural environments. As noted earlier, DO levels are dependent on several key factors: vertical wind mixing, biological production by plants (photosynthesis), biological use, and sinking of colder waters.

Vertical wind mixing of the water column is occurring. This is evident in the stratification of the surface and bottom samples in the canal - the surface samples consistently have higher DO concentrations, as would be expected if the major contributor to DO was atmospheric mixing and there was no vertical mixing of the water column. A dye trace study on a canal in Key Largo of similar configuration as that of Sunset Acres prior to backfilling (i.e., relatively deep as compared to adjacent ambient waters) revealed poor vertical mixing of the canal water (USEPA, 1984). This is only one part of the canal circulation problem. Water quality in the canals will be improved with the removal of organic matter/nutrient loading as well as total water column turnover and circulation with adjacent marine systems. Aeration has provided the vertical mixing without the horizontal transport of water out of the canal system.

Reviewed biological data indicate the center trough of the canals support no benthic macroinvertebrates; however, benthic macroinvertebrates were found on the shallower sidewalls (Rio Palenque Research Corporation, 1979; DEP, 2001). This data is based on one 1984 study of the bottom and sidewalls of the canals, and one 1979 study of the sidewalls only. No studies were available since the addition of the aeration system nor since the 1998 modifications. With aeration, algal growth along the sides of the canals is generally greatly enhanced, especially *Halimeda* spp., but these plants may be a very small part of the total photosynthetic community with water column microbes (phytoplankton, blue green algae) dominating the production processes. (Sealey, 2001). The low diversity of macroalgae species (only Halimeda spp, few

other macroalgae), suggests that the eutrophication process dominates the canal on a cycle of blooms and crashes of photosynthetic microbes.

Management of canal systems should include a goal of mimicking natural coastal processes and ecology. A diverse seagrass/macroalgae community on the bottom and walls of the canal can help support other marine life, as well has perform a critical ecological system service of cleansing minor contaminants and pathogens from the water. The localized eutrophication of canal waters poses not only an ecological threat to nearshore marine environments, but also a potential public health threat as the canal waters become conducive to pathogen growth. The 1984 and 2002 sediment sampling studies found the substrate consisted of fine silts and clays high in organic content (DEP, 2001). As was noted above, DO concentrations showed some improvement after an aeration system was installed. However, stratification and DO concentrations below the regulatory criteria still occurred, which may be due to the inability of the aeration system to overcome the accumulation of organics. Organic matter entering a canal can have one of two fates: 1.) it is processed or eaten by some organism with possible export to adjacent waters or 2.) it becomes locked into a "sink" buried in sediments or locked into a stratified "hypoxic zone" at the canal bottom. More organic input than can be "processed" will resort to accumulation of material in a "sink". Unfortunately, storm events or human activities can facilitate the catastrophic transport of pollutants and accumulated organic matter to adjacent nearshore marine communities. (Sealy**,** 2001). The export of organic material from canals is documented as a source of chronic nutrification to Outstanding Florida Waters of the Keys (Lapointe and Clark, 1992; Lapointe et al, 1994). An understanding of how much organics/nutrients are being input to the Sunset Acres canal system and their fate would be helpful in evaluating the DO trends noted.

The final factor, DO mixing as a result of the sinking of colder waters, is not likely a significant factor in south Florida.

There are several organizations collecting data on Florida Bay - the Nature Conservancy, the FKNMS, Harbor Branch Oceanographic Institution, Inc., DEP, Florida International University and the University of Miami to name a few. Understandably, Florida Bay is a complicated system, and the effect on or by canals, if any, is just one consideration among many others. Nearshore waters have been shown to have lower DO levels than offshore (Lapointe and Clark, 1992). The close alignment of the DO levels in the bay and the Sunset Acres canal system seems

to indicate the presence of a relationship. A study of DO levels in nearshore waters that may and may not be influenced by a canal system may provide some insight as to the effect of canals on nearshore waters. A long-term multi-million dollar water quality monitoring programs is now supported as part of the Florida Keys National Marine Sanctuary. This dataset will become more valuable with time, and help set real ecological goals for canal mitigation projects.

In summary, the remedial measures that were implemented in the Sunset Acres canal, aeration and backfilling, did improve the water quality. However, additional water quality improvements are still needed. The bottom sediments contain an organic source that is an on-going biological oxygen demand on the canal system. Additionally, other land-based inputs are still occurring that need to be addressed. An initiative like the Florida Yards and Neighborhood's program has to identify key actions in the majority of the homes that are contributing to the loading in this canal and assist in the implementation of best management practices for each homeowner.

Recommendations for long-term neighborhood mitigation projects are presented below.

1.) There needs to be county-wide "Water Quality Sampling Plan with recommended methodologies and testing parameters for the canals. EPA guidelines have already been established for each method. It would be helpful for future coordination if a standard Field Sampling Plan was developed and supported through technical assistance from the county or state agencies to be used by the various entities collecting data (ex: regulatory agencies, homeowners, volunteers, universities, environmental groups). The Field Sampling Plan developed during this study can be used as a guideline. This would allow Sunset Acres data to be compared to data collected from other areas in the Keys, such as other canals and various stations in Florida Bay. Such data could then be used to evaluate trends in this and other canals, as well as in Florida Bay. It could also be useful for regulators and homeowners to evaluate proposed improvements to existing canal systems, and set realistic water quality improvement goals.

2.) Continue basic water quality data collection on a long-term basis at the same canal locations using the county-wide SamplingPlan. Long-term data sets are invaluable to evaluate data variables such as tidal, diurnal, seasonal and storm events, and to better determine long term trends.

3.) Coordination among all water quality monitoring programs being performed to enable comparison of the different data and to manage the variables and inputs. In addition, coordination of these studies would make the most effective use of the data available from, and the huge investments made by, a number of agencies and organizations monitoring water quality in the Keys.

4.) There needs to be stated goals for the mitigation - is this water in this canal "good enough"? Performance criteria need to be set for any remedial efforts such as that pollution input has to be reduced to such a level as to support measurable improvements such as seagrass growth on the canal bottom throughout most of the year.

7.0 REFERENCES

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FIGURES

REFERENCE:

STREETS & TRIPS 2001
ISLAMORADA QUADRANGLE
DATED: 2001

SUNSET ACRES CASE STUDY TAVERNIER, FLORIDA	MACTEC MACTEC ENGINEERING & CONSULTING, INC. (F.K.A. LAW ENGINEERING & ENVIRONMENTAL SERVICES, INC.) 5845 N.W. 158th STREET MIAMI LAKES, FL 33014 TEL: (305) 826-5588 / FAX: (305) 826-1799	FIGURE 1 LOCATION OF OF FLORIDA KEYS
LAW PROJECT NUMBER: 40700-1-2681		DRAWN BY: N.A.B. / DATE: 11/14/01 CHECKED BY: / SCALE: N.T.S.

FILE #: 40700-1-2681-1

REFERENCE:

STREETS & TRIPS 2001
ISLAMORADA QUADRANGLE
DATED: 2001

SUNSET ACRES CASE STUDY TAVERNIER, FLORIDA	MACTEC MACTEC ENGINEERING & CONSULTING, INC. (F.K.A. LAW ENGINEERING & ENVIRONMENTAL SERVICES, INC.) 5845 N.W. 158th STREET MIAMI LAKES, FL 33014 TEL: (305) 826-5588 / FAX: (305) 826-1799	FIGURE 2 UPPER, MIDDLE & LOWER FLORIDA KEYS
LAW PROJECT NUMBER: 40700-1-2681		DRAWN BY: N.A.B. / DATE: 11/14/01 CHECKED BY: / SCALE: N.T.S.

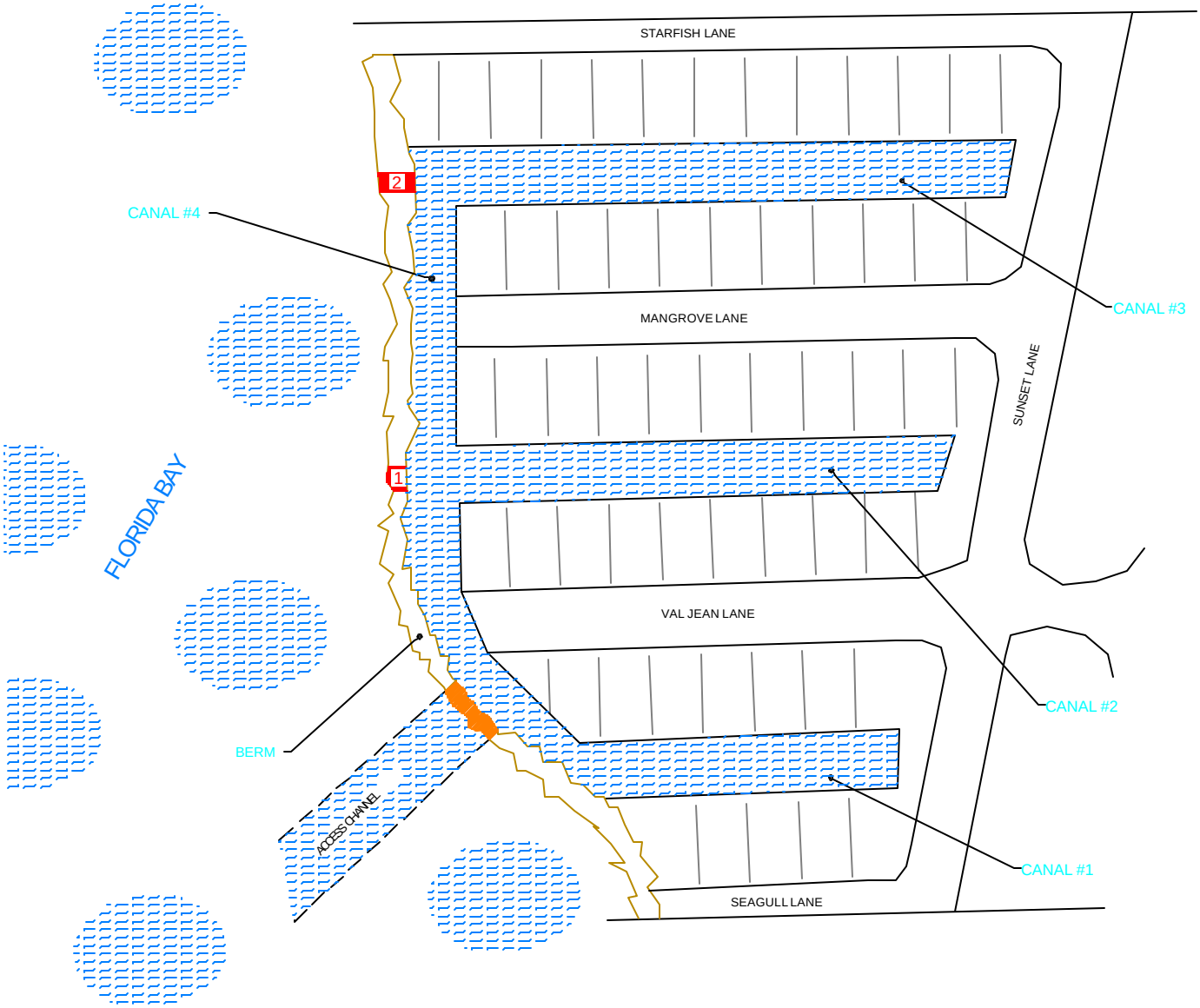
FILE #: 40700-1-2681-2

REFERENCE:

STREETS & TRIPS 2001
ISLAMORADA QUADRANGLE
DATED: 2001

SUNSET ACRES CASE STUDY TAVERNIER, FLORIDA	MACTEC MACTEC ENGINEERING & CONSULTING, INC. (F.K.A. LAW ENGINEERING & ENVIRONMENTAL SERVICES, INC.) 5845 N.W. 158th STREET MIAMI LAKES, FL 33014 TEL: (305) 826-5588 / FAX: (305) 826-1799	FIGURE 3 LOCATION OF OF SUNSET ACRES
LAW PROJECT NUMBER: 40700-1-2681		DRAWN BY: N.A.B. / DATE: 11/14/01
		CHECKED BY: / SCALE: N.T.S.

FILE #: 40700-1-2681-3



LEGEND:

2 FLUSHING CHANNELS

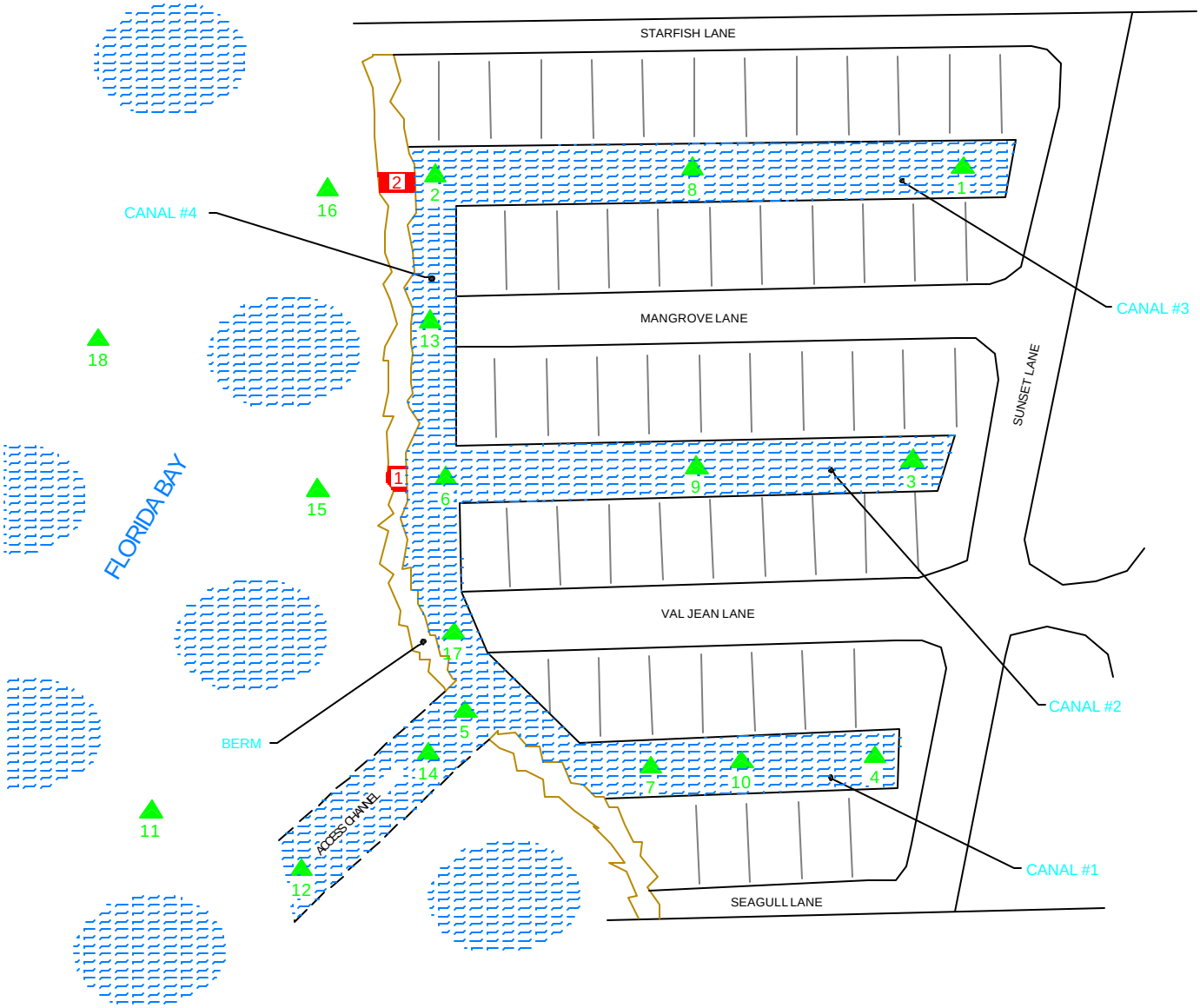
AREA OF BERM REMOVED FOR ACCESS TO FLORIDA BAY

APPROXIMATE GRAPHIC SCALE

REFERENCE: FIELD SKETCH

Sunset Acres CASE STUDY TAVERNIER, FLORIDA	MACTEC MACTEC ENGINEERING & CONSULTING, INC. (F.K.A. LAW ENGINEERING & ENVIRONMENTAL SERVICES, INC.) 5845 N.W. 158th STREET MIAMI LAKES, FL 33014 TEL: (305) 826-5588 / FAX: (305) 826-1799	FIGURE 4 SITE MAP OF SUNSET ACRES
LAW PROJECT NUMBER: 40700-1-2681		DRAWN BY: N.A.B. / DATE: 11/14/01 CHECKED BY: P.G. / SCALE: N.T.S

FILE #: 40700-1-2681-4



LEGEND:

2 SAMPLING LOCATIONS

2 FLUSHING CHANNELS

APPROXIMATE GRAPHIC SCALE

REFERENCE: FIELD SKETCH

Sunset Acres CASE STUDY TAVERNIER, FLORIDA	MACTEC MACTEC ENGINEERING & CONSULTING, INC. (F.K.A. LAW ENGINEERING & ENVIRONMENTAL SERVICES, INC.) 5845 N.W. 158th STREET MIAMI LAKES, FL 33014 TEL: (305) 826-5588 / FAX: (305) 826-1799	FIGURE 5 SAMPLING LOCATIONS
LAW PROJECT NUMBER: 40700-1-2681		DRAWN BY: N.A.B. / DATE: 11/14/01 CHECKED BY: P.G. / SCALE: N.T.S

FILE #: 40700-1-2681-4

TABLES

TABLE 1: Key to Sample Numbers in Reports vs. on Figure 5 Map
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory and Assessment
MACTEC Project No. 40700-1-2681

Figure 5 Sample Numbers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Date Samples were Collected*	Corresponding Station Numbers in Sampling Reports																	
4/27/1988	G4	G5	G6	G2		G3	G7											
10/11/1988	1	3	4	7		6	9	2	5	8	bay							
4/24/1989	5		3	1	2							bay	4					
5/17/1989	5		3	1	2							bay	4					
9/18/1989	G4	C5	G6	G2	C1	C3								C2	C4	C6		
5/11/1989	5		3	1	2							6	4					
5/18/1989	5		3	1	2							6	4					
7/10/1989	5		3	1	2							6	4					
8/20/1989	5		3	1	2							6	4					
9/10/1989	5		3	1	2							6	4					
12/20/1989	5		3	1	2							6	4					
3/5/1990	5		3	1	2								4					
6/3/1990	5		3	1	2								4					
8/5/1990	5		3	1	2								4					
10/12/1990	5		3	1	2								4					
12/14/1990	5		3	1	2								4					
2/9/1991	5		3	1	2							6	4					
3/9/1991	5		3	1	2							6	4					
5/27/1991	5		3	1	2							6	4					
7/28/1991	5		3	1	2							6	4					
9/14/1991	5		3	1	2							6	4					
12/14/1991	5		3	1	2							6	4					
2/9/1992	5		3	1	2							6	4					
4/11/1992	5		3	1	2							6	4					
6/7/1992	5		3	1	2							6	4					
8/9/1992	5		3	1	2							6	4					
9/19/1992								NC	CC	SC	bay			CH				
9/27/1992								NC	CC	SC				CH				
10/10/1992								NC	CC	SC	bay			CH				
10/11/1992								NC										
10/31/1992								NC	CC	SC	bay							
11/7/1992								NC										
12/6/1992								NC	CC	SC				CH				
12/26/1992								NC	CC	SC				CH				
8/10/1995	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
9/19/1995	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
10/18/1995	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
11/15/1995	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
12/15/1995	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
2/5/1996	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	
3/14/1996	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
4/8/1996	S1	S3	S5	S9		S7	S11	S2	S6	S10	S12		S4				S8	S13
8/4/1998	S1	S2	S3	S4	S5													S13
8/30/1998	S1	S2	S3	S4	S5													S13
10/5/1998	S1	S2	S3	S4	S5													S13
11/1/1998	S1	S2	S3	S4	S5													S13
12/5/1998	S1	S2	S3	S4	S5													S13
1/9/1999	S1	S2	S3	S4	S5													S13
2/6/1999	S1	S2	S3	S4	S5													S13
3/11/1999	S1	S2	S3	S4	S5													S13
4/6/1999	S1	S2	S3	S4	S5													S13
5/11/1999	S1	S2	S3	S4	S5													S13
6/5/1999	S1	S2	S3	S4	S5													S13
7/16/1999	S1	S2	S3	S4	S5													S13
8/18/1999	S1	S2	S3	S4	S5													S13
3/19/2002	S1		S2	S3	S4													S5
9/3/2002	S1		S2	S3	S4													S5
11/4/2002	S1		S2	S3	S4													S5
2/17/2003	S1		S2	S3	S4													S5

* Sample dates that are not listed did not have a map identifying sample locations
NC = north canal
CC = center canal
SC = south canal
CH = channel
bay = Florida Bay

TABLE 2: Summary of Parameters Collected for Each Set of Sample Data
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory and Assessment
MACTEC Project No. 40700-1-2681

Date Collected	Entity Collected By/For [a]	Doc #	Document Description	Parameters Collected						
				Temp (°C)	DO (mg/L)	EC (uho/cm)	pH	Salinity ('%)	Turbidity (NTUs)	Other [b]
4/19/1979	DEP	8	field data sheets	x	x	x	x			
8/16/1979	DEP	9	field data sheets	x	x	x	x			x
4/27/1988	DEP	4	field data sheets	x	x	x	x			
10/11/1988	SA	40	report to SA by BKJ Services, Inc. (consultants)	x	x			x	x	
4/24/1989	SA	40	"	x	x			x	x	
5/17/1989	SA	40	"	x	x			x	x	
9/18/1989	DEP	7	field data sheets	x	x			x	x	
5/11/1989	SA	11	report to Mr. Roberts, lawyer for SA, by Rio Palenque Research Corporation (consultants)	x	x			x		
5/18/1989	SA	11	"	x	x			x		
7/10/1989	SA	11	"	x	x					
8/20/1989	SA	11	"	x	x					
9/10/1989	SA	11	"	x	x					
12/20/1989	SA	11	"	x	x					
3/5/1990	SA	11	"	x	x					
6/3/1990	SA	11	"	x	x					
8/5/1990	SA	11	"	x	x					
10/12/1990	SA	11	"	x	x					
12/14/1990	SA	11	"	x	x					
2/9/1991	SA	11	"	x	x					
3/9/1991	SA	11	"	x	x			x		
5/27/1991	SA	11	"	x	x					
7/28/1991	SA	11	"	x	x					
9/14/1991	SA	11	"	x	x					
12/14/1991	SA	11	"	x	x					
2/9/1992	SA	11	"	x	x					
4/11/1992	SA	11	"	x	x					
6/7/1992	SA	11	"	x	x					
8/9/1992	SA	11	"	x	x					
4/2/1992	SA	11	"							x
9/19/1992	SA	46	field data sheets		x					
9/27/1992	SA	46	"		x					
10/10/1992	SA	46	"		x					
10/11/1992	SA	46	"		x					
10/31/1992	SA	46	"		x					
11/7/1992	SA	46	"		x					
12/6/1992	SA	46	"		x					
12/26/1992	SA	46	"		x					
8/10/1995	DEP	31	field data sheets	x	x	x	x	x	x	
9/19/1995	DEP	31	"	x	x	x	x	x		
10/18/1995	DEP	31	"	x	x	x	x	x		

TABLE 2: Summary of Parameters Collected for Each Set of Sample Data
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory and Assessment
MACTEC Project No. 40700-1-2681

Date Collected	Entity Collected By/For [a]	Doc #	Document Description	Parameters Collected						
				Temp (°C)	DO (mg/L)	EC (uho/cm)	pH	Salinity (%)	Turbidity (NTUs)	Other [b]
11/15/1995	DEP	31	"	x	x	x	x	x		
12/15/1995	DEP	31	"	x	x	x	x	x		
2/5/1996	DEP	31	"	x	x	x	x	x		
3/14/1996	DEP	31	"	x	x	x	x	x		
4/8/1996	DEP	31	"	x	x	x	x	x		
8/4/1998	SA	55	field data sheets	x	x			x		
8/30/1998	SA	55	"	x	x		x	x		
10/5/1998	SA	55	"	x	x		x	x	x	
11/1/1998	SA	55	"	x	x		x	x	x	
12/5/1998	SA	55	"	x	x		x	x	x	
1/9/1999	SA	55	"	x	x		x	x	x	
2/6/1999	SA	55	"	x	x		x	x	x	
3/11/1999	SA	55	"	x	x		x	x	x	
4/6/1999	SA	55	"	x	x		x	x	x	
5/11/1999	SA	55	"	x	x		x	x	x	
6/5/1999	SA	55	"	x	x		x	x	x	
7/16/1999	SA	55	"	x	x	x	x	x	x	
8/18/1999	SA	55	"	x	x	x	x	x	x	
3/19/2002	MC	NA	"	x	x	x		x	x	
9/3/2002	MC	NA	"	x	x	x		x	x	
11/4/2002	MC	NA	"	x	x	x		x	x	c
2/17/2003	MC	NA	"	x	x	x		x	x	

[a] Most of the samples were collected by/for either of two entities: consultants for the Sunset Acres homeowners or DEP

[b] Other consists of Specific Ion or Metals (alumunum, cadmium, copper, lead)

Doc# = document number - LAW assigned a document number to each document (report) obtained from DEP and Monroe County (copies provided in Appendix B); the sampling results from these reports are summarized on the table in Appendix A.

Document Description - brief description of document/report from which the water quality data was obtained

DO = dissolved oxygen (mg/L)

EC = electric conductivity (uho/cm)

°C = degrees centigrade

mg/L = milligrams per liter

uho/cm = microohms per centimeter

NTUs = nephelometric turbidity units

DEP = Florida Department of Environmental Protection

SA = Sunset Acres

MC = Monroe County

c - Total organic carbon analysis was performed on sediment samples collected from the canal bottom

TABLE 3: Water Quality Data Before/After Installation of Aeration System in May 1989
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory Assessment
MACTEC Project No. 40700-1-2681

Date	Collected By	Tide	Station Number	Sample Location*	Depth (feet)	Time	Temp (C)	DO (mg/L)	Conduct uho/cm	pH	Salinity %	Turbidity (NTUs)
10/11/1988	SA	incoming	1	1	0	1000	27.0	3.8			28.0	1.50
					5							0.65
					10	1000	31.0	0.5			39.0	0.80
					15							8.80
					20	1000	28.0	0.5			38.0	4.00
			2	8	0	1015	27.0	4.0			27.0	0.50
					5							0.65
					10	1015	28.0	0.2			38.0	0.65
					15							2.80
					18	1015	28.0	0.4			37.5	15.00
			3	2	0	1030	27.0	3.4			27.0	0.60
					5							0.60
					10	1030	28.0	0.3			37.5	1.20
					15							3.00
					20	1030	27.0	0.5			37.0	3.80
			4	3	0	1038	27.5	3.2			26.8	0.50
					5							0.70
					10	1038	29.0	0.2			37.0	0.75
					15							10.00
					20	1038	28.0	0.2			37.5	3.00
			5	9	0	1045	27.0	3.5			26.8	0.85
					5							0.54
					10	1045	28.5	0.2			37.9	0.80
					15							9.20
					20	1045	27.5	0.3			37.9	2.00
			6	6	0	1059	27.0	3.2			27.0	0.55
					4							0.55
					10	1059	28.0	0.2			37.0	
					22	1059	27.5	0.2			37.0	
			7	4	0	1105	27.5	3.6			27.5	
					10	1105	29.0	0.3			38.0	
					22	1105	28.0	0.2			38.0	
			8	10	0	1115	27.0	3.8			27.0	
					10	1115	28.5	0.2			37.5	
					23	1115	27.5	0.3			38.0	
			9	7	0	1120	27.5	3.7			26.5	
					10	1120	28.0	0.3			37.5	
					16	1120	27.5	0.2			37.5	
			bay	11	0	1125	27.0	4.2			27.0	
					2.5	1125	27.5	4.2			27.0	
					5	1125	27.5	4.4			27.5	

TABLE 3: Water Quality Data Before/After Installation of Aeration System in May 1989
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory Assessment
MACTEC Project No. 40700-1-2681

Date	Collected By	Tide	Station Number	Sample Location*	Depth (feet)	Time	Temp (C)	DO (mg/L)	Conduct uho/cm	pH	Salinity %	Turbidity (NTUs)
4/24/1989	SA	out	1	4	0	1003	29.0	3.0			31.0	1.50
					5	1003	28.5	3.2			31.0	0.65
					10	1003	28.5	1.3			31.5	0.80
					15	1003	27.0	0.3			31.0	8.80
					20	1003	26.0	0.4			32.5	4.00
			2	5	0	1040	29.0	3.5			31.0	0.50
					5	1040	29.0	3.4			31.0	0.65
					10	1040	28.5	3.4			31.0	0.65
					15	1040	27.5	0.8			31.5	2.80
					18	1040	26.5	0.4			32.0	15.00
			3	3	0	1107	29.5	3.0			31.0	0.60
					5	1107	29.0	3.2			30.5	0.60
					10	1107	29.0	1.1			31.5	1.20
					15	1107	27.0	0.3			32.0	3.00
					20	1107	26.5	0.2			32.0	3.80
			4	13	0	1127	29.5	4.0			30.0	0.50
					5	1127	29.0	3.7			30.0	0.70
					10	1127	29.0	3.0			31.0	0.75
					15	1127	27.5	0.8			31.5	10.00
					20	1127	26.5	0.4			32.5	3.00
					22	1127	26.5	0.2			32.5	
			5	1	0	1145	29.5	4.0			30.0	0.85
					5	1145	29.0	3.7			31.0	0.54
					10	1145	29.0	3.5			30.5	0.80
					15	1145	27.5	0.3			30.0	9.20
					20							2.00
			bay	12	0	1300	29.0	5.8			32.0	0.55
					4	1300	29.0	5.8			32.0	0.55
5/11/1989	SA	NA	1	4	0	NA	29.0	3.0			31.0	
					10	NA	28.5	1.3			31.5	
					18	NA	26.0	0.4			32.5	
			2	5	0	NA	29.0	3.5			31.0	
					10	NA	28.5	3.4			31.0	
					18	NA	28.5	0.4			32.0	
			3	3	0	NA	29.5	3.0			31.0	
					10	NA	29.0	1.1			31.5	
					18	NA	26.5	0.2			32.0	
			4	13	0	NA	27.5	4.0			30.0	
					10	NA	28.0	3.0			31.0	
					18	NA	27.0	0.4			32.5	
			5	1	0	NA	29.5	4.0			30.0	
					10	NA	29.0	3.5			30.5	
					18	NA	27.5	0.3			30.0	
			6	12	0	NA	29.0	5.8			32.0	
					4	NA	29.0	5.8			32.0	

TABLE 3: Water Quality Data Before/After Installation of Aeration System in May 1989
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory Assessment
MACTEC Project No. 40700-1-2681

Date	Collected By	Tide	Station Number	Sample Location*	Depth (feet)	Time	Temp (C)	DO (mg/L)	Conduct uho/cm	pH	Salinity %	Turbidity (NTUs)
5/17/1989	SA	in	1	4	0	1303	30.0	5.5			31.5	1.20
					5	1303	30.0	5.4			31.5	
					10	1303	29.0	5.4			31.5	
					15	1303	29.0	5.4			31.5	
					20	1303	29.0	3.8			29.5	
			2	5	0	1328	30.5	5.7			32.0	1.30
					5	1328	30.0	5.7			31.5	
					10	1328	30.0	5.4			31.5	
					15	1328	29.5	5.3			31.5	
					18	1328	29.0	4.4			31.0	
			3	3	0	1409	30.0	5.4			31.5	1.10
					5	1409	29.5	5.2			31.5	
					10	1409	29.5	5.1			31.5	
					15	1409	29.5	5.0			31.5	
					20	1409	29.0	4.8			31.5	
			4	13	0	1426	30.0	5.8			31.5	1.30
					5	1426	30.0	5.8			31.5	
					10	1426	29.5	5.5			31.5	
					15	1426	29.5	5.5			31.5	
					20	1426	29.0	3.4			31.5	
					21	1426	27.0	1.2			30.5	
			5	1	0	1458	30.5	5.8			32.0	1.40
					5	1458	30.0	5.8			32.0	
					10	1458	30.0	5.8			32.0	
					15	1458	29.5	3.8			32.0	
			bay	12	0	1517	32.0	8.0			36.0	1.30
					4	1517	32.0	8.0			36.0	
5/18/1989	SA		1	4	0	NA	30.0	5.5			31.5	
					10	NA	29.0	5.4			31.5	
					18	NA	29.0	3.8			31.5	
			2	5	0	NA	30.5	5.7			32.0	
					10	NA	30.0	5.4			31.5	
					18	NA	29.0	4.4			31.0	
			3	3	0	NA	30.0	5.4			31.5	
					10	NA	29.5	5.1			31.5	
					18	NA	29.0	4.4			31.5	
			4	13	0	NA	30.0	5.8			31.5	
					10	NA	29.5	5.5			31.5	
					18	NA	29.0	3.4			31.5	
			5	1	0	NA	30.5	5.8			32.0	
					10	NA	30.0	5.8			32.0	
					18	NA	29.5	3.8			32.0	
			6	12	0	NA	32.0	8.0			36.0	
					4	NA	32.0	8.0			36.0	

TABLE 3: Water Quality Data Before/After Installation of Aeration System in May 1989
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory Assessment
MACTEC Project No. 40700-1-2681

Date	Collected By	Tide	Station Number	Sample Location*	Depth (feet)	Time	Temp (C)	DO (mg/L)	Conduct uho/cm	pH	Salinity %	Turbidity (NTUs)
7/10/1989	SA		1	4	0	NA	30.0	5.8				
					10	NA	30.0	5.3				
					18	NA	30.0	4.1				
			2	5	0	NA	30.0	5.6				
					10	NA	31.0	5.0				
					18	NA	30.5	4.0				
			3	3	0	NA	30.0	5.8				
					10	NA	31.0	5.2				
					18	NA	30.0	4.6				
			4	13	0	NA	30.5	5.0				
					10	NA	30.0	5.3				
					18	NA	30.0	4.1				
			5	1	0	NA	30.0	5.4				
					10	NA	30.5	5.8				
					18	NA	30.5	4.9				
			6	12	0	NA	31.0	7.8				
					4	NA	31.0	7.8				
8/20/1989	SA		1	4	0	NA	31.2	5.0				
					10	NA	31.0	4.9				
					18	NA	31.0	4.0				
			2	5	0	NA	31.0	5.1				
					10	NA	31.0	5.0				
					18	NA	30.5	3.8				
			3	3	0	NA	31.0	5.4				
					10	NA	31.0	5.6				
					18	NA	31.0	4.2				
			4	13	0	NA	31.0	6.0				
					10	NA	31.0	5.6				
					18	NA	30.5	4.4				
			5	1	0	NA	31.0	5.5				
					10	NA	31.0	5.8				
					18	NA	30.5	4.2				
			6	12	0	NA	31.0	6.6				
					4	NA	30.5	6.0				
9/10/1989	SA		1	4	0	NA	31.5	6.1				
					10	NA	31.5	4.8				
					18	NA	31.0	3.9				
			2	5	0	NA	31.5	5.3				
					10	NA	31.0	5.3				
					18	NA	31.0	4.0				
			3	3	0	NA	31.0	5.5				
					10	NA	30.0	5.3				
					18	NA	30.0	4.2				
			4	13	0	NA	31.0	5.9				
					10	NA	31.0	5.4				
					18	NA	30.5	4.0				
			5	1	0	NA	31.0	5.8				
					10	NA	31.0	5.4				
					18	NA	30.5	4.0				
			6	12	0	NA	30.0	6.5				
					4	NA	30.5	6.5				

TABLE 3: Water Quality Data Before/After Installation of Aeration System in May 1989
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory Assessment
MACTEC Project No. 40700-1-2681

Date	Collected By	Tide	Station Number	Sample Location*	Depth (feet)	Time	Temp (C)	DO (mg/L)	Conduct uho/cm	pH	Salinity %	Turbidity (NTUs)
9/18/1989	SA	slack to	C-1	5	1	1230	32.0	8.3			38.0	1.90
		incoming			6	1235	31.0	5.3				
					12	1237	31.0	4.2			37.5	
			C-2	14	1	1245	32.0	8.4			38.5	1.40
			C-3	6	1	1300	31.0	8.0			38.0	2.00
					8	1305	31.0	8.4				
			C-4	15	1	1310	31.9	8.5			38.7	
			C-5	2	1	1330	31.0	6.9			38.5	1.50
					9	1335	31.0	6.1				
					15	1340	31.0	5.9			38.0	
			C-6	16	1	1350	31.0	7.5			38.7	
			G-2	4	1	1400	31.5	6.5			37.5	1.60
					6	1402	31.5	6.4				
					9	1405	31.5	6.4			37.5	
			G-4	1	1	1500	31.0	6.7			37.2	4.00
					7	1502	31.0	6.4				
					14	1505	31.0	6.1			37.0	
			G-6	3	1	1420	31.5	6.2			38.5	4.00
					9	1425	31.0	6.5			38.4	

* The Sample Location corresponds to the locations on Figure 5. The Station Number is the number recorded when the sample was collected. Data were collected by different people and for different entities through the years. See Table 1 for Key to sample numbers in reports vs. sample number on Figure 5.

SA = Sunset Acres homeowners
C = degrees centigrade
mg/L = milligrams per liter
uho/cm = microohms per centimeter
NTU = nephelometric turbidity units

TABLE 4: Total Organic Carbon Content of Sediment from Canal Bottom
Sunset Acres Case Study
Tavernier, Florida
Monroe County Residential Canal Inventory Assessment
MACTEC Project No. 40700-1-2681

		PERCENT ORGANIC CONTENT			PERCENT WATER FROM CORE		
CORE NO.	DESCRITPION	Mean	SD	N	Mean	SD	N
CORE 1-1	fine grain size, black in color, strong smell	4.9%	1.1%	6	46.7%	6.0%	6
CORE 1-2	fine grain size, black in color, strong smell	5.0%	0.2%	6	45.5%	3.4%	6
CORE 2-1	fine grain size, black in color, moderate smell, shell fragments and rubble	3.4%	0.9%	6	35.9%	7.2%	6
CORE 2-2	fine grain size, black in color, moderate smell, shell fragments and rubble	2.8%	0.5%	6	35.7%	5.6%	6
CORE 3-1	fine grain size, black in color, strong smell	4.5%	2.8%	6	44.0%	8.7%	6
CORE 3-2	fine grain size, black in color, strong smell	4.7%	1.3%	6	47.0%	8.6%	6
CORE 4 -1	fine grain size, black in color, strong smell	4.5%	0.9%	6	53.9%	6.6%	6
CORE 4-2	fine grain size, black in color, strong smell	7.9%	2.8%	6	65.7%	2.5%	6
CORE 5-1	fine grain size, black in color, strong smell	4.8%	3.4%	6	48.6%	5.5%	6
CORE 5-2	fine grain size, black in color, strong smell	6.1%	0.4%	6	54.2%	9.3%	6

CHARTS

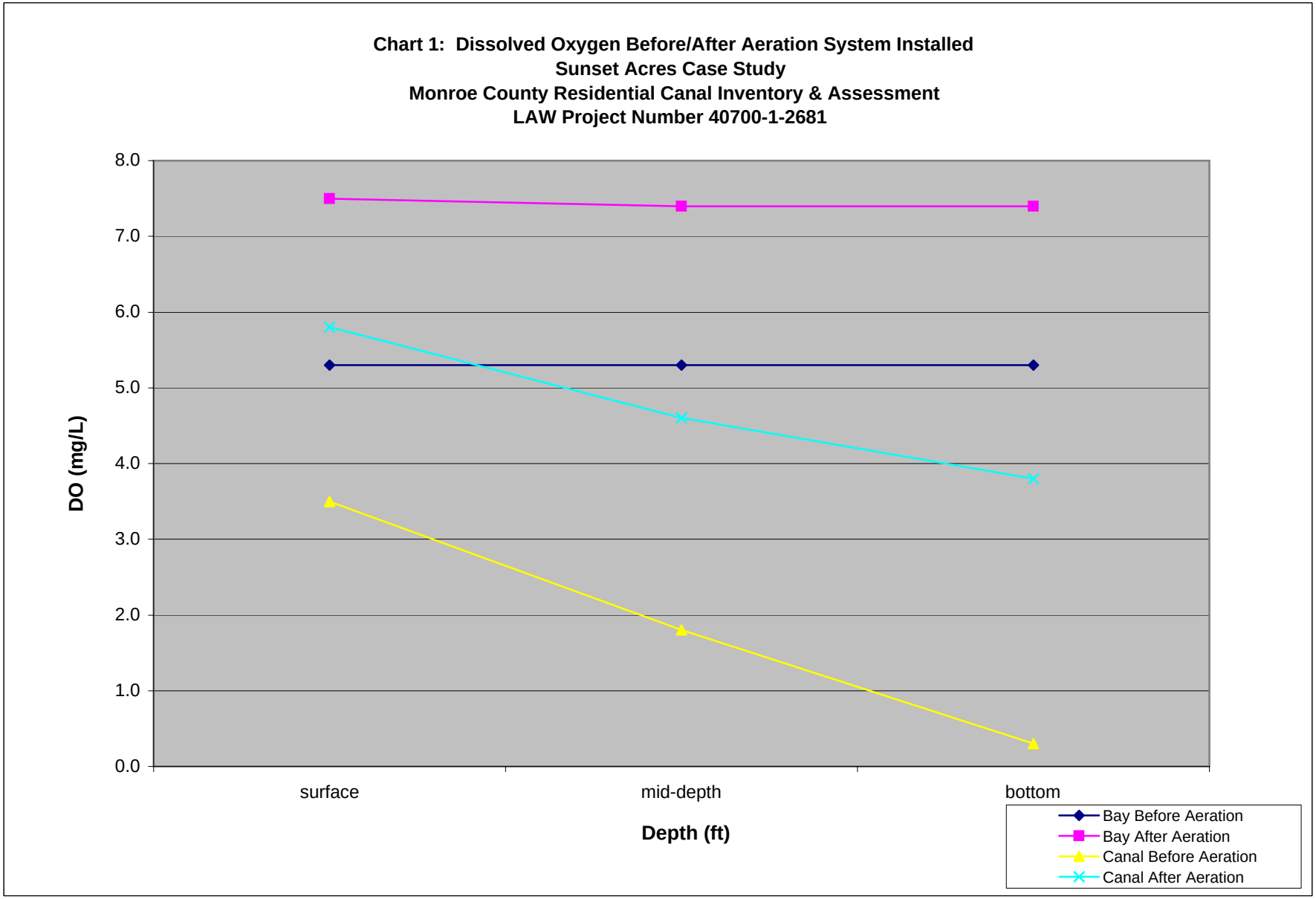


Chart 1: Dissolved Oxygen Before/After Aeration System Installed
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
LAW Project Number 40700-1-2681
DO (mg/L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
surface
mid-depth
bottom
Depth (ft)
Bay Before Aeration
Bay After Aeration
Canal Before Aeration
Canal After Aeration

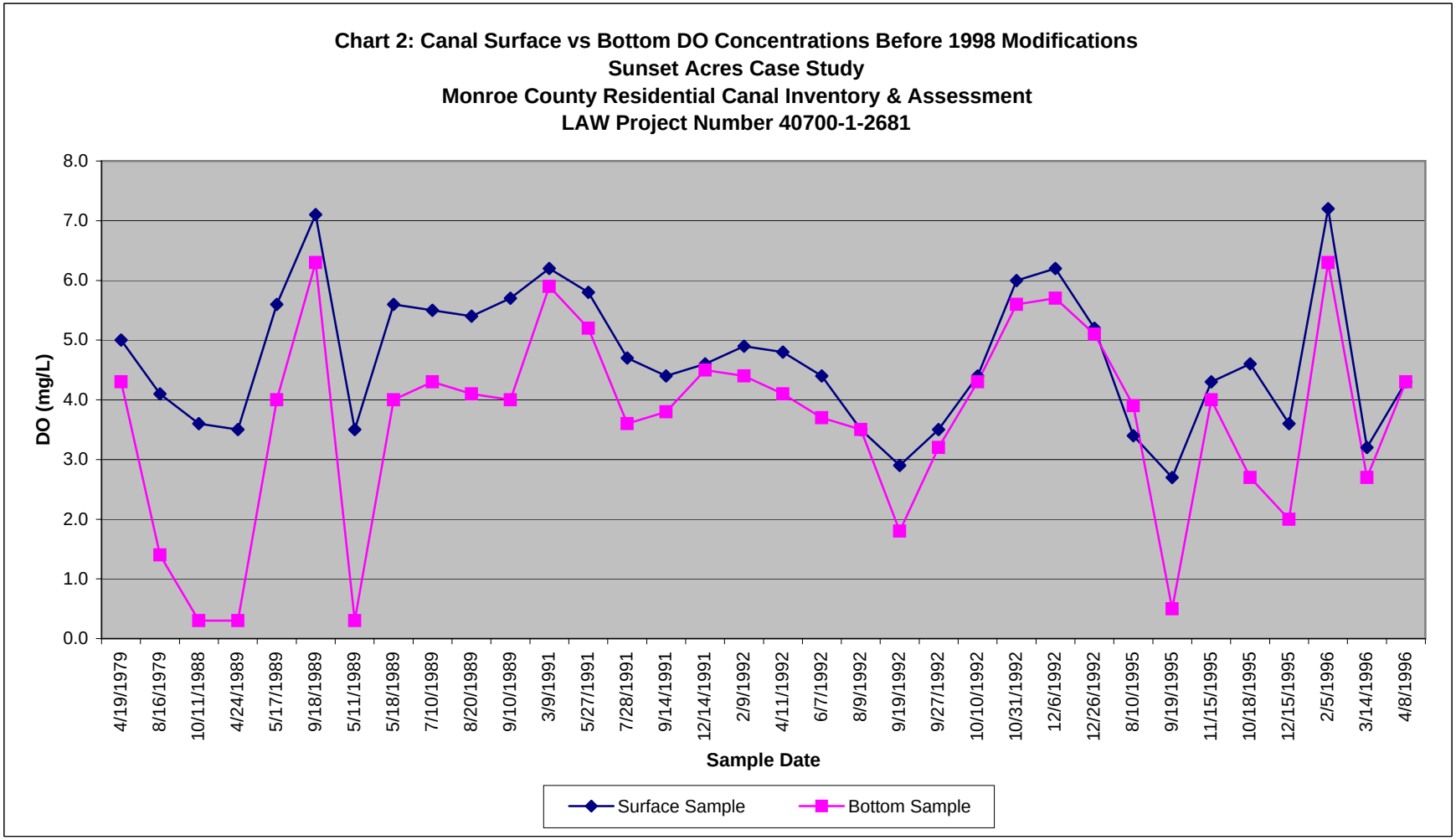


Chart 2: Canal Surface vs Bottom DO Concentrations Before 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
LAW Project Number 40700-1-2681
DO (mg/L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4/19/1979
8/16/1979
10/11/1988
4/24/1989
5/17/1989
9/18/1989
5/11/1989
5/18/1989
7/10/1989
8/20/1989
9/10/1989
3/9/1991
5/27/1991
7/28/1991
9/14/1991
12/14/1991
2/9/1992
4/11/1992
6/7/1992
8/9/1992
9/19/1992
9/27/1992
10/10/1992
10/31/1992
12/6/1992
12/26/1992
8/10/1995
9/19/1995
11/15/1995
10/18/1995
12/15/1995
2/5/1996
3/14/1996
4/8/1996
Sample Date
Surface Sample
Bottom Sample

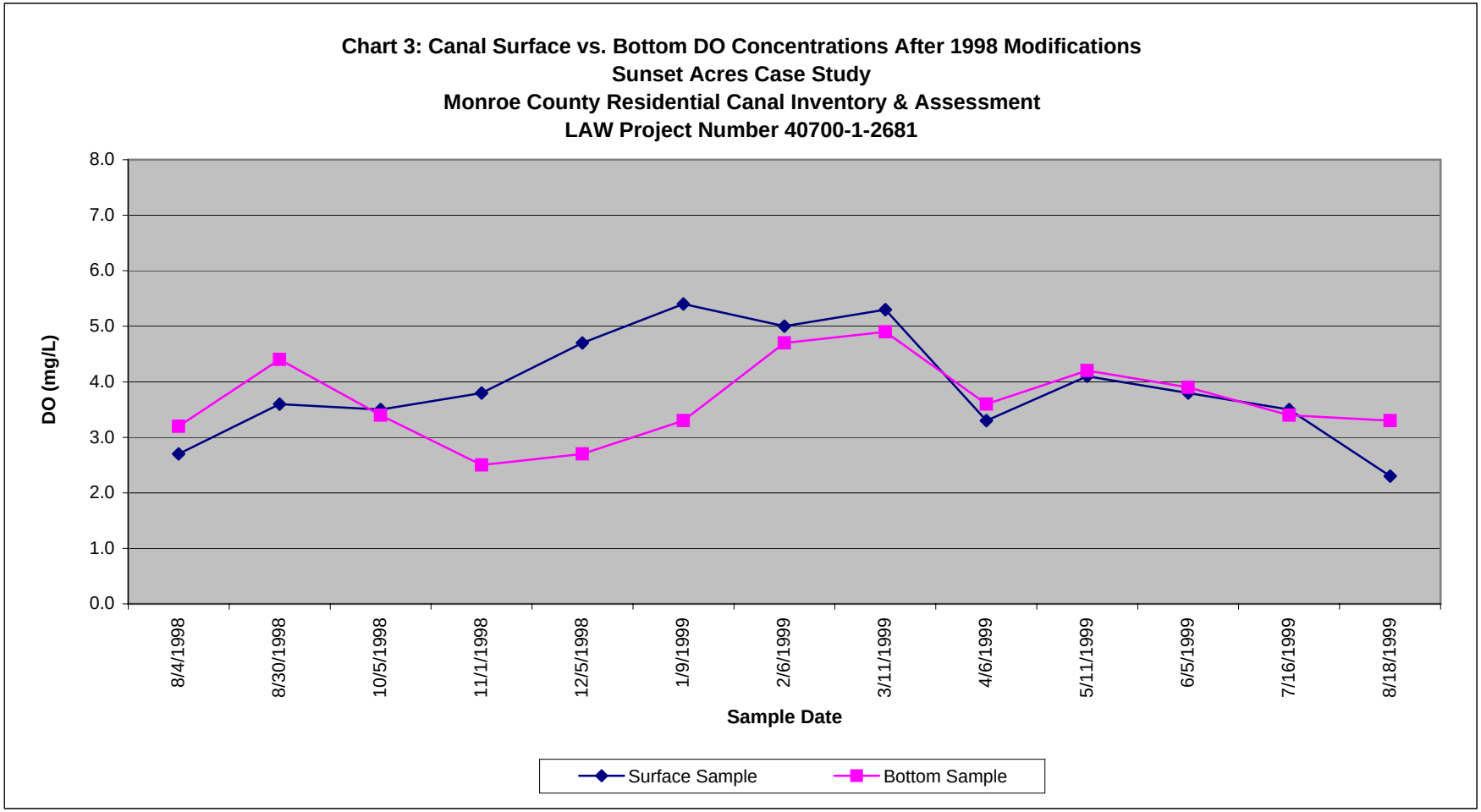


Chart 3: Canal Surface vs. Bottom DO Concentrations After 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
LAW Project Number 40700-1-2681
DO (mg/L)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/4/1998
8/30/1998
10/5/1998
11/1/1998
12/5/1998
1/9/1999
2/6/1999
3/11/1999
4/6/1999
5/11/1999
6/5/1999
7/16/1999
8/18/1999
Sample Date
Surface Sample
Bottom Sample

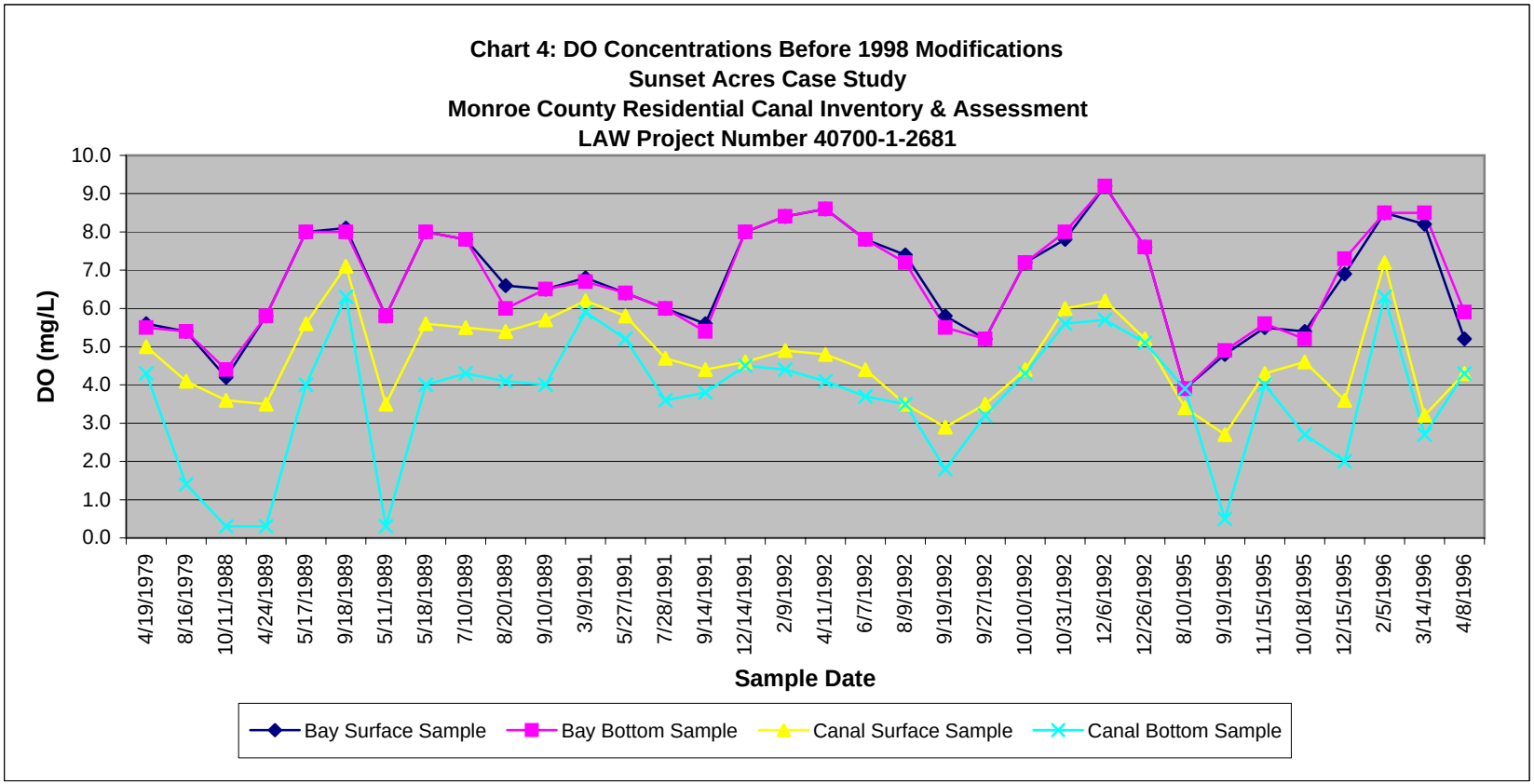


Chart 4: DO Concentrations Before 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
LAW Project Number 40700-1-2681
DO (mg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4/19/1979
8/16/1979
10/11/1988
4/24/1989
5/17/1989
9/18/1989
5/11/1989
5/18/1989
7/10/1989
8/20/1989
9/10/1989
3/9/1991
5/27/1991
7/28/1991
9/14/1991
12/14/1991
2/9/1992
4/11/1992
6/7/1992
8/9/1992
9/19/1992
9/27/1992
10/10/1992
10/31/1992
12/6/1992
12/26/1992
8/10/1995
9/19/1995
11/15/1995
10/18/1995
12/15/1995
2/5/1996
3/14/1996
4/8/1996
Sample Date
Bay Surface Sample
Bay Bottom Sample
Canal Surface Sample
Canal Bottom Sample

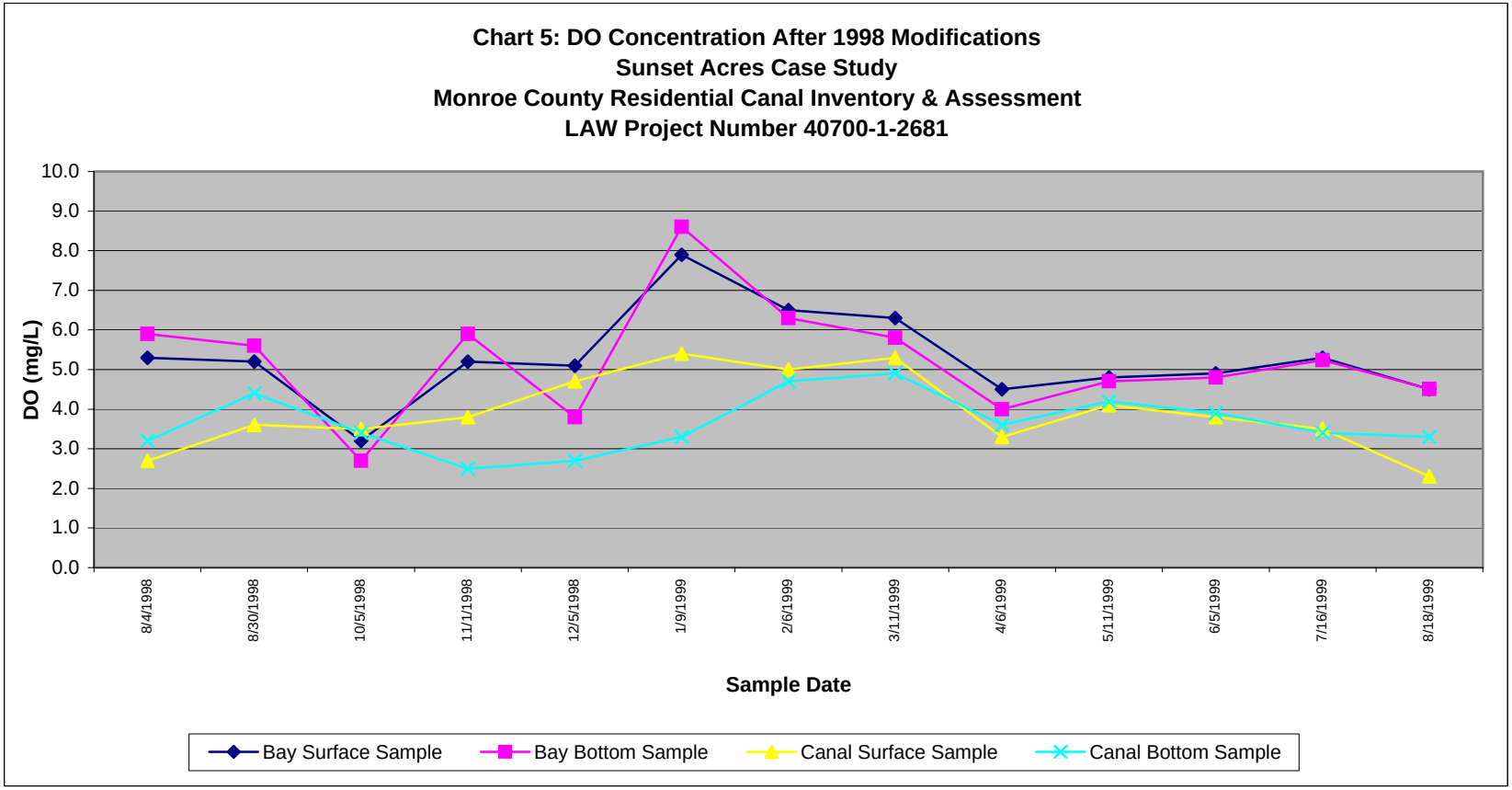


Chart 5: DO Concentration After 1998 Modifications
Sunset Acres Case Study
Monroe County Residential Canal Inventory & Assessment
LAW Project Number 40700-1-2681
DO (mg/L)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
8/4/1998
8/30/1998
10/5/1998
11/1/1998
12/5/1998
1/9/1999
2/6/1999
3/11/1999
4/6/1999
5/11/1999
6/5/1999
7/16/1999
8/18/1999
Sample Date
Bay Surface Sample
Bay Bottom Sample
Canal Surface Sample
Canal Bottom Sample