Dona Bay Watershed Management Plan

Technical Memorandums

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Southwest Florida Water Management District

Sarasota County

DONA BAY
WATERSHED MANAGEMENT PLAN

Final Report Appendices
Technical Memorandums
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1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

1. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
2. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
3. Protect existing and future property owners from flood damage.
4. Protect existing water quality.
5. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBS&J to present a summary of efforts to develop GIS maps and data comparisons for existing and historical shoreline habitats of Dona and Roberts Bays (from Blackburn Bay to northern Lemon Bay). Also, this Technical Memorandum summarizes efforts to produce a draft Monitoring Plan for Dona Bay. These efforts are consistent with Task 4.1.1 of the DBWMP contract.

2.0 INTRODUCTION

This effort is part of the overall Natural Systems efforts defined in Task 4.1 of the DBWMP. Specifically, it included related natural systems evaluations and an assessment of potential restoration/enhancement opportunities for Dona Bay and its watershed. Since the intent of the project is to consider alternatives for watershed restoration/enhancement of the Dona Bay watershed and its associated estuary, PBS&J was tasked with developing GIS-based maps of existing and historical shoreline habitats of Dona Bay (not including the freshwater portions), and the development of a draft monitoring plan.

The size of the historical Dona Bay watershed has been greatly expanded, resulting in the diversion of significantly larger volumes freshwater being discharged to Dona Bay. Various watershed/hydrologic restoration scenarios are being considered to "re-balance" and create a more natural water budget. The re-balanced water budget would closer reflect pre-diversion conditions and restore more natural seasonal salinity regimes in the estuary. It is planned that water use and retention efforts will reduce the volume of freshwater discharging to Dona Bay restoring a more historical condition. Therefore, a draft Monitoring Plan for Dona Bay has been developed to quantify the benefits to the estuary, by monitoring improvements (i.e. nearing a more historical, pre-altered condition) to water quality and populations of the selected biological indicators.

3.0 DEVELOPMENT OF GIS-BASED MAPS OF EXISTING AND HISTORICAL SHORELINE HABITATS

The GIS-based mapping efforts for shoreline features included the production of the following maps: 1) a map of vegetation types along the shoreline using 2004 aerial photography groundtruthed and revised (if necessary) in 2006, 2) a map of shoreline features produced using 2004 aerial photography groundtruthed and revised (if necessary) in 2006, and 3) a map of shoreline features photointerpreted uing aerial photography from 1948.

For the vegetation map, the following vegetation types were mapped:

- Shorelines dominated by Australian Pines
- Shorelines dominated by Brazilian Peppers
- Shorelines dominated by Black Needle Rush
- Shorelines dominated by Leather Fern
- Shorelines dominated by various mangrove species
- Shorelines dominated by mangroves interspersed with various exotic vegetation
- Shorelines dominated by Cordgrass (Spartina alterniflora)
- Shorelines dominated by upland vegetation (and not Australian Pines)
- Shorelines dominated by other vegetation (e.g., landscaping features); and
- Shorelines with no vegetation

Field crews surveyed the entire stretch of shoreline, from Blackburn Bay to northern Lemon Bay, and also the extent of Shakett Creek up to the structure on Cow Pen Slough and Curry Creek. Using GPS, created maps and aerial photography, site survey information was relayed to a GIS specialist, who used this information to create GIS-based maps of these features. Results are displayed in Figure 1.

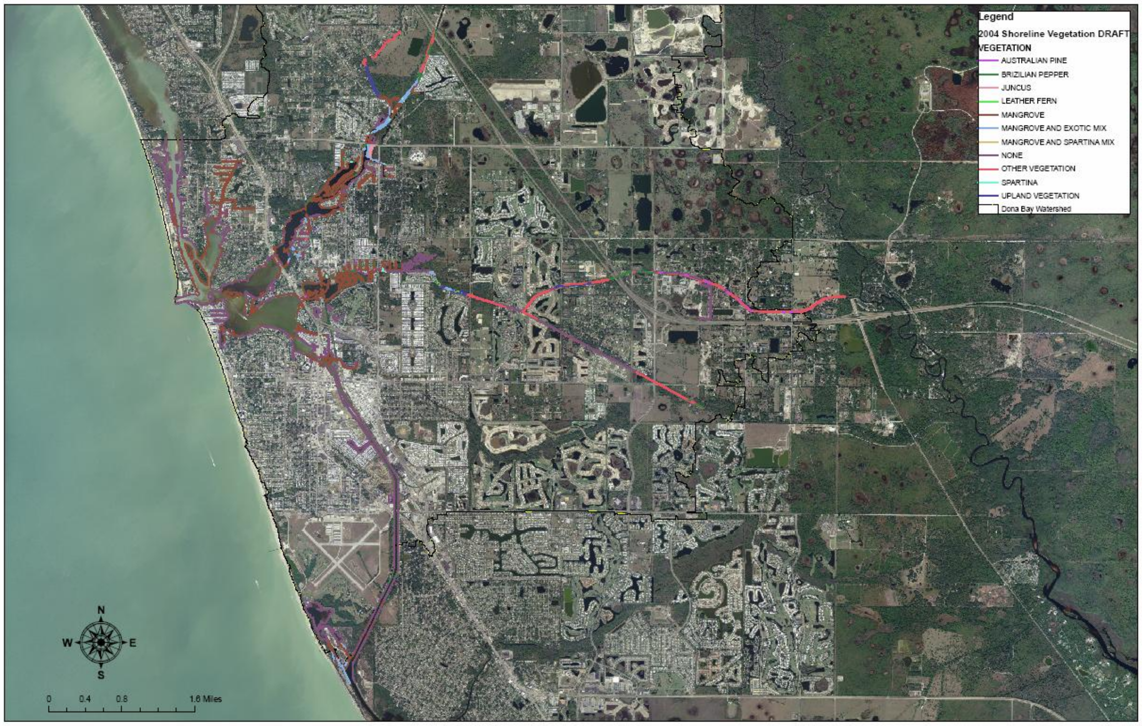

Figure 1 – 2004 Shoreline Vegetation Map

The dominant shoreline vegetation feature, unfortunately, is that of no vegetation at all. The shorelines of most residential neighborhoods are mostly hardened, with seawalls and/or rip rap as the major feature. However, the spoil island located just north of Venice Island has a fairly healthy shoreline of mixed mangroves and Spartina sp., as does much of the shoreline of both Dona and Roberts Bays in those areas located east of U.S. 41. In the farther upstream portions of Curry Creek / Blackburn Canal, there is a considerable amount of shoreline dominated by Black Needle Rush (Juncus roemerianus).

For the shoreline features map, the following shoreline types were mapped:

- Beach
- Cleared land
- Fringing deep wetlands
- Fringing patchy wetlands
- Exposed banks
- Rip rap
- Seawalls
- Upland shorelines

As in the vegetation maps, field crews surveyed the entire stretch of shoreline, from Blackburn Bay to northern Lemon Bay, and also the extent of Shakett Creek up to the structure on the Cow Pen Canal and Curry Creek. Using GPS, created maps and aerial photography, site survey information was relayed to a GIS specialist, who created the GIS-based maps of these features. Results are displayed in Figure 2.

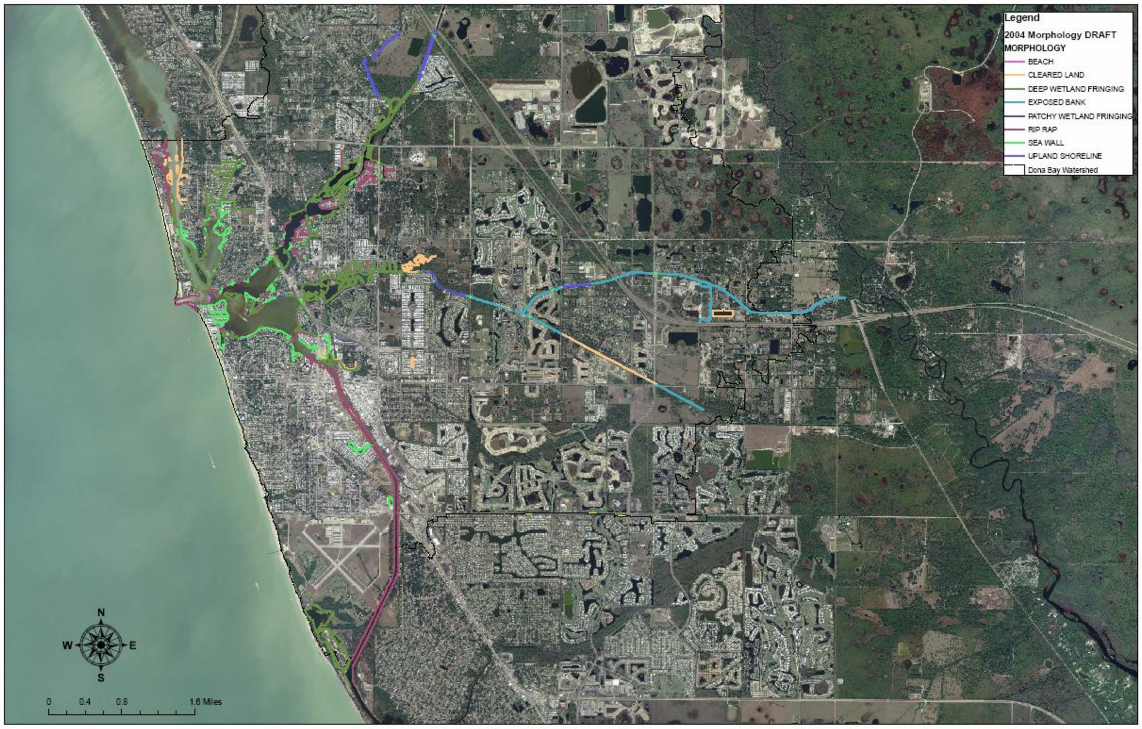

Figure 2 - 2004 Shoreline Features Map

In the areas closest to Venice Inlet, the dominant shoreline type is either rip rap or seawalls. For the most part, seawalls are the dominant shoreline feature for the residential neighborhoods, while rip rap is the dominant shoreline feature along both the inlet itself, and also along the Intracoastal Waterway. Most of the mangrove shorelines noted in Figure 1 are here classified as “fringing deep wetlands” rather than “fringing patchy wetlands.” This indicates that these wetland areas (mostly mangroves or mangroves and Spartina mixed together) have the potential to perform the expected wetland functions of providing habitat for fish and wildlife and also treating surface water runoff from immediately adjacent uplands. These wetland areas are mostly located east of U.S. 41.

For the 1948 shoreline features mapping effort, there was obviously no ground-truthing involved. For this reason, and also because of the reduced quality of the aerial photography for this time period, fewer shoreline features could be differentiated. The categories of “cleared land” and “exposed bank” were not mapped. Results are displayed in Figure 3.

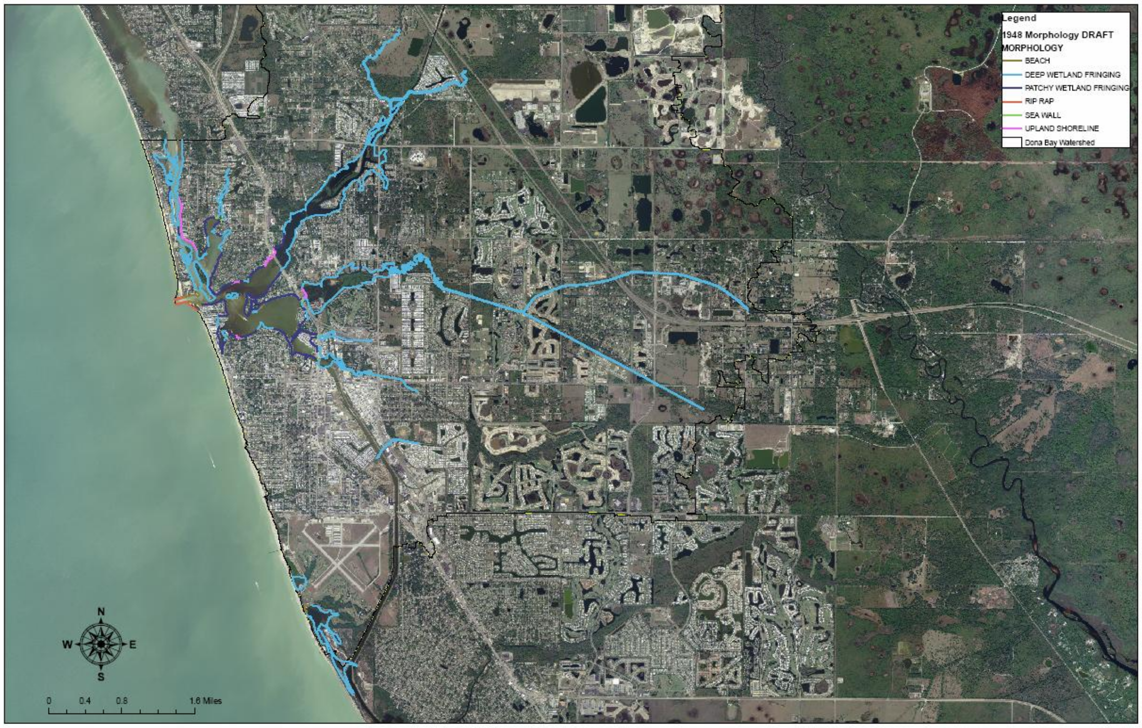

Figure 3 - 1948 Shoreline Features Map

In 1948, the dominant shoreline feature was that of a fringing deep wetland – most probably a shoreline dominated by mangroves. While rip rap was in place in the area of Venice Inlet, most of the areas now dominated by residential neighborhoods with seawalls was instead dominated by either deep or patchy fringing wetland.

Upon comparing the 1948 with 2004 shoreline features, it can be seen that major changes have occurred (Figure 4).

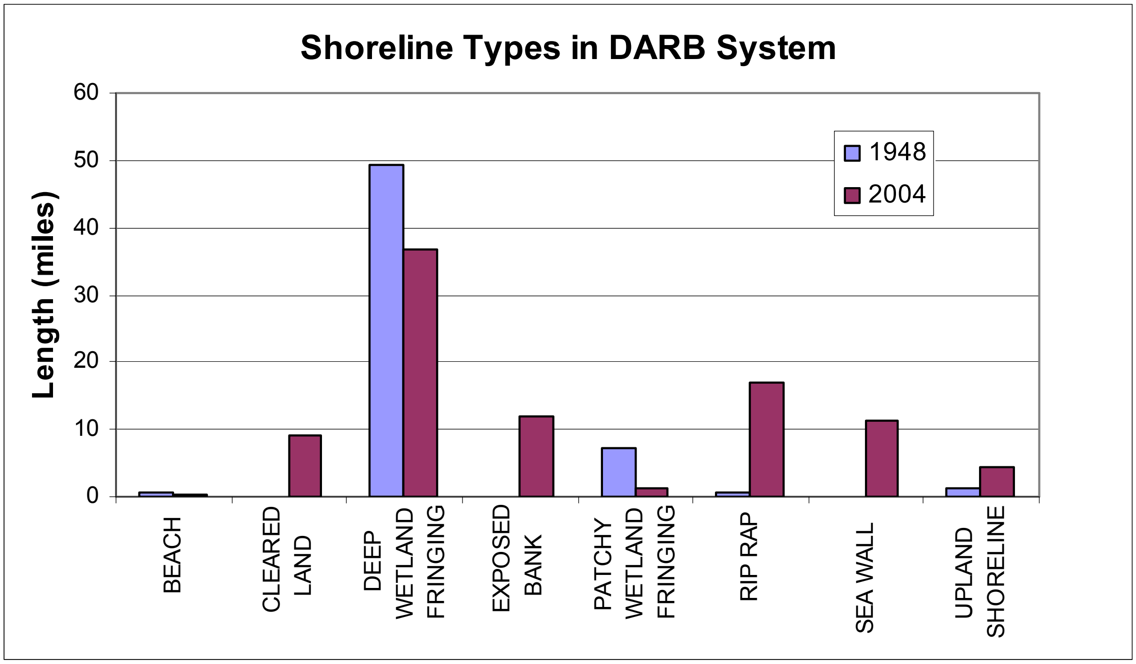

Figure 4 – Comparison of 1948 vs. 2004 Shoreline Features

The actual shoreline length in the DARB system has increased substantially, from 59.4 miles in 1948 to 91.8 miles in 2004, primarily due to the construction of canals for residential development and also the construction of the Intracoastal Waterway. However, most of this increase has been due to increases in the categories of rip rap and seawall. For the more "valuable" shoreline features (ecologically speaking) there have been reductions. The greatest loss of valuable shoreline, in terms of length of shoreline, was that of a loss of fringing deep wetlands. The greatest loss of valuable shoreline, in terms of a percent decline, was that of a loss in fringing patchy wetlands, which were mostly restricted to areas west of U.S. 41 in 1948.

4.0 DEVELOPMENT OF THE DRAFT MONITORING PLAN

An iterative multi-step process was used to develop a useful and effective monitoring plan for the Dona Bay system (Dona Bay, Shakett Creek and Cow Pen Slough). The step by step process is listed below, and then described in more detail:

1. Research the history of the Dona Bay watershed to understand how the current extent of the watershed and inflows related to the historic more "natural" state.
2. Review the current sampling that occurs in the Dona Bay watershed, and gather information on the results of that sampling to better understand the current state of Dona Bay.
3. Review the purpose, function, and elements of two HBMPs currently active in nearby estuaries.

4. Discuss the elements of these existing HBMPs that would be most effective in monitoring changes in Dona Bay. Further, discuss possible new elements, or modifications of existing elements, that would be uniquely effective in a Dona Bay Monitoring Plan.
5. Discuss some salinity/flow models that were run on data from Dona Bay, relative to distribution of sampling in Dona Bay for a Monitoring Plan.
6. Draft a Monitoring Plan for Dona Bay.

A study conducted by Mote Marine Lab (1975) and a more recent study by the Sarasota County Government (SCG, 2005) were critical documents for reviewing the history of the Dona Bay Watershed. Used together, these two documents provided an overview of the current and historical state of Dona Bay, and the extent of the Dona Bay watershed.

Much of the current sampling in Dona Bay is undertaken by the SCG. However a variety of other groups, including the United States Geological Survey (USGS), SWFWMD, and Mote Marine Laboratory (Mote), have ongoing, or recently completed sampling programs in Dona Bay. Many elements of these sampling programs were adopted for the draft Monitoring Plan for Dona Bay. Ongoing sampling efforts in the Dona Bay watershed include monitoring of water quality, oyster populations and seagrass beds.

Two active HBMPs (on the Peace River and Alafia River/ Tampa Bypass Canal) were reviewed. These described the rationale upon which the selected sampling regimes were initiated. Many facets of these programs were applicable to a draft Monitoring Plan for Dona Bay. However, one large difference between these HBMPs and the draft Monitoring Plan for Dona Bay is the actual geographic size of the water bodies. Dona Bay is much smaller than any of these other water bodies. Thus, it was proposed that the extent of sampling for the draft Monitoring Plan for Dona Bay be reduced, both to avoid redundancy in sampling, and to avoid disturbing the system through high levels of sampling activity.

While fish and benthic sampling are integral pieces of other monitoring plans and programs, it was decided that biotic sampling in Dona Bay should focus upon seagrass and oyster populations. Sampling of those populations already exists, and those particular organisms have been very well received as indicators of overall health in Dona Bay. It was clearly necessary that water quality monitoring via both grab samples, and continuous recorders should continue. After a series of discussions, an agreement on the extent and distribution of sampling was reached and an efficient and effective strategy was proposed. This strategy is outlined in the draft Monitoring Plan for Dona Bay. The sampling effort proposed is based upon sampling regimes already in place. It was also decided that it would be useful to compare the oyster and seagrass populations of Dona Bay with corresponding populations in Lyons Bay. The Lyons Bay watershed has not been altered to the same extent as the Dona Bay watershed. As a result, the oyster and seagrass populations of Lyons Bay have been found to be generally healthier than those of Dona Bay. Also, salinity has been found to be consistently higher and less variable in Lyons Bay than in Dona Bay.

Salinity versus flow relationships were created for use in another task of this project. These salinity flow models will be used to distribute continuous recorders (specific conductivity, dissolved oxygen, etc.). In this way the continuous recorders can be placed in areas that are should be most benefited by restoration of freshwater inflows from the Cow Pen Canal diversion. In conjunction with grab samples distributed via a random stratified schema, these continuous recorders should provide a satisfactory overview of changes in Dona Bay water quality characteristics relative to freshwater inflows.

Finally, the draft Monitoring Plan for Dona Bay was written, reviewed and edited by a number of staff with experience in planning and executing monitoring plans. It was widely accepted that the watershed/hydrologic restoration activites proposed are likely to improve water quality in Dona Bay, and are also likely to improve the health of oyster and seagrass populations in Dona Bay.

TM 4.1.1.2 – DATA COLLECTION AND REVIEW (BRA)

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD), are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), EarthBalance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

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This Technical Memorandum has been prepared by BRA to describe the procedures used to access literature and data, sources of acquired data, and all appropriate metadata and documentation, consistent with Task 4.1.1 of the DBWMP contract.

2.0 CURRENT STUDIES

BRA assessed numerous data files to evaluate the natural systems within the Dona Bay watershed, with a focus on four sites: (1) Albritton, (2) West Pinelands, (3) Myakka Connector, and (4) Venice Minerals. All literature and digital files listed below were compiled from Sarasota County and multiple public agencies. The data received from Sarasota County was either downloaded from the FTP site managed by Mr. Mike Jones or hand-delivered by Mr. Jones if the files were too large. The GIS layers were obtained directly from the cited public agencies.

- 1948 Historical Aerials (Sarasota County)
- 2004 Aerials (Sarasota County)
- Soils Map (USDA)
- *Soil Survey of Sarasota County, Florida* (1957, 1991) (USDA)

- 1995, 1999 Land Use (SWFWMD)
- 1847 GLO Survey Plats (Sarasota County)
- ESLPP Land Acquisition Plans (Sarasota County)
- LIDAR data (Sarasota County)
- Pinelands permits (SWFWMD, FDEP, ACOE, Sarasota County)
- *Sarasota County Old Cow Pen Slough Rehydration Area Slough Restoration 11th Semi-Annual Monitoring Report, June 2002* (PBS&J)
- Wading bird layer (FFWCC)
- Bald Eagle Nest Location layer (FFWCC)
- Scrub-jay layer (Sarasota County)
- Quadrangle Map (USGS)
- *Sarasota County Comprehensive Land Management Plan* (Sarasota County)
- *Manatee County Watershed Protection Plan* (Manatee County)
- *Cow Pen Slough Water Quality Monitoring Study: To determine the water quality within Cow Pen Slough as a potential irrigation or drinking water resource, September 2004* (Sarasota County)
- Fox Creek permits (SWFWMD)
- Comprehensive Water Management Program Boundaries (SWFWMD)
- *Dona and Robert's Bay Second Annual Watershed and Estuary Analysis, 2004* (Sarasota County)

USDA = United Stated Department of Agriculture
SWFWMD = Southwest Florida Water Management District
FDEP = Florida Department of Environmental Protection
ACOE = Army Corps of Engineers
PBS&J = Post, Buckley, Schuh & Jernigan
FFWCC = Florida Fish and Wildlife Conservation Commission
USGS = United States Geological Survey

TM 4.1.2 – DEVELOPMENT OF NATURAL SYSTEM WATER BUDGET

1.0 BACKGROUND

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This Technical Memorandum has been prepared by KHA, consistent with Task 4.1.2 of the DBWMP contract. The Deer Prairie watershed is considered a representative natural watershed in Sarasota County and Southwest Florida. A water budget analysis of historical hydrologic data collected in the Deer Prairie watershed has been conducted to estimate a representative natural watershed.

2.0 DESCRIPTION OF THE DEER PRAIRIE CREEK WATERSHED

The Deer Prairie watershed is located within the Myakka River watershed and contains 24,016.6 acres. It extends over portions of both Sarasota and Manatee Counties. The majority of the watershed is located within Sarasota County (15,872.7 acres) and of this portion of the watershed; approximately 86% (20,666.1 acres) is currently under public ownership. To determine the Deer Prairie watershed boundary, several information sources were reviewed. The western and southern boundaries are as defined by Sarasota County's adopted study for the lower Myakka River watershed. The northern and eastern boundaries were determined from SWFWMD 1-foot contour maps, 2004 aerials, and the Big Slough watershed study being conducted by SWFWMD and the City of North Port.

Figure 1 presents a map of the Deer Prairie watershed. **Figure 2** presents a map of the Deer Prairie watershed with the current publicly owned lands identified.

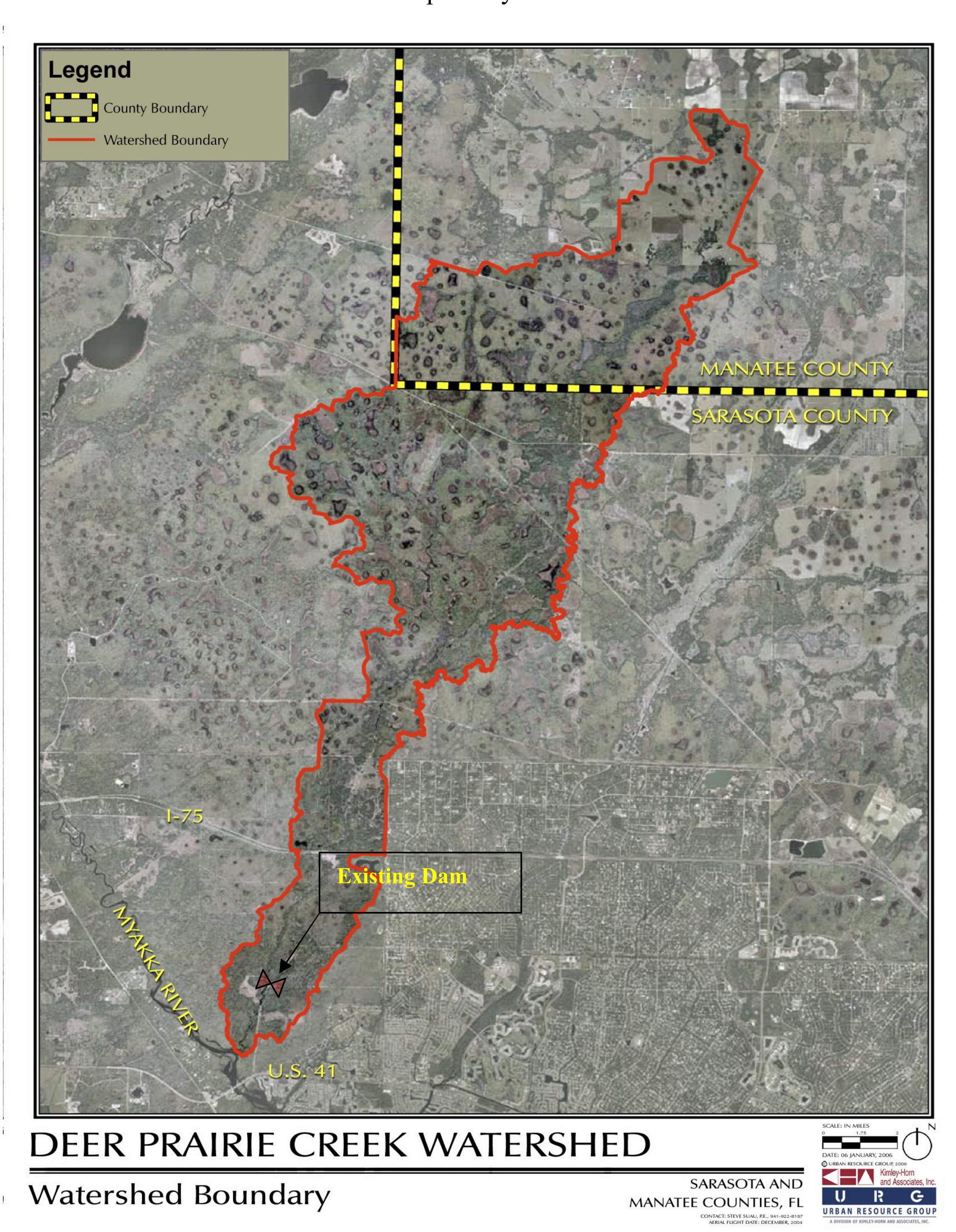


Figure 1 – Deer Prairie Watershed

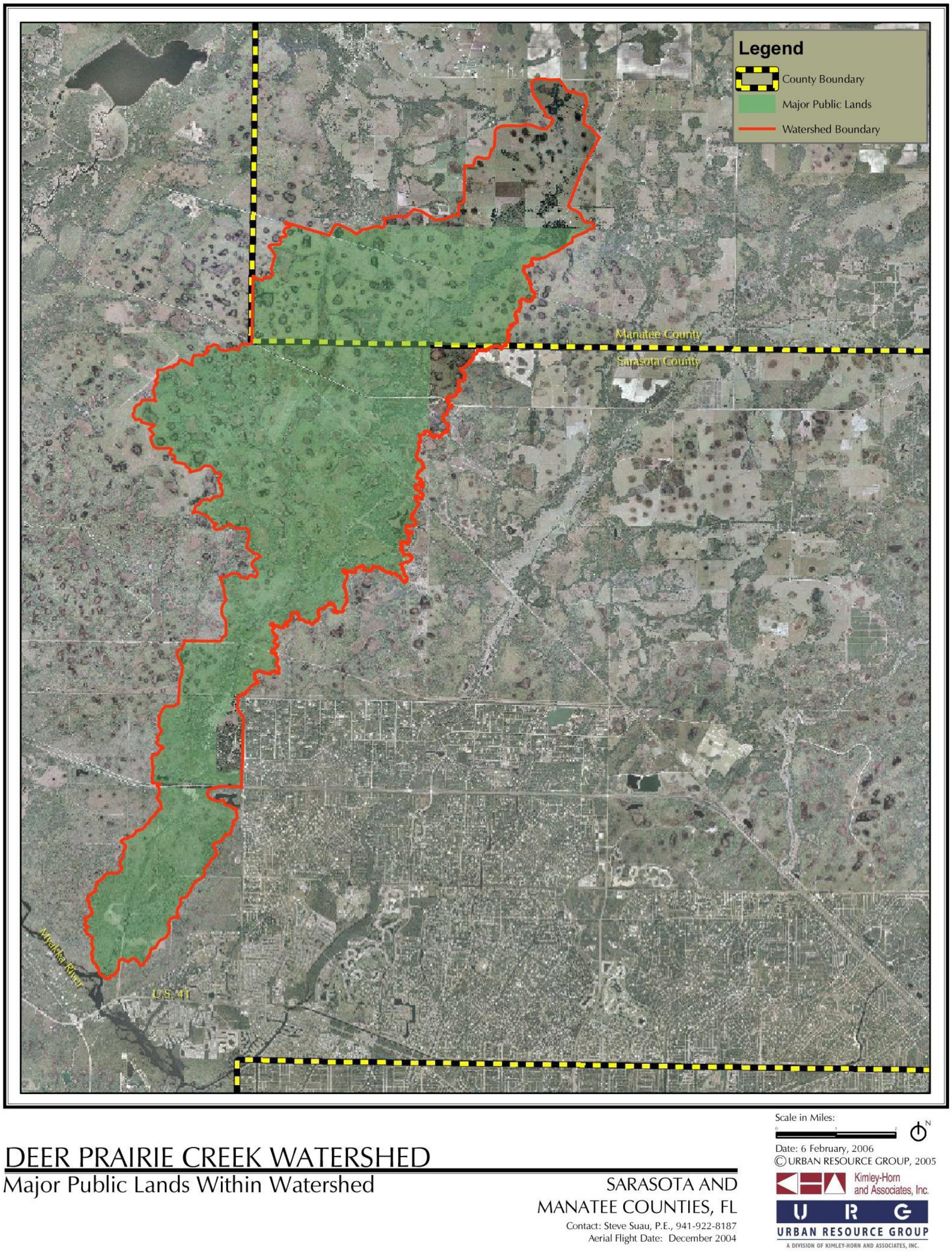


Figure 2 – Publicly Owned Lands within the Deer Prairie Watershed

The Deer Prairie watershed drains from north to south. Historical slough systems within the watershed ultimately drain to the historical Deer Prairie. The Deer Prairie watershed is one of the most natural watersheds in Sarasota County with relatively limited man-made alterations. These limited alterations include a man-made dam in the lower portion of the watershed that was constructed in the 1950's (refer to **Figure 3**). This dam is still in place and it has a crest elevation of 3.31 (National Geodetic Vertical Datum – NGVD 1929), it essentially acts as a salinity barrier. It is estimated that this dam impounds approximately 8.25 acres of surface water. This dam probably effects localized low flows, but has a minimal affect on normal and high flows from the Deer Prairie watershed.

Figure 3 – Deer Prairie Creek Dam

Other alterations include the construction of a bridge crossing associated with I-75 and two (2) Florida Power and Light (FPL) crossings. In addition, a man-made ditch was constructed through much of the historical wetland slough area to facilitate more efficient drainage. This drainage work was directed and tied into the historical Deer Prairie creek, located in the southern portion of the watershed. However, this ditch was not a pronounced drainage work and was probably constructed to facilitate mosquito control and cattle ranching, which appears to have been the predominant land use in the watershed prior to public ownership. Much of the man-made drainage ditch within the publicly owned lands portion of the Deer Prairie watershed has been backfilled under a joint effort by Sarasota County, SWFWMD, and the Charlotte Harbor National Estuary Program (CHNEP). The first phase of this effort was completed in summer of 2001 and the second phase was completed in the spring of 2002. This project has helped to further restore much of this watershed to its natural, even historical, condition. Removal of the Deer Prairie creek dam would further restore Deer Prairie watershed by restoring a more historical water budget from this watershed to Charlotte Harbor. It would also provide for the historical upstream migration of saline and brackish dependent species. The relatively natural condition of the Deer Prairie watershed and the availability of historical rainfall and stream flow data (± 25 years) collected upstream of the salinity dam provides a unique opportunity to analyze a rainfall-runoff conversion process for a relatively natural watershed. This information could be very helpful as a basis for hydrologic restoration and establishing natural system water budget targets in other altered watersheds such as those associated with Dona Bay and Roberts Bay.

3.0 RAINFALL

Several sources of daily rainfall in the vicinity of the Deer Prairie Creek watershed were reviewed to compile monthly rainfall totals for the period of stream flow record (April, 1981 to present). A list of these sources and their respective periods of record are identified in **Table 1** below:

Site Identification	**Period of Record**	**Operation Entity**
ARMS (numerous stations)	January, 1993 to present	Sarasota County
Site 194 (Myakka River)	April, 1981 to present	NOAA
Site 269 (Big Slough)	April, 1981 through August, 1993	NOAA
Site 336 (Deer Prairie)	April, 1981 through December, 2004	NOAA
Site 355 (Big Slough)	April, 1981 through October, 1990	NOAA
Site 409 (Myakka River)	July, 1992 to present	NOAA
Site 417 (Deer Prairie)	July, 1992 to present	NOAA
Site 516 (Big Slough)	January, 2000 to present	NOAA
Site 543 (Big Slough)	September, 2000 to present	NOAA
Myakka River Watershed	April, 1981 to present	SWFWMD Report

Table 1 – Rainfall Stations Reviewed

Figure 4 identifies the locations of the National Oceanic & Atmospheric Administration (NOAA) rainfall monitoring sites located within the vicinity of the Deer Prairie watershed.

Data from Site 336 provided the most complete rainfall record for the Deer Prairie watershed flow period of record (April 1981 to the present). Because of its location in the Deer Prairie watershed, rainfall from this site was used exclusively from April 1981 through March 1991; and July 1991 through December 1992. Since Site 336 appeared to be having reporting problems in April, May and the early part of June of 1991 rainfall data from Site 194 was used for these three (3) months.

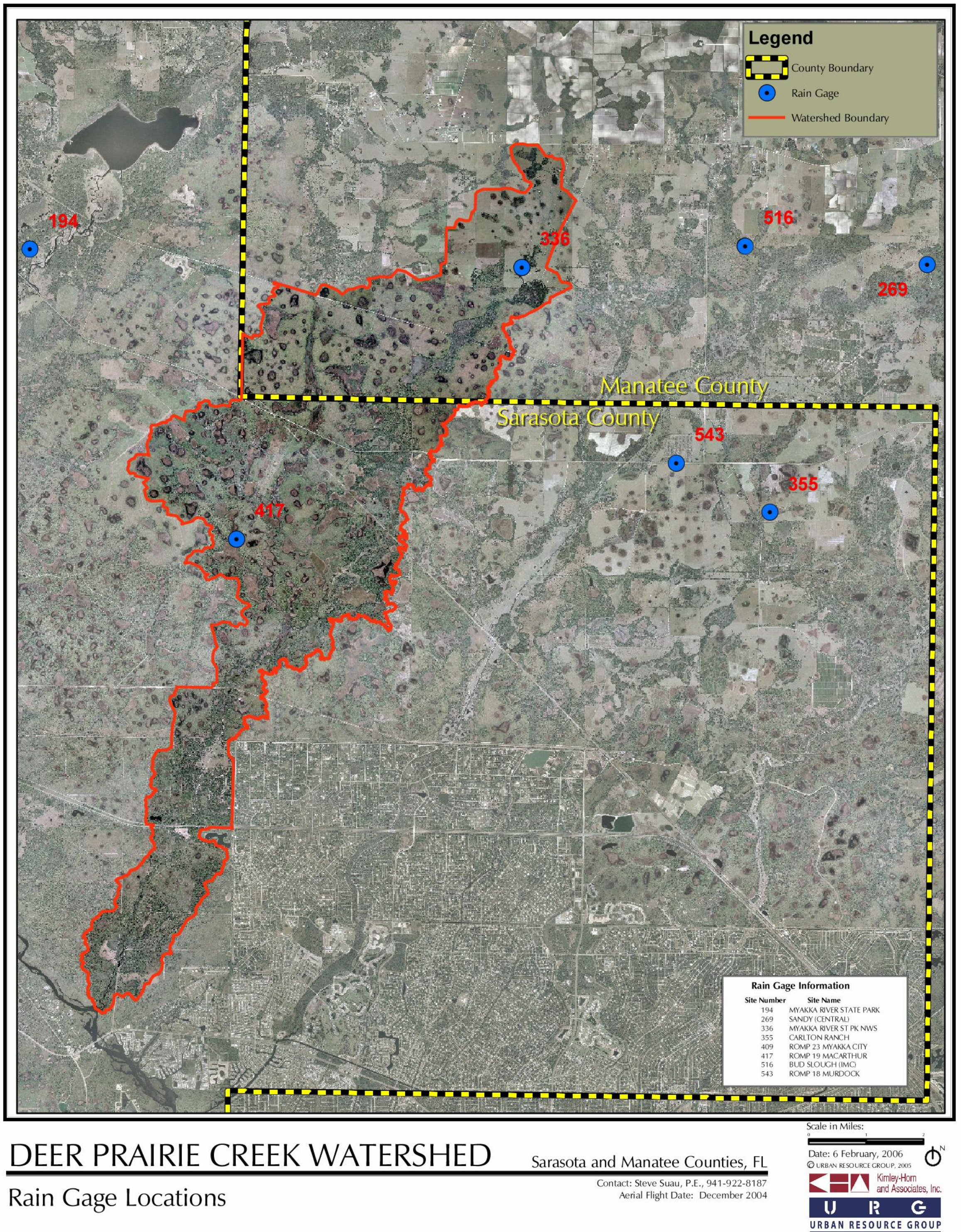


Figure 4 – NOAA Rainfall Station Locations

From January 1993 to present, Sarasota County Government (SCG) has rainfall measurements at up to 12 locations in the vicinity of their Deer Prairie Creek watershed. These sites are part of a radio telemetry network of stations known as the Automated Rainfall Monitoring System (ARMS). Jeffrey Banner of SCG Environmental Services manages the ARMS system, and provided average monthly rainfall totals from these rainfall monitoring sites located in the vicinity of the Deer Prairie Creek watershed.

The ARMS data provided by SCG was averaged with Sites 336 and 417, as available and used to reflect monthly rainfall from January 1993 through December 2005. A summary of rainfall data employed for the Deer Prairie water budget analysis is presented in **Table 2**.

Period	Data Base Used
April, 1981 through March, 1991	Site 336
April, 1991 through June, 1991	Site 194
July, 1991 through December, 1992	Site 336
January, 1993 through December, 2005	ARMS, Site 417, Site 336

Table 2 – Rainfall Data for Deer Prairie

4.0 RUNOFF

Hydrologic flow data from four (4) sites in the Deer Prairie Creek watershed from April 1 1981 through December 2005 were reviewed and analyzed to determine monthly runoff volumes. The site identification, dates of operation, entity responsible for operation, and contributing area are inventoried on **Table 3**. SCG ARMS site DPS-2 and USGS site 02299120 are located at approximately the same location but during different periods of record. All flow monitoring sites are presented on **Figure 5**.

Site Identification	Period of Record	Operation Entity	Contributing Area
02299160	04/01/81 through 09/30/92	USGS	20,017.4 acres
02299120	10/01/93 through 01/29/03	USGS	19,227.7 acres
02299060	10/01/93 through 01/27/03	USGS	6,577.5 acres
DPS-2	06/04/04 to 12/31/05 (1)	Sarasota County	19,227.7 acres

(1) Data from August 18, 2004 through October 11, 2004 not reported.

Table 3 – Stream Flow Stations in the Deer Prairie Creek Watershed

The downstream extent of the contributing area at each gage was determined using subbasin delineations provided by SCG for the portion of the Deer Prairie Creek watershed located in Sarasota County. The upstream extent of the contributing area at each gage is based upon the overall watershed boundary.

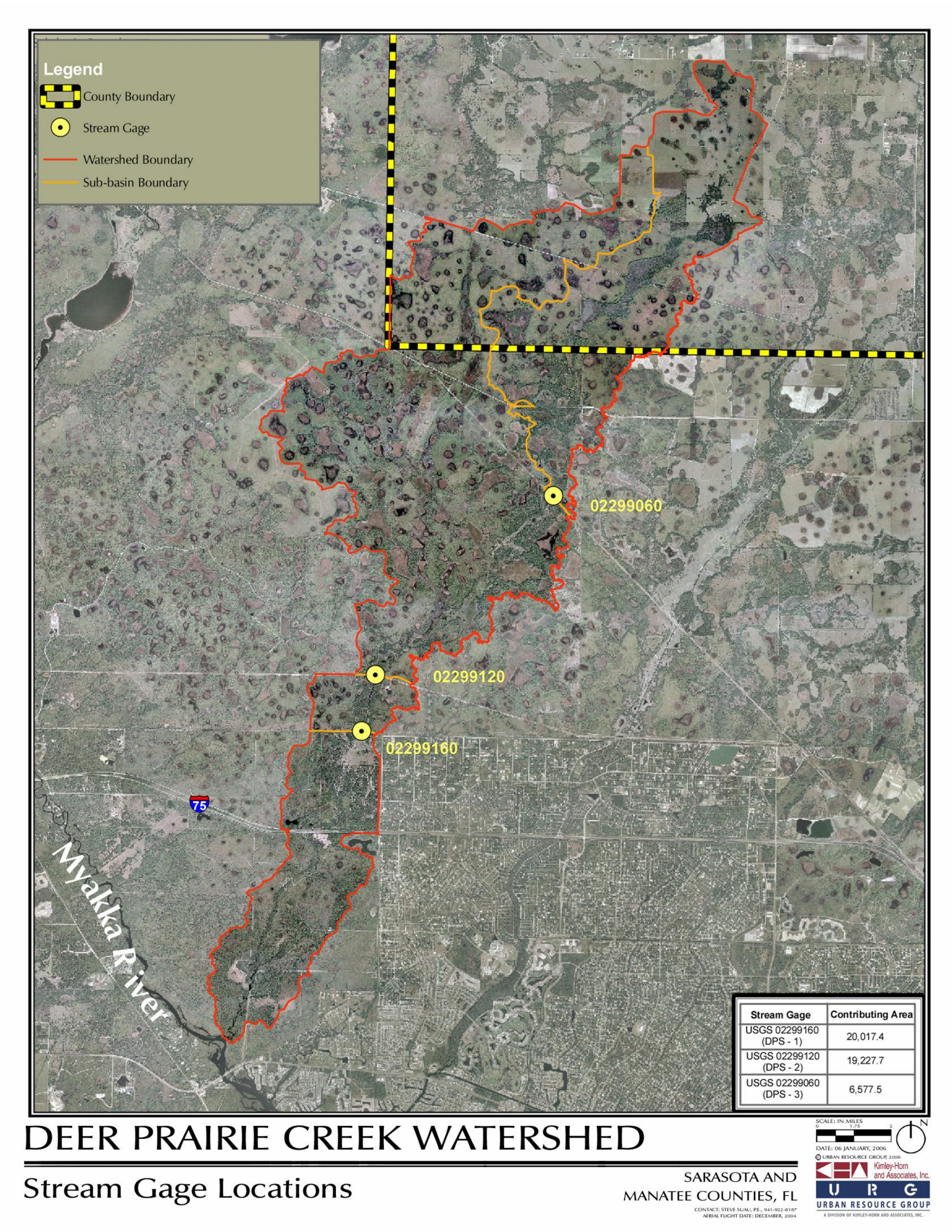


Figure 5 – Stream Gage Station Locations

From **Figure 5**, it can be seen that Site 02299120 is located downstream of Site 02299060. Therefore, flows measured at Site 02299120 include those from Site 02299060. A comparison of measured runoff volumes at these 2 sites indicated that with a couple of exceptions, Site 02299120 consistently reported higher volumes. In light of this comparison, and since the period of record for these two (2) sites is the same, it was decided to use data from Site 02299120 as indicative of the Deer Prairie watershed. **Table 4** provides a summary of stream flow data used for the Deer Prairie Creek water budget analysis.

Period	**Data Base Used**
April 1981 through September 1992	Site 02299160
October 1993 through December 2002	Site 02299120
June 2004 through December 2005	ARMS, Site DPS-2

Table 4 – Stream Flow Data for Deer Prairie

Through a separate contract with SCG, John Coffin with Hydrologic Data, Inc. is developing stage-discharge rating curves at DPS-2 and provided summary tables of flows for the ARMS stage data collected at this monitoring site. For the purpose of this analysis, KHA has relied upon the hourly data collected and provided by SCG and VHB.

Computation of hourly and monthly runoff volumes – Once flows were determined for the entire data base record, runoff volumes (in inches) were computed by averaging hourly flows, converting it to acre-inches, and dividing them by the contributing area in acres. Monthly runoff volumes were computed as the sum of the hourly runoff volumes for each month.

5.0 MONTHLY WATER BUDGET ANALYSES

Table 5 and **Table 6** summarize the monthly rainfall and runoff volumes in inches, respectively, during the study period. Cells highlighted in red correspond to periods with no or incomplete runoff records.

RAINFALL	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1981	0.66	5.88	1.53	0.00	1.91	15.77	8.17	19.85	5.96	1.78	4.87	1.19	
1982	2.06	2.67	6.62	5.05	2.81	15.61	13.24	11.73	11.98	3.24	0.69	1.02	76.72
1983	2.71	9.55	7.81	2.72	1.99	9.33	11.89	7.41	11.67	2.66	4.42	8.20	80.36
1984	1.00	2.44	5.41	3.31	4.29	2.87	15.47	7.29	4.19	2.76	2.36	0.36	51.75
1985	0.81	0.97	2.80	2.09	0.23	5.58	7.46	9.10	9.59	1.91	3.08	0.41	44.03
1986	1.79	1.66	4.40	0.97	1.94	7.53	5.58	7.09	2.40	5.92	1.31	3.53	44.12
1987	4.96	2.54	12.88	0.02	5.57	7.63	9.90	9.51	8.16	4.41	4.12	0.19	69.89
1988	4.49	2.41	5.17	1.66	2.63	3.20	8.67	15.62	11.47	2.14	3.43	1.21	62.10
1989	2.83	0.23	1.02	0.73	1.26	7.68	9.61	5.58	6.89	3.96	1.87	4.23	45.89
1990	0.17	3.67	1.68	0.96	3.57	7.89	10.34	7.20	2.74	5.90	0.88	0.55	45.55
1991	5.42	2.40	4.38	2.70	11.62	7.85	11.04	3.44	3.76	2.35	0.03	0.10	55.09
1992	1.12	4.55	2.85	3.19	0.80	26.16	3.47	10.51	4.48	2.75	0.84	0.80	
1993	7.63	2.85	4.53	6.51	2.62	3.39	5.02	6.83	4.31	5.43	0.24	0.75	
1994	3.67	0.76	2.19	3.08	0.31	8.87	11.33	9.03	13.26	5.15	1.08	1.85	60.58
1995	2.88	1.73	1.20	3.64	0.56	17.53	16.06	13.00	10.49	9.06	1.25	1.31	78.70
1996	3.85	1.09	4.81	2.00	5.87	5.24	4.81	7.30	4.44	4.02	0.23	1.91	45.56
1997	1.72	0.98	2.41	8.22	3.16	5.20	11.22	6.67	11.33	3.53	6.34	9.49	70.26
1998	4.86	7.49	9.80	0.09	2.44	4.57	9.40	8.60	9.30	2.47	4.13	1.01	64.16
1999	4.66	0.03	1.58	0.60	2.38	9.69	7.95	12.78	7.56	5.43	0.67	2.18	55.51
2000	2.72	0.54	2.20	1.99	0.48	10.39	7.41	11.03	7.96	0.49	0.92	1.01	47.14
2001	0.32	0.01	7.42	0.20	1.72	11.71	15.54	6.40	15.28	2.68	0.05	0.56	61.89
2002	2.39	5.24	0.32	2.61	2.78	8.34	7.22	10.97	4.26	2.94	4.40	5.63	57.09
2003	0.82	1.28	2.25	3.89	3.82	17.93	7.23	15.78	9.95	0.93	1.05	4.79	
2004	2.24	4.25	0.79	2.66	0.63	8.51	12.03	13.95	7.17	2.14	1.52	2.96	
2005	2.70	1.91	5.97	3.04	5.13	16.19	9.50	5.21	2.94	7.65	3.14	1.02	64.40
Average	**2.72**	**2.52**	**4.42**	**2.22**	**2.88**	**9.71**	**9.88**	**9.33**	**7.73**	**3.90**	**2.22**	**2.20**	**59.75**

Table 5 – Summary of Monthly Rainfall (in inches) for Deer Prairie Watershed

RUNOFF	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1981				0.00	0.00	0.08	0.14	3.79	3.90	0.33	0.08	0.01	
1982	0.01	0.00	0.03	0.07	0.01	3.70	4.67	2.79	2.42	4.90	0.31	0.04	18.95
1983	0.03	2.01	5.07	1.16	0.04	0.31	1.59	2.35	6.30	1.77	0.60	2.12	23.34
1984	1.04	0.37	1.44	0.69	0.07	0.03	0.16	0.63	0.07	0.03	0.01	0.00	4.53
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.40	1.59	0.20	0.09	0.02	2.33
1986	0.01	0.01	0.06	0.01	0.00	0.22	0.42	0.68	2.49	0.49	0.61	0.63	5.65
1987	3.00	0.39	1.46	3.23	0.20	0.11	1.11	1.42	0.83	0.50	0.22	0.14	12.60
1988	0.11	0.19	0.77	0.35	0.13	0.03	0.02	0.13	7.52	0.23	0.10	0.06	9.65
1989	0.04	0.02	0.04	0.00	0.00	0.00	0.09	0.84	0.74	0.29	0.07	0.09	2.22
1990	0.13	0.06	0.02	0.00	0.00	0.13	0.12	0.10	0.01	0.05	0.00	0.00	0.63
1991	0.01	0.01	0.04	0.16	1.43	1.70	4.53	2.63	0.26	0.28	0.06	0.00	11.11
1992	0.00	0.00	0.00	0.01	0.00	4.03	4.40	3.53	2.25				
1993										0.19	0.34	0.04	
1994	0.05	0.02	0.01	0.01	0.00	0.04	1.39	3.60	8.32	4.46	0.86	0.28	19.05
1995	0.23	0.13	0.07	0.01	0.00	2.20	7.27	9.79	8.09	8.13	1.56	0.10	37.58
1996	0.45	0.11	0.05	0.03	0.04	0.12	0.05	0.74	0.13	1.00	0.04	0.02	2.78
1997	0.02	0.01	0.05	0.21	0.16	0.02	1.33	2.86	1.76	2.75	3.05	6.82	19.03
1998	4.48	4.38	6.08	1.00	0.01	0.00	0.06	0.84	2.50	1.67	1.25	0.29	22.55
1999	0.25	0.13	0.03	0.00	0.00	0.11	1.39	3.90	2.99	3.65	0.18	0.06	12.70
2000	0.03	0.02	0.00	0.00	0.00	0.01	0.10	3.15	2.74	0.77	0.04	0.00	6.87
2001	0.06	0.05	0.01	0.00	0.00	0.03	0.20	6.30	5.48	1.53	0.08	0.00	13.74
2002	0.00	0.00	0.00	0.00	0.00	0.00	4.74	5.95	7.79	0.55	0.17	0.00	19.20
2003													
2004						0.00	0.54				0.10	0.01	
2005	0.08	0.02	0.60	0.46	0.04	7.84	4.00	1.77	0.41	0.67	0.49	0.22	16.59
Average	**0.48**	**0.38**	**0.75**	**0.34**	**0.10**	**0.90**	**1.67**	**2.65**	**3.12**	**1.57**	**0.45**	**0.48**	**12.86**

Table 6 – Summary of Monthly Runoff (in inches) for Deer Prairie Watershed

Using average monthly rainfall and runoff presented in Tables 5 and 6, average monthly water budgets were developed for the Deer Prairie Creek watershed and are presented in **Table 7**. Monthly rainfall in the Myakka River watershed during the study period (as reported by the SWFWMD), the ratio of monthly runoff to monthly rainfall, and evapotransiration plus change in storage are also provided in **Table 7**.

During the flow period of study, the annual rainfall within the Deer Prairie watershed averaged over 3 inches more than the annual rainfall reported by SWFWMD in the Myakka River watershed, as a whole.

	DEER PRAIRIE WATER BUDGET				
	1	2	3	4	5
	Annual Average	Average Monthly	Average Monthly	R/P	Average Monthly
MONTH	RAINFALL	RAINFALL	RUNOFF		ET + STORAGE
	(in inches)	(in inches)	(in inches)		(in inches)
January	2.46	2.72	0.48	0.18	2.24
February	2.55	2.52	0.38	0.15	2.14
March	4.14	4.42	0.75	0.17	3.67
April	2.36	2.22	0.34	0.15	1.88
May	2.91	2.88	0.10	0.03	2.79
June	9.28	9.71	0.90	0.09	8.81
July	8.93	9.88	1.67	0.17	8.21
August	8.46	9.33	2.65	0.28	6.69
September	7.41	7.73	3.12	0.40	4.61
October	3.51	3.90	1.57	0.40	2.34
November	2.07	2.22	0.45	0.20	1.77
December	2.19	2.20	0.48	0.22	1.73
TOTAL	56.27	**59.75**	**12.86**	0.22	46.89

Table 7 – Deer Prairie Water Budget

Where:

1 = Mean Annual Rainfall for the Myakka River Watershed (SWFWMD)
2 = Average Rainfall for Deer Prairie Watershed (1981 to Present)
3 = Average Runoff from Deer Prairie Watershed (1981 to Present)
4 = Average Runoff divided by Rainfall (Column 3 divided by Column 2)
5 = Evapotranspiration plus Change in Storage (Column 2 minus Column 3)

Figure 6 presents a comparison of average monthly rainfall and runoff volumes between April 1981 and December 2005 for the Deer Prairie watershed.

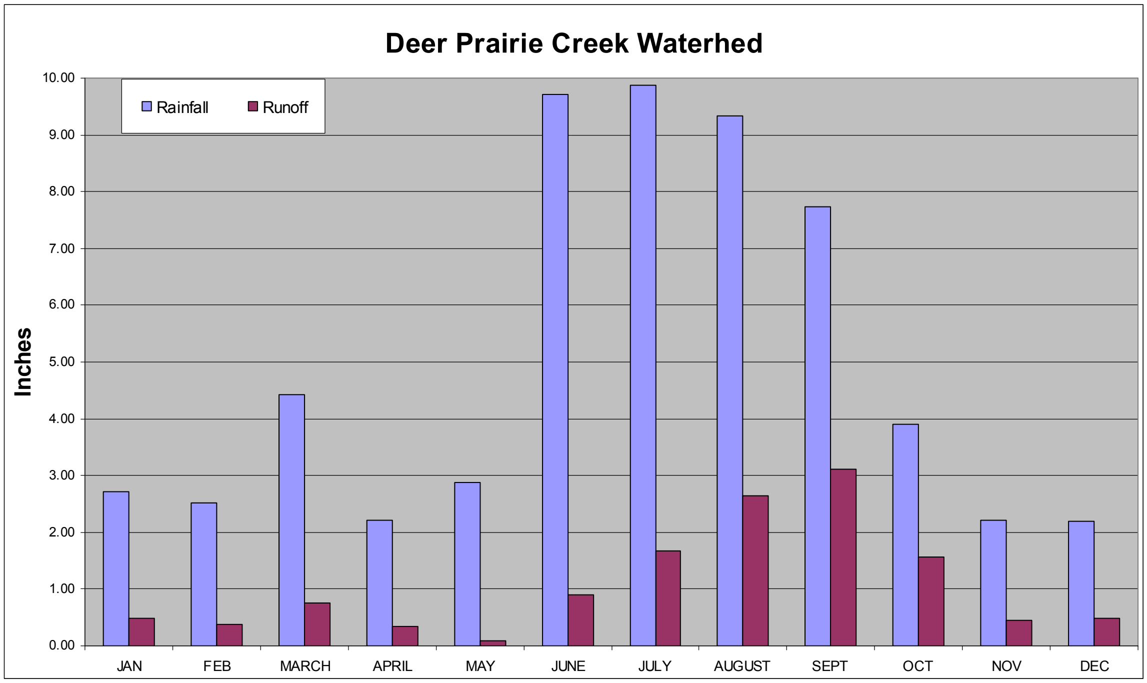


Figure 6 – Deer Prairie Watershed Average Monthly Runoff Conversion

Rainfall and runoff totals for each month for the period of record were plotted to determine if a reliable relationship existed. The results of these plots are provided in **Figure 7** through **Figure 18**. **Table 8** provides a summary of the equations developed for the monthly rainfall/runoff data and the "R" squared value for each equation.

As indicated in **Table 8**, only two months (May and December) resulted in "reliable" best fit equations correlating rainfall to runoff. In fact with 'R" squared values over 0.90, the rainfall/runoff equations for these two months should be quite reliable. However, the rainfall/runoff best fit equations for all other months resulted in "R" squared values under 0.70, with most being under 0.50.

A review of rainfall/runoff data in monthly increments indicated numerous instances where either the rainfall or runoff caused by rainfall, "bleeded" over from the preceding month. Therefore, it was concluded that segmenting water budgets into monthly partitions is too discrete an increment.

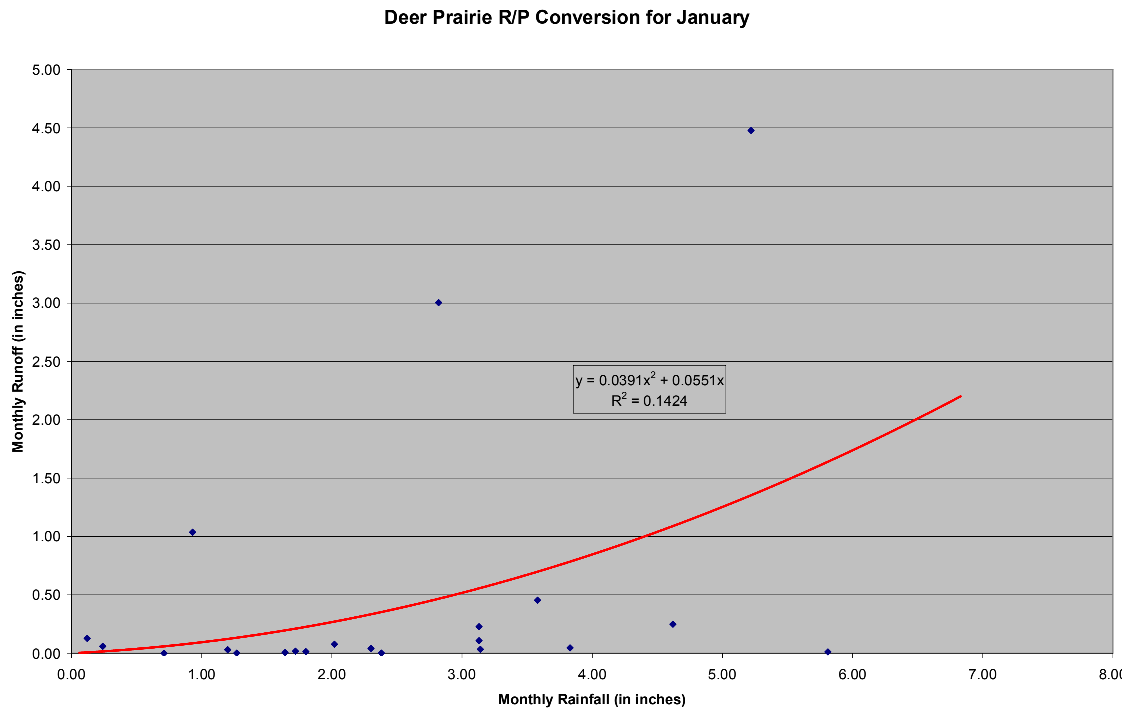


Figure 7 – Deer Prairie Watershed, Runoff vs. Rainfall for January

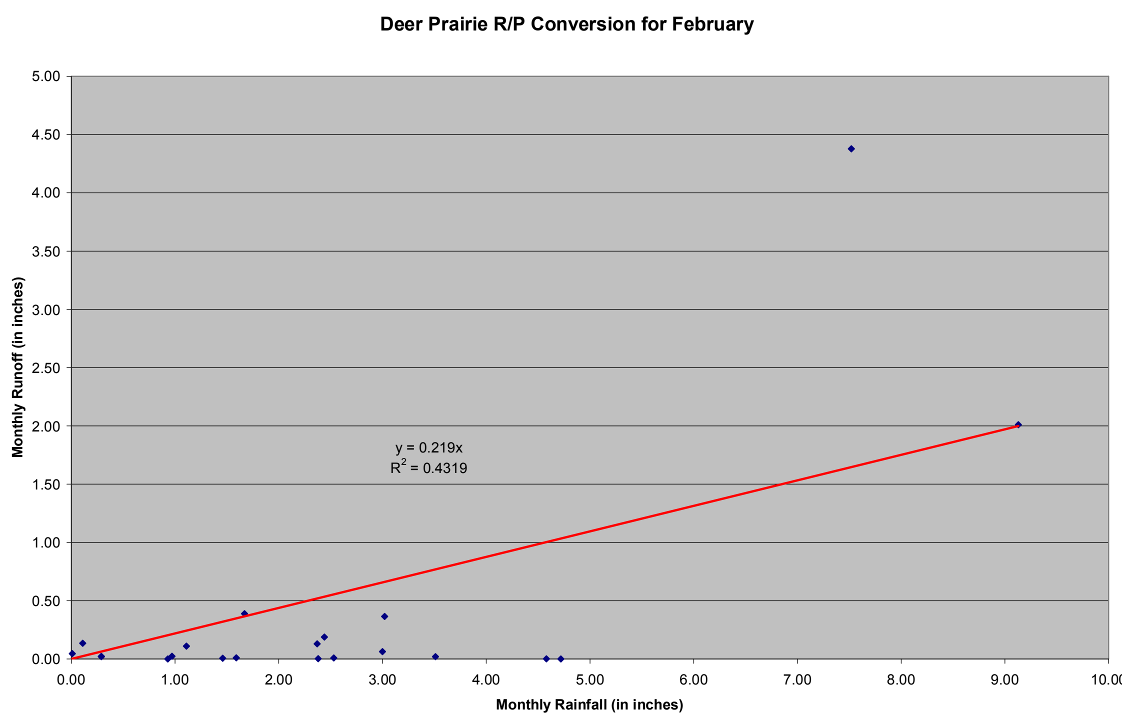


Figure 8 – Deer Prairie Watershed, Rainfall vs. Runoff for February

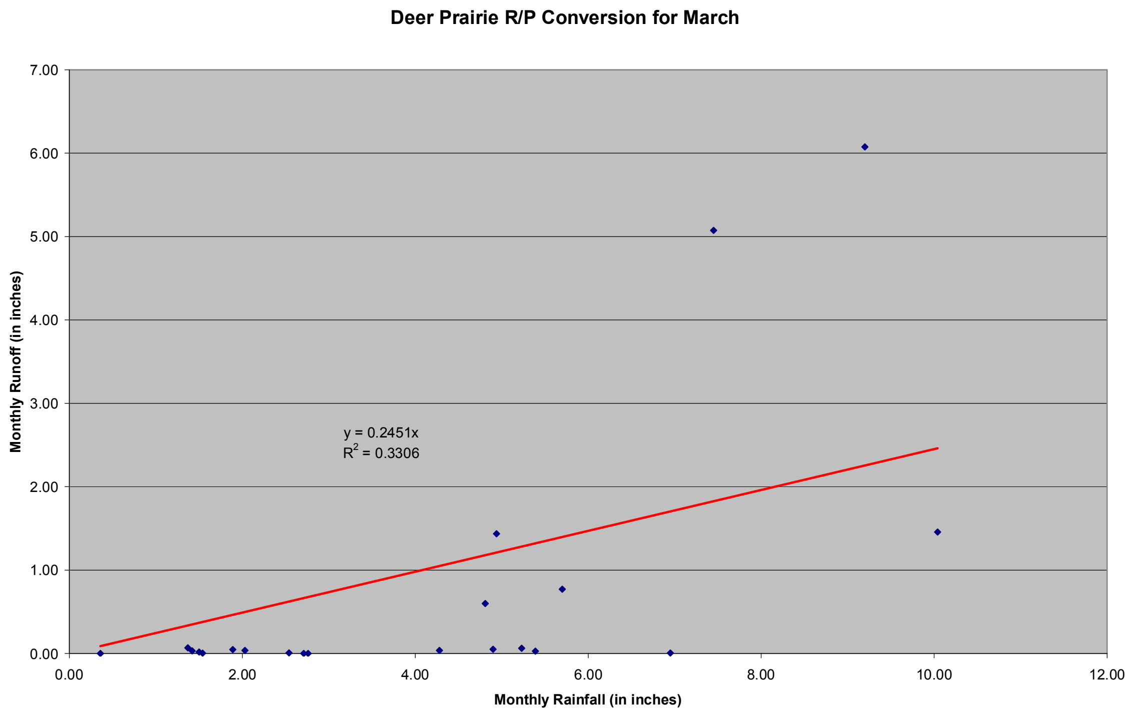


Figure 9 – Deer Prairie Watershed, Rainfall vs. Runoff for March

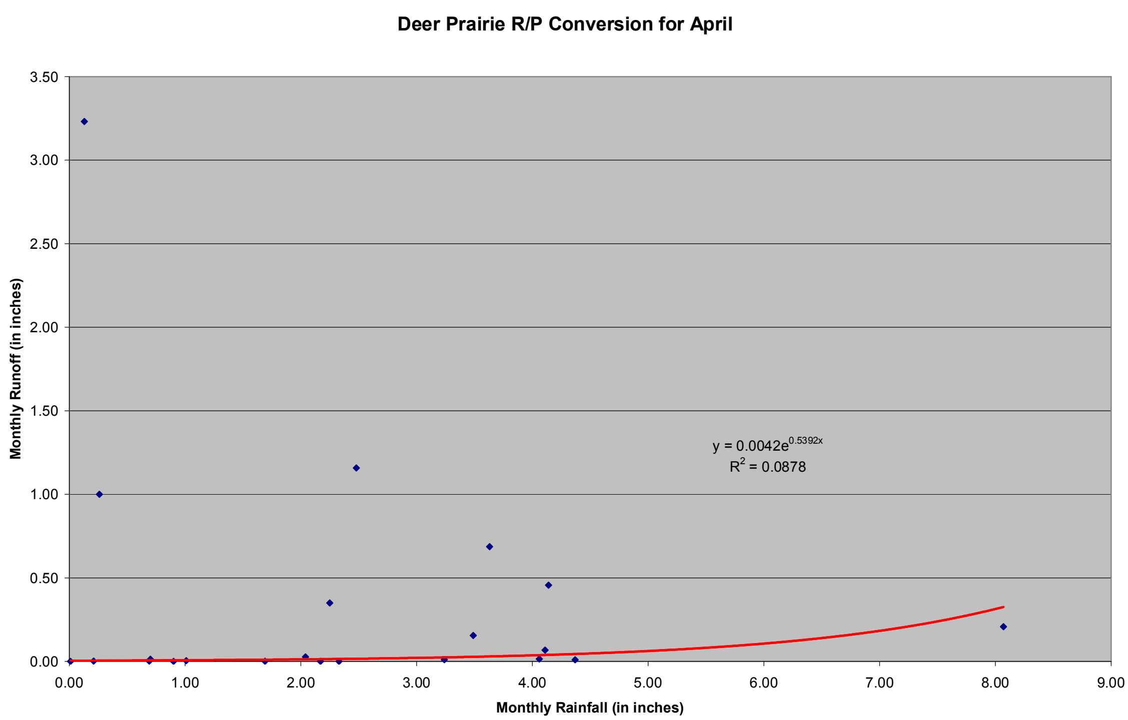


Figure 10 – Deer Prairie Watershed, Rainfall vs. Runoff for April

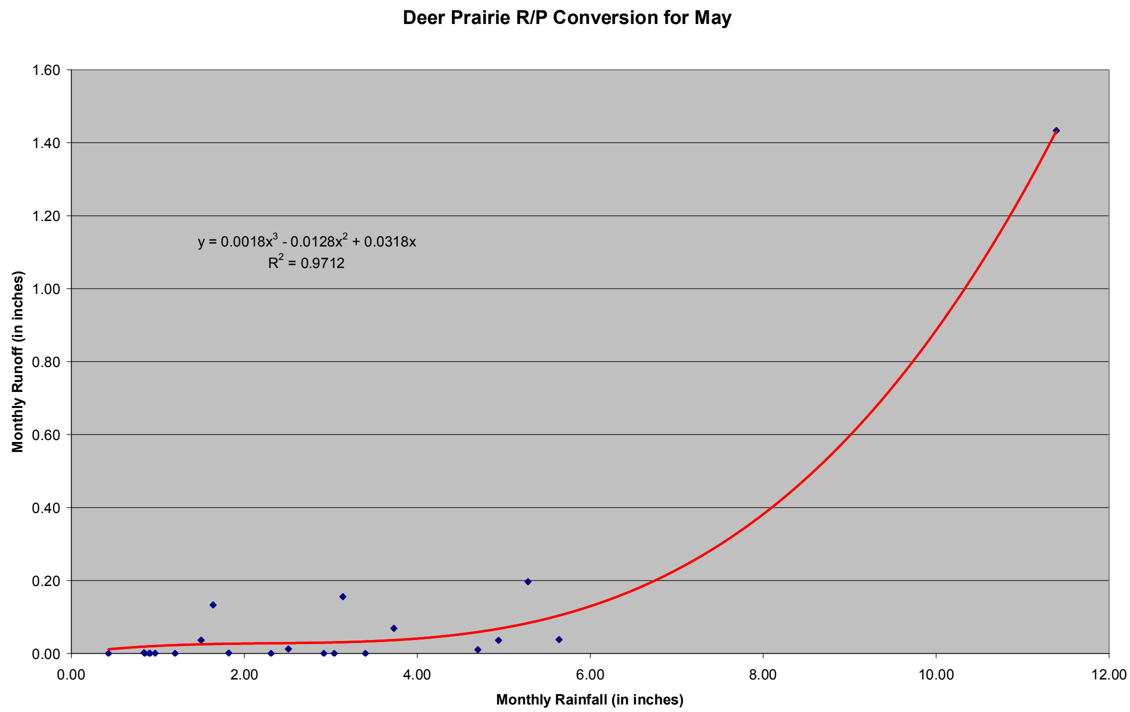


Figure 11 – Deer Prairie Watershed, Rainfall vs. Runoff for May

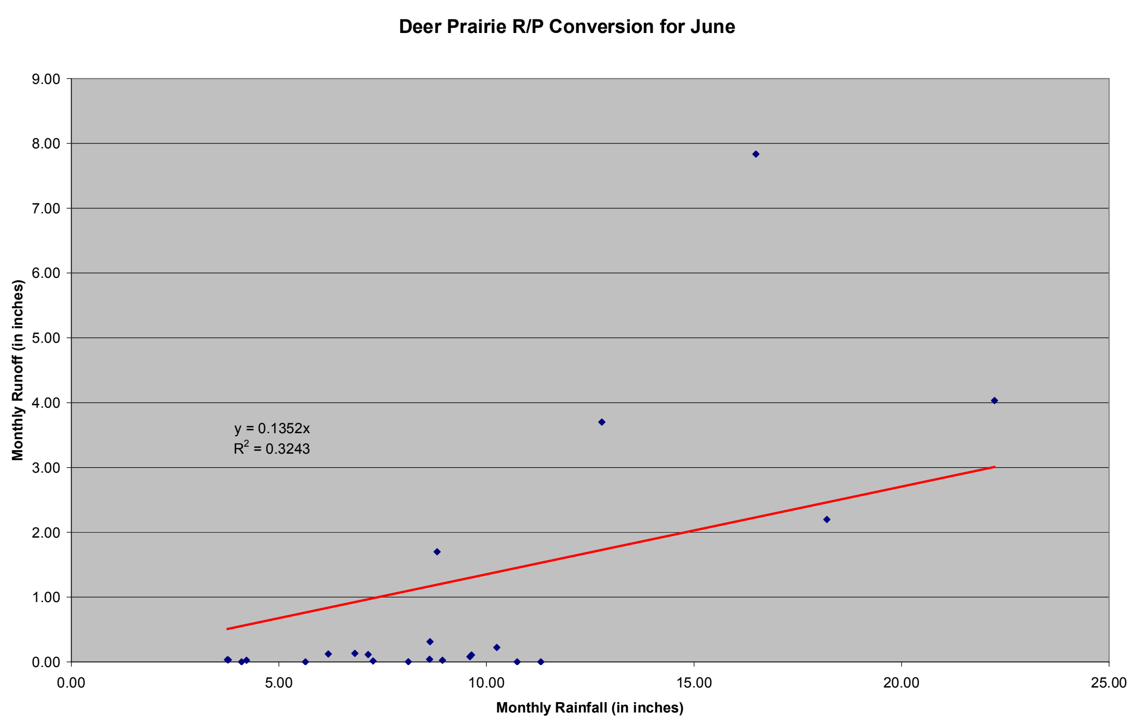


Figure 12 – Deer Prairie Watershed, Rainfall vs. Runoff for June

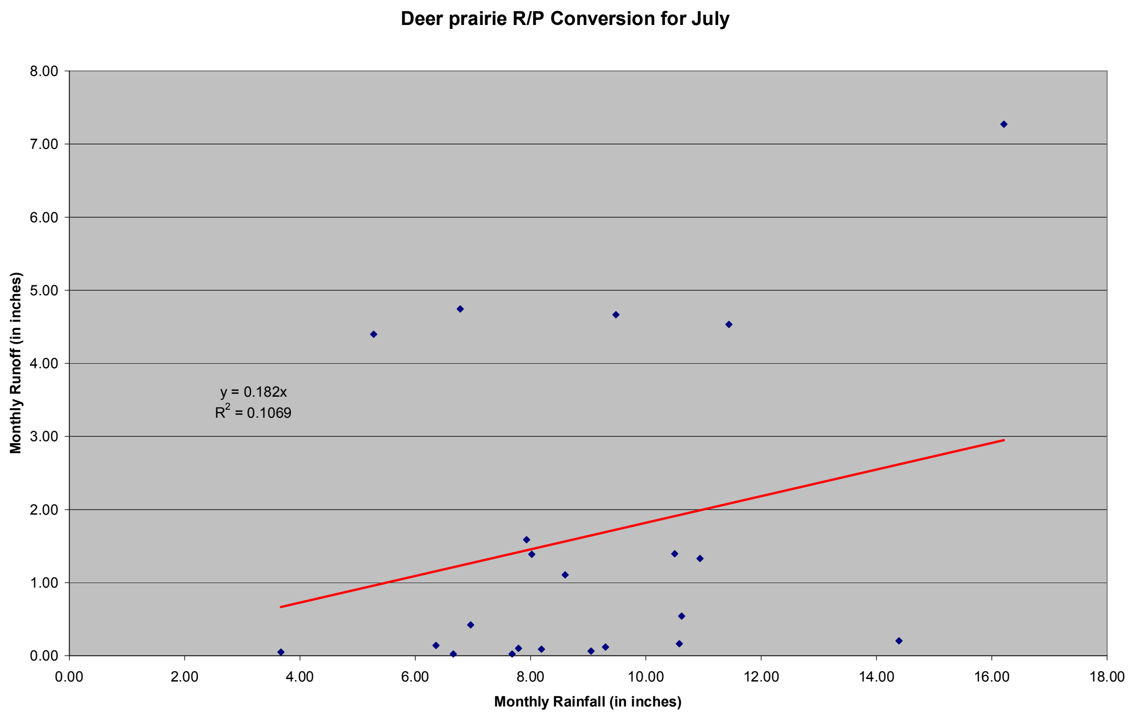


Figure 13 – Deer Prairie Watershed, Rainfall vs. Runoff for July

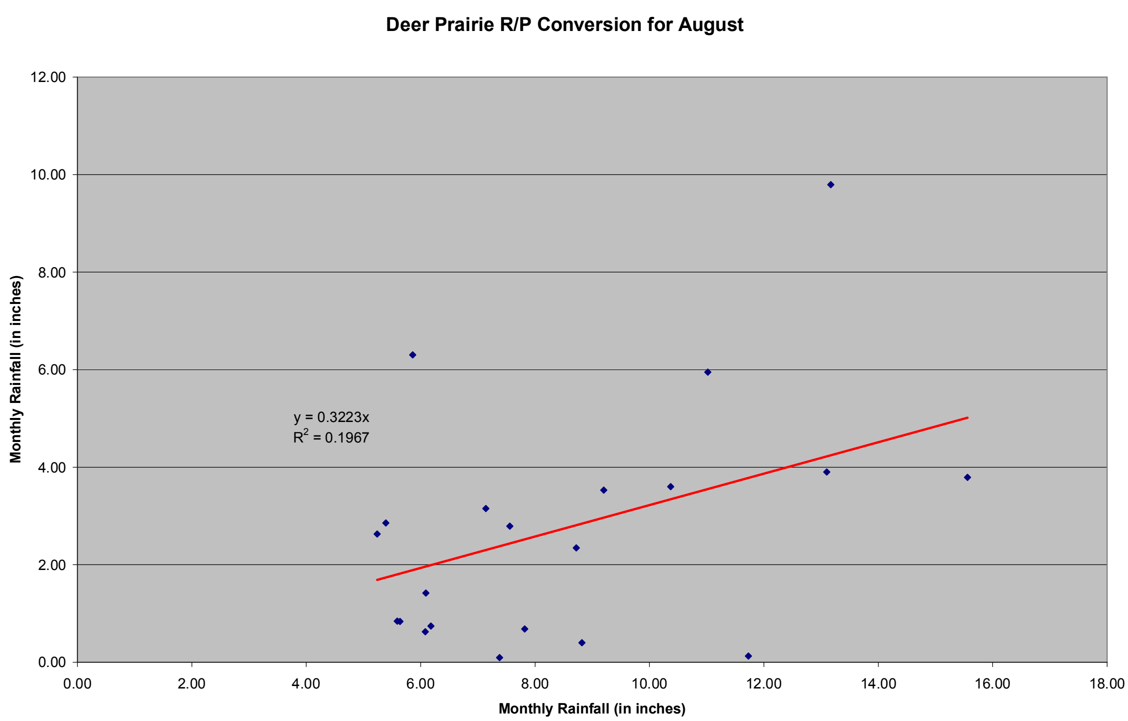


Figure 14 – Deer Prairie Watershed, Rainfall vs. Runoff for August

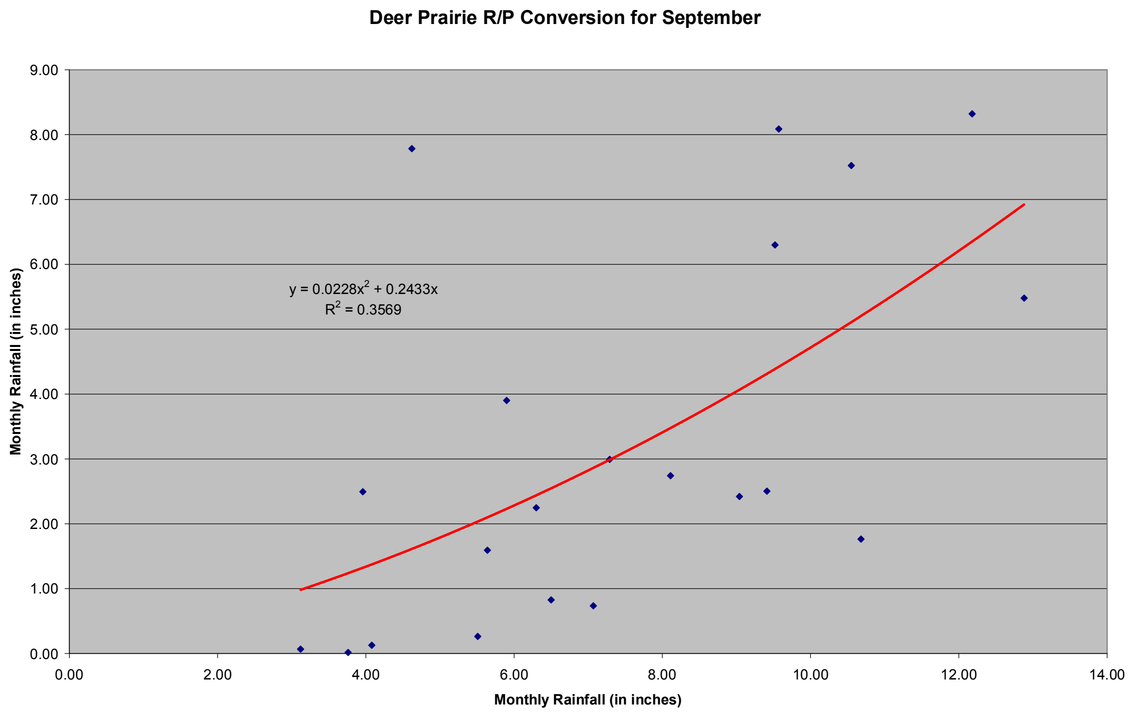


Figure 15 – Deer Prairie Watershed, Rainfall vs. Runoff for September

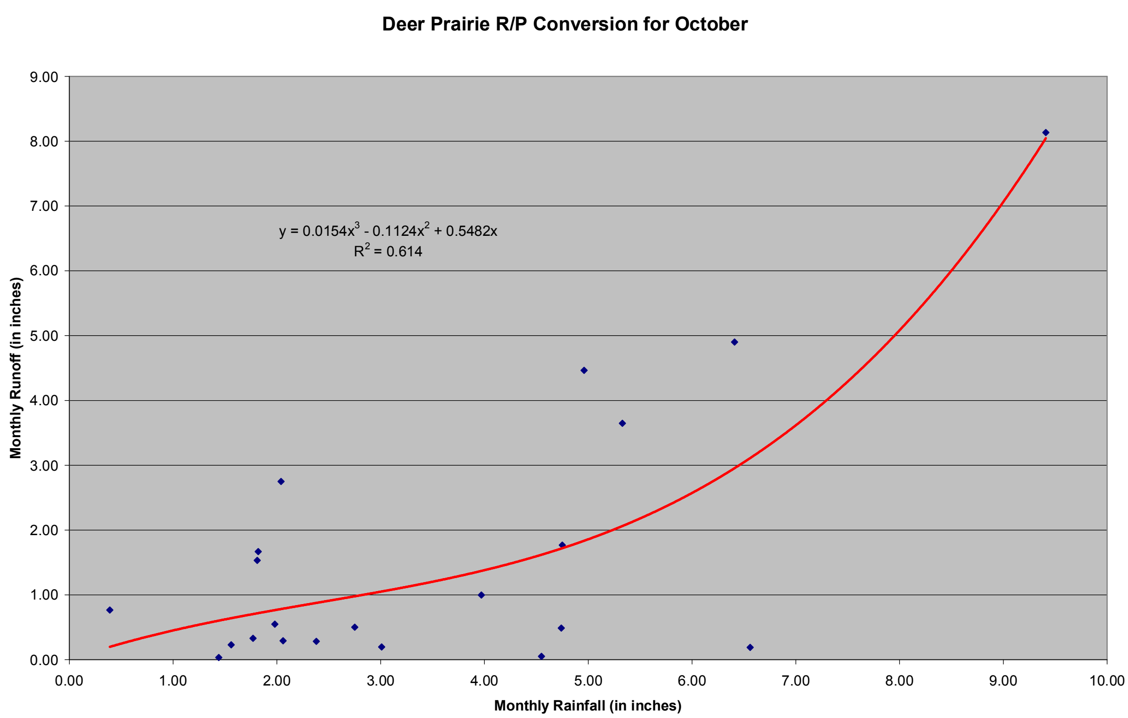


Figure 16 – Deer Prairie Watershed, Rainfall vs. Runoff for October

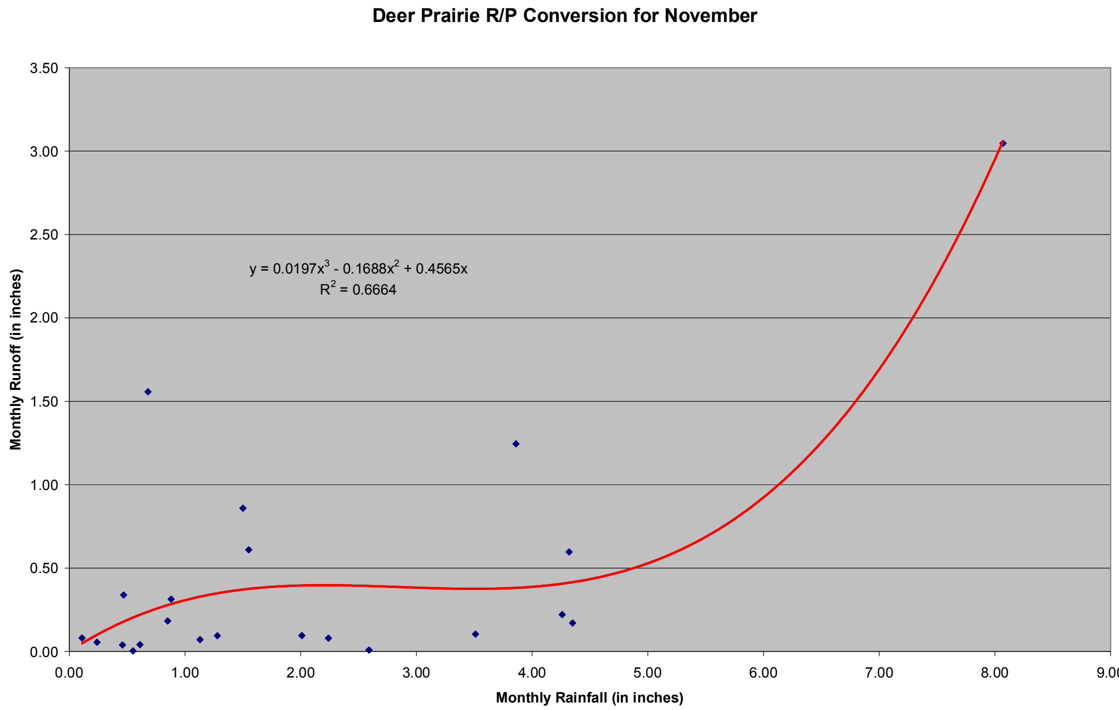


Figure 17 – Deer Prairie Watershed, Rainfall vs. Runoff for November

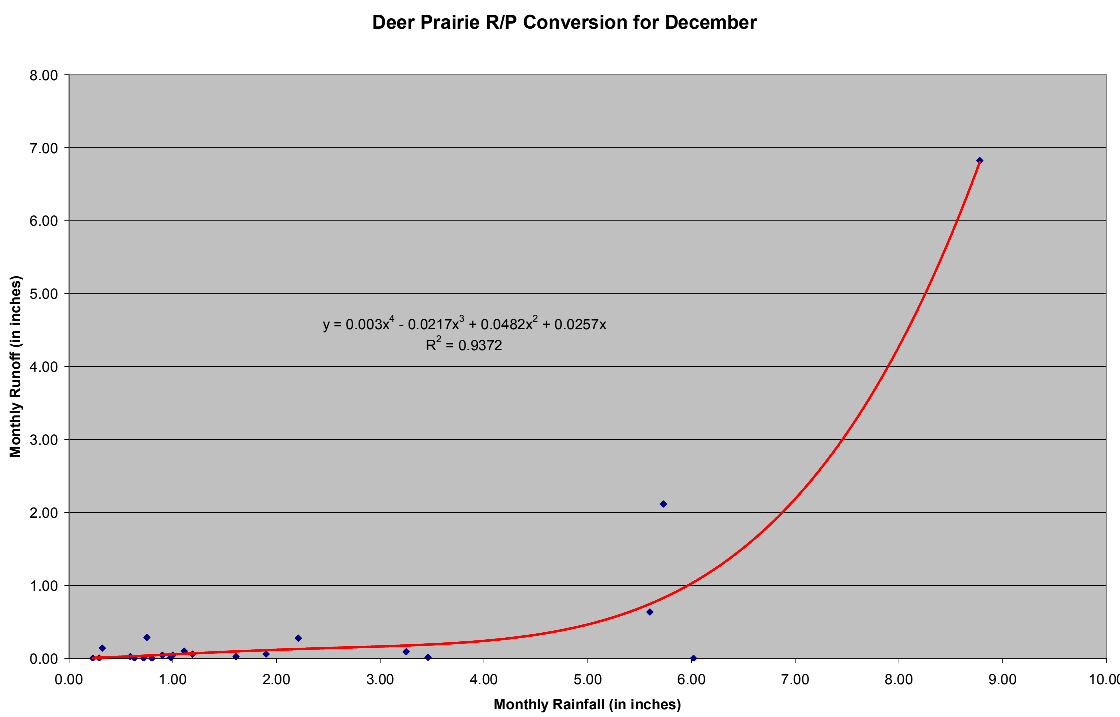


Figure 18 – Deer Prairie Watershed, Rainfall vs. Runoff for December

Month	Equation	R "squared"
January	y = 0.0391x2 + 0.0551x	R2 = 0.1424
February	y = 0.219x	R2 = 0.4319
March	y = 0.2451x	R2 = 0.3306
April	y = 0.0042e0.5392x	R2 = 0.0878
May	y = 0.0018x3 - 0.0128x2 + 0.0318x	R2 = 0.9712
June	y = 0.1352x	R2 = 0.3243
July	y = 0.182x	R2 = 0.1069
August	y = 0.3223x	R2 = 0.1967
September	y = 0.0228x2 + 0.2433x	R2 = 0.3569
October	y = 0.0154x3 - 0.1124x2 + 0.5482x	R2 = 0.614
November	y = 0.0197x3 - 0.1688x2 + 0.4565x	R2 = 0.6664
December	y = 0.003x4 - 0.0227x3 + 0.0482x2 + 0.0257x	R2 = 0.9372

Table 8 – Deer Prairie Watershed, Monthly Rainfall vs. Runoff Equations

6.0 SEASONAL BLOCK ANALYSIS

As indicated, due to the periodic occurrence of rainfall and/or runoff "bleeding" over from one month to the next, it was not possible to develop conclusive predictive relationships between rainfall and runoff on a month to month basis. Therefore, it may be concluded that "seasonal" rainfall and runoff cycles do not necessarily coincide with the narrow level of discretion coinciding to $\pm$30 day periods defined the calendar months. On the other hand, developing water budgets based upon an annual basis spans too broad a period of time to be meaningful.

Pursuant to Additional Services No. 3, the recent seasonal "block" period used by the Southwest Florida Water Management District for the *Proposed Minimum Flows and Levels for the Upper Segment of the Myakka River, from Myakka City to SR 72* was considered to define the rainfall and runoff relationship for the Deer Prairie data base. The 3 seasonal blocks considered are defined as follows:

BLOCK 1 – April 20th through June 24th
BLOCK 2 – October 28th through April 19th
BLOCK 3 – June 25th through October 27th

The results of the seasonal "block" analyses for the Deer Prairie study period are provided in **Table 9** through **Table 11**. **Figure 19** through **Figure 21** present plots of rainfall and runoff for each of the seasonal blocks. **Table 12** presents the best fit runoff/rainfall equations for each seasonal block. These equations consistently resulted in an "R" squared greater than 0.80.

Block 1	Rainfall	Runoff
1981	15.31	0.03
1982	20.80	2.77
1983	6.79	0.35
1984	7.14	0.19
1985	6.20	0.00
1986	8.59	0.09
1987	11.79	0.46
1988	7.23	0.25
1989	7.86	0.00
1990	9.36	0.12
1991	16.22	2.90
1992	7.42	0.01
1994	10.76	0.04
1995	20.55	0.27
1996	11.54	0.13
1997	13.03	0.36
1998	4.73	0.05
1999	11.85	0.05
2000	7.54	0.00
2001	10.73	0.00
2002	8.95	0.00
2005	23.99	7.33
Average	**11.29**	**0.70**

Table 9

Block 2	Rainfall	Runoff
1981	19.59	0.18
1982	24.40	8.64
1983	24.69	6.21
1984	10.17	0.02
1985	12.50	0.23
1986	26.89	9.21
1987	16.64	1.73
1988	9.22	0.27
1989	12.58	0.40
1990	13.63	0.19
1991	10.74	0.09
1993	9.69	0.54
1994	12.12	1.72
1995	14.54	2.74
1996	9.91	0.16
1997	41.28	25.80
1998	11.59	2.03
1999	10.72	0.43
2000	9.60	0.13
2001	11.70	0.25
2004	16.40	1.27
Average	**15.65**	**2.96**

Table 10

Block 3	Rainfall	Runoff
1981	37.11	8.21
1982	41.70	15.62
1983	38.26	12.05
1984	28.46	0.89
1985	27.82	2.20
1986	20.46	4.15
1987	33.39	3.84
1988	37.90	7.90
1989	27.35	1.94
1990	28.28	0.29
1991	25.51	7.95
1994	37.36	17.65
1995	49.55	34.78
1996	21.53	1.92
1997	34.01	8.69
1998	33.29	4.99
1999	30.58	11.91
2000	30.83	13.50
2001	43.23	18.96
2002	28.73	5.69
2005	29.19	7.18
Average	**32.60**	**9.06**

Table 11

As indicated in **Table 9** and **Figure 19**, rainfall between April 20 and June 24 generally varied between 5 and 15 inches, but in 2005 received a high of almost 24 inches. Runoff in seasonal block 1 typically was less than 0.5 inches, with a high of 7.33 inches in 2005.

Relative to seasonal block 2, **Table 10** and **Figure 20** indicate that rainfall between October 28 and April 19 generally varied between 9 and 25 inches, but with a high in the 1997 el-nino year of over 41 inches. Runoff in seasonal block 2 typically was less than 3.5 inches, with a high of 25.80 inches in 1997.

Finally, **Table 11** and **Figure 21** indicate that rainfall between June 25 and October 27 generally varied between 20 and 40 inches, with a high of almost 50 inches occurring in 1995. Runoff in seasonal block 3 typically was less than 20 inches, with a high of 34.78 inches in 1995.

In conclusion, the seasonal block analysis resulted in a marked improvement over the monthly analysis in the ability to predict runoff, given rainfall.

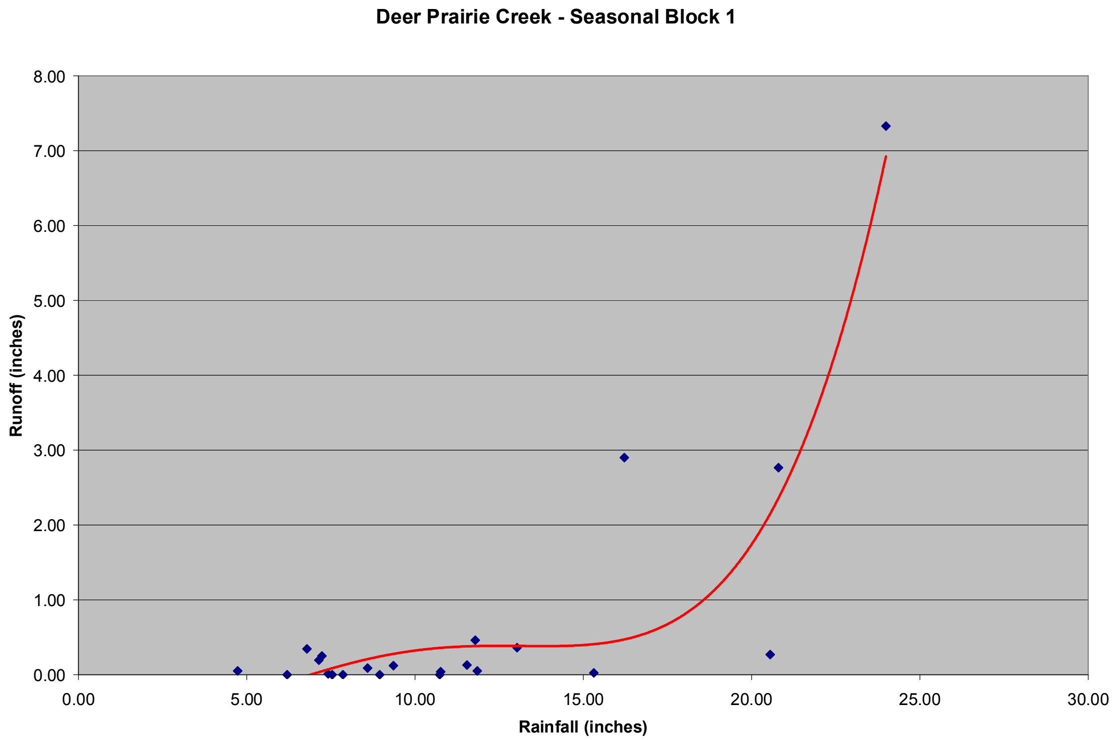


Figure 19 – Deer Prairie Watershed, Seasonal Block 1 Runoff vs. Rainfall

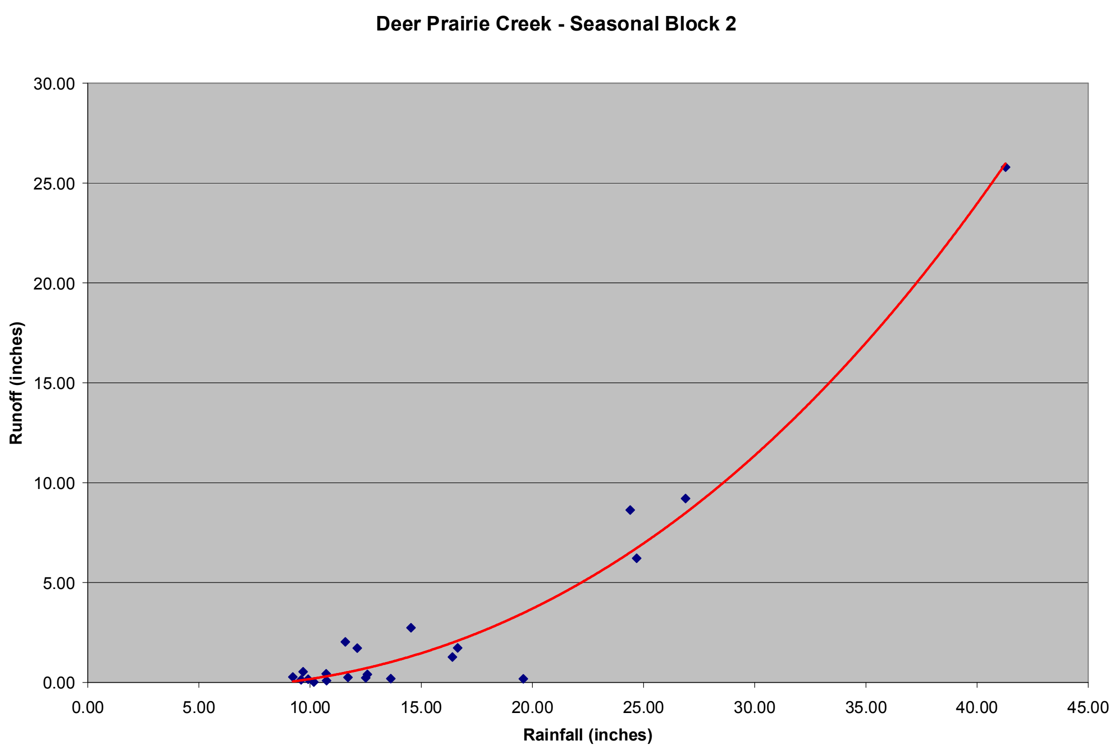


Figure 20 – Deer Prairie Watershed, Seasonal Block 2 Runoff vs. Rainfall

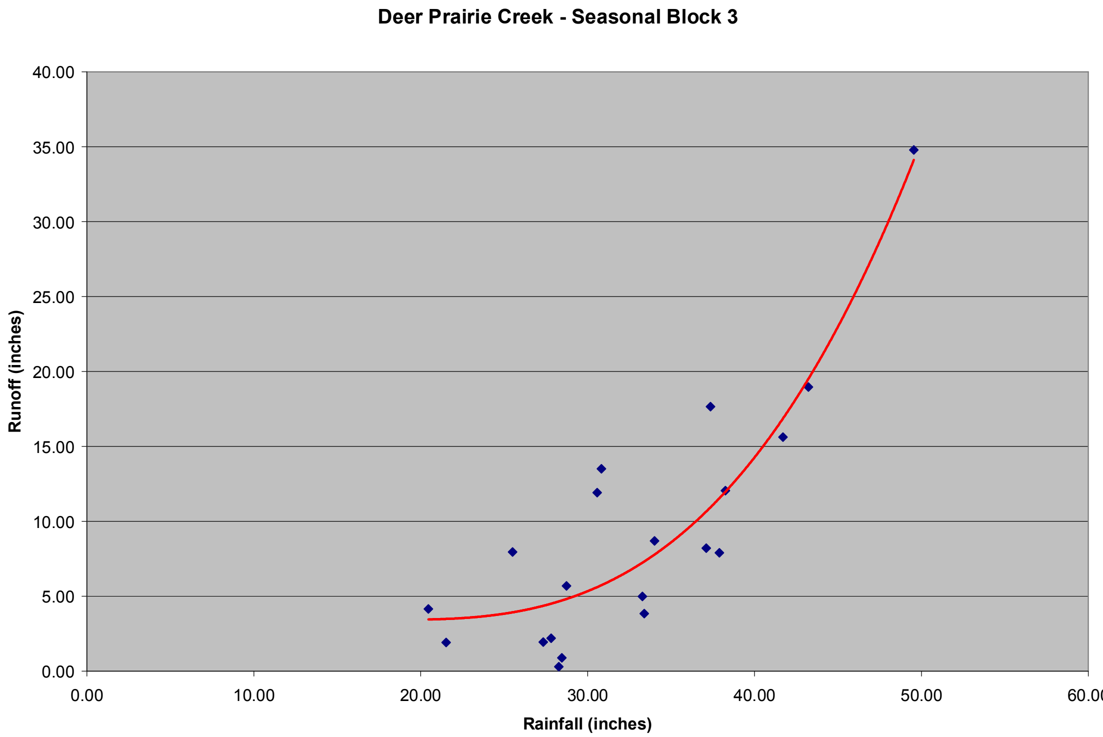


Figure 21 – Deer Prairie Watershed, Seasonal Block 3 Runoff vs. Rainfall

Seasonal Block	Equation	R "squared"
1	y = 0.000210132x4 - 0.0081255x3 + 0.10215x2 - 0.387x	R2 = 0.82
2	y = 0.0001323x3 + 0.01278x2 - 0.124x	R2 = 0.97
3	y = 0.0008651x3 - 0.04269x2 + 0.68x	R2 = 0.81

Table 12 - Deer Prairie Watershed, Seasonal Block Rainfall vs. Runoff Equations

7.0 ESTIMATION OF NATURAL WATER BUDGETS FOR THE HISTORICAL DONA BAY AND ROBERTS BAY WATERSHEDS

A comparison of the historic watershed areas for the Deer Prairie Creek watershed (upstream of USGS Gage location 02299160) and those for Dona Bay and Roberts Bay are presented in **Table 13**. Located within the same latitude range, the hydrologic setting of the historical Deer Prairie, Dona Bay, and Roberts Bay watersheds are also relatively similar in terms of soil types and dispersion, percent wetlands, topography and rainfall patterns. However, it is recognized that present day conditions for both the historical Dona Bay and Roberts Bay watersheds have been modified with coastal development and artificial drainage.

Watershed	**Area (acres)**
Deer Prairie	20,017.4
Dona Bay	10,064.6
Roberts Bay	9,700.3

Table 13 – Comparison of Historic Watersheds

The seasonal block equations developed relating rainfall to runoff in the relatively natural Deer Prairie Creek watershed were used to predict runoff to Dona and Roberts Bays from their respective historical watershed areas. Historical, daily rainfall from NOAA site 336 and dating back to 1944 was used with the seasonal block equations to predict the resulting seasonal runoff totals in inches/acre. This unit volume was then multiplied by the corresponding historical watershed areas to estimate the theoretical natural watershed runoff volumes, in acre-feet for the Dona Bay and Roberts Bay watersheds.

The results of the analyses for Dona Bay and Roberts Bay based upon a seasonal basis are presented graphically on **Figure 22** and **Figure 23**, respectively. **Figure 24** and **Figure 25** present the same results based upon a cumulative basis. These analyses are believed to be a reasonable representation of the amount of freshwater runoff based upon the historical areas and natural hydrologic setting for the Dona Bay and Roberts Bay watersheds, respectively.

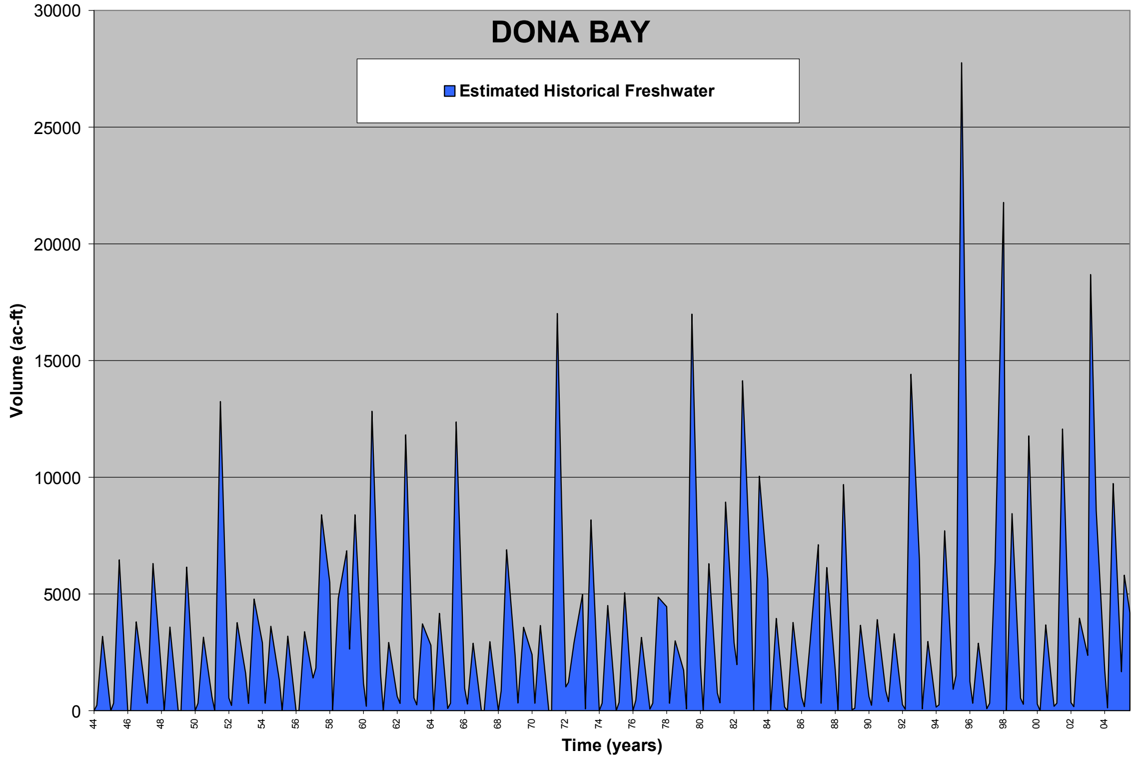


Figure 22 – Historical runoff to Dona Bay based upon seasonal block equations

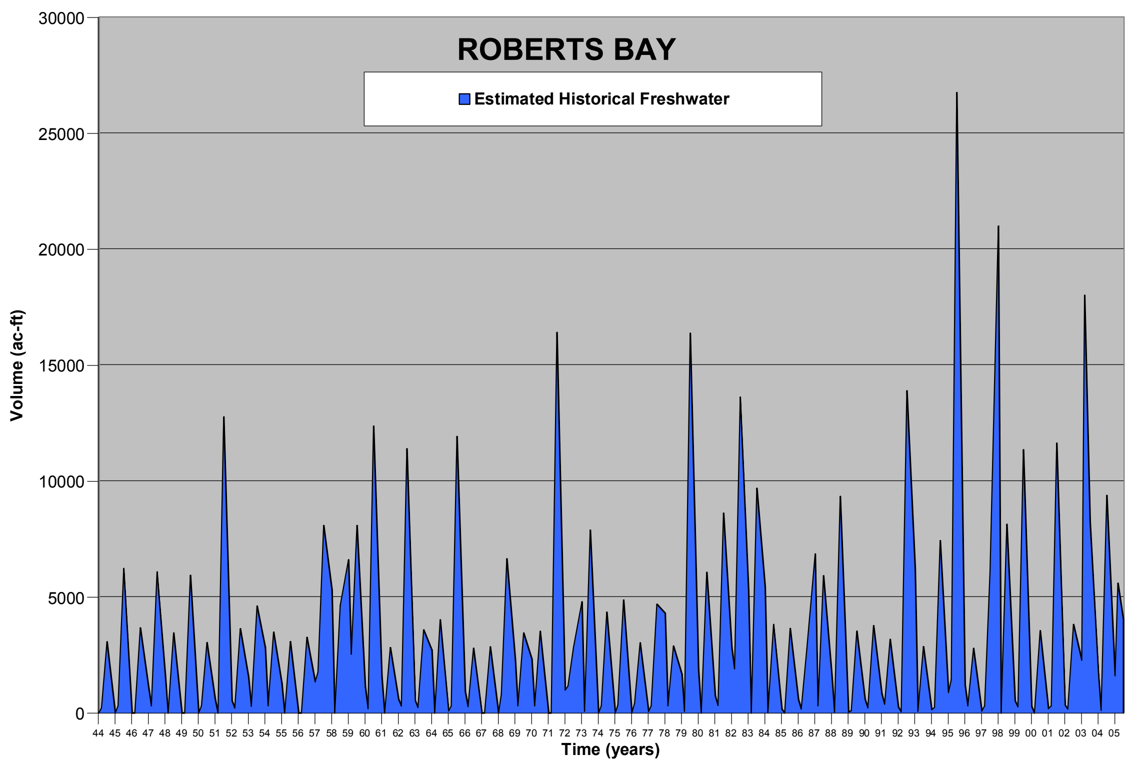


Figure 23 – Historical runoff to Roberts Bay based upon seasonal block equations

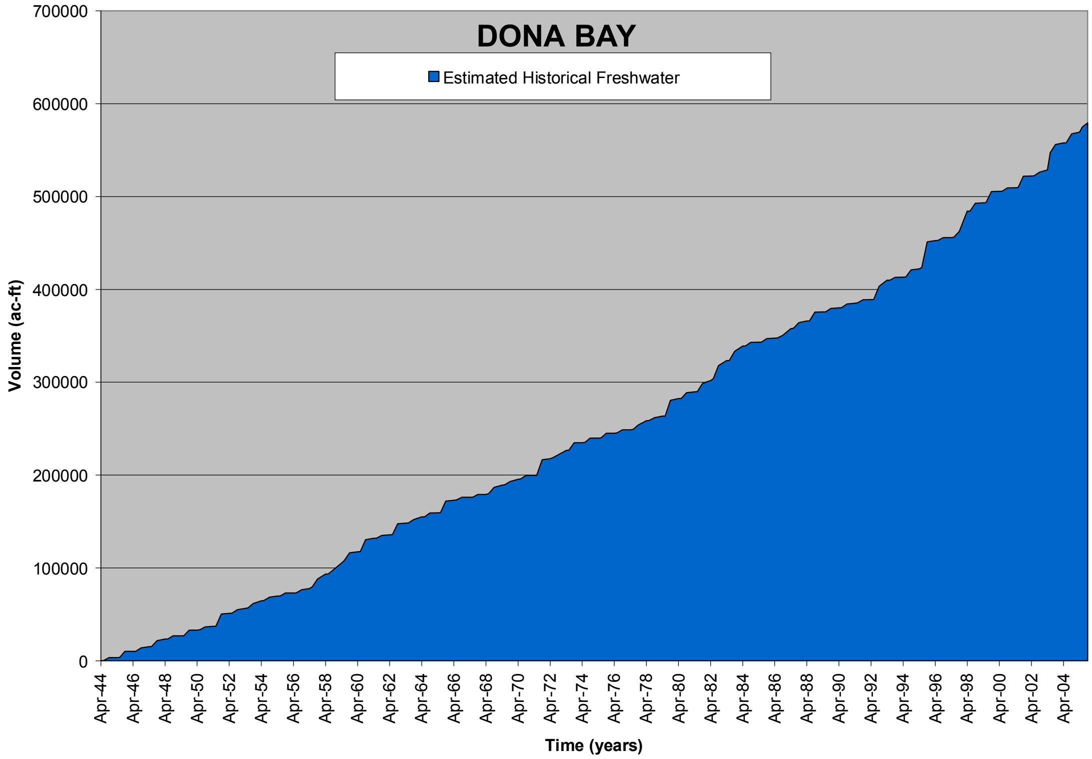


Figure 24 – Cumulative runoff to Dona Bay based upon seasonal block equations

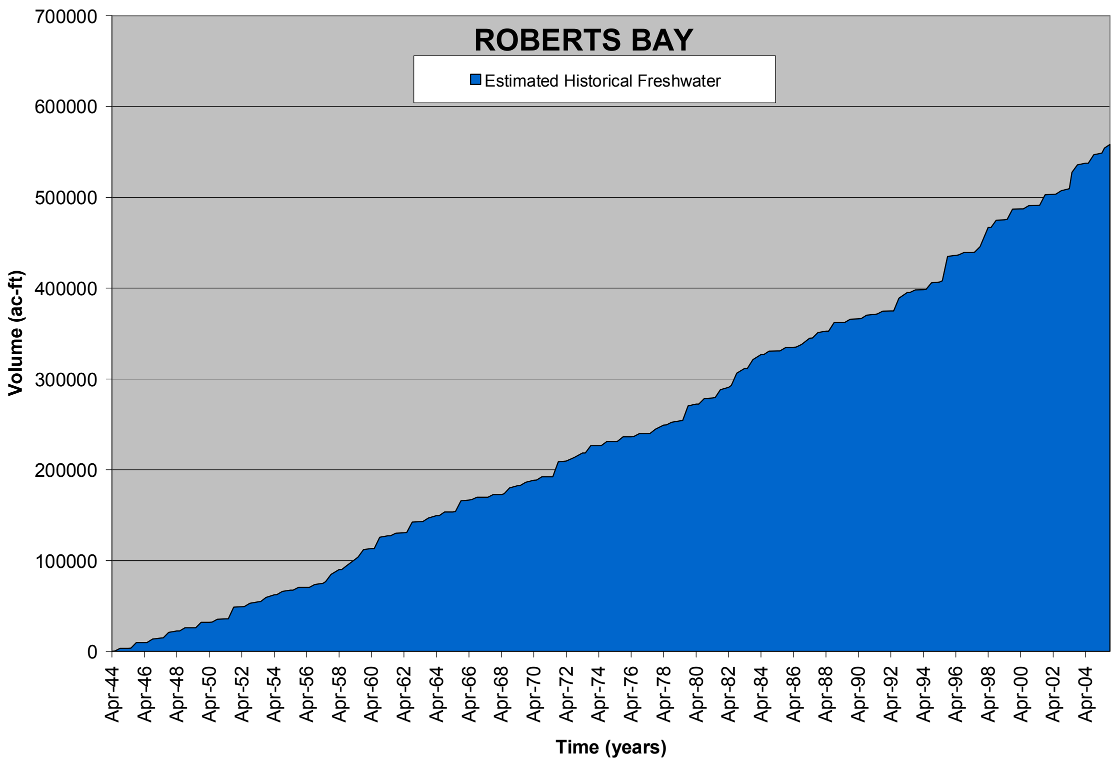


Figure 25 – Cumulative runoff to Roberts Bay based upon seasonal block equations

8.0 PRE & POST RESTORATION ANALYSIS OF DEER PRAIRIE WATERSHED

SCG requested that a comparison be made between runoff volumes prior to, and following the filling of the drainage ditch that drained portions of the sloughs in the Deer Prairie watershed. **Figure 26** compares average monthly runoff volumes for the period of record prior to the restoration of Deer Prairie Slough (April 1981 through June 2001) and since the restoration (July 2001 to present). Although this comparison indicates that there may be a trend that the watershed may be more dynamic since the restoration was completed (lower volumes in the dry season and higher volumes in the wet season), it should be noted that the post-restoration data base is based upon only 2 to 3 data points. This data set is not large enough to make a meaningful comparison. However, continued monitoring over several years is recommended to confirm if such a trend indeed exists.

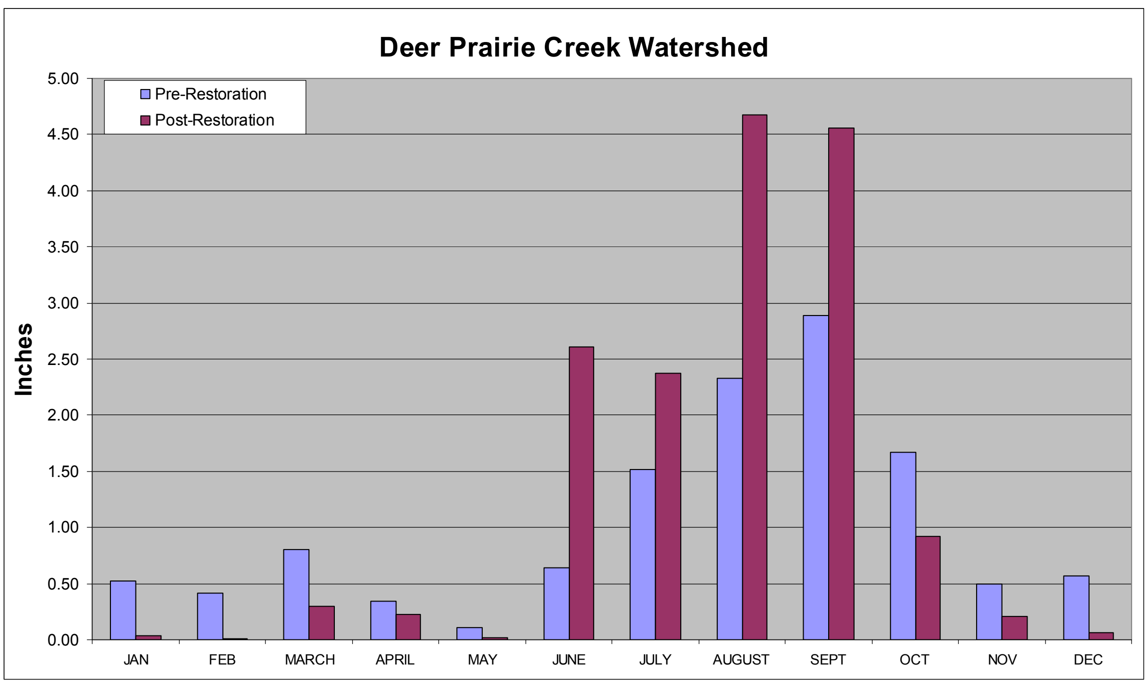


Figure 26 – Deer Prairie Watershed Comparison of Pre and Post-Restoration Runoff

TM 4.1.3.1 – DATA ANALYSIS (PBSJ)

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBS&J to present a summary of efforts to develop an analysis of flow data based on an Indicators of Hyrdrologic Alteration (IHA) approach. The IHA is used to develop statistical descriptions of stream flow variables, and to compare seasonal and annual variability in stream flow parameters with other, perhaps more natural systems. This Technical Memorandum summarizes efforts to produce an IHA for Deer Prairie Creek, the Cow Pen Canal, and the Blackburn Canal, consistent with Task 4.1.3 of the DBWMP contract.

2.0 INTRODUCTION

This effort is part of the overall Natural Systems efforts defined in Task 4.1 of the DBWMP. Specifically, it included related natural systems evaluations and an assessment of potential restoration/enhancement opportunities for Dona Bay and its watershed. Since the intent of the project is to consider alternatives for watershed restoration/enhancement of the Dona Bay watershed and its hydrologic regimes, PBS&J was tasked with calculating various IHA parameters for Deer Prairie Creek, the Cow Pen Canal, and the Blackburn Canal. Deer Prairie Slough is considered a “reference” stream of sorts, as it has a much less developed watershed, and does not display the dramatic watershed alterations (e.g., enlarged watershed, deeply channelized stream channel), as do both the Dona and Roberts Bay watersheds.

As part of this task, hydrologic indicators of associated with the Dona Bay watershed were compared with those from the relatively not-impacted Deer Prairie Creek watershed. In addition, a range of variability analysis was also used to provide the basis for additional comparisons between pre- and post-project development conditions.

3.0 INDICATORS OF HYDROLOGIC ALTERATION

The Indicators of Hydrologic Alteration (IHA) program, developed by Richter et al. in 1996, was used to calculate the values of the 12 indicators listed in Table 1. The IHA program has a built-in utility that conducts the calculations using discharge gage data in USGS format. The analysis was conducted separately for the dry and wet seasons to assess seasonal differences. The data for the Cow Pen Canal was that developed as part of this project using the watershed area draining to the USGS station 02299721 and the flows calculated using the Myakka River transferred equations described in Technical Memorandum 4.2.2 – Water Quantity | Water Budget Approach.

Data for Deer Prairie was available from USGS station 02299160 for the period 1981 through 1992. That information was supplemented with data from USGS station 02299120 for the period 1993 through 2003. Data from the two stations were combined due to the stations' close proximity. The extended data provided a better representation of flow conditions over time. Calculated values of several IHA parameters are shown in Table 1.

As the flow data is dependent on the size of the watershed, IHA flow parameters were normalized to represent unit-area basis (flows in cfs were converted to inches per year) to allow for more direct comparisons. Results are shown in Table 2.

IHA results indicate that the 1-day, 3-day, and 7-day minimum flows during both the wet and dry season in Deer Prairie are zero, whereas minimum flows for Cow Pen Canal are all above zero. Therefore, baseflows are much smaller in natural Deer Prairie Creek watershed than in the man-made Cow Pen Canal. In addition, as other parameters do not show significant differences between the two watersheds, it can be concluded that hydrologic impacts have both reduced storage capacity in the watershed and drained the water table, thus creating, or increasing base flows.

It should be noted that, per the IHA methodology, a value of zero for minimum flows simply indicate that the median of the annual 1-day, 3-day, and 7-day minimums is zero. That is also the case for the number-of-zero-days statistic. During the period of record, approximately three percent of the time (in days) no flow was recorded in the Cow Pen Canal.

	USGS Stations 02299160 and 02299120 Deer Prairie (1981 to 2003)		USGS Station 02299721 Cow Pen Canal (1936 to 2006)	
IHA Parameters	**Season 1 (10/1 - 5/31)**	**Season 2 (6/1 - 9/30)**	**Season 1 (10/1 - 5/31)**	**Season 2 (6/1 - 9/30)**
1-day minimum (cfs)	0	0	0.43	0.47
3-day minimum (cfs)	0	0	0.38	0.48
7-day minimum (cfs)	0	0.0007143	0.3843	0.5043
30-day minimum (cfs)	0.01433	0.9867	0.492	2.476
90-day minimum (cfs)	0.2909	27.78	1.033	15.66
1-day maximum (cfs)	60	228	187.5	327.6
3-day maximum (cfs)	57.83	222.2	181.5	321.6
7-day maximum (cfs)	51.5	187.3	143	302.3
30-day maximum (cfs)	26.61	105.7	70.47	164.7
90-day maximum (cfs)	13.82	62.5	58.91	85.43
Number of zero days	27	11.5	0	0
Base flow (cfs)	0	0.000003944	0.01694	0.009184
Date of minimum	105.5	153	139	157
Date of maximum	276.5	240.5	278	238

Table 1 - Summary of the Indicators of Hydrologic Alteration Analysis

	USGS Stations 02299160 and 02299120 Deer Prairie (1981 to 2003) [a]		USGS Station 02299721 Cow Pen Canal (1936 to 2006) [b]	
IHA Parameters	**Season 1 (10/1 - 5/31)**	**Season 2 (6/1 - 9/30)**	**Season 1 (10/1 - 5/31)**	**Season 2 (6/1 - 9/30)**
1-day minimum (in/yr)	0	0	0.10	0.11
3-day minimum (in/yr)	0.00	0.00	0.09	0.12
7-day minimum (in/yr)	0.00	0.00	0.09	0.12
30-day minimum (in/yr)	0.01	0.45	0.12	0.60
90-day minimum (in/yr)	0.13	12.55	0.25	3.80
1-day maximum (in/yr)	27.11	103.03	45.45	79.41
3-day maximum (in/yr)	26.13	100.41	44.00	77.96
7-day maximum (in/yr)	23.27	84.64	34.66	73.28
30-day maximum (in/yr)	12.02	47.76	17.08	39.92
90-day maximum (in/yr)	6.24	28.24	14.28	20.71
Number of zero days	12.20	5.20	0	0
Base flow (in/yr)	0.00	0.000003944	0.01694	0.009184
Date of minimum	105.5	153	139	157
Date of maximum	276.5	240.5	278	238

[a] Contributing area of 30.04 mi^2,
[b] Contributing area of 56 mi^2

Table 2 - Summary of the Indicators of Hydrologic Alteration Analysis Results Normalized by Watershed Size

4.0 RANGE OF VARIABILITY ANALYSIS

A range of variability analysis of the data was conducted by developing curves that represent the data percentile distribution of flows at both Deer Prairie (USGS Station 02299160) and Cow Pen Canal (at the upstream water level control structure). Figure 1 shows the normalized percentile distribution of flows using the data described previously. Consistent with the IHA analysis, the main flow differences between the two watersheds occur during low flow conditions, namely those below the median value. Comparisons of normalized flow values at selected percentiles are shown in Table 3. Results indicate that he ratio of Cow Pen Canal flows to Deer Prairie flows range from 3.0 to 14.8 for values below median. The ratios at the median and above are much closer to 1. It can be concluded that the hydrologic impacts are associated primarily with low flows, which in turn are associated with the dry season. Excess flows into Dona Bay in the dry season are also due to increases in the size of the watershed.

Percentile	Cow Pen Canal Flow 1956 – 2006 (in/year)	Deer Prairie Flow 1981- 2003 (in/year)	Flow Ratio (CPS / DP)
4	0.09	0.01	9.5
18	0.27	0.02	14.8
25	0.27	0.10	2.7
35	1.37	0.45	3.0
50	1.48	1.27	1.2
75	7.65	9.94	0.8
90	23.64	42.02	0.6

Table 3 – Comparison of Normalized Flows

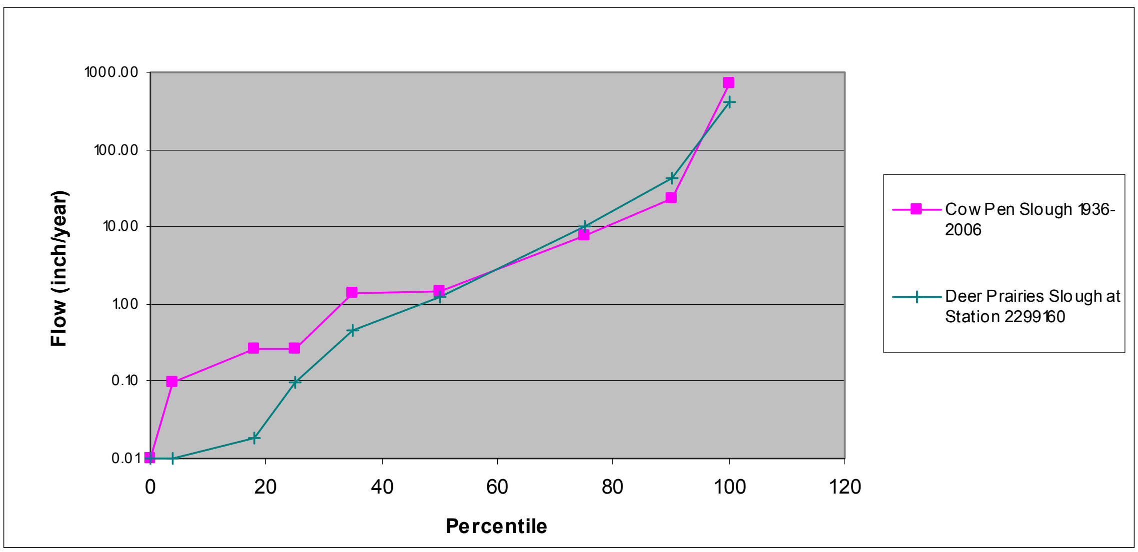


Figure 1 - Comparison of Flow Variability for Cow Pen Canal and Deer Prairie

TM 4.1.3.2 – DATA ANALYSIS (BRA)

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD), are currently completing the necessary, pre-requisite data collection and analysis as well as the Comprehensive Watershed Management Plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), EarthBalance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan, and the Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by BRA to summarize the hydrologic modifications of the Dona Bay watershed, the extensive field assessments, the results of the GIS exercises, and the results of the UMAM analyses, consistent with Task 4.1.3 of the DBWMP contract.

2.0 CURRENT STUDIES

2.1 Introduction

Alterations to the historical Dona Bay watershed have resulted in significant impacts such as the diversion of historical watershed areas, conversion of native habitats for agricultural, residential and commercial development, ditching of wetlands, and excavation, and filling of historical wetland and slough systems have dramatically altered hydrologic flow regimes. These activities have affected the functions and values of historical wetlands such as water filtration, attenuation of flood waters, and wildlife habitat. These activities have also significantly increase freshwater runoff to Dona Bay, which has adversely affected the historical estuarine values and functions.

Historically, the Dona Bay watershed included approximately 10,000 acres, consisting primarily of native upland habitats such as pine flatwoods, cabbage palm hammocks and wetlands. Most significantly, the original Cow Pen Slough was, primarily, a wetland conveyance system to the Myakka River and consisted of large, slow flowing marshes, ultimately discharging downstream to the Myakka River.

Conversion of historical landscapes, primarily for conversion to agricultural uses such as improved pastures, citrus and row crops as well as the excavation of the historical Cow Pen Slough by a series of deeply incised canals with spoil piles, has efficiently drained and significantly altered the character, function and values of historical wetlands. Additionally, the diversion of a significant portion of the Myakka River watershed into the Dona Bay watershed has dramatically increased fresh water flows to Dona Bay.

2.1.1 Watershed Background

The current Southwest Florida Water Management District (SWFWMD) land use database was used to calculate the difference in the land use types between the 2005 Dona Bay watershed and the 1948 limits of the watershed, as summarized in Table 1. The current watershed is approximately five times the size of the historical watershed due to the construction of Cow Pen Canal.

FLUCFCS Code	Description	2005 Acreage	1948 Acreage
1100	Residential Low Density	3294.1	549.5
1200	Residential Medium Density	1240.0	959.7
1300	Residential High Density	347.4	307.6
1400	Commercial and Services	160.7	109.5
1500	Industrial	84.5	84.5
1600	Extractive	729.6	478.1
1700	Institutional	112.6	51.4
1800	Recreational	777.9	336
1900	Open Land	2146.1	235.3
2100	Cropland and Pastureland	11266.1	1895.5
2140	Row Crops	905.7	19.2
2200	Tree Crops	1573.5	156.8
2300	Feeding operations	2.3	0
2400	Nurseries and Vineyards	110.5	9.8
2500	Specialty Farms	52.3	23.2
2600	Other Open Lands	236.7	0
3100	Herbaceous	83.9	0
3200	Shrub and Brushland	3649.1	502.1
3300	Mixed Rangeland	158.3	0
4100	Upland Conifer Forest	213.9	0
4110	Pine Flatwoods	6829.6	1449.7
4200	Upland Harwood Forests Pt 1	6.6	0
4340	Hardwood Conifer Mixed	1358.1	249.9
4400	Tree Plantations	379.4	0
5100	Streams and Waterways	153.2	57.9
5200	Lakes	349.0	58.3
5300	Lakes and Reservoirs	887.4	379.1
5400	Bays and Estuaries	153.3	153.3
6100	Wetland Hardwood Forests	12.5	0
6110	Bay Swamps	2.3	0
6120	Mangrove Swamps	19.9	19.9
6150	Stream and lake Swamps (bottomland)	2763.1	68.4
6200	Wetland Conifer Forests	45.9	34.9
6210	Cypress Swamp	81.4	3.3
6300	Wetland Forested Mixed	338.1	128.1
6410	Freshwater Marshes	4794.6	647.6
6420	Saltwater Marshes	32.4	32.4
6430	Wet Prairies	1149.0	240.6
6440	Emergent Aquatic Vegetation	85.0	32.6
7400	Disturbed Land	6.3	4.5
8100	Transportation	220.9	220.9
8200	Communications	2.7	2.7
8300	Utilities	768.9	32.5
	Total	**47,584.8**	**9,534.8**

Table 1 - Land Use Changes within the Dona Bay Watershed

2.1.2 Sarasota County-Owned Parcels

Historical aerial photography (1948) and the *Soil Survey of Sarasota County* (1957) were used to evaluate the historical land uses of four (4) Sarasota County owned parcels (Albritton, West Pinelands, the Myakka Connector, and Venice Minerals) within the Dona Bay watershed (Exhibit 1). The limits and types of historical land uses were determined by vegetative signatures and soil characteristics, which were interpreted and were digitized. The historical land uses were quantified and compared to the existing land uses. Table 1 summarizes the combined change (all four properties) in land use over the last 60 years.

The current and historical environmental features of the four (4) parcels were evaluated as identified in Figure 1. The evaluation included current wetland delineations and habitat assessments, approximation of historical wetland limits, upland habitat assessments, preliminary wildlife surveys, existing hydroperiod determinations, estimates of historical wetland wet season water levels, Uniform Mitigation Assessment Methodology (UMAM) assessments, and U.S. Army Corps of Engineers (COE) datasheets. Historical aerials and soil surveys were used to compare past land use to the existing onsite conditions. Finally, mitigation alternatives for each parcel were ranked based on an environmental cost-benefit analysis. Technical Memorandum 4.1.1.2– DATA COLLECTION AND REVIEW (BRA) summarizes this effort.

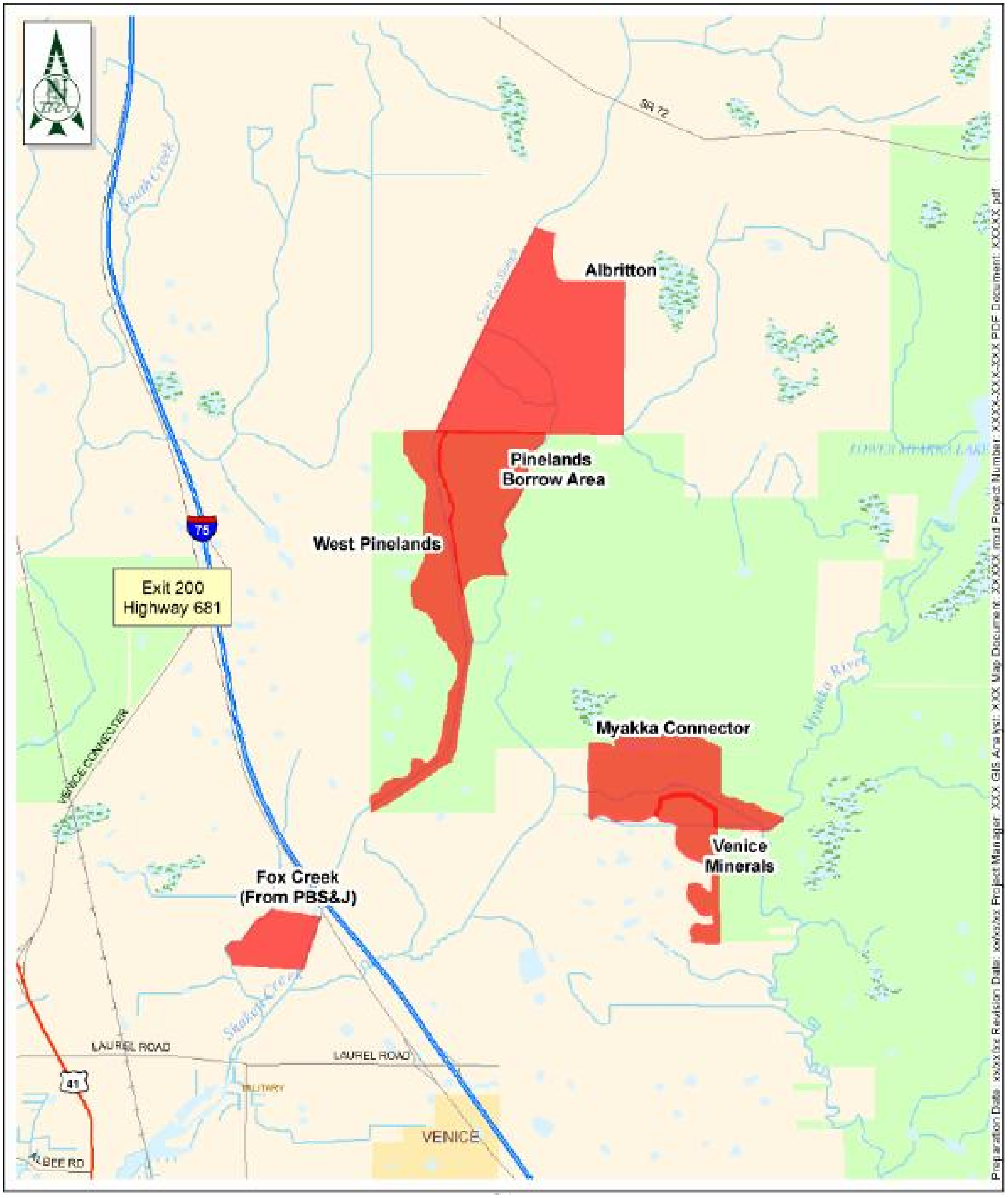


Figure 1 – Locations of Evaluation Areas

FLUCFCS	1948 (Acres)	2005 (Acres)	Change (Acres)
211 Improved Pasture	0.00	66.1	+66.1
212 Unimproved Pasture	0.00	98.1	+98.1
221 Orange Groves	0.00	652.1	+652.1
260 Other Open Lands	0.00	4.9	+4.9
320 Shrub and Brushland	0.00	0.5	+0.5
3201 Wax Myrtle Shrub	0.00	13.8	+13.8
411 Pine Flatwoods	528.1	275.8	-252.3
4111 Pine and Cabbage Palm	8.7	0.00	-8.7
427 Live Oak	0.00	161.7	+161.7
428 Cabbage Palm	89.9	52.9	-37.0
4281 Cabbage Palm and Pine	27.7	0.00	-27.7
434 Hardwood Conifer Mix	17.0	281.3	+264.3
5101 Channelized Waterway	0.00	43.4	+43.4
505 Ditches	0.00	3.7	+3.7
512 Ditches	0.00	27.4	+27.4
534 Agricultural Impoundments	0.00	13.0	+13.0
535 Excavated Areas	0.00	0.1	+0.1
560 Slough Waters	0.00	4.4	+4.4
616 Inland Sloughs	102.6	25.0	-77.6
617 Mixed Wetland Hardwood	0.00	9.2	+9.2
619 Brazilian Pepper	0.00	0.7	+0.7
631 Wetland Shrub	0.00	9.3	+9.3
6311 Buttonbush	0.00	7.7	+7.7
6312 Disturbed Wetland Shrub	0.00	7.3	+7.3
641 Freshwater Marsh	836	166.1	-669.9
6411 Excavated Freshwater Marsh	0.00	0.3	+0.3
643 Wet Prairies	378.1	3.2	-374.9
743 Spoil Areas	0.00	7.9	+7.9
8140 Roads and Highways	0.00	0.2	+0.2
8144 Roads	0.00	11.4	-11.4
8145 Graded & Drained Road	0.00	26.6	+26.6
832 Electrical Transmission Lines	0.00	14.3	+14.3
Total Uplands	**671.4**	**1659.9**	**+988.5**
Total Wetlands/OSW	**1316.7**	**328.7**	**-988.0**

Table 2 – 1948/2005 Land Use Comparison of County Owned Parcels (Albritton, West Pinelands, Myakka Connector, and Venice Minerals)

2.2 Albritton Site

2.2.1 Introduction

The Albritton parcel is located in Sections 27, 33 and 34, Township 37 South, Range 19 East, totals 1000 acres, and is within the SWFWMD Southern Coastal drainage basin and the Sarasota County Dona Bay watershed. The upland and wetland habitats onsite were evaluated during fieldwork conducted over several months in 2005. The parcel is currently being excavated for landfill cover and includes a large orange grove with a hammock system bisecting the property.

2.2.2 Historical Land Use

Historically, the Albritton property consisted primarily of a large freshwater marsh that served as a significant floodplain (Exhibit 2). Due to significant drainage activities, the large freshwater marsh (FLUCFCS 641) transitioned into wet prairies (FLUCFCS 643) and smaller, more distinct freshwater marshes. The uplands were located on the southern and eastern extents of the site and consisted primarily of pine flatwoods (FLUCFCS 411), cabbage palm (FLUCFCS 428), and a combination of the two (FLUCFCS 4281). Currently, the agricultural practices, including an orange grove, improved pasture and an extensive ditch network, have converted 633.2 acres of wetlands to uplands (Table 3). The remaining native habitat consists primarily of live oak (*Quercus laurifolia*), (FLUCFCS 427), a species that prefers drier substrate and probably thrived in the drained conditions, and 82.3 acres of highly disturbed freshwater marshes and wet prairies.

FLUCFCS	1948 (Acres)	2005 (Acres)	Change (Acres)
211 Improved Pasture	0.0	66.4	+66.4
221 Orange Groves	0.0	652.1	+652.1
260 Other Open Lands	0.0	4.9	+4.9
411 Pine Flatwoods	176.7	0.0	-176.7
427 Live Oak	0.0	101.2	+101.2
428 Cabbage Palm	79.0	21.9	-57.1
4281 Cabbage Palm and Pine	27.7	0.0	-27.7
434 Hardwood Conifer Mix	0.0	63.1	+63.1
5101 Channelized Waterway	0.0	13.4	+13.4
512 Ditches	0.0	27.4	+27.4
534 Agricultural Impoundments	0.0	13.0	+13.0
535 Excavated Areas	0.0	0.1	+0.1
619 Brazilian Pepper	0.0	0.7	+0.7
641 Freshwater Marsh	530.3	24.4	-505.9
6411 Excavated Freshwater Marsh	0.0	0.3	+0.3
643 Wet Prairies	185.4	3.2	-182.2
743 Spoil Areas	0.0	7.9	+7.9
8140 Roads and Highways	0.0	0.2	+0.2
Total Uplands	**283.4**	**917.7**	**+634.3**
Total Wetlands/OSW	**715.7**	**82.5**	**-633.2**
Total Acreage	**999.1**	**1000.2**	

Table 3 - 1948 vs. 2005 Land Uses for Albritton Site

2.3 West Pinelands

2.3.1 Introduction

The West Pinelands site is located in Sections 4, 9 and 16, Township 38 South, Range 19 East and totals 393.6 acres within the SWFWMD Southern Coastal drainage basin and the Sarasota County Dona Bay watershed. The upland and wetland habitats onsite were evaluated during fieldwork conducted over several months in 2005. Beginning in the early 1900's and continuing into the 1970's, the historical Cow Pen Slough system was drained and diverted from the Myakka River watershed to Dona Bay. One result was the drainage of the associated riparian wetland system. The West Pinelands site area of study is located both east and west of this canal.

2.3.2 Historical Land Use

The 1948 aerial (Exhibit 3) depicts the area of evaluation as the historical Cow Pen Slough consisting primarily of freshwater marsh (FLUCFCS 641) and wet prairies (FLUCFCS 643). The limited uplands consisted of islands of cabbage palm (FLUCFCS 428) and hardwood-conifer mixed forests (FLUCFCS 434). The floodplain was bordered by pine flatwoods to the west. The draining and diversion of the original Cow Pen Slough has severely altered and marginalized the hydrology of the surrounding wetlands by severely depressing the water table. The wetlands are highly degraded and at least 220 acres of wetlands have been converted to uplands, primarily unimproved pasture, roads, and hardwood-conifer mixed forests (Table 4).

FLUCFCS	1948 (Acres)	2005 (Acres)	Change (Acres)
212 Unimproved Pasture	0.00	98.1	+98.1
411 Pine Flatwoods	50.3	19.3	-31.0
4111 Pine and Cabbage Palm	8.7	0.00	-8.7
428 Cabbage Palm	7.6	14.3	+6.7
434 Hardwood Conifer Mix	17.0	145.1	+128.1
5101 Channelized Waterway	0.00	30.0	+30.0
617 Mixed Wetland Hardwood	0.00	2.1	+2.1
6311 Buttonbush	0.00	7.2	+7.2
641 Freshwater Marsh	215.8	50.6	-165.2
643 Wet Prairies	95.3	0.00	-95.3
8144 Roads	0.00	11.4	+11.4
8145 Graded & Drained Roads	0.00	15.5	+15.5
Total Uplands	**83.6**	**303.7**	**+220.1**
Total Wetlands/OSW	**311.1**	**89.9**	**-221.2**
Total Acreage	**394.7**	**393.6**	

Table 4 - 1948 vs. 2005 Land Uses for the West Pinelands Site

2.4 Myakka Connector

2.4.1 Introduction

The Myakka Connector site is located in Sections 13, 14, 15, 22, 23 and 24, Township 38S, Range 19E and totals 440.5 acres within the SWFWMD and Sarasota County Myakka River watershed. The onsite wetlands, and much of the current extent of uplands, were historically part of a much larger slough system that flowed from the northwest to the Myakka River. The majority of this slough encompassed an area of land larger than the remaining wetland fragments as evidenced by the current and historical *Soil Surveys of Sarasota County* (1991, 1957). Hydric soils located within this larger area include Bradenton fine sand, Delray fine sand, depressional, Felda fine sand, depressional, Felda and Pompano fine sand, frequently flooded, Floridana and Gator soils, depressional, Holopaw fine sand, depressional, Malabar fine sand, Pineda fine Sand, Pompano fine sand, depressional, and Pople fine sand. There were pockets of upland soils, typically within the pine flatwoods, over areas mapped as Eau Gallie and Myakka fine sands.

Relatively undisturbed lands surround the Myakka Connector site to the east, west and north, although Venice Minerals is located adjacent to this parcel to the south. The Myakka River abuts the property to the east, with no barriers separating the Myakka Connector site, thus allowing for easy wildlife access. In addition, the east banks of the Myakka River along this section of the river are protected lands. The property's connection to the historical Cow Pen Slough has been severely reduced due to the creation of the Cow Pen Canal and the berm at the southern end of the Pinelands Reserve.

2.4.2 Historical Land Use

The 1948 aerial (Exhibit 4) indicates that the aerial extent of the Myakka Connector is still situated between the Dona Bay watershed and the Myakka River watershed. In fact, flood analyses indicate that during extreme events, it is likely to move waters between watersheds. The drainage and diversion of the historical Cow Pen Slough effectively increased the size of the Dona Bay watershed, and, therefore, altered the hydrology of the slough through the Myakka Connector site. In 1948, approximately 258 acres of the property within the study area were wetlands and 182 acres were uplands, almost exclusively pine flatwoods. The diversion of the water from the site over the last 50 years has converted approximately 171 acres of wetlands to uplands (Table 5). The increase in extant uplands consists primarily of live oak (*Quercus virginiana)* and hardwood-conifer mixed forests as the decrease in the hydrologic regime has allowed for the succession of species more tolerant of drier conditions.

FLUCFCS	1948 (Acres)	2005 (Acres)	Change (Acres)
320 Shrub and Brushland	0.0	0.5	+0.5
411 Pine Flatwoods	179.1	183.4	+4.3
427 Live Oak	0.0	60.5	+60.5
428 Cabbage Palm	3.3	16.7	+13.4
434 Hardwood Conifer Mix	0.0	73.1	+73.1
560 Slough Waters	0.0	4.4	+4.4
616 Inland Sloughs	102.6	25.0	-77.6
617 Mixed Wetland Hardwood	0.0	7.1	+7.1
631 Wetland Shrub	0.0	2.9	+2.9
6312 Disturbed Wetland Shrub	0.0	6.3	+6.3
641 Freshwater Marsh	66.2	41.1	-25.1
643 Wet Prairie	89.3	0.0	-89.3
8145 Graded & Drained Road	0.0	8.4	+8.4
832 Electrical Transmission Lines	0.0	11.1	+11.1
Total Uplands	**182.4**	**353.7**	**+170.6**
Total Wetlands/OSW	**258.1**	**86.8**	**-171.3**
Total	**440.5**	**440.5**	

Table 5 - 1948 vs. 2005 Land Uses for Myakka Connector Site

2.5 Venice Minerals

2.5.1 Introduction

The Venice Minerals site is located in Sections 14 and 23, Township 38 South, Range 19 East, totals 154.4 acres, and is within the SWFWMD and Sarasota County Myakka River watershed. It is located directly south of the Myakka Connector, west of the FPL Easement and north of Venetian Golf & River Club. The site has historically been used as wetland mitigation for the adjacent sand and shell mining operation to the west. The upland and wetland habitats onsite were evaluated during fieldwork conducted over several months in 2005.

2.5.2 Historical Land Use

The historical condition of the Venice Minerals site, as indicated in the 1948 aerial (Exhibit 5), consisted of pine flatwoods (FLUCFCS 411) and freshwater marshes (FLUCFCS 641), with a small section of wet prairie (FLUCFCS 643) connecting two freshwater marshes. Several separate primitive roads traverse the property. The sole uplands on the property, pine flatwoods, totaled 122.0 acres and the wetlands totaled 31.8 acres. In its current (2005/2006) condition, 31.4 acres of the historical uplands have been converted to wetlands for mitigation purposes (Table 6). In addition 14.7 acres of pine flatwoods have been converted to a wax myrtle shrub mitigation area that surrounds the three northernmost wetlands.

FLUCFCS	1948 (Acres)	2005 (Acres)	Change (Acres)
3201 Wax Myrtle Shrub	0.00	13.8	+13.8
411 Pine Flatwoods	122.0	73.1	-48.9
505 Ditches	0.00	3.7	+3.7
631 Wetland Shrub	0.00	6.4	+6.4
6311 Buttonbush	0.00	0.5	+0.5
6312 Disturbed Wetland Shrub	0.00	1.0	+1.0
641 Freshwater Marsh	23.7	50.0	+26.3
643 Wet Prairies	8.1	0.00	-8.1
8145 Graded & Drained Road	0.00	2.7	+2.7
832 Electrical Transmission Lines	0.00	3.2	+3.2
Total Uplands	**122.0**	**92.8**	**-29.2**
Total Wetlands/OSW	**31.8**	**61.6**	**+29.8**
Total Acreage	**153.8**	**154.4**	

Table 6 - 1948 vs. 2005 Land Uses for Venice Minerals

3.0 DATA EVALUATION

3.1 Albritton Current Land Use

A land use map (Exhibit 6) was created by BRA based on the *Florida Land Use, Cover and Forms Classification System* (FLUCFCS) (Florida Department of Transportation, 1999). Descriptions of each habitat type are provided below. All provided upland acreages are approximate as they are based on aerial interpretation and not surveyed habitat delineations. A preliminary wildlife survey, including pedestrian and vehicular transects, was also conducted and the results follow the habitat assessments. Uplands account for 917.4 acres or 91.8% of the site.

3.1.1 Uplands

Improved Pasture (FLUCFCS 211; 66.4 acres)

Approximately 66.1 acres or 6% consists of improved pasture located in the southwest portion of the project area. These areas occur between the existing orange groves and the remaining natural habitat at the southern project boundary. The dominant vegetation is bahia grass (*Paspalum notatum*) with some scattered dogfennel (*Eupatorium capillifolium*) and cabbage palm (*Sabal palmetto*). Currently the grass is thick from lack of grazing or mowing. Several small swales occur within this area, though no change of vegetation exists between the swales and the surrounding pasture.

Alterations to these areas were initiated in the 1950's when the first of numerous ditches were excavated in order to drain the large slough system that was once located in this area (Exhibit 2). The excavated channel located just west of the subject parcel is called Cow Pen Canal, which was historically excavated from an extensive marsh/slough system. These pastures were created as the slough was drained and agricultural management and maintenance began. Currently the improved pastures are mostly devoid of native vegetation, except for scattered cabbage palms and other opportunistic ruderal species.

The areas primarily identified as improved pasture were mapped over historical Pompano fine sand and some Charlotte fine sand, based on the 1957 *Soil Survey of Sarasota County, Florida*. Both of these soils are associated with wet prairie systems and associated water-tolerant woody species such as slash pine *(Pinus elliottii)*, cabbage palm, and water oak *(Quercus nigra)*.

Orange Groves (FLUCFCS 221; 652.1 acres)
Approximately 688.4 acres, or 68.8%, are currently managed as citrus groves, with the majority of the crop being orange trees, with some grapefruit and tangerines as well. The Cow Pen Slough floodplain historically encompassed much of the area that is now actively managed as citrus groves. The first of numerous ditches were initially excavated in the 1950's in order to drain Cow Pen Slough. Currently, a well-established network of dirt roads and ditches surround and bisect the groves.

The large majority of the citrus groves, particularly to the west, are mapped historically as Pamlico peaty muck, Delray Fine Sand, Delray mucky fine sand, and Pompano fine sand (1957 *Soil Survey of Sarasota County, Florida*). Current soils, based on the 1991 *Soil Survey of Sarasota County, Florida*, are mapped as Delray fine sand, depressional, Floridana and Gator soils, depressional, Gator muck, and Holopaw fine sand, depressional. The current soils in the eastern groves consist of US Hydric Soil Types, with the dominant soil being Adamsville fine sand based on the 1957 *Soil Survey of Sarasota County, Florida*, which are typically pine flatwoods. The 1991 *Soil Survey* identifies the eastern groves as Eau Gallie and Myakka fine sands and Pineda fine sand with several remnant marshes.

Other Open Lands <Rural> (FLUCFCS 260; 4.9 acres)
A few scattered patches of mixed shrubby areas cover about 4.9 acres, or 0.5%. These areas are typically found immediately adjacent to ditches, in areas that have been drained. Mainly shrubs or herbaceous species are present, with individual trees located periodically. Typical species present include dogfennel, caesarweed (*Urena lobata*), some Brazilian pepper (*Schinus terebinthifolius*), and broomgrass (*Andropogon* sp.).

These areas identified as Other Open Lands were wetland areas, as observed on the 1948 aerial imagery (Exhibit 2), prior to the active agricultural maintenance which affected the hydrology of these areas. The mapped soils based on the 1991 *Soil Survey of Sarasota County, Florida* for these areas are Delray fine sand, depressional and Holopaw fine sand, depressional, both hydric soils. Field evaluations confirmed some indicators that show a recent history as a wetland, but sufficient evidence was not present to delineate these areas as wetlands under current delineation methodologies. Restoration of these areas would be possible with adequate hydration to restore the hydric soils and to ultimately produce an area capable of sustaining hydrophytic vegetation long-term.

Live Oak (Potential Mesic Hammock) (FLUCFCS 427; 101.2 acres)

These areas surround the herbaceous wetlands and total ±101.2 acres, or 10.2%. These areas have been identified as potentially meeting Sarasota County requirements for "mesic hammock" designation, a county regulated upland habitat. These areas have not been field verified by Sarasota County Resource Protection Services. Typical species include live oak (*Quercus virginiana*), laurel oak cabbage palm, caesarweed, beautyberry (*Callicarpa americana*), wild coffee (*Psychotria nervosa* and *P. sulzneri*), and several vines, including muscadine grape (*Vitis* sp.) and greenbriar (*Smilax* spp.).

The live oak hammocks occur predominantly over areas mapped as Bradenton fine sand based on the *Soil Survey of Sarasota County, Florida* (1991), though some areas are over mapped Holopaw fine sand, depressional or Pineda fine sand. In the 1948 aerial imagery, much of this area appears to consist of mesic/upland hammock, with some distinct areas contained within the slough system as marsh. These hammock areas represent much of the native habitat as was present in 1948, and provide excellent opportunities for the preservation of wildlife habitat between and around the wetlands.

Cabbage Palm (FLUCFCS 428; 21.9 acres)

Cabbage palm is the dominant canopy species in these areas, with typical understory species including small cabbage palm, scattered beautyberry, wild coffee, and caesarweed. The cabbage palm areas are found in the same landscape positions as the live oak areas, with the main difference being the dominant canopy species. Cabbage palm hammocks are found primarily over Bradenton fine sand, and were historically found within these same areas, as evidenced by the 1948 aerial imagery.

Hardwood-Conifer Mixed (FLUCFCS 434; 63.1 acres)

The dominant canopy species are slash pine and live oak. The dominant understory species is saw palmetto (*Serenoa repens*), with scattered cabbage palm. In the southern portion of the property, the areas identified as Hardwood-Conifer Mixed are fairly open, with large areas of bahia grass interspersed with the saw palmetto understory. These areas total ±63.1 acres, or 6.5%.

These areas are currently mapped as Eau Gallie and Myakka fine sand, Malabar fine sand, and Pineda fine sand. These areas were historically mapped as Adamsville fine sand, a pine flatwoods soil, and Charlotte fine sand, a wet prairie soil (1957 *Soil Survey of Sarasota County)*. Much of these areas were historically pine flatwoods where the oaks have apparently encroached as a consequence of fire suppression.

3.1.2 Wetlands

The jurisdictional wetland limits (per 62-340, *Florida Administrative Code*) were delineated and flagged by BRA ecologists and surveyed by PBS&J over several months in 2005. The wetland limits were verified by Ms. Jennifer Brunty of the SWFWMD, as documented in the enclosed 3 October 2005 letter (Exhibit 7). In addition, Mr. Mark Peterson of the COE attended a site visit on 20 January 2006 and determined that the entire site is not COE jurisdictional due to the conversion to the property to orange groves and the resultant ditching, berming, and pumping of water, which artificially controls the water table (Exhibit 8).

<u>Wetland 4 (FLUCFCS 6411/643; 0.76 acres)</u>
Wetland 4 (Exhibit 9) is a 0.76-acre disturbed freshwater marsh/wet prairie located east of the Cow Pen Canal. It has an excavated core and remnants of a vegetated fringe. The core is open water and supports no hydrophytic vegetation. Small, scattered, spoil piles are present at the edge of the excavated area. Typical vegetation on these spoil piles include dogfennel and several immature cabbage palms. The outer zone of the wetland is degraded due to inadequate hydrology, as evidenced by the species composition of these areas. Limited wetland vegetation, including sand cordgrass (*Spartina bakeri*), scattered soft rush (*Juncus effusus*), pennywort (*Hydrocotyle umbellata*) and coinwort (*Centella asiatica*), are contained in the remaining portions of the wetland.

This wetland is also connected to Wetland 5 through a ditch, which continues to the northwest and south. The immediately surrounding uplands are improved pasture with a mixed hardwood-conifer forest and cabbage palm/live oak hammocks 150 feet to the east and west. No native buffer remains adjacent to this wetland. Wetland functions include the storage of water; however, limited suitability exists as wildlife habitat. The only anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland include: Little Blue Heron *(Egretta caerulea),* White Ibis *(Eudocimus albus),* Snowy Egret *(Egretta thula)* [all state-listed, Species-of-Special-Concern (SSC)], and the Wood Stork *(Mycteria americana)* [state and federally-listed as Endangered (E)]. Wildlife observed in this wetland during the assessment includes a single alligator *(Alligator mississippiensis)* and significant damage from pig *(Sus scrofa)* rooting.

<u>Wetland 5 (FLUCFCS 6411/643; 0.43 acres)</u>
Similar to Wetland 4, Wetland 5 is a 0.43-acre disturbed freshwater marsh/wet prairie located east of the Cow Pen Canal. It has an excavated core and some remnants of a vegetated fringe. The core is open water and supports no hydrophytic vegetation. Small, scattered spoil piles are present at the edge of the excavated area (more prominent than in Wetland 4). Typical vegetative composition on these spoil piles include dogfennel and several small cabbage palms. The outer zone of wetland is degraded due to inadequate hydrology, as evidenced by the species composition of these areas. Limited wetland

vegetation, including sand cordgrass, scattered soft rush, pennywort and coinwort, are contained in the remaining portions of the wetland.

The immediately surrounding uplands are improved pasture with a mixed hardwood-conifer forest and cabbage palm/live oak hammocks 150 feet to the east and west. No native buffer remains adjacent to this wetland. Wetland functions include the storage of water; however, it has limited suitability as wildlife habitat. The only anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading Birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. The only wildlife observed in this wetland during the assessment was an alligator and evidence of feral pigs.

Wetland 7 (FLUCFCS 6411; 11.93 acres)

Wetland 7 is an 11.93-acre freshwater marsh, which has been highly disturbed by past land management practices. Currently, ditches run adjacent to its southern and northeastern boundaries, and another smaller ditch bisects the wetland. In addition, adjacent to the northwest corner of the wetland within its historical footprint is a fenced area with an isolated ditch system that drains into the wetland. This small area was used for growing unknown crops in a private garden for the previous landowner. The garden is currently fallow. The presence of these smaller ditches, combined with the larger nearby ditches, have sufficiently drained the wetland so that the current seasonal high water elevation is more than one (1) foot below the wetland edge.

An excavated core normally contains water year-round and species coverage including cattails (*Typha* spp.), primrose willow (*Ludwigia peruviana*), Carolina willow (*Salix caroliniana*), and some softrush. The next zone forms the majority of the central portion of the wetland, barring the excavated core, and typical species include soft rush, fire flag (*Thalia geniculata*), scattered buttonbush (*Cephalanthus occidentalis*), primrose willow, coinwort, and maidencane (*Panicum hemitomon*). The small, excavated core and ditch, which bisects the wetland, have affected the hydrology of this wetland and in turn, the outer zone of wetland is degraded due to inadequate hydrology as evidenced by the species composition of these areas and comparisons with historical aerials. The outer most zone contains broom grass (*Andropogon virginicus*), coinwort, maidencane, dogfennel, bahia grass, and occasional blackberry *(Rubus* sp.*)*.

Cabbage palm and live oak hammocks, along with the small garden area along a portion of the western boundary, constitute the wetland buffer. Wetland functions include the storage and filtration of water and habitat for wildlife. Anticipated wildlife utilization includes amphibians and reptiles, wading birds, and small and medium mammals. Wading Birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. Pig rooting was present throughout the outer zones. Hawks were observed flying overhead and roosting in trees in the adjacent uplands. A pair of otters (*Lontra canadensis)* was observed at the southern end of the wetland traveling along the ditch.

Wetland 8 (FLUCFCS 641; 0.01 acres)
Wetland 8 is a 0.01-acre freshwater marsh, which is a remnant of a larger system. This small area is a depressional area immediately surrounded by open lands consisting of bahia grass and broomsedge. Beyond this area, live oak hammock surrounds the wetland to the north, south, and east. To the west are orange groves and a large drainage ditch, which ultimately drains to the Cow Pen Canal. This wetland has no zonation and has limited coverage by hydrophytic vegetation, including several small buttonbush, prairie iris (*Iris hexagona)*, and a few small clumps of sand cordgrass. Hydric soil indicators are mostly absent within this wetland. Water is retained after rain events, but due to the presence of the large ditch to the west, water levels recede quickly. Wetland functions currently include minimal wildlife habitat and storage of water. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading Birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. During the assessment many tadpoles were present in the pool of water.

Wetland 9 (FLUCFCS 641; 2.51 acres)
Wetland 9 is a 2.51-acre freshwater marsh. The core retains water year-round and hydrophytic vegetation coverage includes primrose willow, Carolina willow, and some fireflag. Typical species of the middle zone include soft rush, fireflag, scattered buttonbush, primrose willow, coinwort, and maidencane. The outer most zone contains broomsedge, soft rush, primrose willow, coinwort, maidencane, dogfennel, bahia grass, yellow-eyed grass (*Xyris* spp.), and scattered blackberry. The wetland is adjacent to ditches to the north and west, with associated spoil areas located on the wetland side of the ditch. Thus, impounding of water and, alternately, excessive draining are problems depending on rainfall. The wetland is immediately surrounded by live oak hammock to the east and south, by orange groves and a ditch to the west, and by a road and a ditch to the north. Wetland functions currently include storage and filtering of water and limited habitat for wildlife. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. No wildlife was observed in this wetland during the assessment.

Wetland 11 (FLUCFCS 641; 4.17 acres)
Wetland 11 is a 4.17-acre freshwater marsh. This wetland has well-defined zonation with fireflag in the core, pickerelweed (*Pontederia cordata*) and maidencane in the middle zone and sand cordgrass in the outer zone. Other species present in the outer zone include maidencane, pennywort, broomsedge, dogfennel, scattered buttonbush, bahia grass, immature slash pine and laurel oaks. Live oak and cabbage palm hammocks occur to the west and a mixed hardwood/conifer forest occurs to the east. This forested habitat continues to the north and south of the wetland, providing a wildlife corridor. There are large ditches within 200 feet to the east and within 400 feet to the west. Following rain events, water levels within this wetland are raised, but water is not retained due to the lowered water table caused by the surrounding ditch network. Wetland functions

currently include storage and filtering of water and limited habitat for wildlife. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. Skeletons of a variety of animals were found on the wetland edge including: deer *(Odocoileus virginianus),* pig, coyote *(Canis latrans),* rabbit, and cow. These appear to have been transported to the location. No other evidence of wildlife utilization was observed.

Wetland 12 (FLUCFCS 643; 0.90 acres)
Wetland 12 is a 0.90-acre wet prairie. This wetland has moderate zonation and limited species diversity. The core area is comprised of soft rush and prairie iris. The outer zone is comprised of maidencane, buttonbush, broom grass, primrose willow, and coinwort. The transitional zone has caesarweed and bahia grass. A live oak hammock is located to the north, south, and west of the wetland and a mixed hardwood/conifer forest is located to the east. The forested habitat continues to the north and south on the subject parcel. This system has been hydraulically impacted by the presence of the ditches within 600 feet to the east and within 200 feet to the west, which have drawn down the water table. Wetland functions currently include storage and filtering of water and limited habitat for wildlife. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. No wildlife utilization was observed during this assessment.

Wetland 13 (FLUCFCS 643; 0.42 acres)
Wetland 13 is a 0.42-acre wet prairie and is a highly disturbed and drained system. A well-traveled vehicle path bisects this wetland. Typical vegetation present includes broomsedge, smartweed (*Polygonum punctatum*), swamp fern (*Blechnum serrulatum*), maidencane, bahia grass and coinwort. This system has been hydraulically impacted by the presence of the ditches 500 feet to the east and west, and 200 feet to the north, which have lowered the surficial water table. Immediately after rain events, this wetland holds water to its historical level. However, due to the water table impacts caused by the extensive network of ditches, water recedes quickly causing the lack of long-term water retention necessary for the long-term survival of this system. This wetland is surrounded by a live oak hammock to the north, south, and west and by mixed hardwood/conifer forest to the east. The forested habitat continues to the north and south on the subject parcel. Wetland functions currently include storage and filtering of water and limited habitat for wildlife. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. No wildlife utilization was observed during this assessment.

Wetland 14 (FLUCFCS 641; 2.72 acres)
Wetland 14 is a 2.72-acre freshwater marsh. The core of the wetland appears to have been excavated and is comprised of open water with cattails and smartweed. The middle

zone contains large amounts of primrose willow, maidencane and smartweed. The outermost zone is marginal and several upland species are encroaching into the wetland, including greenbriar (*Smilax auriculata*), caesarweed, dogfennel, and broomsedge. Other species present include maidencane, coinwort and Brazilian pepper. Live oak and cabbage palm hammocks surround this wetland. The abutting forested habitat continues to the north and south on the subject parcel. This system has been hydraulically impacted due to excavation of the interior, which caused the unnatural pooling of water in the wetland, and the creation of the ditch immediately adjacent to the eastern wetland edge, which caused the drawing down of the water table. Wetland functions currently include storage and filtering of water and limited wildlife habitat. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. There was evidence of pig rooting around the wetland edge.

Wetland 15 (FLUCFCS 619; 0.79 acres)

Wetland 15 is a 0.79-acre exotic hardwood wetland, with no zonation. It is dominated by nuisance/exotic species including Brazilian pepper and primrose willow. Other species present in smaller quantities include pop ash (*Fraxinus caroliniana*), bitter orange (*Citrus aurantium*), Carolina willow, arrowhead (*Sagittaria* sp.), and fireflag. This wetland is surrounded by live oak and cabbage palm hammocks immediately to the north and farther south, which continue to the north and south on the subject parcel. In addition, other open lands are located immediately adjacent to the southern end of this wetland. This system has been hydraulically impacted by the presence of a ditch immediately to the west, which causes water table draw down. Wetland functions include storage and filtering of water and limited habitat for wildlife. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. Extensive pig rooting was observed.

Wetland 16 (FLUCFCS 641; 0.03 acres)

Wetland 16 is 0.03-acre freshwater marsh located east of the Cow Pen Canal. This small, isolated wetland has no zonation and is comprised of soft rush and broomsedge. Standing water was present during field investigations. It is surrounded by improved pasture with a mixed hardwood-conifer forest and live oak hammock about 150 feet to the east and west. The hydrology of this wetland has been impacted by the nearby ditches, rutting from pig rooting, and agricultural maintenance. Wetland functions currently include limited storage of water and limited suitability as wildlife habitat. Anticipated wildlife utilization is by amphibians and reptiles, wading birds, and small and medium mammals. Wading birds expected to utilize this wetland are listed below: Little Blue Heron, White Ibis, Snowy Egret, and the Wood Stork. During this field investigation utilization by pigs was evident.

3.1.3 Wildlife

A database search was conducted for listed species potentially occurring on the Albritton site (Exhibit 10). The wetlands onsite may be used for foraging and loafing by several species of wading birds, including the state-listed Little Blue Heron, White Ibis, Snowy Egret, and Wood Stork. All of which are state-listed Species of Special Concern (SSC), except for the Wood Stork, which is state and federally listed as Endangered. Some opportunity for the state-listed Threatened Florida Sandhill Crane (*Grus canadensis pratensis*) might exist for foraging and loafing within the improved pastures in the south, though no suitable nesting habitat occurs onsite. Although the wetlands do have the potential for wading bird utilization, the closest documented colony (#615118) is listed as being approximately 1200 meters (0.55 miles) from the eastern property boundary on Hawkins Ranch. Although no colonies containing Wood Stork occur within the vicinity of the project area, the project area does occur within the 18.6-mile Core Foraging Area (CFA) as defined in the draft *Standard Local Operating Procedures for Endangered Species (SLOPES) – Wood Storks* (28 June 2002) published by the U.S. Fish and Wildlife Service. Several Bald Eagle (*Haliaeetus leucocephalus*) nests are in the vicinity of this site, however the closest nest (SA035) documented is approximately 1500 meters (0.68 miles) from the southern property boundary on the Pinelands Reserve, which is significantly beyond the limits of any protection zones for the nests. Other wildlife searches included the Florida Scrub-jay (*Aphelocoma coerulescens*), which has no documented territories within a two-mile radius of the site.

In addition, marginal habitats do exist onsite for the federal and state listed Eastern indigo snake (*Drymarchon corais couperi*), and the state-listed SSC, the gopher tortoise (*Gopherus polyphemus*) (SSC). The Eastern indigo snake is a habitat generalist, which is found in a wide-range of habitats, though none were observed during fieldwork. Marginal habitat does exist for the gopher tortoise in the mixed hardwood-conifer forests, and potentially in the improved pastures or orange groves. Probabilities of gopher tortoise occurring onsite are low due to the heavily managed nature of the parcel, but surveys would be required to make a final statement on their presence or lack thereof. Wildlife observed during BRA's preliminary wildlife survey is documented in the specific land use/wetland descriptions above.

3.1.4 Uniform Mitigation Assessment Methodology

The UMAM, pursuant to Chapter 62-345 of the *Florida Administrative Code*, became effective for the State of Florida on 2 February 2004 and for the COE in Florida on 1 August 2005. UMAM is the sole methodology utilized to determine wetland quality and mitigation requirements in the State of Florida as it incorporates the wetland impact acreages and the quality of the wetland pre- and post-development to compute quantitative compensation acreage. The UMAM datasheets (are divided into Part I, a qualitative description of the assessment area, and Part II, a quantitative description of the assessment area. Scoring on a 0-10, whole-number basis, in Part II, is required for

Location/Landscape Support, Water Environment, and Community Structure indicators. A “0” score is given to an area that no longer performs any functions of a wetland and a “10” score is given to a wetland in an optimal natural condition. Location/Landscape Support is scored relative to the assessment area’s ability to support fish and wildlife during a portion of their life cycle and its relationship to surrounding areas in terms of wildlife habitat connectivity and “water quality and quantity benefits”. Per Chapter 62-345, the Water Environment scoring is based on “the quantity of water in an assessment area, including timing, frequency, depth, and duration of inundation or saturation, flow characteristics, and the quality of that water. . . its ability to perform certain functions and. . . benefit or adversely impact its capacity to support certain wildlife.” Finally, the Community Structure score is based on the vegetative community structure and composition and its ability to support wildlife habitat. The UMAM sheets for each wetland are included as Exhibit 11.

3.2 West Pinelands Current Land Use

A FLUCFCS land use map (Exhibit 12) was created by BRA based on field evaluations by BRA ecologists, aerially mapped and digitized vegetative boundary lines, and GIS analysis. Descriptions of each habitat type are provided below. All provided acreages are approximate as they are based on aerial interpretation and not surveyed habitat delineations. A preliminary wildlife survey, including pedestrian and vehicle transects, was also conducted and the results follow the habitat assessments.

3.2.1 Uplands

The non-jurisdictional wetlands on the site total approximately 303.7 acres, or 77.2%, and include the Cow Pen Canal.

<u>Unimproved Pasture (FLUCFCS 212; 98.1 acres)</u>
The unimproved pasture is a remnant of the former agricultural activities on the site. These pastures of bahia grass and broomgrass provide the immediate upland buffer and transition zones to the wetland features previously described. Often the transition from upland to wetland is gradual which provides a diverse mesic community that is dominated by herbaceous species such as broomgrass, white top sedge, golden rod (*Solidago* sp.), and dogfennel. However, the hydrology does not appear significant to support wetland species outside of occasional flooding events. In addition, further investigation of sub-surface soils did not contain indicators specific to a hydric soil.

<u>Pine Flatwoods (FLUCFCS 411; 19.3 acres)</u>
The mixed forest (described below) gradually transitions into a pine flatwood that is dominated by slash pine in the tree stratum and saw palmetto in the understory. Although live oak remains in scattered locations throughout, the diversity of tree and shrub species diminishes.

Cabbage Palm (FLUCFCS 428; 14.3 acres)
This area is located in the center of the property and is dominated by cabbage palm with an understory of beautyberry and wild coffee. This land use type is located south of a portion of hardwood-conifer mixed forest and, together, they are the extant tree island in the middle of the historical Cow Pen Slough. The edge of this system was used to set historical Wet Season Water Levels (WSWL).

Hardwood-Conifer Mixed (FLUCFCS 434; 145.1 acres)
Uplands to the west of the Cow Pen Canal floodplain include a mixed conifer and hardwood forest (FLUCFCS 434), which is co-dominated by slash pine, live oak and laurel oak, with cabbage palm in the sub-canopy. Other species in the understory include saw palmetto, wax myrtle, gallberry (*Ilex glabra),* and yaupon holly (*Ilex vomitoria)*.

Channelized Waterway (FLUCFCS 5101; 30.0 acres
Cow Pen Canal runs from north to south and is present along the eastern boundary of the project area. This feature fragments the surrounding land use significantly. Spoil piles from the dredging of the canal line the banks on both sides. Upland ruderal species such as dogfennel and panic grasses (*Panicum* sp.) are prominent on the banks. Wading birds and a single American alligator (*Alligator mississippiensis)* were observed on the banks.

Roads (FLUCFCS 8144; 11.4 acres)
This land use type is inclusive of the portion of Knight's Trail that falls within the project boundary. This paved road runs approximately north-south and terminates at the landfill.

Graded and Drained Road (FLUCFCS 8145; 15.5 acres)
This area is the maintained, bermed road west of canal that originates at the bend of the Cow Pen Canal and continues south.

3.2.2 Wetlands

The wetlands contained within the following descriptions (Exhibit 13) were previously delineated and permitted in the COE permit No. 89IPI-90924 (1994) and Florida Department of Environmental Protection permit No. 581723073 (1990). As these delineations were not conducted under the current State of Florida rules governing wetland delineation methodology (62-340, *Florida Administrative Code*) and a significant amount of time has passed, BRA re-delineated all of wetland lines (utilizing aerial interpretation and groundtruthing) based on current conditions and methodology. However, these limits have not been surveyed or verified by either state or federal agencies.

WL-1 (FLUCFCS 641; 3.4 acres)
This small, depressional basin is a remnant of a former large wetland system that comprised the riparian buffer for the original Cow Pen Slough as depicted on the 1948 aerial photograph. Wetland 1 (WL 1) is located approximately 200 feet west of the

slough canal and is now an herbaceous wet prairie dominated by maidencane, smartweed, soft rush, pennywort, and carpet grass (*Axonopus affinis)*. Broomgrass and bahia grass are present along the fringe of the wetland.

The buffer adjacent to WL-1 consists of an upland open improved pasture dominated by bahia grass with isolated live oak trees and cabbage palm. This pasture grades into an extensive upland mixed forest dominated by live oak, saw palmetto, and slash pine.

The *Soil Survey of Sarasota County* (1991) indicates the soils for this wetland as Delray fine sand depressional, a County-listed hydric soil. The description for this soil type indicates that it is poorly drained, often found in depressions in flatwoods. Although the soil within WL-1 has been subjected to historical alteration by decades of drainage activities, this description is further supported by the field observation of soil saturation at surface. No wildlife activities were observed within the wetland at time of the field activities. However, the wetland provides adequate opportunity for wildlife habitat for foraging potential, floodwater attenuation, and sediment or nutrient filtration.

WL-2 (FLUCFCS 643/641; 3.7 acres)
Similar to WL-1, this wetland is also a remnant of the original Cow Pen Slough. The outer rim of this system is a wet prairie dominated by herbaceous species such as maidencane, yellow-eyed grass, Southern blueflag iris (*Iris virginica),* beakrush (*Rhynchospora* spp.) and sand cordgrass. The center of the wetland is a freshwater marsh that is inundated and dominated by emergent herbaceous species including soft rush, smartweed, spikerush, and dayflower (*Commelina diffusa).*

The buffer is an upland improved pasture dominated by bahia grass and broomgrass immediately adjacent to the wetland. This system grades into a large upland mixed forest dominated by live oak, cabbage palm, slash line, saw palmetto and wax myrtle (*Myrica cerifera)*. No indication of recent disturbance is present. However, indication of a non-recent fire event was noted in the upland mixed forest buffer.

Soils within this wetland are similar to those present in WL-1, and are also mapped as Delray Fine Sand Depressional in the *Soil Survey of Sarasota County* (1991). However, observations of the soils during the field event do not support this soil description. This discrepancy is most likely attributed to the alteration of soils from the canal construction several decades ago that resulted in the drainage of historical wetlands in the historical Cow Pen Slough system. However, the soil is sufficiently supporting hydrophytic vegetation as the hydrology to this system appears stable.

Anticipated wildlife utilization within the wetland and buffer system is high. Eagles could potentially utilize the area for foraging. This system can adequately support wading birds and also large and small mammals. Wildlife observations included a flock of swifts, as well as deer and feral pig tracks and trails.

WL-3 (FLUCFCS 643; 1.4 acres)
This wetland is located approximately 200 feet from the Cow Pen Canal. It is a wet prairie remnant of the larger system that comprised the riparian edge for the wetland-stream complex. The species within the wetland are diverse and true zonation is strong, and include maidencane, broomgrass and dogfennel near the edge of the fringe. The center is dominated by smartweed, Vasey's grass (*Paspalum urvillei)*, nutsedge (*Cyperus* sp), and umbrella sedge (*Fuirena pumila).* Other non-dominant species worthy of notation include sand cordgrass, beaksedge, southern blue flag iris, and bristly fox tail (*Setaria geniculata).*

The buffer immediately adjacent to WL-3 is an improved pasture, dominated by bahia grass, with occasional live oak and cabbage palm trees. The buffer rises slightly in elevation toward an extensive mixed oak and pine forest to the west. Cow Pen Canal is located approximately 150 feet to the east. Improved pasture adjacent to the canal provides the buffer to the north and south of the wetland. This upland pasture connects to the other wetlands along the riparian zone to the slough.

The hydrology of this system is marginal due to the former disturbance by drainage; however, it still retains a hydraulic connection to the Cow Pen Canal. The *Soil Survey of Sarasota County* (1991) mapped unit, Felda fine sand, is within the outer fringe of the WL-3, where as the Floridana and Gator depressional unit is located more toward the center of the system. The soils adequately support hydrophytic vegetation although encroachment by upland species was noted. Hydric indicators observed in the soils on site were weak due to the compromised hydrology.

Wildlife utilization within this wetland and surrounding buffer is high. Wild turkeys were observed, and deer and feral pig tracks bisect the system. Eagles, wading birds (SSC), small mammals, reptiles, and amphibians may utilize the wetland for foraging. Another function of the wetland is to provide floodwater attenuation and filtration of sediments in flooding scenario.

WL-4A & WL-4B (FLUCFCS 631/643; 7.2 + 31.0 acres)
This large wetland system is composed of two distinct plant communities, a buttonbush and pop ash swamp, WL 4A, and an emergent wet prairie, WL 4B. The first community, WL 4A, is dominated by buttonbush, with co-dominance shared by Carolina willow shrubs and pop ash saplings. This area is frequently inundated as depicted by water marks and stain lines on the bases of the shrubs. Few groundcover species were noted, but are dominated by maidencane, bushy broomsedge, and pennywort.

The second plant community, WL 4B, is a wet prairie consisting of emergent herbaceous species with a co-dominance of maidencane, bushy broomsedge, smartweed, and spiked beakrush. Other species contributing to the diversity include lance-leaf frogfruit (*Phyla lancifolia)*, iris (*Iris* sp), and white top sedge (*Dichromena colorata)*. Soils for wetland communities consisted of Delray Fine Sand mapped unit typically found in depressional basins according to the *Soil Survey of Sarasota County* (1991).

The wetland provides potential for foraging, nesting and cover for wildlife and anticipated utilization is high both in the system and the surrounding buffer. Observations include trails from deer and feral pigs, tracks of other small mammals, and songbirds. Potential utilization could include foraging by raptors and wading birds. The buffer for the wetland is an upland live oak, laurel oak and slash line forest with an understory of saw palmetto. This plant community grades into a relatively undisturbed pine flatwoods that shows indication of a non-recent fire event.

<u>WL 5 (FLUCFCS 641; 0.8 acres)</u>
This wetland is reduced from its former configuration due to disturbance from drainage by the construction of the Cow Pen Canal. The system is predominantly an herbaceous dominated freshwater marsh. Buttonbush is scattered throughout the marsh. Dominant vegetation includes herbaceous species such as maidencane, smartweed, carpet grass, spiked beakrush, caric sedges (*Carex* spp), and rosy camphor-weed (*Pluchea rosea).* Upland grass species are encroaching into the system.

Soils consist of Delray fine sand, a mapped unit typically found in depressional basins according to the *Soil Survey of Sarasota County* (1991). However, the wetland appears to adequately support hydrophytic vegetation thus sustaining the stability of the wetland.

No wildlife activities were observed within the wetland at time of the field activities. However, the wetland provides adequate opportunity for wildlife habitat for foraging potential, floodwater attenuation, and sediment or nutrient filtration.

<u>WL 6 (FLUCFCS 641; 3.2 acres)</u>
Similar to WL 5, this system is also a wet prairie located adjacent to the current Cow Pen Canal and disturbed native habitat. It was formerly included in the original meandering slough prior to the canal construction that resulted in an altered hydrology to this wetland. Dominant species include such grasses as maidencane, broomgrass, and carpet grass, along with ground cover species including spiked beakrush and lance leaf frogfruit, and buttonbush.

Soils within this wetland are mapped as Delray fine sand, which are typically found in depressional basins along slough systems according to the *Soil Survey of Sarasota County* (1991). The wetland appears to adequately support hydrophytic vegetation thus sustaining the stability of the wetland.

Wildlife activities observed within the wetland at the time of the field activities include feral pig rooting and trails. Wading birds are also assumed to utilize the wetland as it can provide adequate opportunity for wildlife habitat for foraging potential, floodwater attenuation, and sediment or nutrient filtration.

WL 7 (FLUCFCS 641; 0.6 acres)
Wetland 7 is a 0.6-acre freshwater marsh located approximately 50 feet west of Cow Pen Canal. This wetland was part of the original Cow Pen Slough, but was drained in the 1950's, which altered the hydrology, however, hydric soils still persist. This isolated, moderate quality wetland currently has no standing water and an unpaved access road is present on the eastern edge. Pine flatwoods and improved pasture surround this wetland to the north, south, and west.

Vegetation within this wetland has no obvious zonation and is primarily a monoculture of maidencane with some broomsedge. The upland adjacent to Wetland 7 consists of an improved pasture dominated by bahia grass with isolated live oak and cabbage palm trees. Beyond this area is an upland flatwood plant community consisting of saw palmetto and slash pine.

Wetland functions include small mammal feeding, water storage and filtration. The anticipated wildlife utilization is by wading birds, insects, amphibians, small reptiles and small/medium mammals. Wading birds expected to utilize this wetland are listed, these include: Little Blue Heron (SSC), White Ibis (SSC), Snowy Egret (SSC), and Wood stork (E). No evidence of wildlife was observed.

WL-8 (FLUCCS 641; 1.9 acres)
Wetland 8 is part of the historical Cow Pen Slough as depicted on the 1948 aerial photograph. Wetland 8 is located approximately 200 feet from the canal, west of the bermed, graded, and culverted access road. It is now an herbaceous marsh dominated by maidencane, smartweed, carpet grass, and bushy beardgrass (*Andropogon glomeratus)*. The wetland has little to no nuisance/exotic species intrusion, moderate diversity, and evidence of severe drainage. The buffer adjacent to WL-8 consists of mixed hardwoods, including live oak, slash pine, saw palmetto, and scattered cabbage palm.

The *Soil Survey of Sarasota County* (1991) indicates the soils for this wetland as Floridana and Gator soils, depressional, a county-listed hydric soil. The description for this soil type states that it is very poorly drained, found in depressions. Although the soil within WL-8 has been subjected to historical alteration by decades of drainage activities, this description is further supported by the field observation of soil saturation at surface.

No wildlife activities were observed within the wetland at time of the field activities, although a bobcat was seen on the adjacent road. The wetland provides adequate opportunity for wildlife habitat for foraging potential, floodwater attenuation, and sediment or nutrient filtration.

WL-9 (FLUCCS 641; 0.31 acres)
Similar to the other wetlands on the property, this wetland is a remnant of the original Cow Pen Slough. The wetland is a drained freshwater marsh dominated by herbaceous species such as maidencane, smartweed, frog fruit, broomsedge, and meadow beauty

(*Rhexia* spp.). The buffer is a mixed hardwood forest and pine flatwoods area contiguous to the buffers of the adjacent wetlands, including Wetlands 8 and 10.

Soils within this wetland are mapped as Felda fine sand depressional in the *Soil Survey of Sarasota County* (1991). The alteration of soils from the canal construction several decades ago has resulted in the drainage of historical wetlands in the original Cow Pen Slough system and the once-hydric soils are losing their hydric indicators. However, the soil is sufficiently supporting hydrophytic vegetation as the hydrology to this system appears stable.

The only anticipated wildlife utilization in this system is for wading birds, reptiles, and large and small mammals. A bobcat was observed adjacent to the wetland and pig rooting was evident throughout.

<u>WL-10 (FLUCCS 641; 1.7 acres)</u>
This wetland is located approximately 200 feet from the Cow Pen Canal and has been heavily affected by the construction of the canal and the berming of the access road. Wetland 10 is a freshwater marsh remnant of the larger system that comprised the riparian for the wetland-stream complex. The species within the wetland include maidencane, broomgrass, dogfennel, smartweed, and frog fruit. The alteration of the natural hydrology has allowed the encroachment of upland species such as dogfennel, as well as limited species diversity and a lack of zonation. The buffer south of the wetland is the transition between the mixed hardwood forest to the north and the pine flatwoods to the south.

The hydrology of this system is marginal due to drainage from the former disturbance; however, it still retains the hydrological connection to Cow Pen Canal. The *Soil Survey of Sarasota County* (1991) mapped unit is Floridana and Gator soils, depressional, a hydric soil. The soils adequately support hydrophytic vegetation although encroachment by upland species was noted. Hydric indicators observed in the soils on site were weak due to the compromised hydrology.

Wildlife utilization within this wetland and surrounding buffer is high. Feral pig rooting was prevalent throughout the wetland. Floodwater attenuation and filtration of sediments are possible functions of the wetland.

<u>WL-12 (FLUCSS 617/641; 2.6 acres)</u>
This large wetland system is composed of two distinct plant communities, a wetland hardwood swamp with a herbaceous marsh core. The outer community is dominated by buttonbush, cabbage palm, and laurel oak with little to no herbaceous understory. This area is frequently inundated as depicted by watermarks, stain lines, buttressing, and rooting on the bases of the trees.

The wetland core is a freshwater marsh consisting of herbaceous species with a co-dominance of maidencane, bushy beardgrass, smartweed, and beakrush. A natural, meandering waterway drains the adjacent pine flatwoods, particularly to the south, and funnels the water into the wetland core.

Soils consist of Felda fine sand, depressional; typically found in depressional basins according to the *Soil Survey of Sarasota County* (1991). The altered hydrology from the construction of Cow Pen Canal compromised the hydric characteristics of the soil. However, hydric characteristics such as high organic content (muck) at grade support hydrophytic vegetation thus sustaining the stability of the wetland.

The wetland provides foraging, nesting and cover for wildlife. Utilization is high both in the system and the surrounding buffer. Potential utilization could include foraging by raptors, wading birds, herptiles, and mammals.

3.2.3 Wildlife

A database search was conducted for listed species potentially occurring on or adjacent to the subject property (Exhibit 10). The wetlands onsite may be used for foraging by several species of wading birds, including the state-listed Little Blue Heron, White Ibis, Snowy Egret, and Wood Stork. All are state-listed SSC, except for the Wood Stork, which is state and federally listed as Endangered. Some opportunity for the state-listed Florida Sandhill Cranes might exist for foraging or nesting within the herbaceous wetlands in the south, though no nesting habitat was observed. Although the wetlands have high potential for wading bird utilization, the closest documented colony is identified approximately 0.75 miles to the northwest of the project limits. Although no colonies containing Wood Storks were found on the subject property, the project area occurs within two 18.6-mile CFA as defined in the draft *Standard Local Operating Procedures for Endangered Species (SLOPES) – Wood Storks* (28 June 2002) published by the U.S. Fish and Wildlife Service. Several Bald Eagles' nests are in the vicinity of this site; however the closest nest is documented on the Pinelands property to the southeast, well outside of the primary and secondary protection zones. Other wildlife searches included the Florida Scrub-jay, which has no documented territories within a two-mile radius of the site. No scrub-jays or suitable habitat were observed on or adjacent to the subject property.

Although site conditions are marginal, potential habitats exist onsite for the federally and state threatened Eastern indigo snake and the state-listed SSC, the gopher tortoise. The Eastern indigo snake is a habitat generalist, which is found in a wide-range of habitats. However, none were observed during fieldwork. Potential habitat for the gopher tortoise is located within the upland mixed hardwood-conifer forests adjacent to the Cow Pen Canal. Probabilities of gopher tortoises occurring onsite are low due to the heavily managed nature of the parcel, but formal surveys would be required to make a final statement on their presence or lack thereof. Wildlife observed during the preliminary wildlife survey is documented in the specific land use/wetland descriptions above.

3.2.4 Uniform Mitigation Assessment Methodology

The UMAM sheets for each West Pinelands wetland are included as Exhibit 14. COE datasheets are provided as Exhibit 15. These datasheets will be used by COE staff to assess each wetland during COE permitting.

3.3 Myakka Connector Current Land Use

The upland and wetland habitats onsite were evaluated during fieldwork conducted in December 2005. A land use map (Exhibit 16) was created based on the FLUCFCS. Descriptions of each habitat type are provided below. All provided acreages are approximate as they are based on aerial interpretation and not surveyed habitat delineations.

3.3.1 Uplands

Shrub and Brushland (FLUCFCS 320; 0.5-acre)
This area totals 0.1% of the property and is dominated by wax myrtle, with highly patchy sawgrass *(Cladium jamaicense).* The soils in the area are mapped as Pineda fine sand, but no indicators of hydrology or hydric soils were observed in the field.

Pine Flatwoods (FLUCFCS 411; 183.4 acres)
The majority of the site (41.6%) is mapped as pine flatwoods, with a dominant canopy of slash pine. Typical understory species include saw palmetto, gallberry, some wax myrtle, and scattered cabbage palm. The pine flatwoods include areas identified within the *Soil Survey of Sarasota County* (1991) as both hydric and non-hydric soils. In areas where the soils are mapped as hydric, the pine flatwoods appear slightly sparser in vegetation and a bit more open. Several fire breaks were created for maintenance within the last year separating the pine flatwoods into sections.

Live Oak Hammock (FLUCFCS 427; 60.5 acres)
This land use type constitutes 13.7% of the property, is located in areas that were part of the historical slough and are identified as hydric soils according to the *Soil Survey of Sarasota County (*1991). The live oak hammocks are typically located in the same landscape position as the cabbage palm hammocks, but dominant canopy species differ slightly. The live oak hammocks appear to have a vegetative composition consistent with the Sarasota County regulated mesic hammock, especially in areas towards the south. In the eastern portion of the parcel, the live oak hammock is located around the braided channel before it opens into the live oak and cabbage palm dominated wetland area identified as Wetland 8A.

Live oak dominates the canopy with variable understory vegetation, but typical species include cabbage palm, some scattered saw palmetto, beautyberry, wild coffee, broomsedge, St. John's Worts (*Hypericum* sp.), and Panicgrass (*Dichanthelium* sp.).

Cabbage Palm (FLUCFCS 428; 16.7 acres)
The cabbage palm hammocks generally define flowways, are found adjacent to the live oak hammocks and wetlands and total 3.8% of the site. One main area of cabbage palm hammock is the connection between Wetlands 6A and 8A, which has been slightly disturbed due to the construction of a fire break. These areas do not meet the definition of Sarasota County-regulated mesic hammock. Few species other than cabbage palms are found within these areas.

Hardwood Conifer Mixed (FLUCFCS 434; 73.1 acres)
This landuse type constitutes 16.6% of the property. The canopy in these areas is dominated by slash pine and live oak with cabbage palm in the mid-canopy. Saw palmetto is typical in the understory. The hardwood-conifer mixed areas are adjacent to the current slough area and on the north side of Wetlands 3A and 4A, where fires have been far less frequent than in the pine flatwoods. These areas are typically located in soils identified as Pineda fine sand (31) and partially within the historical slough limits, according to the *Soil Survey of Sarasota County* (1991).

Graded and Drained Roads (FLUCFCS 8145; 8.4 acres)
A graded and drained road (2% of the site area) originates from the FPL easement, west along the north side of Wetlands 2A, 3A and 4A. This road is raised on a gravel bed, and has swales on either side, which serves as a berm to impound water in the adjacent wetlands.

Electrical Power Transmissions Lines (FLUCFCS 832; 11.1 acres)
The FPL transmission lines are located north-south through the eastern portion of this parcel and total 2.5% of the site. There are several culverts located under the easement toward the south end of the parcel where the slough drains towards the Myakka River. However, sufficient culvert crossings under the easement appear to be lacking and water is impounded within Wetlands 7A and 8A. The FPL easement does not hinder wildlife movement, and the culverts do allow for movement of fish and other aquatic small wildlife.

3.3.2 Wetlands

Wetland 9A and portions of Wetlands 2A and 4A were previously delineated and permitted under COE permit No. 89IPI-90924 (1994) and Florida Department of Environmental Protection permit No. 581723073 (1990). As these delineations were not conducted under the current State of Florida rules governing wetland delineation methodology (62-340, *Florida Administrative Code*) and a significant amount of time has passed, BRA re-delineated all of wetland lines based on current conditions and methodology. However, the limits have not been verified by the federal, state or local agencies.

WL 1A (FLUCFCS 560; 12.4 acres)

Wetland 1A (Exhibit 17) is part of a slough system formed by waters draining east to the Myakka River. The area exists as a combination of pockets of vegetated forested wetland, two distinct flow-ways, and scattered upland islands. The wetland is vegetated with Carolina willow, pop ash, laurel oak, cabbage palm, carpetgrass, and pennywort. The two flow-ways consist of one defined non-vegetated, meandering flow-way and one defined non-vegetated linear flow-way. The linear flow-way appears to have been altered either by creation or enhancement of its historical condition by the channeling of water through culverts under the FPL easement. The upland islands consist of saw palmetto, cabbage palm, and laurel oak and are too small to delineate as separate land uses.

The *Soil Survey of Sarasota County* (1991) indicates the soils for this wetland as Felda and Pompano fine sands, frequently flooded, a state and federal hydric soil. The description for this mapping unit states that it is poorly drained and is often found in floodplains throughout the county. This description is further supported by the field observation of soil saturation at surface in the wetlands and inundation in the flow-ways. The upland islands contain non-hydric soils, however they are also mapped as Felda and Pompano fine sands, frequently flooded.

Wildlife observations include pig rooting, wallows and trails, a Little Blue Heron, a Great Blue Heron *(Ardea herodias),* a green anole *(Anolis carolineansis)*, Glossy Ibis *(Plegadis falcinellus)*, and a black racer *(Coluber constrictor).* The buffer immediately adjacent to WL-1A is dominated by pine flatwood species, including slash pine and saw palmetto, with laurel oak and cabbage palm also present. Overall, the quality of WL-1A is high.

WL 2A (FLUCFCS 641; 1.3 acres)

Wetland 2A is a small depressional area which has a small core dominated by a buttonbush and Carolina willow. Typical species within the outer transitional zone include maidencane, a small red maple, wax myrtle, *Iris* spp., smartweed, asters (*Aster* spp.), broomgrass, sand cordgrass, and beakrush. Saw palmetto forms a hard edge to this wetland system, with scattered cabbage palm and wax myrtle.

This wetland is connected to Wetland (5A) to the south via a small channel. Two (2) additional wetlands (Wetlands 6A and 7A) and the remnant of a third are all connected to Wetland 2A through a series of hammocks. Based on the current and historical soil surveys, the current extent of this series of wetlands is smaller than the historical extent, and smaller than the area mapped as Holopaw fine sand, depressional (022). The surrounding uplands are pine flatwoods except for the cabbage palm hammocks that link several of the wetlands together. Observed wildlife includes a Limpkin *(Aramus* *guarauna)* and a Red-Tailed Hawk *(Buteo jamaicensis).* Suitable habitat exists for wading birds, including the Little Blue Heron*,* White Ibis*,* Snowy Egret (all state-listed Species of Special Concern) and the state and federal listed Wood Stork.

WL 3A (FLUCFCS 641; 11.6 acres)

The northern portion of this wetland is shrubby, dominated by buttonbush with primrose willow and some cattails (*Typha* sp.). Just south of the buttonbush, there is a deepwater core dominated by spatterdock (*Nuphar lutea*), which is surrounded by a zone of pickerelweed. The southern portion of this wetland is freshwater marsh. The outer zone is dominated by maidencane, then St. John's wort, umbrella grass, lemon water-hyssop (*Bacopa monnieri*), blue flag, coinwort, smartweed, asters, pennywort, sand cordgrass, sawgrass, and scattered wax myrtle.

This is a large herbaceous system located in soils mapped as Floridana and Gator soils, depressional and Holopaw fine sand, depressional. Based on the soil surveys, this marsh was surrounded by a large swath of Felda fine sand, depressional that formed the main portion of the historical slough system which flowed through this area to the Myakka River. Currently the majority of the areas mapped as Felda fine sand, Depressional are pine flatwoods, dominated by slash pine, saw palmetto, and gallberry.

Wildlife species observed within this wetland include a Great Egret and Little Blue Heron. Potential exists for usage by other listed wading birds. The surrounding uplands consist of hardwood/conifer mixed and pine flatwoods. There are some areas south of this wetland which show some tendencies towards wet prairie, including some patchy grassy hydrophytic vegetation. In addition, a small stream which during the dry season, appears to double as a road in some places, connects this wetland south to Wetland 3B.

WL 4A (FLUCFCS 641; 22.5 acres)

This high quality, large herbaceous marsh is also part of the main portion of the historical slough which traversed through this parcel. The main portion of this marsh remains intact, but the surrounding habitats have transitioned to hardwood/conifer mixed and pine flatwoods. Dominant soils include Floridana and Gator soils, depressional (15) and Holopaw fine sand, depressional (22). No connections or flow-ways to or from this wetland were located. A graded and maintained road (FLUCFCS 8145) was constructed around the northern boundary of this wetland which impounds water within this system.

This marsh is dominated by two (2) distinct pickerelweed cores, with some scattered buttonbush and Carolina willow. The western portion contains some cattails and sawgrass, which are particularly dense along the wetland edge. Wax myrtle is found regularly along the eastern boundary. The remaining zones of this wetland system are herbaceous, including St John's Wort, yellow-eyed grass, jointed knotweed (*Eleocharis interstincta*), beakrush, bog button (*Lachnocaulon* sp.), asters, smartweed, broomgrass, musky mint (*Hyptis alata*), and umbrella grass.

This wetland contains suitable habitat for wading birds and small and medium mammals. Evidence of pig rooting was observed, and a red-shouldered hawk was observed perched on a slash pine snag in the marsh.

WL 5A (FLUCFCS 641; 1.6 acres)
This high quality wetland is a pop ash swamp with scattered Carolina willow and a freshwater marsh outer zone. Typical species found in the outer zone include sand cordgrass, beakrush, sawgrass, maidencane, rosy camphor-weed, smartweed, some wax myrtle, and a few buttonbush. Laurel oak, live oak and cabbage palm are located at the wetland edge, with some minor encroachment of oaks into the outer zone of the wetland. In addition, several bromeliads were identified in the live oaks, including *Tillandsia setacea*, *T. utriculata*, and *T. fasciculata*.

This wetland is part of a larger system which includes Wetlands 2A, 6A, and 7A. Historically these systems were all connected and formed a large interlinked wetland system. Those connections are currently limited to small flowways through uplands areas and cabbage palm hammocks. The remaining uplands surrounding this wetland are pine flatwoods.

Observed wildlife in this wetland include a Barred Owl *(Strix varia),* cormorant *(Phalacrocorax* spp.), robins *(Turdus migratorius),* and evidence of usage by white-tailed deer, pigs and small mammals. Potential wildlife using this wetland include several listed wading birds.

WL 6A (FLUCFCS 641; 1.0 acres)
Wetland 6A is high quality and part of the Wetland 2A, 5A, and 7A complex. The core is dominated by pop ash. No understory exists in the core of this wetland. The outer zone is freshwater marsh with typical species present including beakrush, iris, smartweed, maidencane, and sand cordgrass. Edge species include live oak, laurel oak and cabbage palm. The surrounding uplands are live oak/cabbage palm hammock and pine flatwoods. The live oak/cabbage palm hammocks provide connections to Wetlands 5A and 7A.

Evidence of pig rooting was found throughout all the hammocks and along the wetland edge. A water-filled gopher tortoise burrow was observed at the wetland edge that appeared to be inactive. In addition, the potential exists for use of this wetland by wading birds, though no suitable nesting habitat is present.

WL 7A (FLUCFCS 641; 1.3 acres)
This high quality wetland contains two distinct zones, an inner core dominated by pop ash with some buttonbush, and an herbaceous outer zone. Typical species in the outer zone include maidencane, sand cordgrass, yellow-eyed grass, saw grass, coinwort, and pennywort. At the wetland edge some wax myrtle was present. A single clump of Brazilian pepper was located within the wetland. The majority of the uplands are pine

flatwoods, with the exception of a live oak/cabbage palm dominated hammock that appears to provide a connection to Wetlands 5A and 6A.

This wetland is located within areas mapped as hydric soils. The hydrology of this system is healthy, however, it is adjacent to the FPL easement swale, which impounds water. At this location, there is a large open water area in the FPL swale that appears too deep to support any hydrophytic vegetation. An immature Bald Eagle was observed perched in the FPL easement adjacent to this wetland.

<u>WL 8A (FLUCFCS 641; 14.0 acres)</u>
This large, high quality wetland is the main fragment that comprised the historical slough that traversed this area flowing towards the Myakka River. There is a braided channel that starts at the eastern edge of Wetland 3B with widths varying from a few feet to more than 15-feet that flows east. The channel has clearly defined banks throughout much of this area. However, before reaching the FPL easement, the channel opens into this large, open wetland. Little wetland vegetation exists. Live oaks dominate the canopy, with cabbage palm more prevalent along the wetland edges. The understory is mostly open with no shrub layer and minimal herbaceous layer. Some herbaceous species are found on the tree hummocks, but generally vegetation is lacking. There are four (4) culverts that drain under the FPL and connect Wetland 8A to Wetland 1A. This wetland along its entire length is mapped over Holopaw fine sand, depressional soils, a listed hydric soil for both the state and federal level.

<u>WL 9A (FLUCFCS 641; 7.7 acres)</u>
Wetland 9A is a high quality, isolated system surrounded by pine flatwoods to the north and hardwood-conifer mixed to the south. This wetland appears to have been historically isolated, surrounded by Pineda fine sand, which are typically found in association with pine flatwoods, consistent with the current conditions. This wetland contains both a forested and shrub component. The dominant canopy species is pop ash. Additional species present within this system include wax myrtle, buttonbush, St. John's wort, yellow-eyed grass, lance-leaf arrowhead (*Sagittaria lancifolia*), sand cordgrass, some red maple, beakrush, pickerelweed, sawgrass, coinwort, lemon water-hyssop, umbrella grass, rosy camphorweed, and iris. This wetland receives water from the surrounding uplands discharging to the flow south and east. However, the road to the south and west of this wetland is raised and graded, which prohibits water from sheet flowing in its natural direction towards the Myakka River.

<u>WL 1B (FLUCFCS 560; 1.7 acres)</u>
Wetland 1B is abutting Wetland 1A to the west. A north-south primitive road divides the two wetlands, which causes impounding of water and temporary dispersement of the meandering flow-way. Both the flow-ways that are present in Wetland 1A are also present in Wetland 1B and the linear flow-way remains unchanged. The meandering flow-way of Wetland 1B, however, is a defined channel through pine flatwoods with no inclusion of upland islands. The channel was approximately 3-4 feet deep and 5-10 feet

wide. The flow-way is primarily non-vegetated, although pop ash, cabbage palm, Carolina willow, and buttonbush are scattered along the banks and periodic floodplain of the wetland.

The *Sarasota County Soil Survey* (1991) maps the soils for this wetland and its surrounding uplands as Felda and Pompano fine sands, frequently flooded, which was supported by field observation of soil inundation at surface. Wildlife observations include pig rooting, wallows and trails and wading birds. The buffer immediately adjacent to WL-1B is dominated by pine flatwood species, including slash pine and saw palmetto, with laurel oak and cabbage palm also present. Overall, the quality of WL-1B is high.

<u>WL-2B (FLUCCS 641; 6.3 acres)</u>
This depressional basin is within an historical slough complex that is the remnant of the former flow-way between the original Cow Pen Slough and the Myakka River as depicted on the 1948 aerial photograph. Wetland 2B (WL 2B) is located approximately 200 feet north of a manmade canal and currently exists as a shrub system dominated by buttonbush, wax myrtle, pop ash, carolina willow, and scattered laurel oak. The understory is comprised of smartweed, soft bulrush (*Scirpus* sp), pickerelweed, and bull paspalum grass (*Paspalum boscianum).* Maidencane and sand cord grass are present along the fringe of the wetland.

The buffer adjacent to WL-2B consists of a mesic cabbage palm hammock with isolated live oak trees and wild coffee shrubs in the understory. This mesic hammock is located to the north of the WL-2B with connection to WL-3B. An extensive pine flatwood area is present south and east of the wetland. St Andrew’s cross (*Hypericum hypericoides)* and broomgrass are prevalent in the groundcover.

The *Soil Survey of Sarasota County* (1991) identifies the soils for this wetland as Delray fine sand depressional, a county-listed hydric soil. The description for this soil type states that it is poorly drained, often found in depressions within flatwoods. Although the soil within WL-2B has been subjected to historical alteration by decades of drainage activities, this description is further supported by the field observation of soil saturation at surface.

Wildlife activities were observed within the wetland at time of the field activities including foraging by an osprey and wading birds. In addition, deer tracks and other mammal trails were observed through the system. The wetland provides adequate opportunity for wildlife habitat for foraging potential, floodwater attenuation, and sediment or nutrient filtration.

<u>WL-3B (FLUCCS 643/641; 3.6 acres)</u>
Similar to WL-2B, this wetland is high quality and is a remnant of the former slough system. A drainage swale provides flow-through hydrology for this wetland and may be the remnant channel for the historical slough. A narrow herbaceous dominated inundated

swale connects two depressional basins. The two basins are freshwater marshes with distinct zonation of an inner core of buttonbush and carolina willow, and an intermediate zone of herbaceous species such as cattail (*Typha latifolia),* flatsedge, and lance leaf arrowhead. The outer rim of this system as well as the connecting swale is a wet prairie dominated by herbaceous species such as maidencane, Southern blueflag iris*,* bull paspalum and water-hyssop.

As described above, a mesic cabbage palm hammock buffer connects this system to WL-2B to the south. This system grades into a large upland mixed forest dominated by live oak, cabbage palm, slash pine, saw palmetto and wax myrtle. No indication of recent disturbance is present.

Soils within this wetland are similar to those present in WL-1, and are also mapped as Delray fine sand, depressional in the *Soil Survey of Sarasota County* (1991). Observations of the soils during the field event support this soil description. The soil is sufficiently supporting hydrophytic vegetation as the hydrology to this system appears stable.

Potential wildlife utilization within the wetland and buffer system is high. As discussed previously, no Bald Eagle nests are known to be within two (2) miles of the site; however, eagles could potentially utilize the area for foraging. This system can adequately support wading birds and also large and small mammals. Wildlife observations include deer and feral pig tracks and trails.

WL 4B (FLUCFCS 641; 1.9 acres)

Wetland 4B is a high quality wetland located in the southwestern portion of the Myakka Connector site. This wetland is connected to Wetland 3B via a small channel, which coincides with the mapped Delray fine sand, depressional soil series according to the *Soil Survey of Sarasota County* (1991). This wetland was part of the large, historic slough system that drained toward the Myakka River, and which is still present, though reduced in size. The immediate uplands around this wetland are live oak/cabbage palm hammock, surrounded by pine flatwoods. Species typical in this system include St. John's wort, wax myrtle, smartweed, beakrush, lemon water-hyssop, and Baldwin's spikerush. Several trees are located at wetland fringe including laurel oak, cabbage palm, and red maple. Potential wildlife usage is high including wading birds, amphibians, reptiles and small mammals.

WL 5B (FLUCFCS 641; 0.2 acres)

Wetland 5B is a small, moderate quality herbaceous wetland which transitions into a hydric-mesic hardwood swamp. Typical vegetation within this system includes wax myrtle, beakrush, Baldwin's spikerush, torpedo grass, bulrush, smartweed, maidencane, pennywort, watergrass (*Axonopus furcatus*), and dayflower with patchy cover by laurel oak, cabbage palm, American elm (*Ulmus americana*), and red maple. This wetland transitions into a cabbage palm hammock to the north, east and west, with pine flatwoods to the south. Some Brazilian pepper was identified in the buffer at the edge of the wetland. A fire break is located immediately adjacent to the east and hinders the flow of water. Improved pastures are located within 50-feet to the west of this wetland across a fence, which is heavily grazed. A Snowy Egret was observed using this marsh. In addition, tracks were found for pigs, and several songbirds and a squirrel *(Scirpus* sp.) were sighted.

3.3.3 Wildlife

A database search was conducted for listed species potentially occurring on the Myakka Connector (Exhibit 10). The wetlands onsite may be used for foraging and loafing by several species of wading birds, including the state-listed Little Blue Heron, White Ibis, Snowy Egret, and Wood Stork. All are state-listed SSC, except for the Wood Stork, which is a state and federal endangered species. No suitable nesting habitat is found onsite. Limited opportunity exists for the state-listed Florida Sandhill Crane because of the closed canopy typical of most of this area. Although no colonies containing Wood Storks occur within the vicinity of the project area, the project area does occur within the 18.6-mile CFA of at least one (1) colony as defined in the draft *Standard Local Operating Procedures for Endangered Species (SLOPES) - Wood Storks* (28 June 2002) published by the U.S. Fish and Wildlife Service. No Bald Eagle nests are documented as occurring within one (1) mile of this site. However, a nest was observed in a slash pine, but it appeared to be unfinished (or old) and no eagles were seen to utilize it. Other wildlife searches included the Florida Scrub-jay, which has no documented territories within a two-mile radius of the site.

In addition, habitats do exist onsite for the federal and state threatened Eastern indigo snake and the state-listed gopher tortoise (SSC). The Eastern indigo snake is a habitat generalist, which is found in a wide-range of habitats, though none were observed during fieldwork. Sufficient habitat does exist for the gopher tortoise in the pine flatwoods and mixed hardwood-conifer forests. The water table in this area is relatively high, which may limit the ability of tortoises to use this area. Probabilities of gopher tortoises occurring onsite are moderate due to the presence of moderately suitable habitat, but surveys would be required to make a final statement on their presence or lack thereof. Wildlife observed during BRA’s preliminary wildlife survey is documented in the specific land use/wetland descriptions above.

3.3.4 Uniform Mitigation Assessment Methodology

The UMAM sheets for each wetland within the Myakka Connector site are included as Exhibit 18. COE datasheets are provided as Exhibit 19. These datasheets will be used by COE staff to assess each wetland during COE permitting.

3.4 Venice Minerals Current Land Use

A land use map (Exhibit 20) was created by BRA based on the FLUCFCS. Descriptions of each habitat type are provided below. All provided acreages are approximate as they are based on aerial interpretation and not surveyed habitat delineations. A preliminary wildlife survey, including pedestrian and vehicle transects, was also conducted and the results follow the habitat assessments.

3.4.1 Uplands

Wax Myrtle Shrub (FLUCFCS 3201; 13.8 acres)
This land use area was permitted (ERP No. 458405.00 and EM No. 483) as a transitional wetland, however it now exists as an upland buffer area. The shrub layer is almost exclusively wax myrtle with an understory of broomsedge. No hydric soil indicators are present.

Pine Flatwoods (FLUCFCS 411; 73.1 acres)
The majority of the uplands onsite are mapped as pine flatwoods, with a dominant canopy of slash pine. Typical understory species include saw palmetto, gallberry, some wax myrtle, and grape vine.

Recharge Ditch (FLUCFCS 505; 3.7 acres)
A large ditch which surrounds the Venice Minerals mining operation was installed several decades ago and exists along the western boundary of the property. The ditch has severely drained the southern wetlands, however, the large mitigation area was designed to receive water from the ditch and direct it offsite to the east towards the Myakka River.

Roads and Highways (FLUCFCS 8145; 2.7 acres)
A graded and drained road follows the recharge ditch along the western extent of the property.

Electrical Power Transmissions Lines (FLUCFCS 832; 3.2 acres)
The FPL transmission lines run north-south through the eastern portion of this parcel. There are several culverts located under the easement toward the south end of the parcel where the slough drains towards the Myakka River. However, sufficient culvert crossings appear to be lacking, and the ditches on either side of the FPL easement berm water within the wetlands. The FPL easement does not hinder wildlife movement, and the culverts do allow for movement of fish and other aquatic wildlife.

3.4.2 Wetlands

WL 1A (FLUCFCS 641; 1.7 acres)
This small depressional basin is a mitigation site for previous impacts associated with Venice Minerals (Exhibit 23). The 1948 aerial does not indicate the existence of a wetland at the present location. The wetland is dominated by herbaceous species with

dominant zones relative to the depth of water within the inundation. The center of the system is dominated by pickerelweed and grassy arrowhead (*Sagittaria graminea).* Open water is present in the center of the wetland. An inner rim is present at the shallow inundation and consists of herbaceous emergent species dominated by maidencane grass and large-headed rush (*Juncus megacephalus*), with a ground cover of water hyssops and the invasive exotic alligatorweed (*Alternanthera philoxeroides).* A transitional fringe of wax myrtle surrounds the outer fringe of the basin.

Soils appear to have been disturbed and are in transition to developing more hydric indicators, characteristic of created wetland mitigation. The *Soil Survey of Sarasota County* (1991) maps the soils for this wetland as Malabar fine sand, a county-listed hydric soil. The description for the Malabar fine sand unit states that it is poorly drained, often found in poorly defined drainage ways and sloughs. This description is further supported by the field observation of soil saturation at surface.

Wildlife observations include wading birds, amphibians, songbirds and small fish. The buffer around the wetland is extensive; however, an active surface mine is within 500 feet. The system provides nesting and foraging habitat for wildlife. A known eagle nest (SA023) is located 2.5 miles south of the wetland, however, adjacent to the south side of Laurel Road. Although no eagles were observed during field activities, the wetland could be used for foraging habitat by eagles. With the exception of wading birds, no other listed species are known to be within this system or immediately adjacent lands. The hydrology appears stable and adequate to sustain healthy hydrophytic vegetation. The vegetation did not appear stressed and no recent disturbance was observed. Overall, the quality of WL 1A is high.

The buffer immediately adjacent to WL-1A consists of a mesic to upland dominated by wax myrtle, laurel oak, saltbush (*Baccharis halimifolia),* and saw palmetto. Ground cover consists of carpet grass and broomgrass. Soils consist of fine sand lacking hydric characteristics. This is further supported in the *Sarasota County Soil Survey* (1991) as they are identified as Pineda fine sand, a non-hydric soil unit.

WL 2A (FLUCFCS 631/641; 5.1 acres)
This depressional basin is shown on the 1948 aerial and therefore is assumed to be a natural system. It is dominated by shrubby vegetation such as wax myrtle, St. John's wort, gallberry, stagger-bush (*Lyonia lucida)*, with a ground cover of herbaceous species such chalky broomgrass *(Andropogon capillipes),* pipewort (*Eriocaulon compressum),* yellow-eyed grass and pink sundew (*Drosera capillaris).* Toward the center of the system where the inundation becomes significantly deeper, the zone of vegetation changes to that dominated by emergent herbaceous species including pickerelweed, grassy arrowhead and cattails (*Typha dominigensis).*

Soils within this wetland are indicated as Holopaw fine sand, a listed hydric soil for Sarasota County. It is described in the *Soil Survey of Sarasota County* (1991) as being a poorly drained soil found in depressions. Field observations support this description as hydric characteristics are present.

The buffer to the south of the system is fragmented by an elevated road and an associated ditch located within a disturbed upland scrub habitat. Active mining is within 200 feet to the south. However, there is extensive undisturbed buffer to the west, north and east that provides non-fragmented land tracts including wetlands, mesic and upland habitats. Immediately surrounding WL 2A is a mesic plant community that connects to WL 1A and WL 3A. The dominant vegetation is wax myrtle, laurel oak, live oak, and cabbage palm.

Wildlife utilization within the wetland and buffer system is high. As discussed previously, no Bald Eagle's nest is known to be within 2 miles of the site; however, eagles could potentially utilize the area for foraging. Wildlife observations included a Great Blue Heron, songbirds, as well as sign of White-tailed deer and wild pigs.

Overall quality of the WL 2A is considered moderate to high. The system appears stable with good species diversity, natural hydrology, and a minor presence of invasive nuisance or exotic species, and good wildlife usage potential. The buffer is extensive with the exception of the road and berm that represents the only disturbance to the system.

<u>WL 3A (FLUCFCS 631/641; 4.2 acres)</u>
Similar to WL 1A, this small depressional basin is a previously permitted mitigation site as it is not shown as a wetland on the 1948 aerial. This inundated system also has a deeper inner zone that is dominated by herbaceous emergent species such as pickerelweed and grassy arrowhead. Surrounding this inner core is a shrubby and herbaceous zone dominated by St. John's wort, sand cordgrass and cattails. Ground cover herbaceous vegetation includes Asian coinwort, pennywort and water hyssop. Wax myrtle, water primrose (*Ludwigia octovalvis),* and yellow-eyed grass are present along the outer transitional fringe ring along the edge.

The buffer of the wetland is predominantly a mesic plant community with wax myrtle and slash pine comprising the dominant vegetation in the tree and shrub strata. Ground cover is dominated by broomgrass and flat-topped goldenrod (*Euthamia minor).* The buffer to the west connects to WL-2A and to additional wetlands to the east. The buffer is extensive for several hundred feet in all directions with exception of the southeast where an access road is located less than 100 feet from the wetland edge. An active mine is to the south of the road.

Soils are mapped as Pineda fine sand, a soil that often includes hydric units within it. It is classified as a poorly drained soil that is found on low hammocks and in broad, poorly defined sloughs. Although it is not considered a hydric soil unit, some of the inclusions found within the unit are often hydric soils. Field observations indicate that the soils are in transition to hydric from the created mitigation site.

Wildlife utilization is similar to both WL 1A and WL 2A in that no nesting was observed; however, wading birds, amphibians, and small mammal tracks/scat were observed. Red-shouldered Hawks *(Buteo lineatus)* were observed during field activities. The presence of an eagle nest located approximately 2 miles to the south suggests this wetland system is potential foraging habitat. The overall quality of the wetland is high. The vegetation species diversity is good, however, the overall system is small. The hydrology of this mitigated site is stable, but soils are still in hydric development and indicate progress toward a healthy, sustainable wetland system.

WL 1B (FLUCFCS 641; 31.9 acres)

Wetland 1B is a created freshwater marsh characterized by broom grass, sand cordgrass, water pennywort, wax myrtle, maidencane, smartweed *(Polygonum densiflorum),* marsh fleabane, assorted sedges, jointed spikerush *(Eleocharis interstincta*), St John's wort, pickerelweed, duck potato, tufted foxtail (*Aloperius carolinianus*), laurel oak, water hyssop and dogfennel. Scattered cattails were also observed.

Overall, this wetland is diverse and does not appear to have significantly altered hydrology. In addition, this wetland is hydrologically connected to other on-site wetlands and is surrounded by a high quality upland buffer. Venice Minerals is located to the west and an FPL easement is located on the east. The remaining uplands however, are part of a continuous mix of habitats which continue to the Myakka River. This continuum provides good habitat for wildlife and allows free movement from the wetlands to the surrounding uplands. The upland areas on site are characterized by cabbage palm, gallberry, slash pine, saw palmetto and live oak. Based on the above observations, this would be rated as a high quality wetland.

No threatened or endangered species were observed during the surveys of the Venice Minerals site. However, a Bald Eagle nest is located less than 3 miles away. It does not appear that any Wood Stork nest within a 10 mile radius of the subject property. However, this property is within the 18.6-mile foraging radius of 2 nests. The upland areas on site are characterized by slash pine and thick saw palmetto. While the upland areas may be too dense to be ideal gopher tortoise habitat, gopher tortoises may be present onsite, but none was observed in the initial survey.

WL 2B (FLUCFCS 641; 3.2 acres)

Wetland 2B is a naturally occurring freshwater marsh characterized by sand cord grass, wax myrtle, maidencane, smartweed, marsh fleabane, assorted sedges, jointed spikerush, St John's wort, red root, pickerelweed, duck potato, water hyssop, coinwort, buttonbush, dogfennel. There is a buttonbush core and good zonation. There is no evidence of nuisance or exotic vegetation in this wetland.

Overall, this wetland is diverse and does not appear to have significantly altered hydrology. In addition, this wetland is hydrologically connected to other on-site wetlands and is surrounded by a high quality upland buffer. There is existing overland flow to Wetland 3B. Venice Minerals is located to the west and an FPL easement is located on the east. The remaining uplands however, are part of a continuous mix of habitats which continue to the Myakka River. This continuum provides good habitat for wildlife and allows free movement from the wetlands to the surrounding uplands. The upland areas on site are characterized by cabbage palm, gallberry, slash pine, saw palmetto, live oak, and laurel oak. Based on the above observations, this would be rated as a high quality wetland.

No threatened or endangered species were observed during the surveys of the Venice Minerals site. However, a Bald Eagle nest is located less than 3 miles away. It does not appear that any Wood Stork nest within a 10 mile radius of the subject property. However, this property is within the 18.6-mile foraging radius of 2 nests. The upland areas on site are characterized by slash pine and thick saw palmetto. While the upland areas may be too dense to be ideal gopher tortoise habitat, gopher tortoises may be present onsite. But, none were observed in the initial survey.

<u>WL 3B (FLUCFCS 641; 5.3 acres)</u>

Wetland 3B is a naturally occurring freshwater marsh characterized by broom grass, water pennywort, wax myrtle, maidencane, jointed spikerush, St John's wort, red root, duck potato. There is a small core dominated by fire flag, buttonbush, and pickerelweed. No evidence of nuisance or exotic vegetation was seen during the initial survey. This wetland is diverse and shows good zonation.

Overall, this wetland is diverse and does not appear to have significantly altered hydrology. In addition, this wetland is hydrologically connected to other on-site wetlands and is surrounded by a high quality upland buffer. There is existing overland flow to Wetland 2B. Venice Minerals is located to the west and an FPL easement is located on the east. The remaining uplands however, are part of a continuous mix of habitats which continue to the Myakka River. This continuum provides good habitat for wildlife and allows free movement from the wetlands to the surrounding uplands. The upland areas on site are characterized by cabbage palm, gallberry, slash pine, and saw palmetto. Based on the above observations, this would be rated as a high quality wetland.

No threatened or endangered species were observed during the surveys of the Venice Minerals site. However, a Bald Eagle nest is located less than 3 miles away. It does not appear that any Wood Stork nest within a 10 mile radius of the subject property. However, this property is within the 18.6-mile foraging radius of 2 nests. The upland areas on site are characterized by slash pine and thick saw palmetto. While the upland areas may be too dense to be ideal gopher tortoise habitat, gopher tortoises may be present onsite, but none were observed in the initial survey.

<u>WL 4B (FLUCFCS 631; 0.9 acres)</u>

Wetland 4B is a wetland scrub system characterized by sand cord grass, wax myrtle, maidencane, smartweed, jointed St John's wort, red root, floating hearts (*Nymphoides cordata*), coinwort, water dropwort (*Oxypolis filiformis*) water pennywort, slash pine and assorted sedges. Patches of 15-ft punk tree (*Melaleuca quinquenervia)* were observed. No other signs of nuisance or exotic vegetation were noted during the survey. There was no well-defined core to this wetland.

Overall, this wetland is diverse and does not appear to have significantly altered hydrology. In addition, this wetland is hydrologically connected to other on-site wetlands and is surrounded by a high quality upland buffer. There is existing overland flow to Wetland 2B. The major concern in this wetland is the presence of *Melaleuca* and the potential for its spread. Venice Minerals is located to the west and an FPL easement is located on the east. The remaining uplands however, are part of a continuous mix of habitats which continue to the Myakka River. This continuum provides good habitat for wildlife and allows free movement from the wetlands to the surrounding uplands. The upland areas on site are characterized by cabbage palm, gallberry, slash pine, and saw palmetto. Based on the above observations, this would be rated as a high quality wetland.

No threatened or endangered species were observed during the surveys of the Venice Minerals site. However, a Bald Eagle nest is located less than 3 miles away. It does not appear that any Wood Stork nest within a 10 mile radius of the subject property. However, this property is within the 18.6-mile foraging radius of 2 nests. The upland areas on site are characterized by slash pine and thick saw palmetto. While the upland areas may be too dense to be ideal gopher tortoise habitat, gopher tortoises may be present onsite, but none were observed in the initial survey.

WL 1C (FLUCFCS 641; 4.2 acres)

Wetland 1C is a freshwater marsh located approximately 300 feet east of the mining operation within the Myakka River watershed. This moderate quality wetland has little standing water, is bisected by a road to the south, and, therefore, has no hydrologic connection to the offsite southern wetland. The remnant wetland to the south is isolated and offsite. The Venetian Golf and River Club is south of the road, and there is a swale between the road and the wetland. To the north, east and west of the wetland are pine flatwood areas.

This wetland has three distinct zones. The core of the wetland consists of buttonbush, maidencane, pickerelweed, broomsedge, and hemp vine. The middle zone consists of dogfennel, St. Johns wort, spike rush, broomsedge, and wax myrtle. The outer most zone consists of wax myrtle, broomsedge, dogfennel, slash pine, torpedograss and Brazilian pepper. The immediately surrounding uplands consist of a hard saw palmetto outer edge with scattered pine (*Pinus* spp.).

Wetland functions include small mammal feeding, water storage and filtration. The anticipated wildlife utilization is by wading birds, insects, amphibians, small reptiles and small/medium mammals. Wading birds expected to utilize this wetland are listed, these include: Little Blue Heron (SSC), White Ibis (SSC), Snowy Egret (SSC), and Wood stork (E). Evidence of wildlife observed were pig and raccoon tracks and pig wallows.

WL 2C (FLUCFCS 641; 0.5 acres)

Wetland 2C is a freshwater marsh located approximately 1200 feet east of the mining activities and is within the Myakka River watershed. (This moderate quality, remnant wetland has no standing water; it is connected to a ditch that runs parallel on the wetland's eastern edge. East of the ditch is the FPL easement. The majority of the wetland is east of the easement.) A culvert under the road connects the two portions of the wetland. The Venetian Golf and River Club subdivision is south of this wetland. To the north and west of this wetland are pine flatwood areas.

This wetland has no zonation. The vegetation that dominates this wetland is smartweed, sawgrass, sand cordgrass, buttonbush, redroot, wax myrtle, Carolina willow with a small amount of arrowhead and primrose willow. The surrounding uplands consist of saw palmetto and scattered pine to the west and north of the wetland, and a large ditch and dirt road to the east of the wetland.

This wetland is significantly more degraded than the other onsite wetlands. Functions include small mammal feeding, water storage and filtration. The anticipated wildlife utilization is by wading birds, insects, amphibians, small reptiles and small/medium mammals. Wading birds expected to utilize this wetland are listed, these include: Little Blue Heron (SSC), White Ibis (SSC), Snowy Egret (SSC), and Wood Stork (E). No evidence of wildlife was observed.

WL 3C (FLUCFCS 6311; 0.6 acres)

Wetland 3C is a disturbed shrub wetland located approximately 600 feet north and west of the mining activity and within the Myakka River watershed. This moderate quality wetland has a shallow swale on the western edge and has very little standing water. It has a cabbage palm hammock on the northwest corner which appears to be a historical flow way. To the east is an FPL easement, and about 1400 feet to the south is the Venetian Golf and River Club subdivision. This wetland has no hydrologic connection to the northwest wetland (WL 4C). To the north, south, east, and west are pine flatwood areas.

The zonation of this wetland is poor, but it appears to have two zones. The core of the wetland consists of popash, cattail, smartweed, hemp vine, dandelion (*Taraxacum* spp.), Carolina willow and Brazilian pepper. The outer zone consists of Brazilian pepper, wax myrtle, salt bush, musky mint, dogfennel, and sawgrass. The surrounding uplands consist of saw palmetto, scattered cabbage palm, and scattered pine to the north, south, east, and west of the wetland.

This wetland is similar to Wetland 1C in function, which includes small mammal feeding, water storage and filtration. The anticipated wildlife utilization is by wading birds, insects, amphibians, small reptiles and small/medium mammals. Wading birds expected to utilize this wetland are listed, including: Little Blue Heron (SSC), White Ibis (SSC), Snowy Egret (SSC), and Wood stork (E). Evidence of wildlife observed was pig rooting. Observed wildlife includes Bald Eagle, hawk and vulture flyovers, and apple snails were observed on the ground.

WL 4C (FLUCFCS 6311; 0.4 acres)
Wetland 4C is a disturbed shrub wetland located approximately 400 feet north and west of mining activity and within the Myakka River watershed. This moderate quality wetland has no standing water. It has a cabbage palm hammock on the southeast corner which appears to be a historical flow way. To the east is an FPL easement, and approximately 1600 feet to the south is the Venetian Golf and River Club subdivision. This wetland has no hydrologic connection to the southeast wetland (WL 3C). To the north, south, east, and west are pine flatwood areas.

The zonation of this wetland is poor, but appears to have two zones. The core of the wetland consists of popash, cattails, sand cordgrass and Carolina willow. The outer zone consists of dogfennel, wax myrtle, frog fruit, sugarcane (*Saccharum officinarum*), Brazilian pepper and plume grass (*Erianthus* spp.). The surrounding uplands consist of saw palmetto, scattered pine, and scattered cabbage palm to the north, south, east, and west of the wetland.

This wetland is similar to wetland 1C in function, which includes small mammal feeding, water storage and filtration. The anticipated wildlife utilization is by wading birds, insects, amphibians, small reptiles and small/medium mammals. Wading birds expected to utilize this wetland are listed, these include: Little Blue Heron (SSC), White Ibis (SSC), Snowy Egret (SSC), and Wood Stork (E). Evidence of wildlife included pig and raccoon tracks and pig wallows.

3.4.3 Wildlife

A database search was conducted for possible listed species present on the Venice Minerals site (Exhibit 10). Although the wetlands do have the potential for several species of wading bird utilization, the closest documented colony is over two miles away. The closest Bald Eagles' nest is approximately 6,000 feet to the north on the Pinelands property. The closest Florida Scrub-jay habitat appears to be approximately 2734 meters away. Other wildlife searches included the Wood Stork, which have does not have documented territories or colonies within a two-mile radius of the site. Wildlife observed during the preliminary wildlife survey is documented in the specific land use/wetland descriptions above.

3.4.4 Uniform Mitigation Assessment Methodology

The UMAM sheets for each Venice Minerals wetland are included as Exhibit 22. COE datasheets are provided as Exhibit 23. These datasheets will be used by COE staff to assess each wetland during COE permitting.

3.5 Mitigation Alternative Analysis

To assess potential mitigation scenarios within the Dona Bay watershed, the 1948 wetland limits were superimposed on the current 2005 wetland limits to graphically evaluate how each property has changed in the last 60 years (Exhibits 24-27). The acreages were used as a baseline to determine the cost and benefit of returning the site to its historical condition. TM 4.1.5 – Alternative Impact Analysis presents the summary of this effort for each of the four (4) properties.

LIST OF EXHIBITS (previously provided and loaded onto the FTP site)

Exhibit 1: aerial_36x48_darb_r1
Exhibit 2: albritton_1948lu
Exhibit 3: cow_1948_lu_r3
Exhibit 4: gp_48_lu_r1
Exhibit 5: vm_48_lu_r1
Exhibit 6: alb_landuse_r2
Exhibit 7: Albritton 3 October 2005 SWFWMD JD Verification Letter
Exhibit 8: Albritton COE Letter
Exhibit 9: albritton_jd
Exhibit 10: dona_listed-basin_r2
Exhibit 11: Albritton UMAM sheets and Calculation Summary
Exhibit 12: cow_flucfcs_r3
Exhibit 13: cow_jd_r3
Exhibit 14: WP UMAM sheets and Calculation Summary
Exhibit 15: WP COE Datasheets
Exhibit 16: gp_fluc_r3
Exhibit 17: gp_jd_r3
Exhibit 18: MC UMAM sheets and Calculation Summary
Exhibit 19: MC COE Datasheets
Exhibit 20: vm_fluc_r1
Exhibit 21: vm_jd_r3
Exhibit 22: VM UMAM sheets and Calculation Summary
Exhibit 23: VM COE Datasheets
Exhibit 24: alb_enhance-restore
Exhibit 25: cow_enhance_restore_r3
Exhibit 26: gp_enhance_restore_r2
Exhibit 27: vm_enhance_restore

TM 4.1.4 - EVALUATION OF RESTORATION/ENHANCEMENT VALUE

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and Southwest Florida Water Management District (SWFWMD), is currently completing the pre-requisite data collection and analysis and comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), EarthBalance®, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan, and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay Watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay Watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with and support other plan objectives.

This Technical Memorandum has been prepared by EarthBalance® to estimate the wetland and hammock mitigation credit potential and associated costs of three potential projects associated with the DBWMP, pursuant to Task 4.1.4 of the DBWMP contract. The purpose of the analysis is to determine if any of the potential projects would be appropriate as a mitigation bank and further, to determine the overall feasibility of establishing a mitigation bank in the Southern Coastal Basin.

2.0 INTRODUCTION

The Albritton site and the Cow Pen Slough corridor within public ownership (West Pinelands) may provide an opportunity to leverage habitat restoration value for private property habitat impacts within the Southern Coastal Basin. This task proposes to evaluate the feasibility of leveraging mitigation credits created by potential restoration and enhancement pursuant to state rules, and credits for upland mesic hammocks to satisfy local requirements. The work from this task will allow the County to consider the feasibility of such a mitigation proposal.

This task includes the following basic elements:

- Estimate ranges of credit for the three alternate mitigation projects using the State's Uniform Mitigation Assessment Methodology (UMAM) rule for wetlands and acreage ratios for uplands
- Provide recommendations to help optimize credit generation with preliminary cost estimates of restoration
- Evaluate the potential for establishing a wetland mitigation bank for the Southern Coastal Basin of SWFWMD

Specifically, EarthBalance® biologists have determined the feasibility, constraints, costs, and potential mitigation value of three potential projects: restoring and enhancing wetlands in the West Pinelands; and restoring and enhancing wetlands and preserving upland habitat associated with Albritton Reservoir Alternatives 2 and 3 (ARA2) and (ARA3). This report has been divided into four main sections that address the scope of work. The first three sections discuss the mitigation potential, costs, constraints/optimization, and recommended actions for each of the three potential mitigation projects. A final section addresses mitigation banking potential in the Southern Coastal Basin.

2.1 SCOPE OF WORK

EarthBalance® has collected data from the field and GIS databases that have been used to assess the mitigation value of the three potential mitigation designs determined as conceptually feasible by the project team. To determine mitigation feasibility and potential mitigation credits, the following tasks were completed.

<u>Research/ Field Preparation:</u>

- Acquire and review electronic versions of alternative mitigation parcels from the project team
- Research databases for GIS information on soils, wildlife, targeted lands, water quality, ownership, land use plans, and other relevant information for the targeted site(s) and the surrounding area
- Acquire and review aerial imagery including recent true color, 1996-2004 infrared, and historical aerial series
- Acquire and review site specific survey information for CPS control structures
- Obtain and review SWFWMD one-foot topography in digital form

Selected graphics from the GIS research are provided as Figures 1 through 4 at the end of this report. These provide a good general overview of the landscape setting where the three project areas are located.

<u>Field Work:</u>

- Perform field surveys of potential mitigation sites to review wetland extents and habitat maps prepared by the project team.
- Assess conditions of upland and wetland habitats with specific emphasis on impacts and their sources to determine feasible restoration measures
- Determine mitigation assessment area (AA) configuration
- Review baseline field datasheets for each AA to assist in the UMAM analysis
- Analyze field data and make comparisons with historic data and research findings

For each of the three potential mitigation areas, results of the field work are summarized in the Existing Conditions sections. Based on an analysis of the field work, a review of other project team information, and project team meetings, a conceptual work plan is described in the Mitigation Plan sections.

Preparing the UMAM analysis involved field data reduction and analysis of existing habitat conditions as well as the assessment of restoration needs within targeted mitigation areas. In addition, future uses of adjacent properties were assessed to determine compatibility of restoration activities. An understanding of current habitat impacts, achievable restoration goals, and future land use considerations was used to perform a UMAM analysis on each mitigation area to determine credit potential. The following is a breakdown of major task activities:

- Determine restoration needs of the three potential mitigation areas
- Assess the degree to which habitats can be reasonably restored given adjacent land uses and natural or man-made constraints
- Assess the current and future condition and uses of surrounding land
- Review the UMAM analysis of the current condition provided by the project team for all AAs
- Perform UMAM analysis on enhanced/restored/preserved condition of AAs
- Prepare draft UMAM scoring rationale text (datasheets not appropriate at this stage)
- Prepare UMAM credit potential tables for the three mitigation areas

The estimates of potential mitigation credits and a summary of scoring rationale are provided in the Potential Mitigation Credit Generation section for each potential mitigation project.

An estimate of the costs to achieve the potential mitigation credits is provided in the Estimated Mitigation Costs sections. The focus to this point is maximizing credit potential. By developing cost estimates of the restoration activities, cost/benefit analyses can be performed in future phases of the project. The following mitigation cost factors will be estimated and presented in tabular form:

- Environmental permitting
- Engineering
- Construction
- Restoration

- Bank-specific costs
- Long-term management

The cost estimates proposed are highly dependant on final design related data that is lacking at this point. The cost estimates are very preliminary and tend to be worst-case estimates that will require close scrutiny and refinement as the design proceeds. Avoiding uncertain estimates altogether was contemplated, but it was decided that providing preliminary estimates for review by the project team and County can serve as a starting point for cost refinement.

To summarize each project, sections on Constraints and Optimization as well as Recommended Actions are provided at the end of the discussion on each mitigation project.

In the final section of the report, Mitigation Banking Potential in the Southern Coastal Basin, variables such as credit demand, credit price, permitting considerations, and project phasing are addressed.

3.0 UMAM

The Uniform Mitigation Assessment Method (UMAM) is still a fairly new rule and is just now becoming more standardized in its application. Mathematically, the method is straightforward, but the concepts that drive the scoring of the individual factors can be complicated. Because UMAM is the driving force behind mitigation credit generation, an explanation of the rule and its implementation is summarized below.

UMAM provides a standardized procedure for assessing the functions provided by wetlands and the amount that those functions are reduced by a proposed impact, thereby quantifying the number of UMAM credits required to offset wetland losses. Similarly, the UMAM method is used to calculate the number of mitigation credits generated by mitigation activities such as wetland creation, enhancement, and restoration. The rule also allows the evaluation of uplands for mitigation credit based on the benefits provided to the fish and wildlife of the associated wetlands or other surface waters.

3.1 MECHANICS OF UMAM

UMAM is the mitigation assessment methodology adopted by the State in February 2004. In August 2005, the U.S. Army Corps of Engineers (USACOE) recognized UMAM as an accepted assessment methodology. Application of the UMAM methodology results in an overall wetland score between 0 and 1, with 1 representing full wetland function. Therefore, the overall wetland score can be thought of as a percentage of full function. In simplest terms, UMAM is used to quantify the change in the percentage of value that a wetland provides under either impact or mitigation scenarios. This change is then multiplied by the acreage of the wetland to yield the number of debits or credits. The remainder of this narrative pertains exclusively to the generation of mitigation credits.

The first step in determining the number of credits a mitigation area will yield is to define the assessment area (AA), which is an area of land that is sufficiently homogeneous in character, function, and mitigation benefits to be assessed as a single unit. The applicant describes the AA in detail in the Qualitative Characterization (Chapter 62-345.400, Florida Administrative Code [FAC]) on the Part 1 data form. This critical step provides a frame of reference that is used to identify the community target type of the AA, the wildlife species served by the AA, and the key wetland functions to those species. The AAs must be defined in acres, which are later multiplied by the percent improvement in wetland function to yield the number of mitigation credits generated.

To calculate the percent improvement in wetland function, the UMAM method must be performed on the "with mitigation" and "without mitigation" scenarios. The "with mitigation" scenario is based on the anticipated future condition of the AA with the mitigation plan in place. The "without mitigation" scenario is either the current condition, or, in the case of preservation, the reasonably expected outcome of not preserving the AA.

3.1.1 Scoring

The UMAM scoring methodology is based on a critique of three categories of wetland functions including Location and Landscape Support, Water Environment, and Community Structure. The three UMAM categories are scored on a scale of 0 to 10 based on indicators listed in subsection 62-345.500(6), FAC. The sum of the scores is then divided by 30, resulting in a numerical score between 0 and 1. For uplands, the Water Environment category is not assessed and the sum of the UMAM category scores is divided by 20. Upland AAs are scored based on the benefits provided to fish and wildlife of the associated wetlands or other surface waters. The scoring of each category is driven by how well each AA provides the functions that benefit the fish and wildlife described in the Part 1 data form.

The difference between the UMAM score with the mitigation or preservation plan in place, and the absence of the mitigation or preservation plan is the mitigation delta, or the raw change in the function that a wetland provides. The mitigation delta must then be modified to account for time-lag, risk, and in the case of preservation, a Preservation Adjustment Factor (PAF).

3.1.2 Preservation Adjustment Factor

The Preservation Adjustment Factor (PAF) scoring criteria listed in Chapter 62-345.500(3)(a), FAC, is a numerical score between 0 and 1, scored on one-tenth increments. A score of 0 represents no preservation value while a score of 1 represents maximum preservation value. The preservation AA's mitigation delta is multiplied by the PAF to yield an adjusted mitigation delta. The PAF scoring is based on the applicability and relative significance of the five criteria found in the rules that are paraphrased below.

(1) *Management techniques to promote natural ecological conditions such as fire patterns or the exclusion of invasive exotic species.*

Fire management is critical for a number of native Florida habitats including most upland and wetland habitats. Periodic fire events eliminate the overgrowth of brush and recycle nutrients. As a result of the proximity of development to many mitigation areas, fire management is not feasible. Alternatively, the use of mechanical brush reducing techniques can be successful. Fire management or a surrogate method must be appropriate in fire-dependant communities to optimal conditions.

Nuisance and exotic vegetation control is required at some level throughout Florida, particularly in the southern peninsula. Depending on baseline conditions and surrounding habitat, the level of control is variable but must be sufficient to maintain permit success criteria. Similarly, exotic animal species (such as feral hogs) can be problematic, and should be addressed under this criterion.

To optimally address this criterion, the mitigation project should be accompanied by an appropriate management plan that is enforceable and funded.

(2) *The ecological and hydrological relationship of habitats to be preserved.*

This criterion addresses the appropriateness and compatibility of preserved habitats and how they complement one another. Preservation of a wetland without sufficient surrounding or connected upland habitat can reduce the function of the wetland preserve. However, preservation of a narrow or disturbed pasture around a wetland perimeter may offer little value depending on adjacent upland land use. This criterion also addresses how sheetflow from wetlands or development affects wetland preserves and how wetlands are hydraulically connected.

To address this criterion, preserves should be designed with maximum connectivity between on-site preserves as well as connectivity to off-site preserves. Habitats to be preserved should complement one another.

(3) Th*e scarcity of the habitat provided and the degree to which listed species use the area.*

This criterion assesses the rarity of a habitat to be preserved and unique characteristics or functions that are provided. In general, preservation of common habitats should not be penalized substantially, but scarce habitats would typically be valued higher for preservation. This criterion encourages the applicant to preserve habitats that are scarce or that support listed species.

(4) *The proximity of the site to preserved land, land targeted for preservation, or significant natural resources habitats and the connections between them.*

The ability of a preserve to provide functions in the long term is critically dependant on its location. While some large preserves are somewhat "self-buffering", the value of all preserves is ultimately influenced by the ability of the site to support genetically viable wildlife populations. Migration of populations and gene pools to and from the preserve to adjacent preserves or ecological corridors must be considered when evaluating this criterion.

(5) *Extent and likelihood of adverse impacts if not preserved.*

The alternative use of the proposed preserve is often the most significant factor in determining preservation value. Habitats that are threatened by likely and significant degradation are valued highest, while habitats threatened by unlikely or minor degradation are valued lowest.

The PAF is scored by assessing how well the five criteria are met. Ideally, if all criteria are fully met, the proposed preserve would be worthy of a score of 1. Typically, a preserve cannot completely meet all criteria due to outside constraints (i.e., inability to perform prescribed burning) or the inherent properties of the preserve (i.e., habitat is in need of enhancement). There is no formal guidance on setting intermediate scores, but logically, the significance of the preserve's deficiencies should be assessed on a weighted basis. For example, if a preserve meets all criteria but is not rare, a slight deduction from a perfect score may be appropriate. However, if a proposed preserve is an island that cannot be expected to provide value to terrestrial species over the long term, a very low PAF may be assigned.

3.1.3 Time-Lag

UMAM also takes into account time-lag and risk, which modify the mitigation delta and have a profound effect on the number of mitigation credits generated. Time-lag is an estimate of the length of time between the initiation of the mitigation effort and the realization of the proposed improved condition ("with mitigation" scores). Time-lag and permit timeframes may be different. For example, permit success criteria may require 5 years of monitoring prior to release from monitoring requirements, however, the time-lag period may be 25 years for planted trees to attain the size and coverage necessary to support the proposed "with mitigation" scores.

Restored and enhanced habitats require time to develop hydric soils, microhabitats, and vegetative structure, but to some extent, time-lag can be altered. The use of innovative mitigation techniques or the implementation of an accelerated project schedule could reduce time-lag. Proposing optimal UMAM scores may require long periods of time, but reducing the proposed UMAM scores lowers expectations and reduces the time-lag. Pre-determined time-lag scores (t-factors) are provided in the UMAM rule based on the number of years between mitigation initiation and achievement of the proposed condition (e.g., reaching the “with mitigation” category scores).

There is typically no time-lag involved with preservation because credits are derived from preserving the parcel in its existing condition, and there is no time required for vegetative communities to develop or mature. However, if an immature habitat is proposed for preservation, a time-lag adjustment may be necessary, or alternatively, the “with preservation” scores could be lowered to reflect the existing immature state.

3.1.4 Risk

Risk is a measure of the uncertainty that the proposed condition (reflected in the with mitigation scores) will be achieved and maintained in the long term. Actually, most of the risk score pertains to the sustainability of the mitigation effort beyond the monitoring period required to prove success criteria are met. Mitigation projects that require long periods of time to reach maturity generally involve more risk than those that require shorter time periods.

Six factors specified in Chapter 62-345.600, FAC, including vulnerability to altered hydrologic conditions, vulnerability to sustainability of the desired vegetative community, vulnerability to exotic species, vulnerability to degraded water quality, and the vulnerability of the site to direct and secondary impacts, are analyzed to establish a numeric risk factor between 1 (no risk) and 3 (high risk) based on quarter point increments. Economically sound, innovative techniques can be used to minimize the risk score, however, some externally induced risk will typically remain, such as the threat of secondary impacts from adjacent development.

If no risk factors exist or all are nullified by project modifications, a perfect score of 1 would be appropriate. Similar to PAF scoring, the risk score should be calculated by determining how severely potential risk factors could affect the proposed mitigation. For example, if there is a significant threat of invasion by exotic species from an adjacent disturbed habitat, the risk score may be very high. However, proposing a perpetually funded management plan may significantly reduce the risk score.

Relative Functional Gain

The amount of mitigation credit generated per acre is defined as the Relative Functional Gain (RFG). The RFG is calculated by first determining the mitigation delta (or adjusted mitigation delta in the case of preservation), then dividing the delta by the product of the risk and time-lag. Therefore, the negative effects of high risk or a large t-factor have a compounding effect that reduces mitigation potential. Finally, to determine the potential mitigation credits provided by an AA, the RFG is multiplied by the acreage of the AA.

4.0 WEST PINELANDS

The West Pinelands parcel is a potential linear wetland enhancement and restoration parcel located on the western side of the historical Cow Pen Slough within County-owned lands. The parcel extends for approximately 3.3 miles and is approximately 277 acres. Historically, the parcel was comprised of deep, internal, herbaceous wetland zones and outer, shallow, wet prairie habitat fringed by pine flatwoods and oak hammock. Excavation of a canal through the slough system has lowered water tables resulting in the conversion of shallow wetland habitat to uplands and alteration of the hydroperiod of deeper wetland zones. The parcel is currently preserved and managed, which limits mitigation potential to the enhancement of existing wetlands and the restoration of former wetlands.

A preliminary mitigation plan map, credit estimates, and mitigation cost estimates for the West Pinelands project area are contained as Figure 5, Table 1 and Table 2, respectively at the end of this report..

4.1 WEST PINELANDS - EXISTING CONDITIONS

The entire project area is comprised of historic slough wetlands. The western wetlands and the deeper zones of the slough currently meet the jurisdictional wetland definition but have been altered by the effects of the adjacent canal. Existing wetland habitats are classified predominantly as herbaceous marsh, while there are small amounts of shrubby and forested wetland habitat. Remaining wetlands have highly organic soils, which allow surface waters to perch. However, water levels and hydroperiods are reduced compared to the historic condition, resulting in changes in vegetation composition and zonation and the invasion of nuisance and exotic species. Overall, these wetlands are quite different from the historic condition, but they are still viable wetland habitats. These wetlands are collectively referred to as wetland enhancement areas in the remainder of this section, although enhancement potential of the individual wetlands ranges from 0-12 percent (0-0.12 credits/acre).

Shallower wetland zones closer to the canal have been converted to upland habitats including unimproved pasture and a mix of pine and oak trees with a grassy understory. These habitats have primarily sandy soils, which allow water to percolate quickly to the lowered water table induced by the adjacent canal. In many areas, these former wetlands display evidence of a hydrophytic seed bank, as many wetland grasses and herbs are present in scattered patches. These habitats are collectively referred to as wetland restoration areas in the remainder of this section and have a potential restoration value of approximately 29 percent (0.29 credits/acre).

4.2 WEST PINELANDS - MITIGATION PLAN

In addition to the drawdown of the water table caused by the canal, surface water is shunted from the wetlands to the canal via control structures. Many of the control structures have become washed out or have rusted pipes that allow water to discharge at even lower elevations than the control elevations. In addition, there are 12 breaches in the canal that were created to allow high flows from the canal spill out into the floodplain. Though not created to facilitate discharge to the canal, 7 of the breaches have an invert elevation below the estimated historic wet season water level (WSWL), which allows water to quickly fall with the canal level. At 100 to 200 feet wide, these breaches allow substantial water conveyance of flood waters and prevent long-term ponding at the estimated historic WSWL.

Adding water pumped from the canal to the West Pinelands without changing breach elevations was considered. However, after reviewing topography relative to breach inverts, it appears that very little hydroperiod improvement could be gained. Obviously additional water would help the system, however gains would only be accomplished in the lowest elevations below the breaches. Most of these areas are existing wetlands that have been scored moderately high, therefore, there is little mitigation credit.

To restore historic wetlands, surface water overflow elevations must be raised. Raising the breaches should improve water storage in the wetlands. The control structures could also be raised or eliminated. Because the surrounding property to the west is owned by the County, it is assumed that the breaches can be araised without affecting upstream landowners. However, because flooding is a sensitive issue, it should be the first item considered in a more thorough feasibility study.

Repairing and raising control structure inverts alone will not likely completely restore wetland hydroperiods, but would cause some improvement. Raising all breaches and control structures may have a cumulative beneficial effect, but it is likely that the groundwater drawdown must be addressed to realize substantial hydroperiod improvement. Our experience confirms that groundwater drawdown near deeply incised drainage features substantially affects wetlands particularly early and late in the hydroperiod.

One way to reduce the groundwater drawdown is to construct a slurry wall along the entire 3.3-mile length of canal, however, this in intuitively cost prohibitive. Similarly, lowering all the wetlands in place (vertical relocation) would also be expensive. The project team has decided to explore the implementation of solar pumps to pump water from the canal to the West Pinelands. Several details regarding installation need to be addressed, but assuming that the pumps can be used to replace water lost to the canal to re-create a fairly normal hydroperiod, the project area has been designed and evaluated to determine the maximum credit potential. The following is a list of the major tasks needed to complete the mitigation plan:

- Raise or remove existing control structures.
- Adjust existing canal breaches up or down to increase water storage. Ideally the breaches would be re-established at or near the historic WSWL
- Construct a series of narrow earthen berms to maintain WSWL of restoration "cells."
- Perform initial herbicide treatment.
- Rely on seed bank regeneration in the wetland restoration areas. Supplemental planting of herbaceous wetland vegetation may be required.
- Install approximately eight 10,000-gallons/day solar pumps. Each requires six 56-inches x 26-inches solar panels.
- Perform active management of vegetation and hydroperiods through establishment.

4.3 WEST PINELANDS - POTENTIAL MITIGATION CREDIT

The summary UMAM credit analysis is provided in Table 1 at the end of this report. Baseline scores were provided by the project team. To determine mitigation credit potential, proposed "with mitigation" scores were determined for each enhancement and restoration area. Preservation value was not assessed as the project area is currently in County ownership.

Because these are potential future scores, and the site is very homogenous, a single "with mitigation" score was assigned to all wetland enhancement areas that reflects the proposed condition (i.e., all areas are proposed to have less than 5 percent exotic coverage, etc.). Similarly, the restoration area was assessed as a single assessment area (AA). By rule, baseline UMAM scores for wetland restoration AAs are zero (0).

Below is a summary of the West Pinelands UMAM analysis justification.

4.3.1 Location and Landscape Support

This category was scored fairly high (7-8) by the project team in the existing condition as the project area is situated on a large parcel of native, County-owned and managed land. Implementing the management plan would not alter the surrounding high-quality upland and wetland habitats significantly, though there could be some subtle improvement to hydrologic conditions and a corresponding improvement in natural vegetation communities. However, re-hydrating the slough would improve connectivity between wetland zones and would likely improve wildlife utilization of the adjacent uplands, which would improve the UMAM score to 8 in all cases. The site is proposed to be limited to an 8 because the canal is a substantial barrier that prevents the movement of many species to other managed lands to the east. In addition, surrounding lands to the north, west, and south of the County parcel are not managed native lands. These will likely be intensified with low-density development based on future land use. The future condition of the parcel is a large island that is somewhat self-buffering but yet not optimally connected to other natural habitats.

4.3.2 Water Environment

There are many challenges to restoring the natural hydroperiod of the slough system. Even if sufficient pumping could be used to offset percolation, the periodicity of the hydroperiod would be extremely difficult to mimic. In addition, the chemistry of the water pumped into the mitigation area would be different than water that would naturally flow into the system. The score for this category is limited to 8 for existing wetlands with organic soils, and 7 for sandy restoration areas that will be more challenging to re-hydrate in a natural pattern.

4.3.3 Community Structure

All areas would be managed to minimize nuisance and exotic cover to less than 5 percent. Vegetation in the existing wetlands would be expected to thrive in response to an increased hydroperiod. Typically, emergent species recruit well from the organic seed bank, and it is expected that a UMAM score of 8 is feasible. However, the restoration area has been converted to upland habitat for several decades, and while the seed bank is likely still there, it is typically less robust than in organic soils. Approximately half of the restoration area is expected to require supplemental planting. It is likely that maintaining a desirable hydroperiod in these shallow areas will be difficult, making the site susceptible to weedy and exotic invasion. Therefore, the potential UMAM score in the restoration AA is limited to 7.

4.3.4 Time-Lag

It is expected that the enhancement wetlands will respond well to an increased hydroperiod, and with management, will stabilize in three years. The restoration AA is expected to require more management but, with supplemental planting, should develop appropriate coverage within five years.

4.3.5 Risk

As the project is proposed as a mitigation bank, financial assurances to carry out long-term maintenance will be required, which eliminates many forms of risk. The site will also be required to be protected from any land-use changes (i.e., conservation easement). However, at this point, the vulnerability to alterations in hydrology and water quality are highly questionable.
There is low to moderate risk in enhancing the existing wetlands. The topography, soils, and mostly desirable vegetation are currently in place. It seems apparent that hydroperiods can be improved immediately by removing breaches, but that obtaining the

prolonged historic water depths may prove challenging, therefore a moderate risk score of 1.5 is proposed.

Mimicking the historic hydroperiod appears to be extremely challenging in the shallow and sandy restoration areas. It seems that the pumps are fairly effective and reliable but research revealed that the solar pumps have low functionality and can only be turned on or off. Because the rate of percolation of water to the canal may be highly variable based on antecedent conditions (rainfall) and the difference between the water levels in the wetlands and canal (head), a variable pumping regime may be desirable. Without the ability to program the pumps, they would need to be turned on or off periodically. Possibly, pumps could somehow be linked remotely to a background wetland or local rainfall that could be used as a control to drive the pumping regime. Therefore a high risk factor (2.25) is proposed until these issues can be further addressed.

The current UMAM analysis yields a total of 54.11 UMAM credits. If the hydroperiods of all wetlands can be conclusively restored to the near-natural condition, the risk and category scores can be improved, which could increase the credit potential to as high as 80 credits.

4.4 WEST PINELANDS - ESTIMATED MITIGATION COSTS

Mitigation cost estimates for the West Pinelands are provided in Table 2 at the end of this report. The second page of the table provides the assumptions used to estimate costs. At this point, conservative estimates based on industry standards and project experience were used because many details are still unknown.

The site has been assessed as a potential mitigation bank, which includes costs specific to mitigation banks such as marketing/sales, legal/accounting, and funding the management trust. Also typical of mitigation banks, the estimated revenue generated from credit sales has been compared to the expenses on an annual basis and a net-present-value has been calculated for the income streams. This format allows a more comprehensive understanding of the timing of expenses and credit availability, and the calculation of net-present-value provides an overall understanding of project value. Again, the proposed expenses are only preliminary estimates at this point.

Overall project expenses for the 10-year project are estimated at approximately $3.8 million, or approximately $70,000 per credit. The most significant and uncertain cost factors are permitting, construction, and restoration. The hydrologic modeling required appears to be highly complex, making the ecological translation of the modeling into success criteria and mitigation credits similarly difficult. Modeling will also directly affect construction costs. The estimates for construction currently assume earthen breaches can simply be altered and allowed to stabilize. However, if modeling shows that significant hardened structures are required, the costs could increase dramatically. Restoration costs are a large cost factor. The proposed costs are based on the assumption that significant herbicide treatment would be required as wetland seed sources are re-established. These costs could be reduced depending on how the site responds. Conversely, if exotic and weedy species dominate, supplemental planting may be required. In addition, it is likely the pumps will need to be "programmed", which may require wiring, equipment, and technical time that have not been considered yet. These are only preliminary costs for consideration; however, it appears that the project is economically feasible at this early stage.

4.5 WEST PINELANDS - PROJECT CONSTRAINTS AND OPTIMIZATION

The major constraints with this project revolve around water issues. Perhaps most importantly, will the project adversely affect upstream or downstream users? The level of improvement attainable may be governed by outside constraints. Secondly, can solar pumps or any type of pumps be permitted? The SWFWMD does not typically embrace mechanical means such as pumps. Third, can the natural hydroperiod be mimicked? This will have a direct effect on project cost and credit generation. Preliminary engineering modeling could be used to more closely address these issues, and determine the hydrologic regime that is possible given on-site and off-site constraints.

Restoration costs can be optimized with careful active management. Allowing vegetative succession by weedy species instead of consistently treating all nuisance species with herbicide can actually improve results. However, immediately eradicating aggressive exotic species can reduce future management efforts. If the native seed bank is not responding, selective supplemental planting or seeding may improve vegetative establishment. The use of fire may help attain beneficial coverage.

Perhaps the project can be performed in phases, where initially all breaches are removed, and depending on the results, solar pumps could be added. Cost-benefit analyses could be used to determine how many credits the pumps could add and at what cost (time, complexity, and dollars). Alternatively, more efficient electric pumps could be considered as there is power nearby and the disturbed canal berm could be used to install necessary electric and automation wiring.

4.6 WEST PINELANDS - RECOMMENDED ACTIONS

The following are recommended actions to consider:

- Perform preliminary modeling to determine off-site impacts to identify what level of restoration is feasible
- Determine realistic permeability rates to more accurate estimate horizontal water loss
- Determine what effect structures alone would have on wetland hydroperiods
- Determine what additional credit pumps provide and at what cost
- Determine if electric pumps would be favorable to solar in terms of performance and cost
- Prepare a revised design(s) and perform more detailed cost estimating
- Consider phasing the project to reduce uncertainties

- Evaluate the project as a County project or ROMA and not a mitigation bank to determine cost and time savings

5.0 ALBRITTON RESERVOIR ALTERNATIVE 2

The Albritton Reservoir Alternative 2 (ARA2) mitigation project involves the preservation of substantial upland habitat and the enhancement and restoration of historic herbaceous wetlands that have been severely drained by the Albritton Grove ditch network. The surrounding grove was historically a large marsh that was part of the original Cow Pen Slough system.

Wetland hydroperiods are proposed to be restored by impounding water in a surrounding reservoir at the land surface in conjunction with the Alternative 2 Reservoir design. In addition to hydroperiod restoration, nuisance and exotic vegetation in the project area would be removed and maintained to generate mitigation credits. The project has also been assessed to determine potential mesic hammock credits. The project includes approximately 21 acres of wetland enhancement, 9 acres of wetland restoration, 80 acres of upland preservation, and 80 acres of potential mesic hammock for a total project size of approximately 190 acres in two separate areas.

A mitigation plan map, credit estimates, and mitigation cost estimates for the ARA2 mitigation project area are provided as Figure 6, Table 3, and Table 4, respectively at the end of this report.

5.1 ARA2 - EXISTING CONDITIONS

Upland habitat in the project area is comprised of generally good quality pine flatwoods, mixed pine-oak forest, and potential mesic oak hammock. The groundwater table in the project area has been significantly lowered, which has altered species composition and soil characteristics. Nuisance and exotic vegetation is moderate overall and generally limited to the understory, with occasional dense stands of Brazilian pepper along habitat edges.

Wetlands in the project area have also been significantly drained, causing the conversion of the outer zones in many areas to uplands and allowing the invasion of nuisance and exotic vegetation. Remaining wetland habitats suffer from a reduced hydroperiod and moderate to heavy invasion of undesirable vegetative species.

5.2 ARA2 - MITIGATION PLAN

The mitigation plan provided as Figure 6 at the end of this report is straightforward, and involves the preservation and restoration of native habitats. However, ensuring that the adjacent reservoir will maintain a natural hydroperiod in the project area could be complicated depending on pumping and storage regimes. At this point, however, it is assumed that hydroperiods will be restored to a high, though not optimal level by the construction of the adjacent reservoir. This is a conservative approach to avoid overestimating credit value in the event that reservoir levels can not be manipulated in a manner that promotes optimal hydroperiod maintenance.

No work effort or associated costs have been estimated to restore hydrology. It is assumed that this mitigation project would be completed in conjunction with reservoir construction. Therefore, all major earthmoving is assumed to be accomplished with the reservoir construction. Without the reservoir project, or an alternative effort that could restore the depressed groundwater table, the ARA2 mitigation project would not be possible as proposed. The following is a summary of the major tasks needed to complete the mitigation plan:

- Perform initial exotic removal/herbicide treatment in uplands and wetlands.
- Remove existing irrigation ditches.
- Plant supplemental herbaceous wetland vegetation in approximately 50 percent of the overall wetland restoration and enhancement areas. Rely on seed bank regeneration in remaining wetland habitat.
- Plant supplemental groundcover species in approximately 25 percent of upland and hammock habitat including habitat edges, road removal areas, and internal areas lacking beneficial coverage. Rely on seed bank regeneration in the balance of the uplands.

5.3 ARA2 - POTENTIAL MITIGATION CREDIT GENERATION

The summary UMAM credit analysis is provided in Table 3 at the end of this report. Baseline scores were provided by the project team. Preservation values for each AA were determined by assessing the difference in UMAM scores between the future “without preservation” and “with preservation” conditions. In addition, each AA was then assessed to determine if additional credit could be generated by enhancing the preserved condition. The following is a summary of the ARA2 UMAM analysis justification.

5.3.1 Preservation

Wetland restoration areas were not assessed for preservation value because they will be converted from uplands that score zero (0) by UMAM rule.

In the “with preservation” condition, assessed AAs are expected to be maintained in the current condition, therefore, baseline UMAM scores are used to estimate the “with preservation” condition. Preservation credits in this analysis have been determined by calculating the UMAM value of protecting the existing habitat by conservation easement or similar restrictive covenant.

Without preservation, location scores would be somewhat degraded in existing wetlands (enhancement areas) that are greater than 0.5 acre assuming the surrounding upland land use would be intensified through some form of development (housing, agriculture, mining). However, many of the wetlands are imbedded in potential mesic hammock, which can only be impacted by 25 percent per County rules. These areas would be less affected by development than wetlands in or near unprotected upland habitats. Development would also require surface water permitting; therefore, the water environment scores are expected to remain the same with and without preservation. Community structure would likely continue to degrade without management. Overall, existing wetlands would be moderately degraded without preservation primarily from upland land use intensification and a lack of management. However, other isolated wetlands that are less than 0.5 acre could be eliminated without mitigation, therefore, without preservation, these wetlands would score zero (0) in all categories. Wetland preservation values are moderate to high overall, but based on the small amount of acreage, only 1.04 credits could be generated as shown in Table 3 at the end of this report.

Upland habitats could be developed (i.e., excavated) without preservation and are not specifically regulated; therefore, without preservation, uplands would score zero (0) in all categories. With preservation, the existing native uplands would be protected, creating the opportunity for over 22 UMAM credits.

The preservation adjustment factor (PAF) for wetland enhancement areas was estimated to be in the middle range (0.5-0.6) based on the scoring criteria listed in Chapter 62-345.500(3)(a), FAC, which generally focus on habitat quality, ability to be managed, and the risk of degradation if not preserved. These wetlands are moderate quality, can be managed, and are at risk of moderate to extreme degradation if not preserved. The PAF for the UP-1 AA in the northern portion of the project was estimated at 0.8 because this habitat provides good wetland support and is at risk of extreme degradation. However, the southern uplands (UP-2) were assigned a PAF of 0.4 because though they are high quality at risk of extreme degradation, these uplands are not well associated with wetland habitats.

Mesic hammock habitat was not assessed with UMAM, but was assessed using a ratio to determine credit value. Because the County allows impacts to only 25 percent of mesic hammock habitat, the preservation of every 4 acres of functioning mesic hammock would yield a net increase of 1 acre of mesic hammock. Therefore, potential mesic hammock credits estimated at the bottom of Table 3 at the end of this report, are the acres of potential mesic hammock divided by four. It is assumed that one mesic hammock credit represents the ability to impact one acre of functioning mesic hammock.

5.3.2 Enhancement/Restoration

Because the “with mitigation” condition for all wetland enhancement areas is very similar, a single “with mitigation” score was assigned to all wetland enhancement areas. Similarly, all restoration areas were assessed as a single AA. By rule, baseline UMAM scores for wetland restoration AAs are zero (0). Enhancement credits shown in Table 3 at the end of this report have been determined by calculating the UMAM value of enhancing the "with preservation" condition after a conservation easement is in place.

5.3.3 Location and Landscape Support

In the "with mitigation" scenario, all enhancement and restoration areas are assigned a score of 7, which is similar to the existing condition scores (6-7). The existing surrounding low-quality habitat is comprised of an active orange grove, which will be converted to an open-water reservoir. The minimal improvement to location scores results from the synergistic effects of enhancement of the upland and wetland habitat to be preserved. The surrounding reservoir will provide little beneficial habitat though it will provide an adequate buffer.

The UP-1 AA location score is also improved slightly by enhancement activities, from a score of 5 to 6. The category score for this AA is slightly lower than the internal wetland habitats that it protects. The enhanced location score for the southern upland (UP-2) that is contiguous with County-owned land remains unchanged at 7.

5.3.4 Water Environment

In the "with mitigation" scenario, all wetland enhancement areas are assigned a score of 8, indicating that wetland hydrology is expected to function at a high level. This may be difficult to achieve adjacent to the reservoir. Wetland restoration areas are shallower and more susceptible to hydrologic alterations, therefore a slightly lower score (7) is proposed in this AA.

This category is not scored for uplands.

5.3.5 Community Structure

This category is expected to be improved by supplemental planting and regular maintenance activities in conjunction with improved hydrology. A conservative estimate of 8 is expected for wetland enhancement areas while a slightly lower score of 7 is expected in the fringing restoration areas.

Upland habitats can be improved by exotic removal, supplemental planting, and implementation of an aggressive management plan. The moderately degraded northern habitats are expected to improve from 5 to 9, while the more intact southern habitats could improve from 7 to 9.

5.3.6 Time-Lag

As there is some uncertainty as to how the wetland hydroperiods will be affected by the adjacent reservoir, a conservative estimate of five years is expected for enhanced and restored wetlands to reach the proposed condition. Upland areas should respond to enhancement activities within three years.

5.3.7 Risk

As with the West Pinelands project, hydrologic restoration is the critical component that affects risk as well as the physical UMAM category scores (water and vegetation) and time-lag. Enhancing or restoring existing or previous wetlands generally entails low risk because topography, soils, and seed sources are present. However, appropriate hydrology is the key component to sustainable mitigation. At this point, a moderate risk score of 1.75 has been assigned to enhancement areas, while a slightly higher score of 2.0 is assigned to the exterior restoration areas. Depending on the ultimate water level regime in the reservoir and the results of modeling, these risk scores could be adjusted up or down.

There is little risk associated with the enhancement of upland habitat, however, the value of the upland directly corresponds to the value of the wetland habitat it supports, therefore a higher than typical score of 1.5 is assigned.

Overall, the ARA2 project potentially generates 2.36 wetland enhancement credits and 9.22 upland enhancement credits. When added to the 23.41 preservation credits, the total credit potential is 37.83 UMAM credits. In addition, there is the potential to generate 19.96 mesic hammock credits. This is an estimate of credit potential of the habitat in the project area. However, the overall linear and disjunctive configuration of the mitigation areas combined with the atypical hydrologic design may not be desirable to the regulatory agencies.

5.4 ARA2 - ESTIMATED MITIGATION COSTS

Mitigation cost estimates are provided in Table 4 at the end of this report. The second page of the table provides the assumptions used to estimate costs.

Overall project expenses for the 7-year project are approximately $1.93 million, or approximately $51,000 per UMAM credit. Compared to the West Pinelands, UMAM credits associated with ARA2 are less than half as expensive. In addition, mesic hammock credits worth approximately $1 million would be created with this plan. Because one mesic hammock credit represents the ability to build on one acre of mesic hammock, it is assumed that a mesic hammock credit is worth the value of an acre of land. A reasonable estimate of the value of an acre of land in Sarasota County is $50,000, thus, an estimated credit value of $50,000. The value of 19.96 mesic hammock credits at $50,000 per credit is approximately $1 million. When combined with UMAM credits, the total potential credit value is approximately $5.4 million, at a cost of less than $2 million. While land costs have not been considered, this appears to be the most economically feasible project. However, agency reviewers may require that the design be modified into a single, well-connected project area.

Cost factors for this project are rather straightforward. Significant costs include planting and maintenance. With more detailed field studies and assurances of stable hydrology, these costs may be reduced.

5.5 ARA2 - PROJECT CONSTRAINTS AND OPTIMIZATION

This project is fairly simple, however, as with the West Pinelands project, the ability to restore natural hydrology is critical. If off-site impacts are caused by the project, it may be very difficult to re-hydrate wetlands sufficiently.

If it can be demonstrated that wetland hydroperiods will mimic natural conditions, it may be possible to improve credit generation slightly by reducing risk and time-lag scores. In addition, improving connectivity of the northern project area to the County-owned land to the south would improve the location category score and generate slightly more mitigation credit. In the current design, the northern project area does not support terrestrial species well.

5.6 ARA2 - RECOMMENDED ACTIONS

The following are recommended actions to consider:

- Perform preliminary modeling to determine if there are off-site impacts and the level to which hydrologic restoration is feasible
- Determine if operation of the reservoir will conflict with natural wetland hydroperiods
- Determine if the project can be configured with connectivity to other preserved lands
- Incorporate design changes from the project team and perform more detailed cost estimating
- Determine the UMAM credit potential of mesic hammock habitat
- Evaluate the project as a County project or ROMA and not a mitigation bank to determine cost and time savings given the small number of potential credits

6.0 ALBRITTON RESERVOIR ALTERNATIVE 3

The Albritton Reservoir Alternative 3 (ARA3) mitigation project involves the creation of a 104-acre marsh system in the southern portion of the Albritton site in conjunction with preservation and enhancement of upland habitat and the enhancement and restoration of historic herbaceous wetlands. As compared to the ARA2 project, this project area is more regular in shape and is well connected to County owned land. However, the ARA3 project is much more costly to construct and carries more project risk.

Wetland hydroperiods are proposed to be restored by impounding water in the surrounding reservoir and discharging it to the project wetlands in conjunction with the Alternative 3 Reservoir design. In addition to wetland creation and hydroperiod restoration, nuisance and exotic vegetation in the project area would be removed and maintained to generate mitigation credits. The project has also been assessed to determine potential mesic hammock credits. The project includes approximately 104 acres of wetland creation (and 12 acres of buffer sideslope), 15 acres of wetland enhancement, 31 acres of wetland restoration, 38 acres of upland preservation, and 63 acres of potential mesic hammock for a total project size of approximately 263 acres.

A mitigation plan map, credit estimates, and mitigation cost estimates for the ARA3 mitigation project area are provided as Figure 7, Table 5, and Table 6, respectively at the end of this report.

6.1 ARA3 - EXISTING CONDITIONS

Portions of the native ARA2 habitats described above are also part of the ARA3 project area. In addition, the ARA3 project area contains a 116-acre portion of active citrus grove that will be converted to wetland habitat. A 30-acre portion of the historic slough system that has been converted to improved pasture is also present in the southwest portion of the site. Both the grove and pasture were previously wetland habitats, though the restoration of the grove to wetland habitat is differentiated as wetland creation in this section.

6.2 ARA3 - MITIGATION PLAN

Similar to the ARA2 mitigation plan, the mitigation plan provided as Figure 7 at the end of this report involves the preservation and enhancement of generally native habitats. In addition, a historic portion of the slough that has been converted to pasture is proposed to be treated with herbicide, replanted, and re-hydrated in conjunction with the ARA3 reservoir project. A larger area of historic marsh that has been converted to citrus will be cleared, leveled, possibly excavated, and planted with herbaceous wetland vegetation. This area has been graded, bedded, and ditched substantially. It is unlikely that substantial amounts of soil will be removed from the grove as it was historically a deep marsh system and the water table must be raised above the historic land surface to maintain hydroperiods in the northeastern enhanced wetlands. At a minimum, substantial earthwork will be required to level and contour the creation area. Therefore, the construction cost estimate allows for the removal of up to 3 feet of soil, which should cover the cost of any combination of grading and hauling necessary to restore proper wetland elevations in the citrus grove.

Similar to ARA2, it is assumed that hydroperiods will be restored to a high, though not optimal level in all wetland habitats as a result of the adjacent reservoir project. This is a conservative approach to avoid overestimating credit value in the event that reservoir levels can not be manipulated in a manner that promotes optimal hydroperiod maintenance.

It is assumed that this mitigation project would be completed in conjunction with reservoir construction; therefore, all necessary infrastructure required to restore hydrology is assumed to be included in the reservoir design. Without the reservoir project, or an alternative effort that could restore the depressed groundwater table, the ARA3 mitigation project would not be possible as proposed. The following is a summary of the major tasks needed to complete the mitigation plan:

- Clear and grade the citrus grove to appropriate wetland elevations in the Marsh Creation (MC) area.
- Treat the improved pasture area (WR) with herbicide at least twice using large scale agricultural equipment; remove exotics in the remaining project area.
- Remove existing ditches and roads through native habitats
- Plant supplemental herbaceous wetland vegetation in approximately 50 percent of existing Wetlands 4, 5 and 7-9 in both restoration and enhancement portions. Rely on seed bank regeneration in remaining wetland habitat.
- Plant supplemental groundcover species in approximately 25 percent of upland and hammock habitat including habitat edges, road removal areas, and internal areas lacking beneficial coverage. Rely on seed bank regeneration in the balance of the uplands.
- Plant the entire marsh creation area (MC) and the western pasture restoration area (WR).
- Perform initial exotic removal/herbicide treatment in uplands and wetlands and maintain the site in perpetuity.

6.3 ARA3 - POTENTIAL MITIGATION CREDIT GENERATION

The summary UMAM credit analysis for ARA3 is provided in Table 5 at the end of this report. The UMAM analysis was very similar to analysis performed for the ARA2 project discussed above. Only the differences in the two analyses are discussed below.

6.3.1 Preservation

In the ARA3 design, the southern upland preserve area (UP-2) is well connected to wetland habitat. The improved association between the upland preserve and wetland habitats results in an increase of the PAF from 0.4 to 0.8 for this AA, which doubles the credits generated per acre of UP-2. All other preservation values were similar to the ARA2 analysis.

6.3.2 Enhancement/Restoration

Because the project area is regularly shaped and contiguous with County owned land, the location scores of all AAs in the “with mitigation” scenario are slightly higher than in the ARA2 design. This results in a slight increase in enhancement values.

The risk factors were also similar to those described in the ARA2 analysis, with the exception that risk for wetland creation in ARA3 was established at a high value (2.5). A high risk value is assigned because the grove soils have been heavily manipulated, it lacks a native seed source, and topography has been altered substantially. There is also some risk that hydrologic improvement will not meet expectations.

Overall, the ARA3 project could potentially generate 62.23 UMAM credits and 15.7 mesic hammock credits with a value of $7.9 million.

6.4 ARA3 - ESTIMATED MITIGATION COSTS

Mitigation cost estimates are provided in Table 6 at the end of this report. The second page of the table provides the assumptions used to estimate costs.

Overall project expenses for the 10-year project are estimated at $7 million, therefore, each UMAM credit is estimated to cost approximately $113,000 to create, which is similar to the West Pinelnads and double ARA2.

Significant costs include earthwork and planting. While the planting estimate is not likely to change substantially, the earthwork estimate is simply a placeholder at this point. The amount of soil to be removed (if any) and the level of effort needed to grade and re-contour the highly disturbed grove must be determined to refine the cost estimate. The cost estimate assumes that up to 3 feet of soil may be required to be removed from the grove, thus, the proposed estimate is likely a worst-case scenario.

6.5 ARA3 - PROJECT CONSTRAINTS AND OPTIMIZATION

Again, hydrologic restoration is the key to success. If off-site impacts can be avoided, and stable hydrology restored, the project may be feasible. Achieving appropriate hydrology would mean that only minimal excavation would be required, and construction costs could be lowered.

In the event that target hydrology cannot be met and excavation of the grove is required, the cost of excavation may be offset by the value of the fill material removed. This would likely reduce the number of credits somewhat, but the project could be feasible.

6.6 ARA3 - RECOMMENDED ACTIONS

The following are recommended actions to consider:

- Perform preliminary engineering modeling to determine if there are off-site impacts and the level to which hydrologic restoration is feasible.
- Determine if operation of the reservoir will conflict with natural wetland hydroperiods.

- Estimate the amount of earthwork required based on preliminary engineering estimates.
- Evaluate the project as a County project or ROMA and not a mitigation bank to determine cost and time savings.

7.0 MITIGATION BANKING POTENTIAL IN THE SOUTHERN COASTAL BASIN

There is clear demand for a mitigation bank in the Southern Coastal Basin. For both the private and public sector, individuals and elected officials have pondered the lack of mitigation banking in the coastal basins. High land values are a deterrent making investors withstand years of negative cash flow before enough credits can be brought to the market to turn the tide. Perhaps the real issue is that credit prices have not caught up with land values. A credit price of possibly $200,000-300,000 is unheard of in Florida, but may be necessary in expensive coastal basins.

The preliminary cost estimates from the three projects demonstrate that the most complicated project (ARA3) that requires a large amount of earthwork and infrastructure is nearly twice as expensive (per credit generated) as the simplest project (ARA2) that restores and preserves native habitats. The West Pinelands project is very conceptual at this point, and at best it appears more costly than ARA2, and could approach the ARA3 costs if hardened structures are required. Land costs have not been included in the analyses therefore, true costs are not revealed. Even with land cost, simpler mitigation methods should be the most cost effective.

For the projects analyzed, only the ARA2 project appears economically feasible even without land costs. However, there are only a small number of credits (38) involved with that project and many uncertainties to resolve. The linear and disjunctive ARA2 project is not a typical mitigation bank design as currently designed. Perhaps with design alterations, and even with land costs included, this project could be feasible.

It appears that the West Pinelands project could be feasible as long as critical issues such as upstream flooding and SWFWMD approval of pumps can be satisfactorily addressed. However, if modeling shows that more complicated hardened structures are required, costs could rise substantially. This appears to be the most uncertain option, but still one worth pursuing.

At the proposed credit prices, the ARA3 project is not likely to be economically feasible, even if the conservatively estimated implementation costs were reduced substantially. A sensitivity test could shed light on this assumption.

Despite uncertainties and formidable costs, the County, because of its large land holdings, may be uniquely positioned to bring credits to the market, although possibly at a higher credit price than $115,000. With more precise cost estimates based on engineering design, it may be feasible to reduce costs without a substantial reduction in credits. This improvement, coupled with higher credit prices, may allow the development of an economically sound mitigation bank on existing County owned lands.

Another approach that may improve the economic feasibility of the projects would be to implement the mitigation activities in phases. This may increase the total time to generate credits, but it allows the reduction of project risk as active management is used to refine the project progressively. For example, phase 1 of the West Pinelands project could be raising the surface water discharge inverts into the canal and determining how the seed bank responds. Phase 2 could include supplemental pumping and planting.

In summary, the cost estimates proposed are very preliminary and assumptions are subject to engineering verification. We encourage the project team and the County to closely scrutinize and troubleshoot the analysis to determine how the projects can be refined.

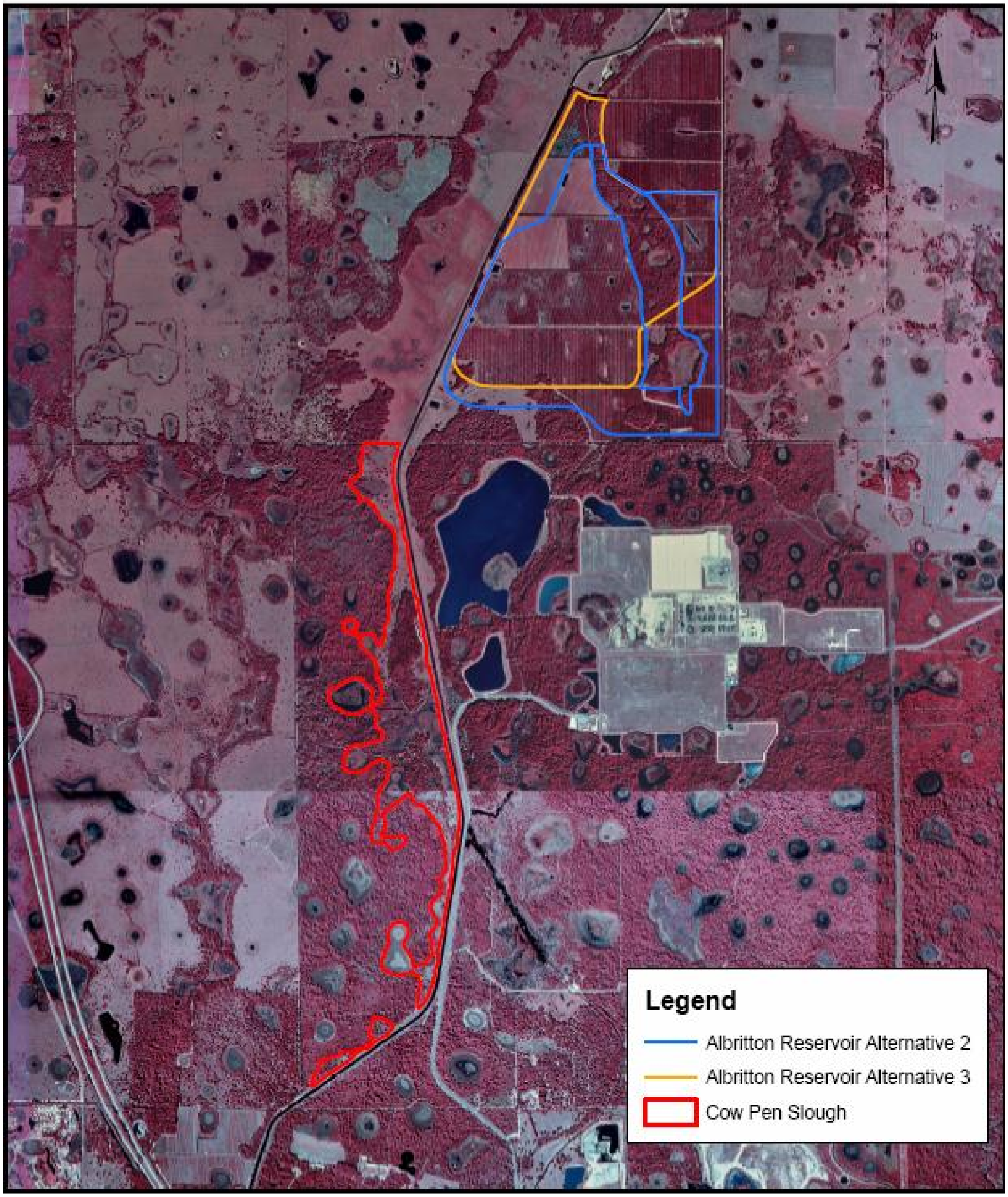


Figure 1 – Potential Mitigation Bank Sites

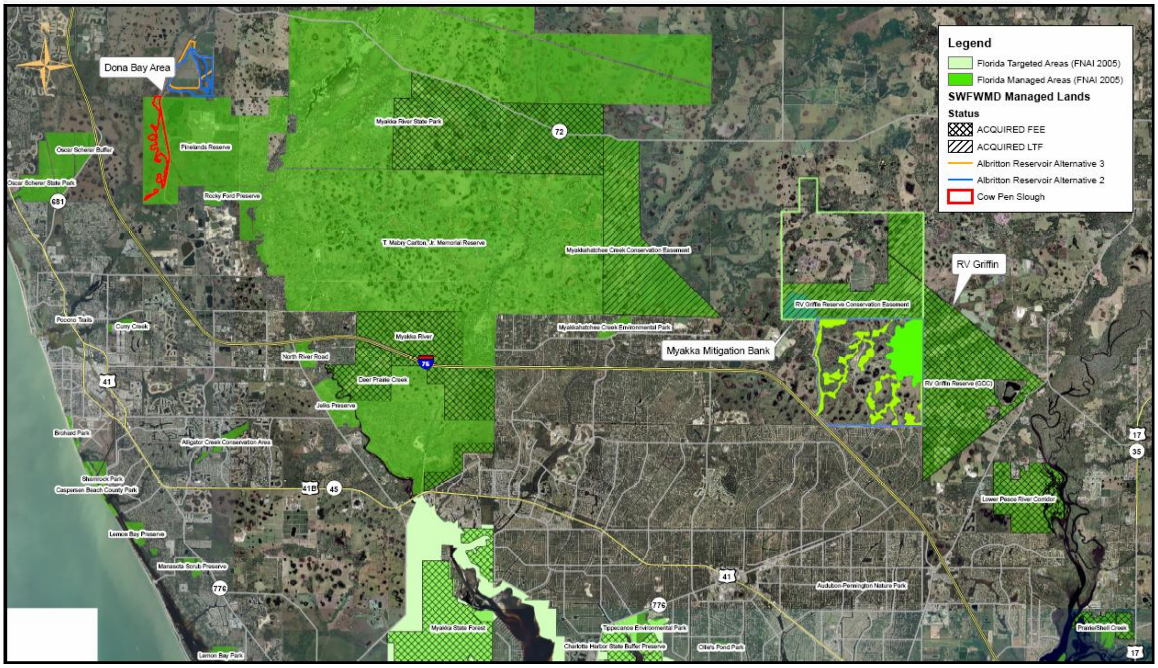


Figure 2 – Regional Preservation Lands

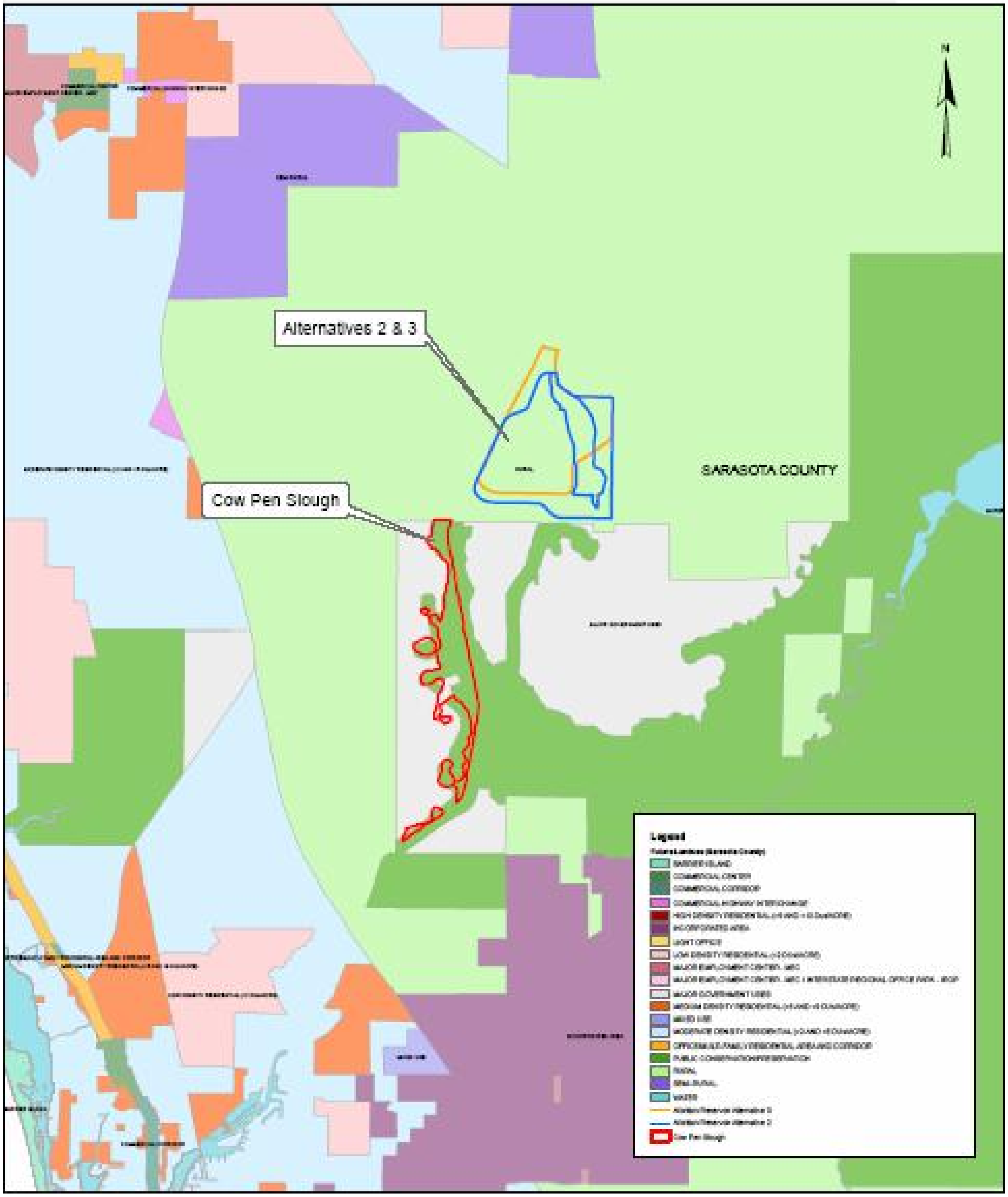


Figure 3 – Future Land Use Map

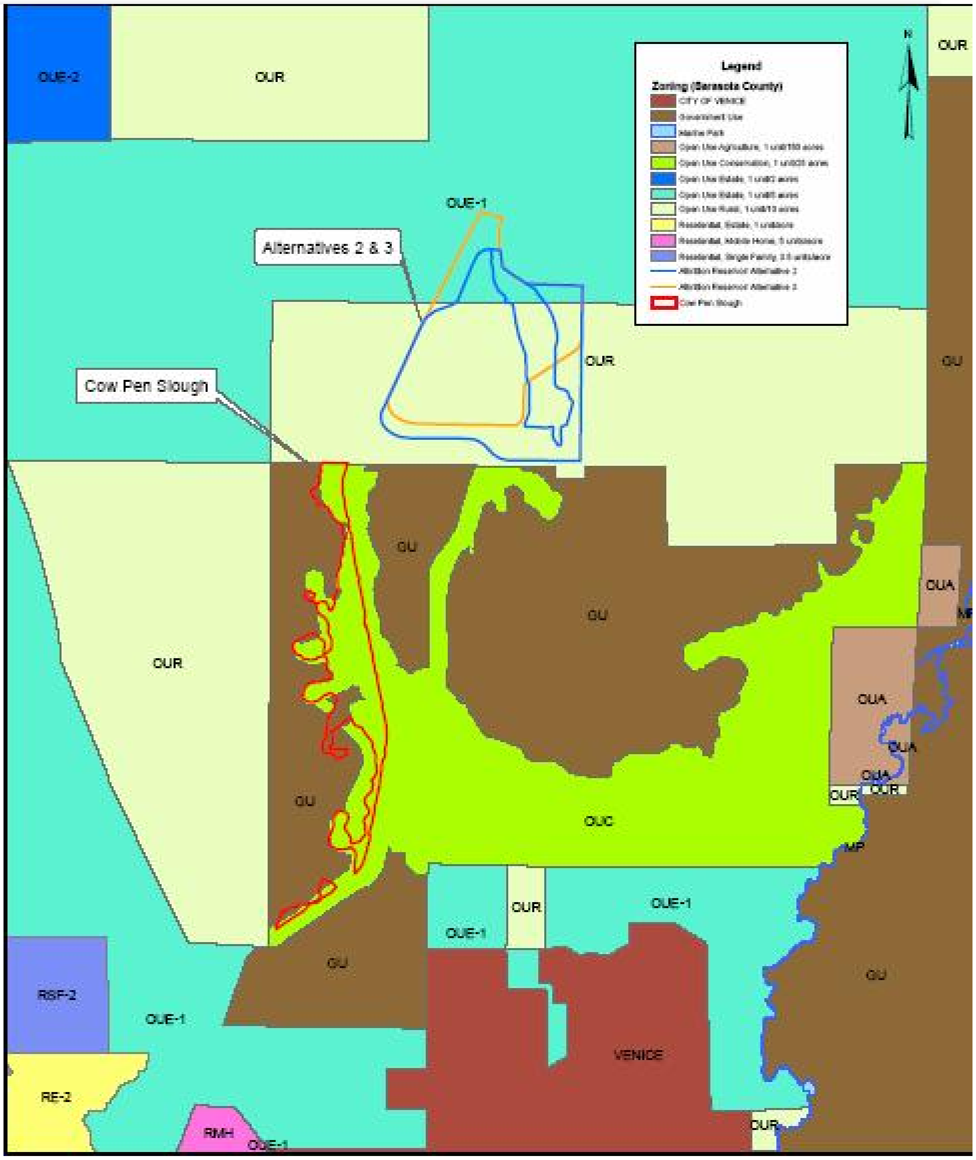


Figure 4 – Sarasota County Zoning

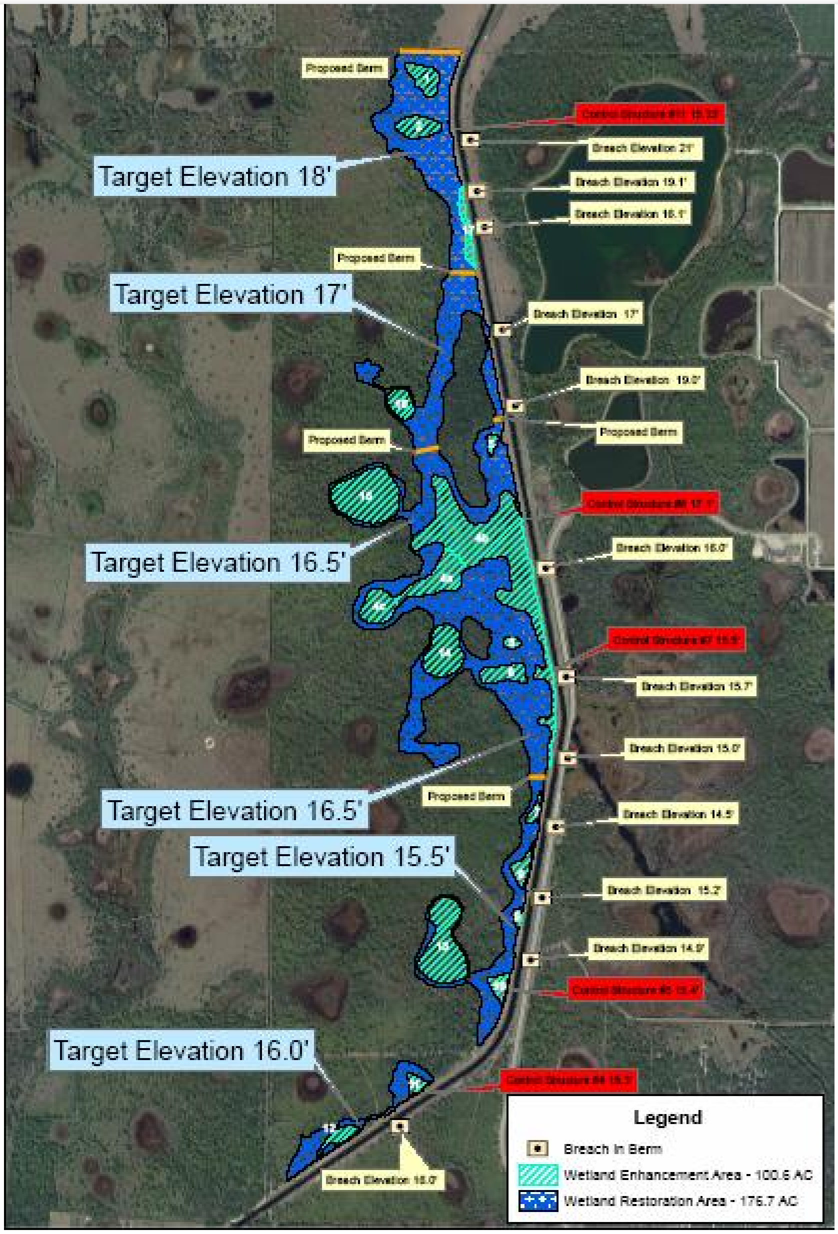


Figure 5 – West Pinelands Preliminary Mitigation Plan

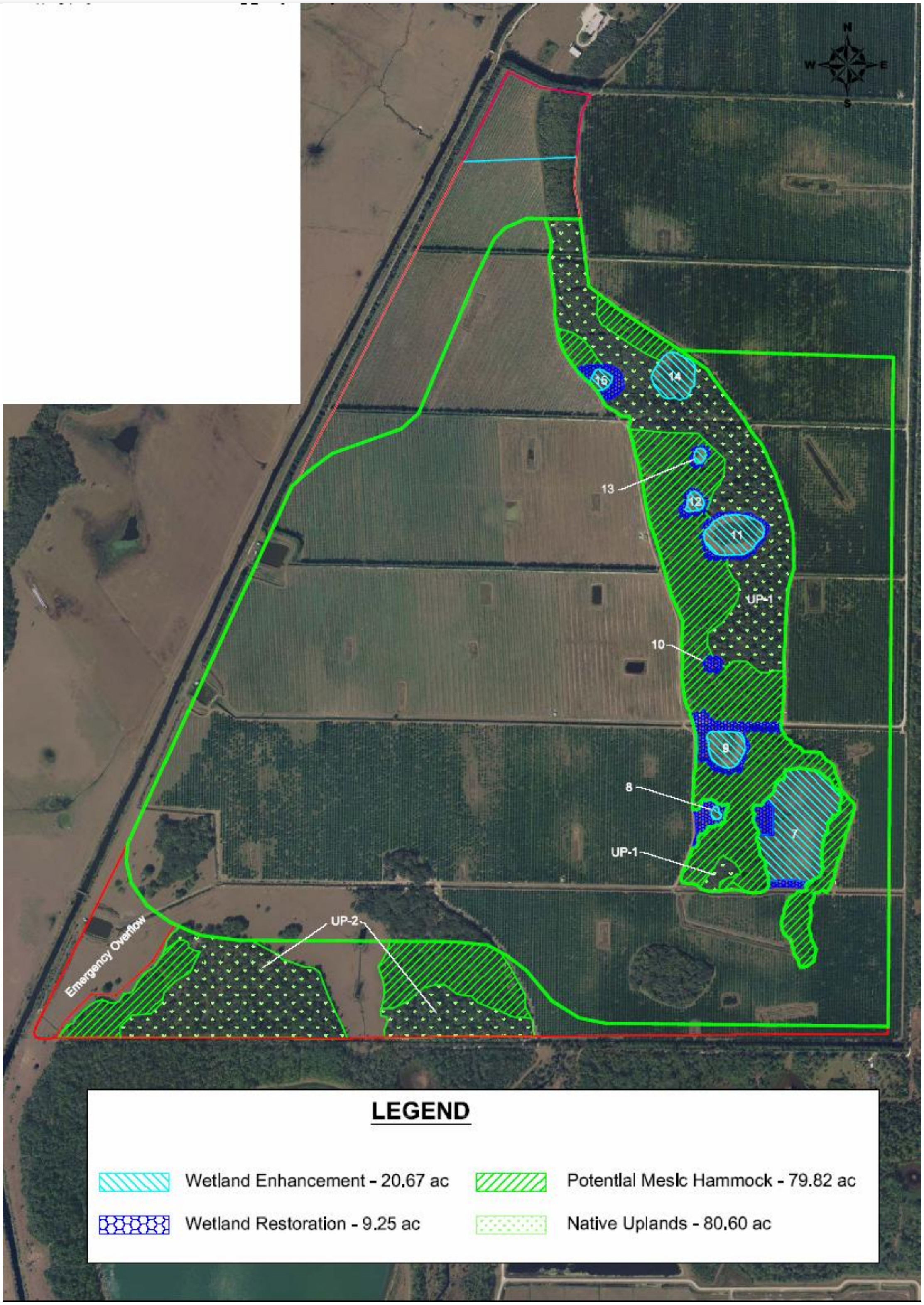


Figure 6 – Albritton Reservoir, Alternative 2 Mitigation Plan

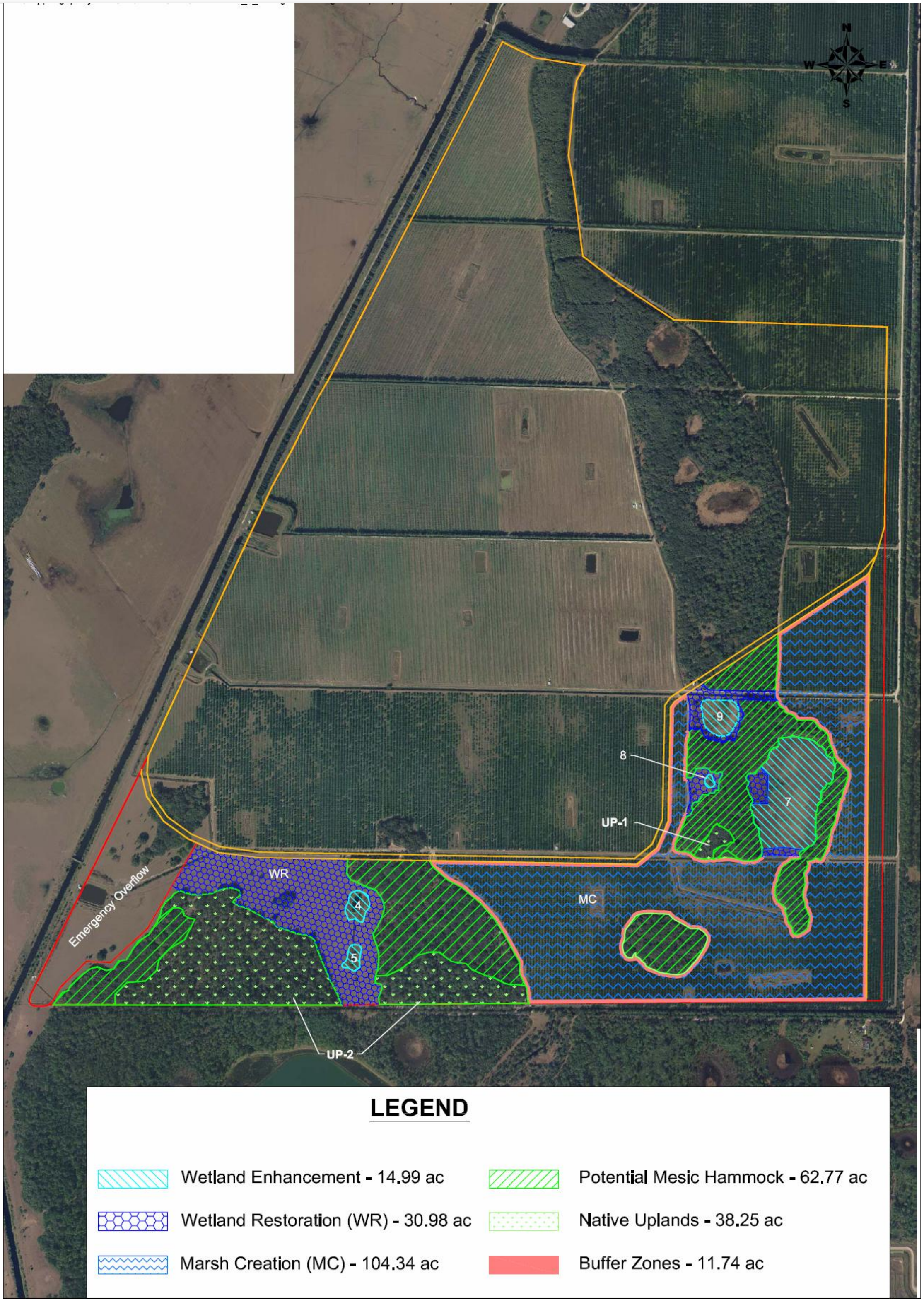


Figure 7 – Albritton Reservoir, Alternative 3 Mitigation Plan

ASSESSMENT AREA	MITIGATION AREA (acres)	SCORE: LOCATION AND LANDSCAPE BASE LINE	SCORE: LOCATION AND LANDSCAPE WITH MIT	SCORE: WATER ENVIRONMENT BASE LINE	SCORE: WATER ENVIRONMENT WITH MIT	SCORE: COMMUNITY STRUCTURE BASE LINE	SCORE: COMMUNITY STRUCTURE WITH MIT	BASELINE	WITH ENHANCEMENT	ENHANCEMENT DELTA	Time Lag	Risk	ENHANCEMENT RFG	ENHANCEMENT CREDIT
Wetland Enhancement														
Wetland 1	3.11	7	8	6	8	6	8	0.63	0.80	0.17	1.07	1.50	0.10	0.32
Wetland 2	3.32	7	8	6	8	6	8	0.63	0.80	0.17	1.07	1.50	0.10	0.34
Wetland 3	0.85	7	8	5	8	6	8	0.60	0.80	0.20	1.07	1.50	0.12	0.11
Wetland 4a	6.78	8	8	7	8	7	8	0.73	0.80	0.07	1.07	1.50	0.04	0.28
Wetland 4b	33.99	7	8	7	8	8	8	0.73	0.80	0.07	1.07	1.50	0.04	1.41
Wetland 4c	4.22	8	8	8	8	8	8	0.80	0.80	0.00	1.07	1.50	0.00	0.00
Wetland 5	0.72	8	8	8	8	7	8	0.77	0.80	0.03	1.07	1.50	0.02	0.01
Wetland 6	3.22	7	8	7	8	7	8	0.70	0.80	0.10	1.07	1.50	0.06	0.20
Wetland 7	0.87	7	8	5	8	6	8	0.60	0.80	0.20	1.07	1.50	0.12	0.11
Wetland 8	1.92	7	8	7	8	7	8	0.70	0.80	0.10	1.07	1.50	0.06	0.12
Wetland 9	0.60	7	8	7	8	7	8	0.70	0.80	0.10	1.07	1.50	0.06	0.04
Wetland 10	1.70	7	8	6	8	6	8	0.63	0.80	0.17	1.07	1.50	0.10	0.18
Wetland 11	1.25	7	8	7	8	6	8	0.67	0.80	0.13	1.07	1.50	0.08	0.10
Wetland 12	1.93	7	8	6	8	7	8	0.67	0.80	0.13	1.07	1.50	0.08	0.16
Wetland 13	11.88	8	8	8	8	8	8	0.80	0.80	0.00	1.07	1.50	0.00	0.00
Wetland 14	7.03	8	8	8	8	8	8	0.80	0.80	0.00	1.07	1.50	0.00	0.00
Wetland 15	12.48	8	8	8	8	8	8	0.80	0.80	0.00	1.07	1.50	0.00	0.00
Wetland 16	2.84	8	8	8	8	8	8	0.80	0.80	0.00	1.07	1.50	0.00	0.00
Wetland 17	1.94	7	8	6	8	6	8	0.63	0.80	0.17	1.07	1.50	0.10	0.20
Subtotal	100.65													3.59
Wetland Restoration														
Cow Pen Restoration	176.70	0	8	0	7	0	7	0.00	0.73	0.73	1.14	2.25	0.29	50.52
Total	**277.35**													**54.11**

Table 1 – West Pinelands, UMAM Credit Assessment

Note	Expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Total
A	Project Management	$ 62,400	$ 62,400	$ 62,400									$ 187,200
B	Survey	$ 53,200	$ 53,200	$ 53,200									$ 159,600
C	Environmental Permitting	$ 150,000	$ 150,000	$ 150,000									$ 450,000
D	Environmental Oversight			$ 91,800									$ 91,800
E	Engineering	$ 200,000	$ 100,000	$ 100,000									$ 400,000
F	As-Built Certification				$ 50,000								$ 50,000
G	Construction				$ 1,775,648								$ 1,775,648
H	Maintenance				$ 209,000	$ 129,600	$ 129,600	$ 129,600	$ 64,800	$ 64,800	$ 64,800	$ 64,800	$ 857,000
I	Planting				$ 320,710								$ 320,710
J	Miscellaneous Costs				$ 20,000								$ 20,000
K	Monitoring				$ 72,000	$ 36,000	$ 36,000	$ 36,000	$ 36,000	$ 5,000	$ 5,000	$ 5,000	$ 231,000
L	Fencing and Security				$ 5,000								$ 5,000
M	Legal/Accounting	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 110,000
N	Management/Marketing	$ -	$ -	$ -	$ -	$ -	$ 28,900	$ 80,500	$ 80,500	$ 80,500	$ 80,500	$ 84,686	$ 435,586
O	Trust Fund Escrow	$ -	$ -	$ -	$ -	$ -	$ 77,185	$ 215,000	$ 215,000	$ 215,000	$ 215,000	$ 226,180	$ 1,163,365
P	Trustee Fees	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 22,000
	Subtotal	$ 477,600	$ 377,600	$ 469,400	$ 2,464,358	$ 177,600	$ 283,685	$ 473,100	$ 408,300	$ 377,300	$ 377,300	$ 392,666	$ 6,278,909
	Revenue												
Q	UMAM Credits Sold	0.00	0.00	0.00	0.00	0.00	3.59	10.00	10.00	10.00	10.00	10.52	54.11
R	UMAM Credit Price	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	
	UMAM Credit Gross Revenue	$ -	$ -	$ -	$ -	$ -	$ 412,850	$ 1,150,000	$ 1,150,000	$ 1,150,000	$ 1,150,000	$ 1,209,800	$ 6,222,650
	Total Net Revenue	$ (477,600)	$ (377,600)	$ (469,400)	$ (2,464,358)	$ (177,600)	$ 129,166	$ 676,900	$ 741,700	$ 772,700	$ 772,700	$ 817,134	$ (56,259)
	NPV	($1,025,411.63)											
	Discount Rate	7%											

Table 2- West Pinelands Pro Forma (Page 1)

A	Project Management	Management of all schedules, deliverables, billing, etc. Estimate based on a bill rate of $150/hour, 8 hours per week, Years 1 -3 through implementation = $150 x 8 hrs/week x 52 weeks = $62,400/year
B	Survey	Survey SHWL elevations, establish benchmarks, conservation easement description, as-builts. Estimate based on 75 field days @$1,500/day and 40 office days @$800/day plus expenses of $15,000. Total approx. $53,200 per year over first 3 years.
C	Environmental Permitting	Highly complex, approximately 3 years. Estimate $450,000 based on previous projects.
D	Environmental Oversight	Oversee weir installation, pump installation, culvert removal, berm construction, planting, and inspect erosion control. Biologist @$85/hour on site 6 hours/day through construction (180 day total) = $91,800
E	Engineering Design and Permitting	Highly complex surface and groundwater modeling, ensure no impact to adjacent lands, substantial ERP support, model water levels, canal drawdown, prove all wetland hydroperiods will be improved and maintained. Provide plan set and engineers report. Estimate $400,000.
F	As-Built Certification	Engineer's certification that creation area, berms, control structures, and ditch removal is performed correctly. Estimate $50,000.
G	Construction	1) Remove 5 structures @$3,000 each = $15,000. 2) Remove 35% of canal berm and install rock weir at SHWE. Earthmoving = 17,351ft. X 35% = (6,073 ft. x 85 ft. wide x 3 ft. high)/27 = 57,356 cy. x $4/cy. = $229,424. Rock weir = 6,073 ft. x $122/ft (based on recent similar project) = $740,906. 3.) Construct earthen berms to separate restoration cells = (1,892 ft. x 20 ft. wide x 2 ft. high)/27 = 2,803 cy x $6/cy. = $16,818. 4.) Purchase and install solar pumps. Horizontal water loss eto canal estimated at 1.8MGD based on average Kh of 4.65in./hr for the soil types. (4.65 in./hr./12 = 0.3875 ft./hr. x 1.5 ft deep x 17,424 ft. of canal = 10,128 cubic ft./hr. x 7.48 cubic ft./gallon = 75,757 gal./hr. x 24 = 1,818,179 gal day of loss.) Each $6,000 pump = 20,000 gal/day = approximately 91 pumps ($546,000). Installation of 8 solar panels for each well (requires crane, concrete setting, wiring) and digging wells $2,500 each = $227,500. Total = $1,775,648.
H	Maintenance	Maintenance of nuisance/exotic vegetation estimated at $2,700/crew day. Year 4 : Initial mechanical spray out of grasses $20,000, plus seven 10-day events ($209,000). Year 5-7: six 8-day events ($129,600). Year 8 and beyond: quarterly 6-day events ($64,800).
I	Planting	Assume supplemental planting required in 50% of restoration area (none in enhancement wetlands): 176.7 ac x 4,840 units @ $0.75/unit x 50%= $320,710.
J	Miscellaneous Costs	Monitoring wells (12@$1,500 = $18,000), transect markers ($2000) = $20,000
K	Monitoring	Semi-annual monitoring for 5 years, baseline and completion report in Year 4 for a total 12 events at $18,000/event. Year 4 = $48,000, Years 5-8 = $36,000. After success, $5,000/year.
L	Fencing and Security	Site currently fenced; fencing may require repair after construction and signage may be required by agencies. Estimate $5,000 as a placeholder.
M	Legal/Accounting	Legal review of conservation easement, title insurance, trust fund documents, federal legal documents, etc. Banking, expense tracking, government reporting. Estimate $10,000 per year average.
N	Management/Marketing	Promotion of credits, advertising, sales expenses, credit ledger adjustments, record keeping, agency reporting, etc. 7% of sales is typical.
O	Trust Fund Escrow	Annual maintenance, monitroing, and reporting estimated at $69,800/yr requiring escrow amount of $1,163,333 @6%. Paid from credit sales at $21,500 per credit.
P	Trustee Fees	Industry standard.
Q	Credits Sold	No preservation credits. Total of 3.59 enhancement credits available in Year 6. Remainder available by Year 8. When available, credit sales conservatively estimated at 10/year.
R	Credit Price	Herbaceous credit prices in adjacent basins are currently Braden River $100,000 and Myakka $90,000. Southern Coastal land values generally higher and credits will not be sold for several years. Assume credit price will be $115,000

Table 2- West Pinelands Pro Forma (Page 1)

ASSESSMENT AREA	MITIGATION AREA (acres)	SCORE: LOCATION AND LANDSCAPE				SCORE: WATER ENVIRONMENT				SCORE: COMMUNITY STRUCTURE				BASELINE	WITHOUT PRESERVATION	WITH PRESERVATION	PRESERVE DELTA	P - FACTOR	Time Lag	Risk	PRESERVATION RFG	PRESERVE CREDIT	WITH ENHANCEMENT	ENHANCEMENT DELTA	Time Lag	Risk	ENHANCEMENT RFG	ENHANCEMENT CREDIT	Total Potential Credits
		BASE LINE	W/O PRES	WITH PRES	WITH MIT	BASE LINE	W/O PRES	WITH PRES	WITH MIT	BASE LINE	W/O PRES	WITH PRES	WITH MIT																
Wetland Enhancement																													
Wetland 7	11.33	6	5	6	7	4	4	4	8	5	4	5	8	0.50	0.43	0.50	0.07	0.50	1.00	1.25	0.03	0.30	0.77	0.27	1.14	1.75	0.13	1.51	1.82
Wetland 8	0.16	6	0	6	7	4	0	4	8	4	0	4	8	0.47	0.00	0.47	0.47	0.60	1.00	1.25	0.22	0.04	0.77	0.30	1.14	1.75	0.15	0.02	0.06
Wetland 9	1.94	6	5	6	7	5	5	5	8	6	4	6	8	0.57	0.47	0.57	0.10	0.50	1.00	1.25	0.04	0.08	0.77	0.20	1.14	1.75	0.10	0.19	0.27
Wetland 11	3.26	7	4	7	7	7	7	7	8	7	4	7	8	0.70	0.50	0.70	0.20	0.50	1.00	1.25	0.08	0.26	0.77	0.07	1.14	1.75	0.03	0.11	0.37
Wetland 12	0.46	7	0	7	7	6	0	6	8	6	0	6	8	0.63	0.00	0.63	0.63	0.60	1.00	1.25	0.30	0.14	0.77	0.13	1.14	1.75	0.07	0.03	0.17
Wetland 13	0.24	7	0	7	7	6	0	6	8	6	0	6	8	0.63	0.00	0.63	0.63	0.60	1.00	1.25	0.30	0.07	0.77	0.13	1.14	1.75	0.07	0.02	0.09
Wetland 14	2.71	6	4	6	7	4	4	4	8	5	4	5	8	0.50	0.40	0.50	0.10	0.60	1.00	1.25	0.05	0.13	0.77	0.27	1.14	1.75	0.13	0.36	0.49
Wetland 15	0.57	6	4	6	7	4	4	4	8	2	2	2	8	0.40	0.33	0.40	0.07	0.60	1.00	1.25	0.03	0.02	0.77	0.37	1.14	1.75	0.18	0.10	0.12
Subtotal	20.67																					1.04						2.36	3.39
Wetland Restoration																													
Wetlands 7-13 and 15	9.25	0	0	0	7	0	0	0	7	0	0	0	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.70	1.14	2.00	0.31	2.84	2.84
Native Uplands																													
UP-1	44.96	5	0	5	6	NA	NA	NA	NA	5	0	5	9	0.50	0.00	0.50	0.50	0.80	1.00	1.25	0.32	14.39	0.75	0.25	1.07	1.50	0.16	7.00	21.39
UP-2	35.64	7	0	7	7	NA	NA	NA	NA	7	0	7	9	0.70	0.00	0.70	0.70	0.40	1.00	1.25	0.22	7.98	0.80	0.10	1.07	1.50	0.06	2.22	10.20
Subtotal	80.60																					22.37						9.22	31.59
Total UMAM	**110.52**																					**23.41**						**14.42**	**37.83**
Mesic Hammock	79.82																												19.96

Table 3 – Albritton, Alternative 2 UMAM Credit Assessment

Note	Expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Total
A	Project Management	$ 31,200	$ 31,200	$ 31,200					$ 93,600
B	Survey	$ 11,000	$ 11,000	$ 11,000					$ 33,000
C	Environmental Permitting	$ 100,000	$ 100,000						$ 200,000
D	Environmental Oversight			$ 15,300					$ 15,300
E	Engineering	$ 40,000	$ 40,000						$ 80,000
F	As-Built Certification			$ 15,000					$ 15,000
G	Road Removal/Ditch Backfill			$ 36,000					$ 36,000
H	Maintenance			$ 108,000	$ 64,800	$ 43,200	$ 43,200	$ 43,200	$ 302,400
I	Planting			$ 263,730					$ 263,730
J	Miscellaneous Costs			$ 9,500					$ 9,500
K	Monitoring			$ 28,000	$ 14,000	$ 14,000	$ 14,000	$ 14,000	$ 84,000
L	Fencing and Security			$ 12,000					$ 12,000
M	Legal/Accounting	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 70,000
N	Management/Marketing	$ -	$ -	$ 80,500	$ 80,500	$ 40,250	$ 40,250	$ 63,032	$ 304,532
O	Trust Fund Escrow	$ -	$ -	$ 105,430	$ 105,430	$ 52,715	$ 52,715	$ 82,552	$ 398,842
P	Trustee Fees	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 14,000
	Subtotal	$ 194,200	$ 194,200	$ 727,660	$ 276,730	$ 162,165	$ 162,165	$ 214,783	$ 1,931,903
	Revenue								
Q	Credits Sold	0.00	0.00	10.00	10.00	5.00	5.00	7.83	37.83
R	Credit Price	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	
	Gross Revenue	$ -	$ -	$ 1,150,000	$ 1,150,000	$ 575,000	$ 575,000	$ 900,450	$ 4,350,450
	Total Net Revenue	$ (194,200)	$ (194,200)	$ 422,340	$ 873,270	$ 412,835	$ 412,835	$ 685,667	$ 2,418,547
	NPV	$1,656,285.49							
	Discount Rate	7%							

Table 4 – Albritton, Alternative 2 Pro Forma (Page 1)

A	Project Management	Management of all schedules, deliverables, billing, etc. Estimate based on a bill rate of $150/hour, 4 hours per week, Years 1 - 3 through implementation = $150 x 4 hrs/week x 52 weeks = $31,200/year
B	Survey	Survey SHWL elevations, establish benchmarks, conservation easement description, as-builts. Estimate based on 15 field days @$1,500/day and 10 office days @$800/day plus expenses of $2,500. Total approx. $33,000 over first 3 years.
C	Environmental Permitting	Low to moderate complexity, approximately 2 years. Estimate $200,000 based on previous projects.
D	Environmental Oversight	Oversee reservoir construction near wetlands, oversee road removal/ditch backfill, inspect erosion control. Biologist @$85/hour on site 6 hours/day intermittently through construction (30 days total) = $15, 300
E	Engineering Design and Permitting	Most issues resolved with reservoir design. Provide ERP support, model water levels, reservoir drawdown, prove wetland hydroperiods will be improved and maintained. Provide plan set and engineers report. Estimate $80,000.
F	As-Built Certification	Engineer's certification that ditching is removed and topography re-established at grade. Estimate $15,000.
G	Ditch Backfill/Grading	Push trails and spoil into ditch to create shallow spreader swales. Estimate based on previous projects. Excavator and bulldozer, $1,500 /day each x 12 days $36,000.
H	Maintenance	Maintenance of nuisance/exotic vegetation estimated at $2,700/crew day. Year 3 : Initial 10 days plus five 6-day events ($108,000). Year 4: six 4-day events ($64,800). Years 5-7: quarterly 4-day events ($43,200), Year 8 and beyond: quarterly 2-day events($21,600).
I	Planting	Assume supplemental planting required in 50% of wetland area (15 acres x 4,840 units x $0.75/unit = $54,450). Assume supplemental groundcover (10' on-center) required in 25% of uplands (40 acres x 436 units x $1 2= $209,280).
J	Miscellaneous Costs	Monitoring wells (6@$1,500), transect markers ($500) = $9,500.
K	Monitoring	Semi-annual monitoring for 5 years, baseline and completion report in Year 3 for a total 12 events at $7,000/event. Year 3 = $28,000, Years 4-7 = $14,000. $2,400/year after success.
L	Fencing and Security	Estimate based on industry standards at $2.00 per linear foot of perimeter. Security will likely be resolved with reservoir, but estimate 6,000 feet of perimeter on south and northeast sections as a placeholder ($12,000).
M	Legal/Accounting	Legal review of conservation easement, title insurance, trust fund documents, federal legal documents, etc. Banking, expense tracking, government reporting. Estimate $10,000 per year average.
N	Management/Marketing	Promotion of credits, advertising, sales expenses, credit ledger adjustments, record keeping, agency reporting, etc. 7% of sales is typical.
O	Trust Fund Escrow	Annual maintenance, monitoring, and reporting estimated at $24,000/yr requiring escrow amount of $400,000.@ 6%. Paid from credit sales at $10,574 per credit.
P	Trustee Fees	Industry standard.
Q	Credits Sold	Limited by available credits. Total of 23 preservation credits available in Years 3-4. Progressive success releases over following 3 years.
R	Credit Price	Herbaceous credit prices in adjacent basins are currently Braden River $100,000 and Myakka $90,000. Southern Coastal land values generally higher and credits will not be sold for several years. Assume credit price will be $115,000.

Table 4 – Albritton, Alternative 2 Pro Forma (Page 2)

ASSESSMENT AREA	MITIGATION AREA (acres)	SCORE: LOCATION AND LANDSCAPE				WATER ENVIRONMENT				COMMUNITY STRUCTURE				BASELINE	WITHOUT PRESERVATION	WITH PRESERVATION	PRESERVE DELTA	P - FACTOR	Time Lag	Risk	PRESERVATION RFG	PRESERVE CREDIT	WITH ENHANCEMENT	ENHANCEMENT DELTA	Time Lag	Risk	ENHANCEMENT RFG	ENHANCEMENT CREDIT	Total Potential Credits
		BASE LINE	W/O PRES	WITH PRES	WITH MIT	BASE LINE	W/O PRES	WITH PRES	WITH MIT	BASE LINE	W/O PRES	WITH PRES	WITH MIT																
Wetland Enhancement																													
Wetland 4	0.98	6	4	6	8	5	5	5	8	5	4	5	8	0.53	0.43	0.53	0.10	0.50	1.00	1.25	0.04	0.04	0.80	0.27	1.14	1.75	0.13	0.13	0.17
Wetland 5	0.58	6	4	6	8	5	5	5	8	5	4	5	8	0.53	0.43	0.53	0.10	0.60	1.00	1.25	0.05	0.03	0.80	0.27	1.14	1.75	0.13	0.08	0.11
Wetland 7	11.33	6	5	6	8	4	4	4	8	5	4	5	8	0.50	0.43	0.50	0.07	0.50	1.00	1.25	0.03	0.30	0.80	0.30	1.14	1.75	0.15	1.70	2.01
Wetland 8	0.16	6	0	6	8	4	0	4	8	4	0	4	8	0.47	0.00	0.47	0.47	0.60	1.00	1.25	0.22	0.04	0.80	0.33	1.14	1.75	0.17	0.03	0.06
Wetland 9	1.94	6	5	6	8	5	5	5	8	6	4	6	8	0.57	0.47	0.57	0.10	0.50	1.00	1.25	0.04	0.08	0.80	0.23	1.14	1.75	0.12	0.23	0.30
Subtotal	14.99																					0.48						2.17	2.65
Wetland Restoration																													
Wetlands 7-9 and WR	30.98	0	0	0	8	0	0	0	7	0	0	0	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.73	1.14	2.00	0.32	9.96	9.96
Wetland Creation																													
MC	104.34	0	0	0	7	0	0	0	7	0	0	0	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.70	1.14	2.50	0.25	25.63	25.63
Native Uplands																													
UP-1	1.33	5	0	5	8	NA	NA	NA	NA	5	0	5	9	0.50	0.00	0.50	0.50	0.80	1.00	1.25	0.32	0.43	0.85	0.35	1.07	1.50	0.22	0.29	0.72
UP-2	36.92	7	0	7	8	NA	NA	NA	NA	7	0	7	9	0.70	0.00	0.70	0.70	0.80	1.00	1.25	0.45	16.54	0.85	0.15	1.07	1.50	0.09	3.45	19.99
Buffer Zones	11.74	0	0	0	7	NA	NA	NA	NA	0	0	0	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.70	1.25	2.00	0.28	3.29	3.29
Subtotal	49.99																					16.97						7.03	23.99
Total UMAM	**200.30**																					**17.45**						**44.79**	**62.23**
Mesic Hammock	62.77																												15.69

Table 5 – Albritton, Alternative 3 UMAM Credit Assessment

Note	Expenses	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
A	Project Management	$ 46,800	$ 46,800	$ 46,800								$ 140,400
B	Survey	$ 32,000	$ 32,000	$ 32,000								$ 96,000
C	Environmental Permitting	$ 175,000	$ 175,000									$ 350,000
D	Environmental Oversight			$ 61,200								$ 61,200
E	Engineering	$ 100,000	$ 100,000									$ 200,000
F	As-Built Certification			$ 30,000								$ 30,000
G	Construction			$ 2,374,440								$ 2,374,440
H	Maintenance			$ 216,000	$ 129,600	$ 129,600	$ 129,600	$ 129,600	$ 64,800	$ 64,800	$ 64,800	$ 928,800
I	Planting			$ 881,060								$ 881,060
J	Miscellaneous Costs			$ 20,000								$ 20,000
K	Monitoring			$ 48,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 24,000	$ 3,000	$ 3,000	$ 174,000
L	Fencing and Security			$ 18,000								$ 18,000
M	Legal/Accounting	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 100,000
N	Management/Marketing	$ -	$ -	$ 80,500	$ 59,973	$ -	$ 30,107	$ 80,500	$ 80,500	$ 80,500	$ 88,872	$ 500,952
O	Trust Fund Escrow	$ -	$ -	$ 181,580	$ 135,277	$ -	$ 67,911	$ 181,580	$ 181,580	$ 181,580	$ 200,464	$ 1,129,972
P	Trustee Fees	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 20,000
	Subtotal	$ 365,800	$ 365,800	$ 4,001,580	$ 360,850	$ 165,600	$ 263,618	$ 427,680	$ 362,880	$ 341,880	$ 369,136	$ 7,024,824
	Revenue											
Q	UMAM Credits Sold	0.00	0.00	10.00	7.45	0.00	3.74	10.00	10.00	10.00	11.04	62.23
R	UMAM Credit Price	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	$ 115,000	
	UMAM Credit Gross Revenue	$ -	$ -	$ 1,150,000	$ 856,750	$ -	$ 430,100	$ 1,150,000	$ 1,150,000	$ 1,150,000	$ 1,269,600	$ 7,156,450
	Total Net Revenue	$ (365,800)	$ (365,800)	$(2,851,580)	$ 495,900	$ (165,600)	$ 166,482	$ 722,320	$ 787,120	$ 808,120	$ 900,464	$ 131,626
	NPV	($812,678.77)										
	Discount Rate	7%										

Table 6 – Albritton, Alternative 3 Pro Forma (Page 1)

A	Project Management	Management of all schedules, deliverables, billing, etc. Estimate based on a bill rate of $150/hour, 6 hours per week, Years 1 -3 through implementation = $150 x 6 hrs/week x 52 weeks = $46,800/year
B	Survey	Survey SHWL elevations, establish benchmarks, conservation easement description, as-builts. Estimate based on 45 field days @$1,500/day and 25 office days @$800/day plus expenses of $8,000. Total approx. $32,000 per year over first 3 years.
C	Environmental Permitting	Moderate complexity, approximately 2 years. Estimate $350,000 based on previous projects.
D	Environmental Oversight	Oversee wetland creation, sideslopes, road removal/ditch backfill, planting, and inspect erosion control. Biologist @$85/hour on site 8 hours/day through construction (90 days total) = $61,200
E	Engineering Design and Permitting	Design considered in reservoir permitting, provide ERP support, model water levels, reservoir drawdown, prove all wetland hydroperiods will be improved and maintained. Provide plan set and engineers report. Estimate $200,000.
F	As-Built Certification	Engineer's certification that creation area, berms, control structures, and ditch removal is performed correctly. Estimate $30,000.
G	Construction	1) Clear creation area (MC): 104 ac. X $1,500/ac. = $156,000. 2) Excavate MC avg. of 3 ft. = 104 ac. X 3 ft. = 503,360 cy. X $4/cy. = $2,013,440. 3) Dress sideslopes and transitional areas, back fill ditches = 30 days @ $1,500/day = $45,000. 4) Install discharge structures = 20 days @$3,000/day = $60,000. Hardened discharge structure budget $100,000.
H	Maintenance	Maintenance of nuisance/exotic vegetation estimated at $2,700/crew day. Year 3 : Eight 10-day events ($216,000). Year 4-7: six 8-day events ($129,600). Year 8 and beyond: quarterly 6-day events($64,800).
I	Planting	Assume supp. planting required in 50% of existing wetland area (12 ac x 4,840 units @ $0.75/unit = $43,560). Plant MC and WR (130ac.) = $471,900. Assume supp. groundcover (10' on-center) planted in 25% of uplands (25 ac. x 436 units x $12= $130,800). Plant buffer sideslope @ $20,000/ac. = $234,800.
J	Miscellaneous Costs	Monitoring wells (12@$1,500 = $18,000), transect markers ($2000) = $20,000
K	Monitoring	Semi-annual monitoring for 5 years, baseline and completion report in Year 3 for a total 12 events at $12,000/event. Year 3 = $48,000, Years 4-7 = $24,000. After success, $3,000/year.
L	Fencing and Security	Estimate based on industry standards at $2.00 per linear foot of perimeter. Security will likely be resolved with reservoir, but estimate 9,000 feet of perimeter on south and eas sections as a placeholder ($18,000).
M	Legal/Accounting	Legal review of conservation easement, title insurance, trust fund documents, federal legal documents, etc. Banking, expense tracking, government reporting. Estimate $10,000 per year average.
N	Management/Marketing	Promotion of credits, advertising, sales expenses, credit ledger adjustments, record keeping, agency reporting, etc. 7% of sales is typical.
O	Trust Fund Escrow	Annual maintenance, monitroing, and reporting estimated at $67,800/yr requiring escrow amount of $1,130,000 @6%. Paid from credit sales at $18,158 per credit.
P	Trustee Fees	Industry standard.
Q	Credits Sold	Limited by available credits. Total of 17.45 preservation credits available in Years 3-4. Progressive success releases in years 5-8. When available, credit sales conservatively estimated at 10/year.
R	Credit Price	Herbaceous credit prices in adjacent basins are currently Braden River $100,000 and Myakka $90,000. Southern Coastal land values generally higher and credits will not be sold for several years. Assume credit price will be $115,000.

Table 6 – Albritton, Alternative 3 Pro Forma (Page 2)

TM 4.1.5 – ALTERNATIVE IMPACT ANALYSIS (BRA)

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD), are currently completing the necessary, pre-requisite data collection and analysis as well as the Comprehensive Watershed Management Plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), EarthBalance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan, and the Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by BRA to rank and prioritize the assessed tracts based on project cost benefit and overall enhancement to water resources subsequent to restoration, to present a table comparing existing and proposed natural system conditions within the freshwater segment of the watershed, to summarize the natural system improvements or degradation that would occur as a result of implementing any of the alternatives, and to describe the permitting issues/constraints related to each alternative, consistent with Task 4.1.5 of the DBWMP contract.

2.0 ANALYSES

2.1 Introduction

BRA used the results of the extensive field and database evaluations to rank the mitigation alternatives for each of four (4) publicly-owned tracts included within the Dona Bay Watershed Plan [Albritton (AL), West Pinelands (WP), the Myakka Connector (MC), and Venice Minerals (VM)]. To assess potential mitigation scenarios and opportunities, the approximate, historical wetland limits were superimposed over the current wetland limits to graphically evaluate how their extent had changed in the last 60 years. The difference in the acreages was used as a baseline to determine the cost and benefit of restoring and/or enhancing the site to its historical condition to the extent practicable. Assuming that additional property will not have to be purchased, the cost per acre for wetland creation is estimated to be $60,000. The scoring/ranking of these alternatives assumes an appropriate hydrologic regime.

The rankings are based on a cost-benefit analysis of each alternative. For the **Environmental Cost Ranking**, a "low" ranking is based on the highest mitigation cost per acre; for the **Environmental Benefit Ranking**, a "low" ranking is for a lowest onsite environmental benefit; and for the **Environmental Overall Ranking**, a "low" ranking is the least desirable option. Table 1 is a ranking summary of all the tracts included within this evaluation.

Site	Alt.	Environmental Cost Ranking	Environmental Benefit Ranking	Environmental Overall Ranking	Notes
AL	1	Medium	low	medium	Impacts hammock
AL	2	Low	medium	low	Enhances most wetlands
AL	3	High	high	high	Impacts ½ hammock, restores 113 acres
AL	4	Medium	low	medium	Impacts hammock
WP	1	Medium	high	high	Enhances all wetlands, restores 221 acres
WP	2	Low	medium	low	Enhances all wetlands
WP	3	High	low	medium	Impacts all wetlands
MC	1	Medium	high	high	Enhances all wetlands, restores 171 acres
MC	2	Low	medium	low	Enhances all wetlands
MC	3	High	low	medium	No action
VM	1	Medium		high*	Impacts all wetlands
VM	2	Low		medium*	Impacts lowest quality wetlands
VM	3	High		low*	Preserves all wetlands

Table 1 - Environmental Cost-Benefit Analysis Ranking by Parcel
*Overall ranking based on KHA analysis, including water supply benefits

The remainder of this report is a detailed description of each alternative and the factors used in the cost and benefit analyses of each.

2.1.1 Albritton Site

The Albritton alternatives analysis is based on the four (4) alternatives provided by Post, Buckley, Schuh & Jernigan, Inc. (PBSJ):

- Alternative 1 (refer to Figure 1) proposes impact to all the onsite wetlands, except Wetlands 5 and 16, and 10.84 acres of wetland restoration.

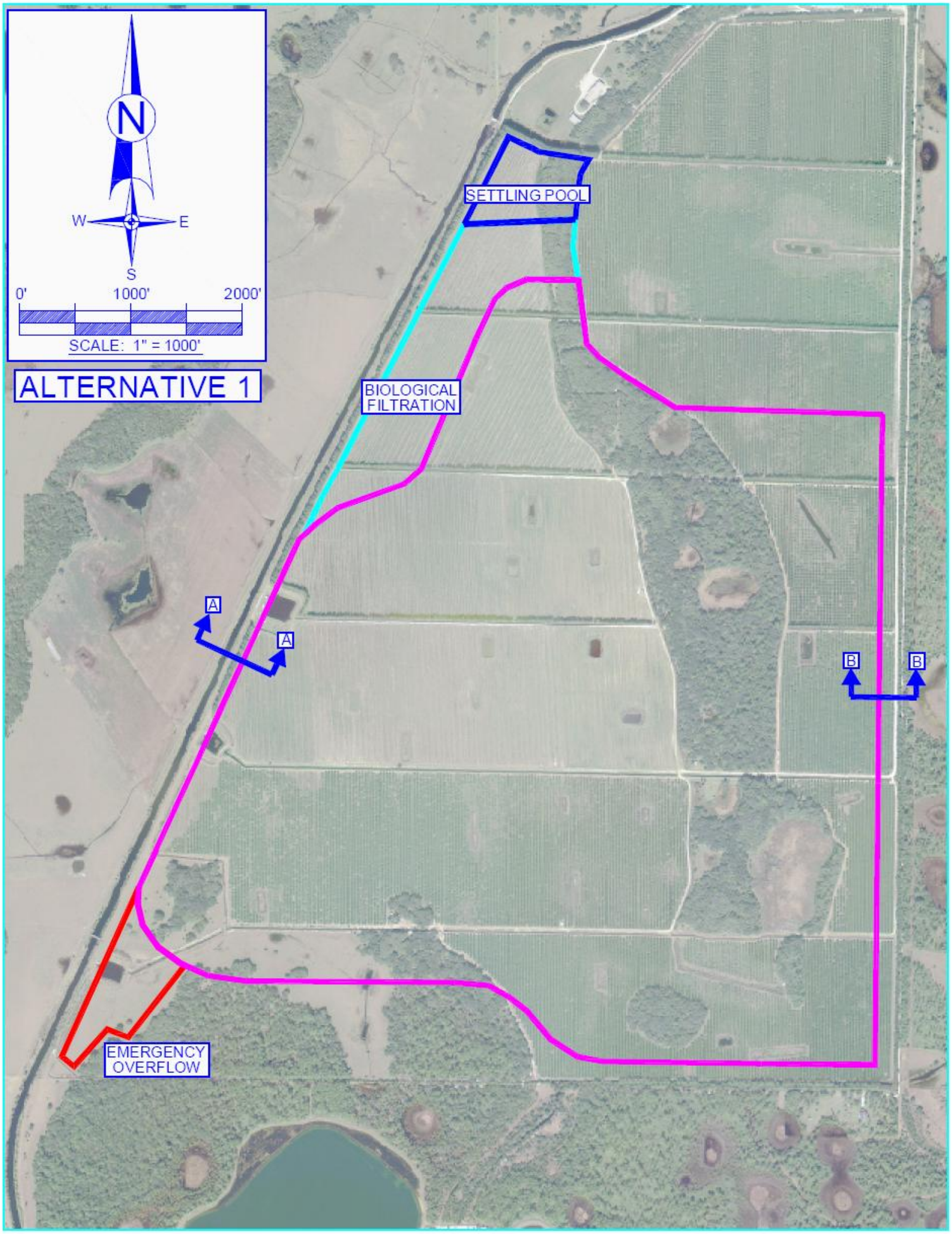


Figure 1 – Albritton, Alternative 1

- Alternative 2 (refer to Figure 2) proposes impacts to Wetland 4 only, enhancement to all the non-impacted wetlands, and the restoration of 10.84 acres of wetland along the southern property boundary.

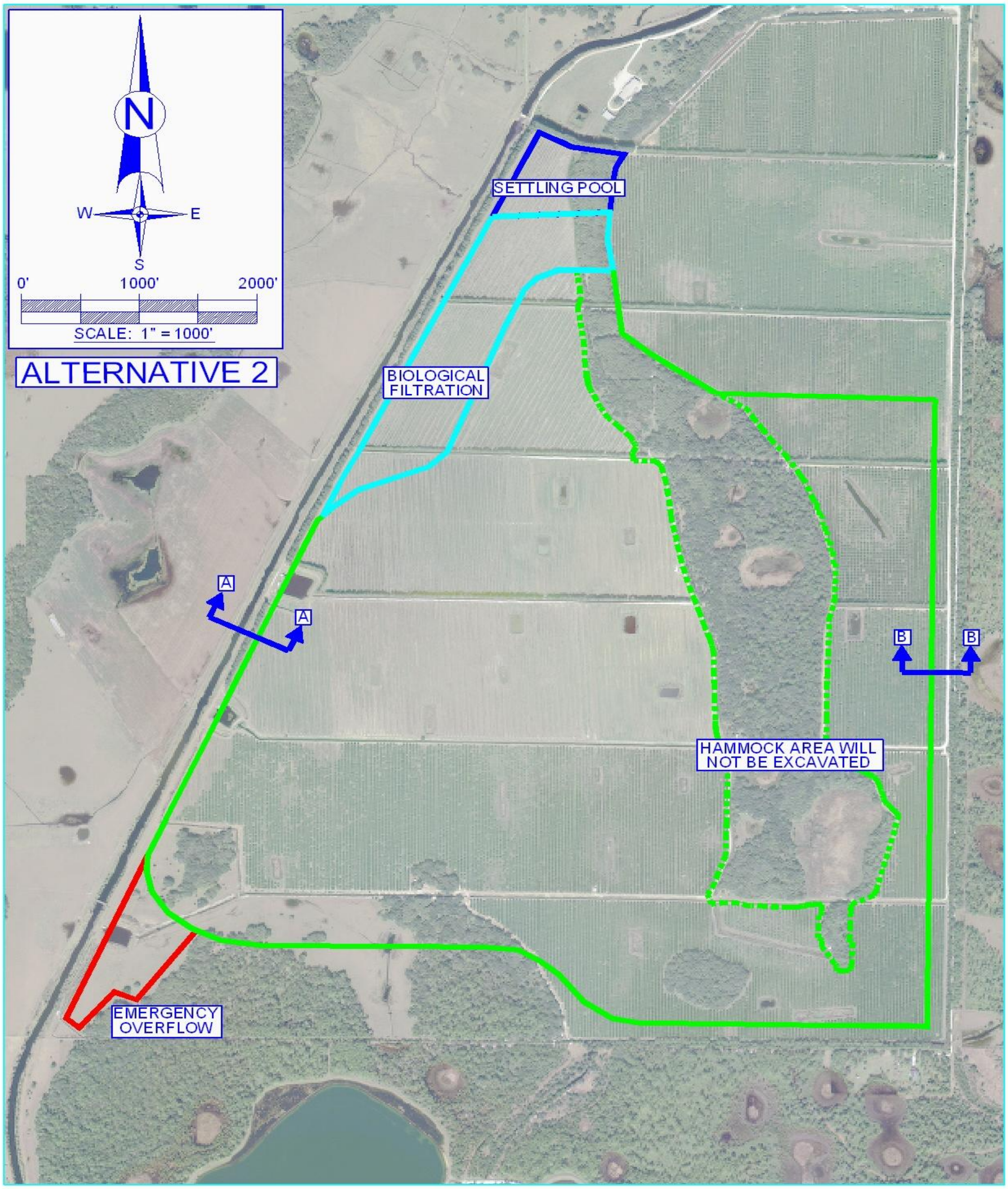


Figure 2 – Albritton, Alternative 2

- Alternative 3 (refer to Figure 3) proposes impact to Wetlands 11, 12, 13, 14 and 15, enhancement of Wetlands 4, 5, 7, 8, 9 and 16, and the restoration of 113.1 acres of wetland.

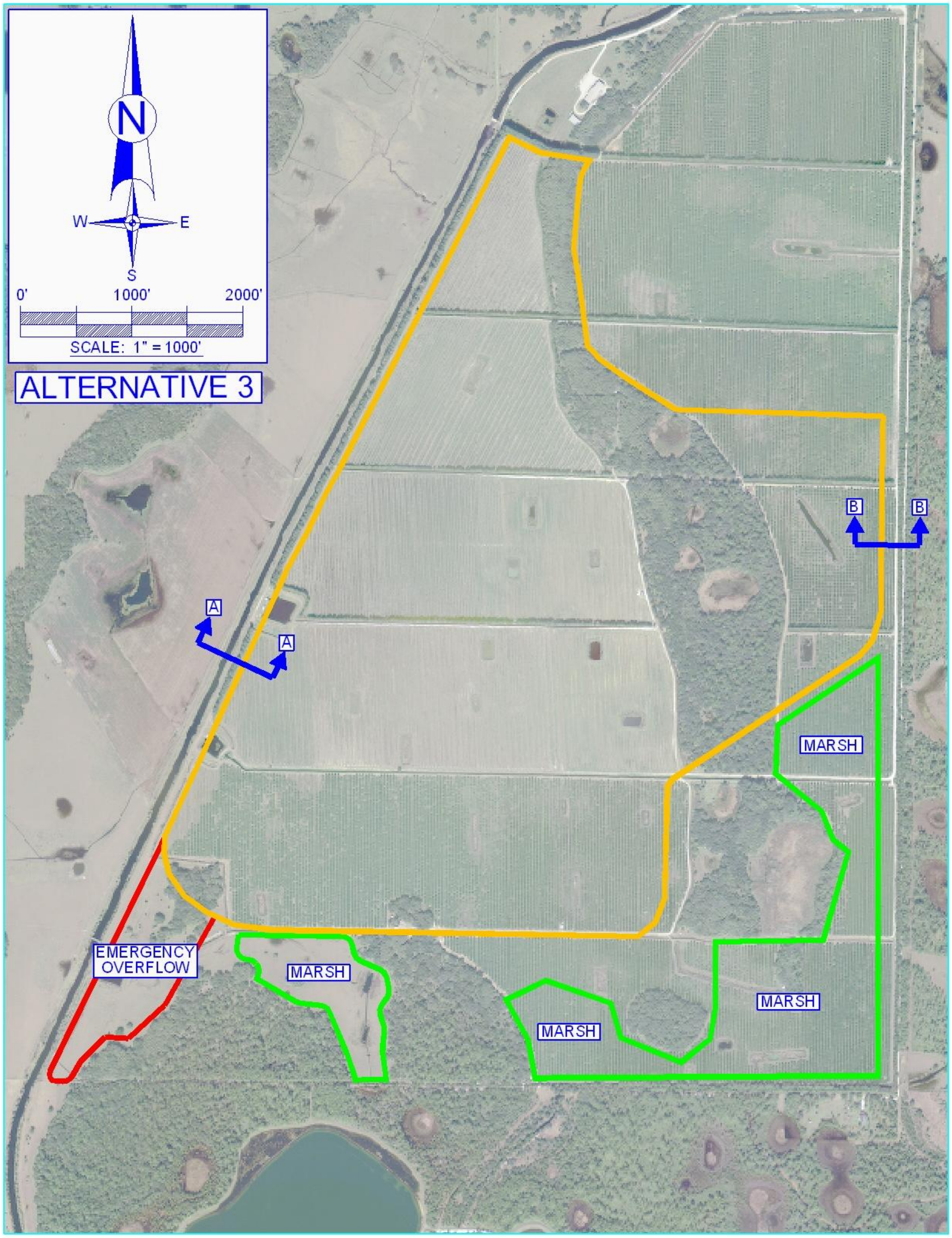


Figure 3 – Albritton, Alternative 3

- Alternative 4 (refer to Figure 4) is environmentally identical to Alternative 1.

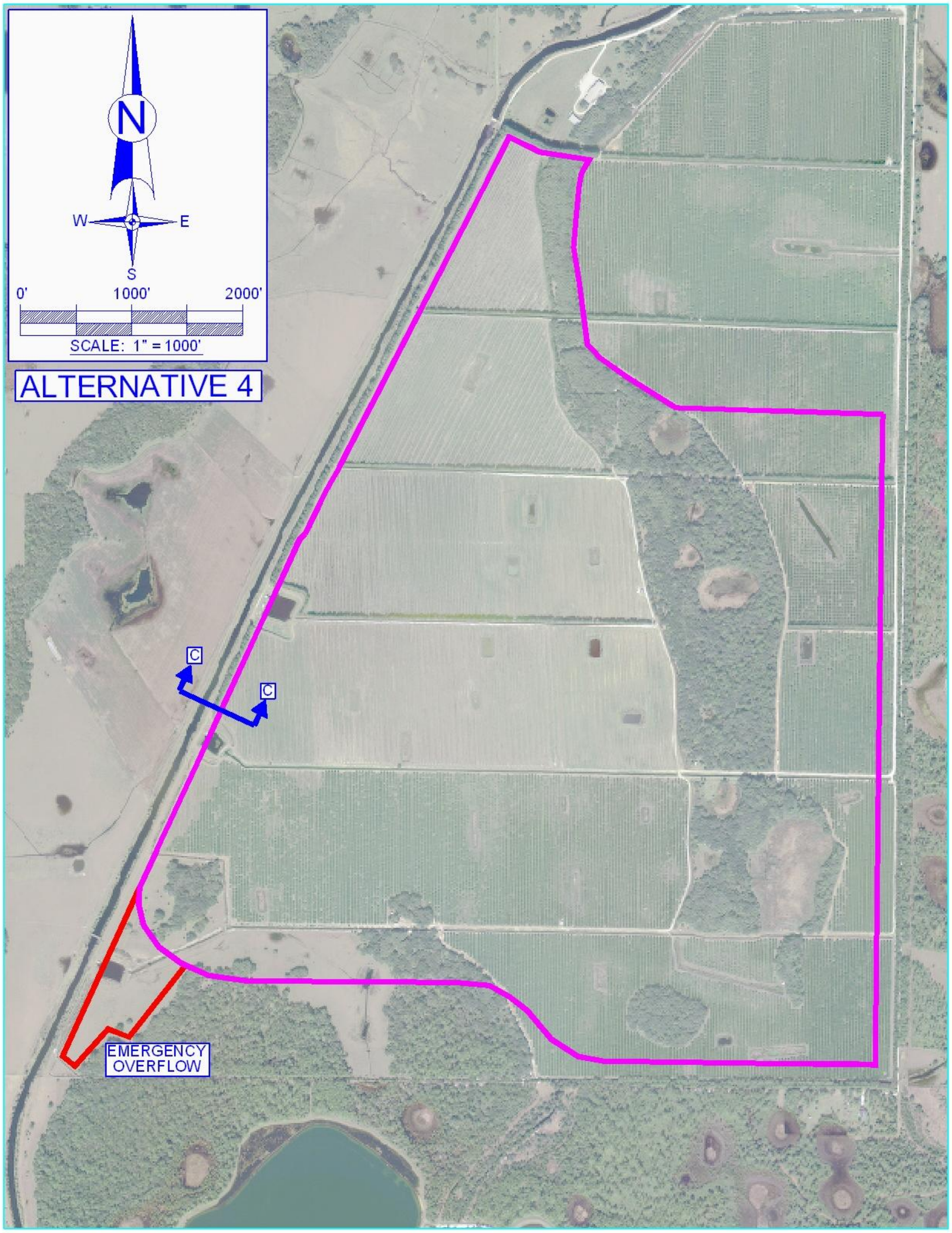


Figure 4 – Albritton, Alternative 4

Table 2 summarizes the environmental rankings associated with each alternative for the Albritton site.

Alt.	Alternative Detail	Environmental Cost Ranking	Environmental Benefit Ranking	Environmental Overall Ranking
1	Impact nine wetlands; restore 10.84 acres	medium ($226,177)	low	medium
2	Impact one wetland; enhance ten wetlands; restore 10.84 acres	low ($229,879)	medium	low
3	Impact five wetlands; enhance six wetlands; restore 113.1 acres	high ($166,434)	high	high
4	Impact nine wetlands; restore 10.84 acres	medium ($226,177)	low	medium

Table 2 - Albritton Alternatives Ranking

Based solely on the estimated cost of mitigation per unit of loss or gain (Environmental Cost), the alternatives would be ranked in the following order:

1. Alternative 3
2. Alternatives 1/4
3. Alternative 2

However, based solely on the Environmental Benefit associated with the functional gain, which could be banked and used as mitigation for future Sarasota County projects, achieved by each alternative, the alternatives be ranked as follows:

1. Alternative 3
2. Alternative 2
3. Alternatives 1/4

A final ranking was determined by using an equal weighting of Environmental Cost and Environmental Benefit as follows:

1. Alternative 3
2. Alternatives 1/4
3. Alternative 2

Wetland	Wetland Acreage	Functional Loss Units [1]	Functional Gain Units*	Alt 1	Alt 2	Alt 3	Alt 4
4	0.76	(0.40)	0.16	(0.40)	(0.40)	0.16	(0.40)
5	0.43	(0.23)	0.09	0.09	0.09	0.09	0.09
7	11.93	(5.97)	2.86	(5.97)	2.86	2.86	(5.97)
8	0.01	(0.01)	0.00	(0.01)	0.00	0.00	(0.01)
9	2.51	(1.42)	0.47	(1.42)	0.47	0.47	(1.42)
11	4.17	(2.92)	0.33	(2.92)	0.33	(2.92)	(2.92)
12	0.90	(0.57)	0.12	(0.57)	0.12	(0.57)	(0.57)
13	0.42	(0.27)	0.06	(0.27)	0.06	(0.27)	(0.27)
14	2.72	(1.36)	0.65	(1.36)	0.65	(1.36)	(1.36)
15	0.79	(0.32)	0.25	(0.32)	0.25	(0.32)	(0.32)
16	0.03	(0.01)	0.01	0.01	0.01	0.01	0.01
Wetland Restoration				4.63	4.63	48.26	4.63
Total (FL)[2] Or FG[3]		**(13.48)**		**(8.51)**	**9.07**	**46.41**	**(8.51)**
Total Est. Mitigation Acreage				19.79			19.79
Total Est. Cost**				$1,246,770+ $678,000= $1,924,770	$2,085,00 0	$7,724,400	$1,246,770+ $678,000= $1,924,770
Cost Per Functional Unit***				$226,177	$229,879	$166,434	$226,177

Table 3 – Albritton Site UMAM Functional Loss and Gain Units

* Based on projected UMAM scores of "8" for location/landscape, hydrology, and species composition for the value of the created mitigation area

**Total Estimated Cost = (restoration/enhancement acreage X $60,000)

***Cost per Functional Unit = Total Estimated Cost/Total FL or FG

[1] Total Functional Loss units if wetland is impacted in its entirety.

[2] Functional Loss

[3] Functional Gain

2.1.2 West Pinelands Site

The West Pinelands alternatives analysis is based upon the three (3) alternatives presented by BRA:

- Alternative 1 (refer to Figure 5) is an enhancement of all the current wetlands and the restoration of the historical floodplain limits (221.2 acres) within the project boundary.
- Alternative 2 (refer to Figure 5) is an enhancement of all the current wetlands.
- Alternative 3 is the impact to all onsite wetlands for floodplain storage.

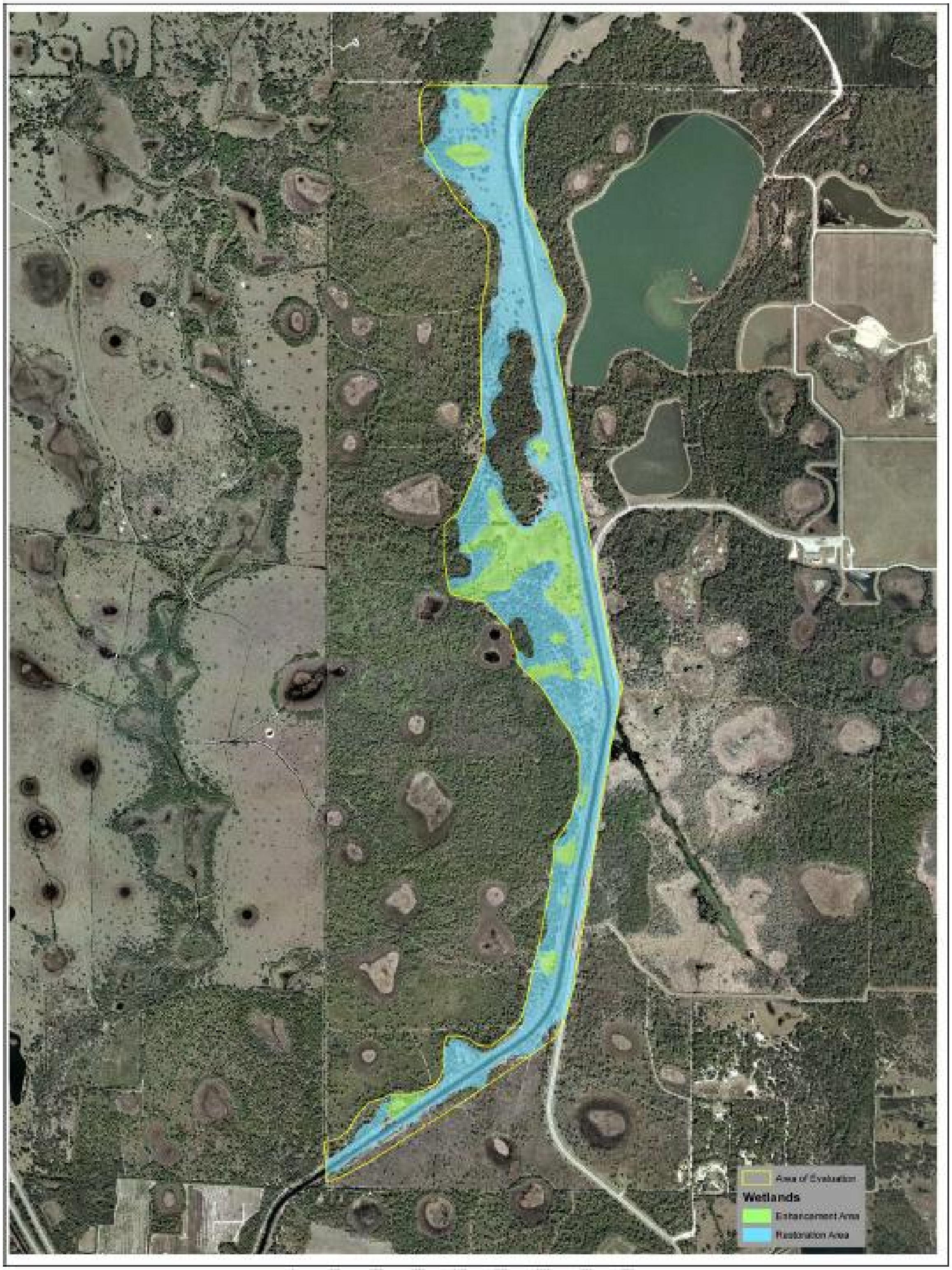


Figure 5 – West Pinelands, Alternatives 1 and 2

Table 4 summarizes the environmental rankings associated with each alternative for the West Pinelands site.

Alt.	Description	Environmental Cost Ranking	Environmental Benefit Ranking	Environmental Overall Ranking
1	Enhance all wetlands; restore 221.2 acres	medium ($170,589)	high	high
2	Enhance all wetlands	low ($799,674)	medium	low
3	Impact all wetlands	high ($146,465)	low	medium

Table 4 - West Pinelands Alternatives Ranking

Based solely on the estimated cost of mitigation per unit functional gain or loss (Environmental Cost), the alternatives would be ranked as follows:

1. Alternative 3
2. Alternative 1
3. Alternative 2

However, based solely on the Environmental Benefit associated with the functional gain, which could be banked and used for future Sarasota County projects, achieved by each alternative, the alternatives are ranked as follows:

1. Alternative 1
2. Alternative 2
3. Alternative 3

A final ranking was determined by using an equal weighting of Environmental Cost and Environmental Benefit as follows:

1. Alternative 1
2. Alternative 3
3. Alternative 2

Wetland	Wetland Acreage	Functional Loss Units[1]	Functional Gain Units*	Alt 1	Alt 2	Alt 3
1	3.40	(2.15)	0.45	0.45	0.45	(2.15)
2	3.70	(2.34)	0.49	0.49	0.49	(2.34)
3	1.40	(0.84)	0.22	0.22	0.22	(0.84)
4A	7.20	(5.28)	0.38	0.38	0.38	(5.28)
4B	31.00	(22.73)	1.65	1.65	1.65	(22.73)
5	0.80	(0.61)	0.02	0.02	0.02	(0.61)
6	3.20	(2.24)	0.26	0.26	0.26	(2.24)
7	0.60	(0.36)	0.10	0.10	0.10	(0.36)
8	1.90	(1.33)	0.15	0.15	0.15	(1.33)
9	0.31	(0.22)	0.02	0.02	0.02	(0.22)
10	1.70	(1.08)	0.23	0.23	0.23	(1.08)
12	3.10	(2.07)	0.33	0.33	0.33	(2.07)
Wetland Restoration			94.01	94.01		
Total (FL)[2] or FG[3]		**(41.25)**	**98.31**	**98.31**	**4.30**	**(41.25)**
Total BRA-estimated mitigation acreage*						95.9
Total BRA-estimated cost**				$16,770,600	$3,438,600	$6,041,700
Cost per Functional Unit***				$170,589	$799,674	$146,465

Table 5 - West Pinelands UMAM Functional Loss and Gain Units

* Based on projected UMAM scores of "8" for location/landscape, hydrology, and species composition for the value of the created mitigation area

**Total Estimated Cost = (restoration/enhancement acreage X $60,000)

***Cost per Functional Unit = Total Estimated Cost/Total FL or FG

[1] Total Functional Loss units if wetland is impacted in its entirety.

[2] Functional Loss

[3] Functional Gain

2.1.3 Myakka Connector

The Myakka Connector alternatives analysis is based upon the three (3) alternatives as follows:

- Alternative 1 (refer to Figure 6) is an enhancement of all the current wetlands and the restoration of the historical floodway limits (171.3 acres) within the project boundary. The estimated cost of enhancement/restoration is $20,000 per acre as no planting or grading is proposed, only restoration of hydrology and minimal nuisance/exotic species removal.
- Alternative 2 (refer to Figure 6) is an enhancement of all the current wetlands.
- Alternative 3 is no action.

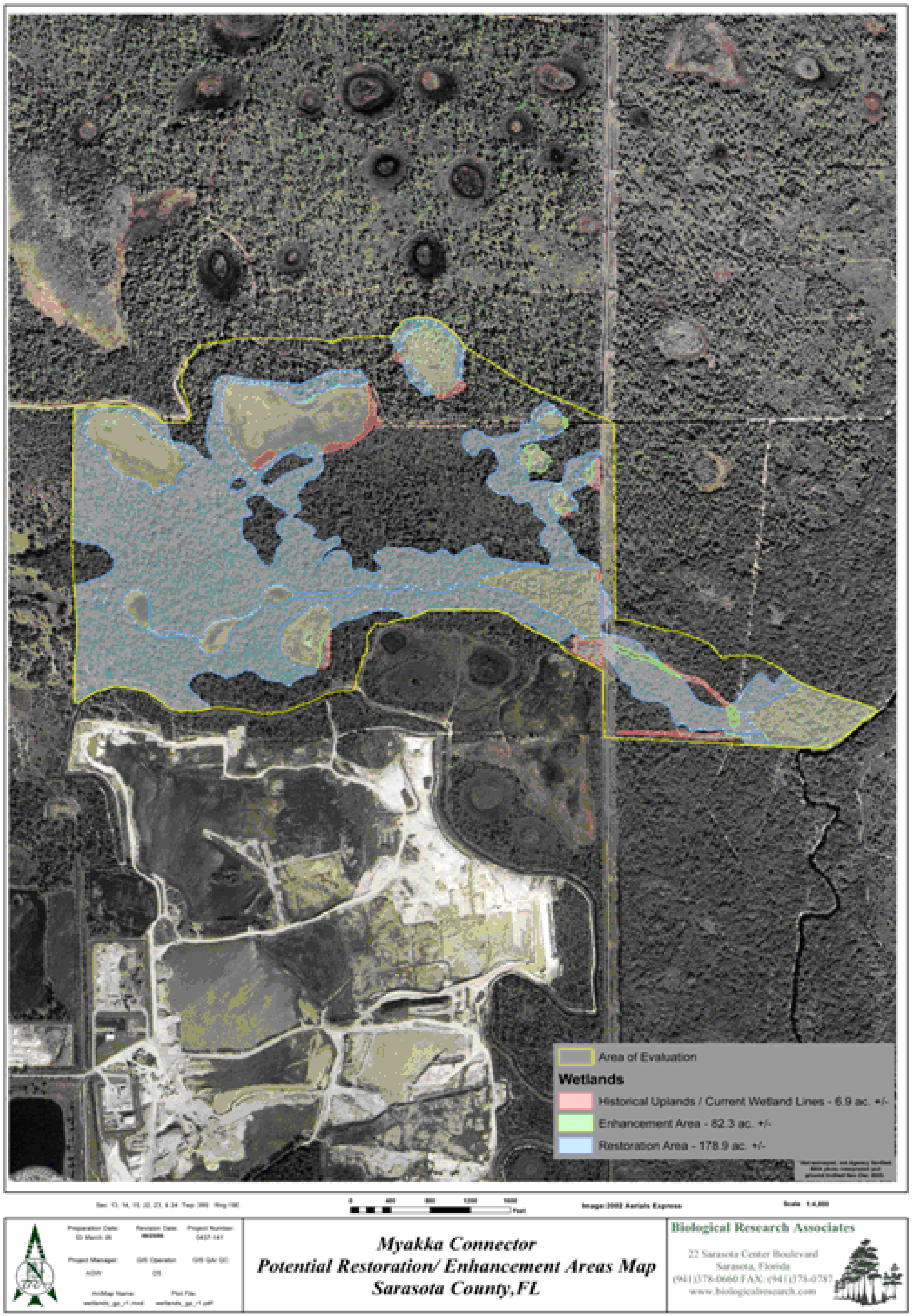


Figure 6 – Myakka Connector, Alternatives 1 and 2

Table 6 summarizes the environmental rankings associated with each alternative for the Myakka Connector site.

Alt.	Alternative Detail	Environmental Cost Ranking	Environmental Benefit Ranking	Environmental Overall Ranking
1	Enhance all wetlands; restore 171.3 acres	medium ($59,652)	high	high
2	Enhance all wetlands	low ($392,118)	medium	low
3	No action	high ($0)	low	medium

Table 6 – Myakka Connector Alternatives Ranking

Based solely on the estimated cost of mitigation per unit functional gain or loss (Environmental Cost), the alternatives would be ranked as follows:

1. Alternative 3
2. Alternative 1
3. Alternative 2

However, based solely on the Environmental Benefit associated with the functional gain, which could be banked and used for future Sarasota County projects, achieved by each alternative, the alternatives are ranked as follows:

1. Alternative 1
2. Alternative 2
3. Alternative 3

A final ranking was determined by using an equal weighting of Environmental Cost and Environmental Benefit and is provided as follows:

1. Alternative 1
2. Alternative 3
3. Alternative 2

Wetland	Wetland Acreage	Functional Loss Units[1]	Functional Gain Units*	Alt 1	Alt 2
1A	12.37	(0.72)	0.33	0.33	0.33
2A	1.30	(1.08)	0.07	0.07	0.07
3A	11.60	(9.67)	0.62	0.62	0.62
4A	22.50	(18.75)	1.20	1.20	1.20
5A	1.60	(1.33)	0.09	0.09	0.09
6A	0.40	(0.33)	0.02	0.02	0.02
7A	1.30	(1.04)	0.10	0.10	0.10
8A	14.00	(11.67)	0.75	0.75	0.75
9A	1.80	(1.56)	0.05	0.05	0.05
1B	7.20	(6.24)	0.19	0.19	0.19
2B	6.30	(5.04)	0.50	0.50	0.50
3B	3.60	(2.88)	0.29	0.29	0.29
4B	1.90	(1.52)	0.15	0.15	0.15
5B	0.20	(0.14)	0.03	0.03	0.03
Wetland Restoration			81.90	81.90	
Total (FL)[2] or FG[3]		**(61.97)**	**86.29**	**86.29**	**4.39**
Total BRA-estimated mitigation acreage*					
Total BRA-estimated cost**				$5,147,400	$1,721,400
Cost per Functional Unit***				$59,652	$392,118

Table 7 – Myakka Connector, UMAM Functional Loss and Gain Units

* Based on projected UMAM scores of "9" for location/landscape, hydrology, and species composition for the value of the created mitigation area

**Total Estimated Cost = (restoration/enhancement acreage X $60,000)

***Cost per Functional Unit = Total Estimated Cost/Total FL or FG

[1] Total Functional Loss units if wetland is impacted in its entirety.

[2] Functional Loss

[3] Functional Gain

2.1.4 Venice Minerals Site

The Venice Minerals alternatives analysis is based on the three (3) impact alternatives provided by KHA:

- Alternative 1 (refer to Figure 7) proposes to impact all of the onsite wetlands.

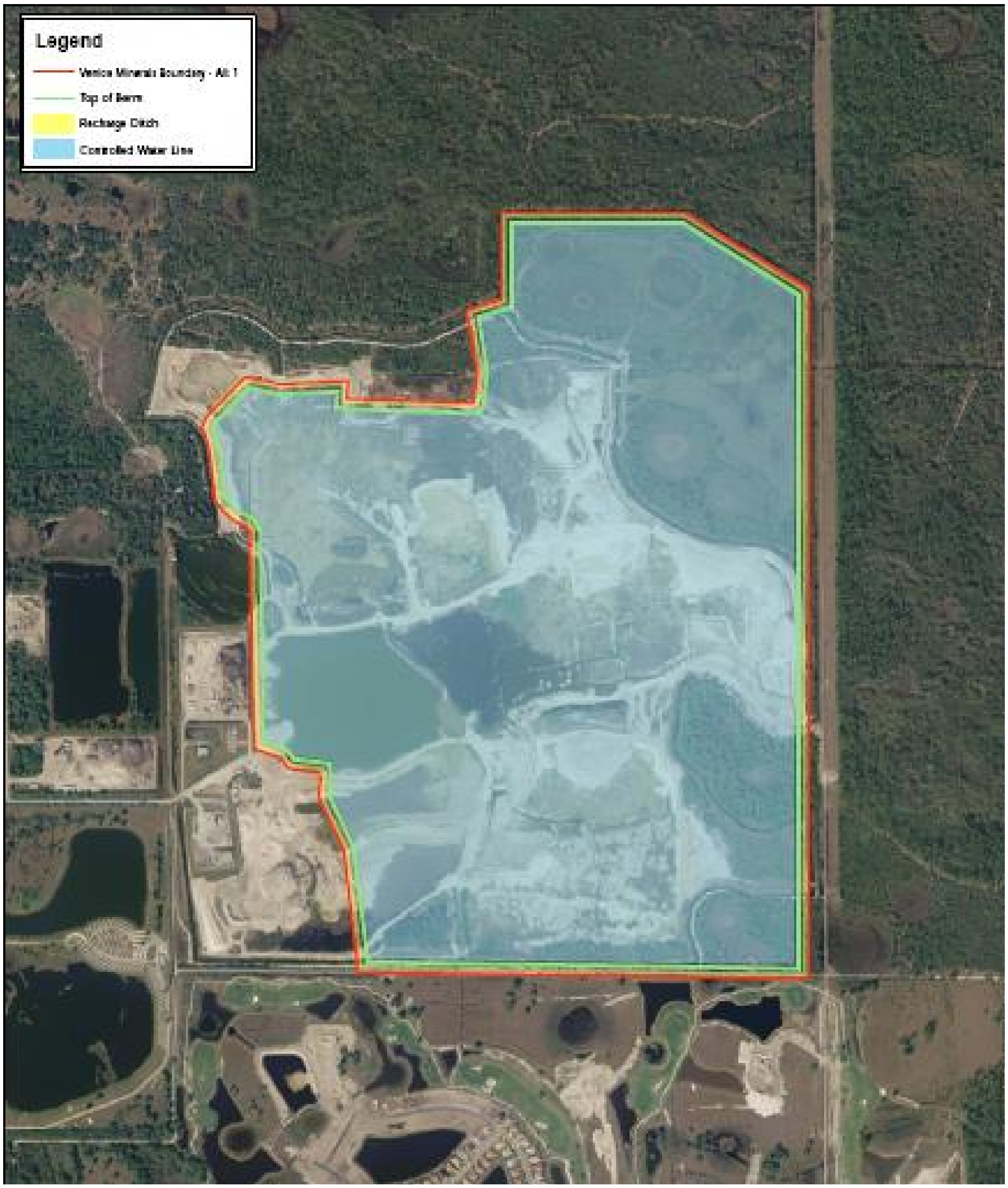
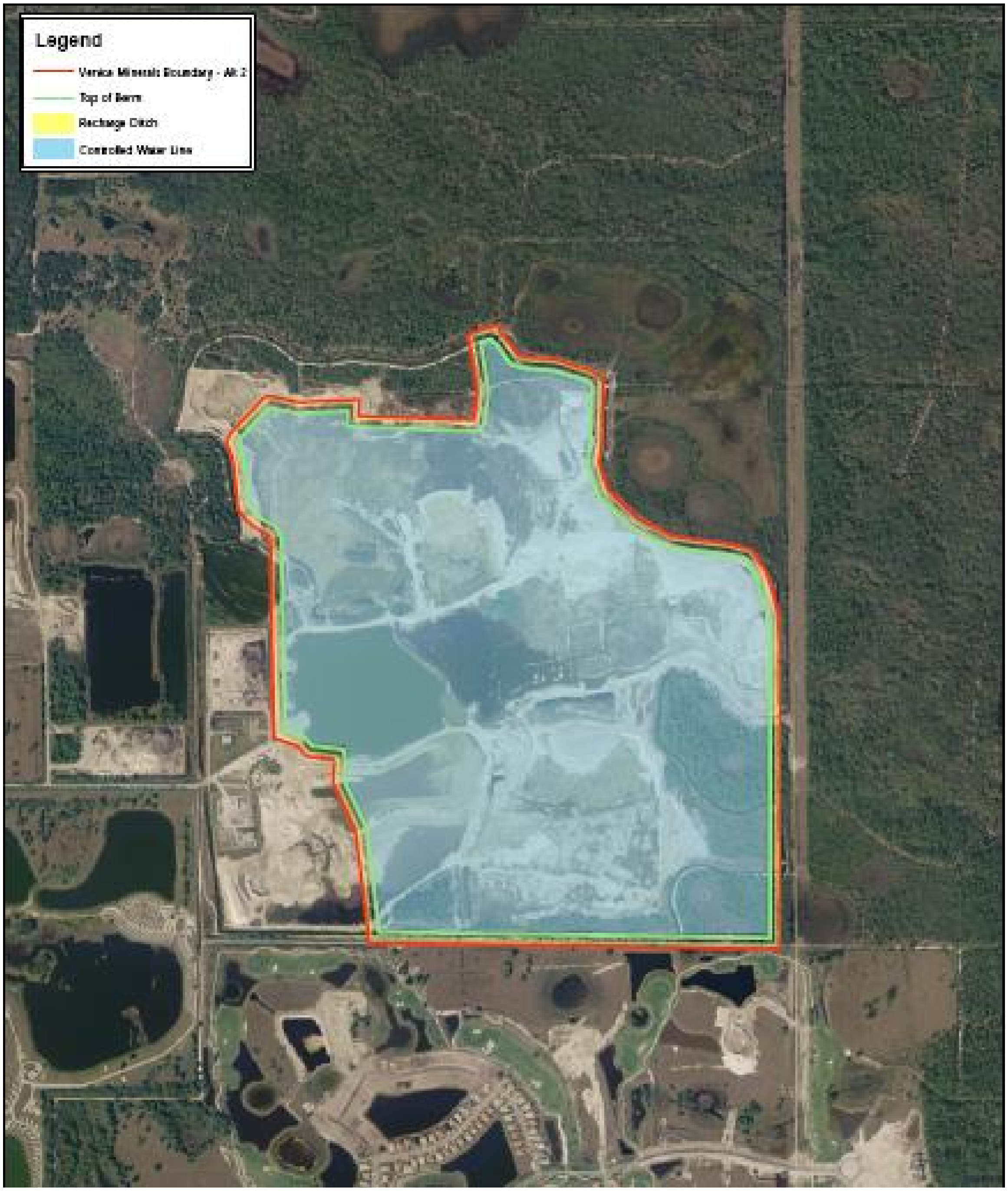


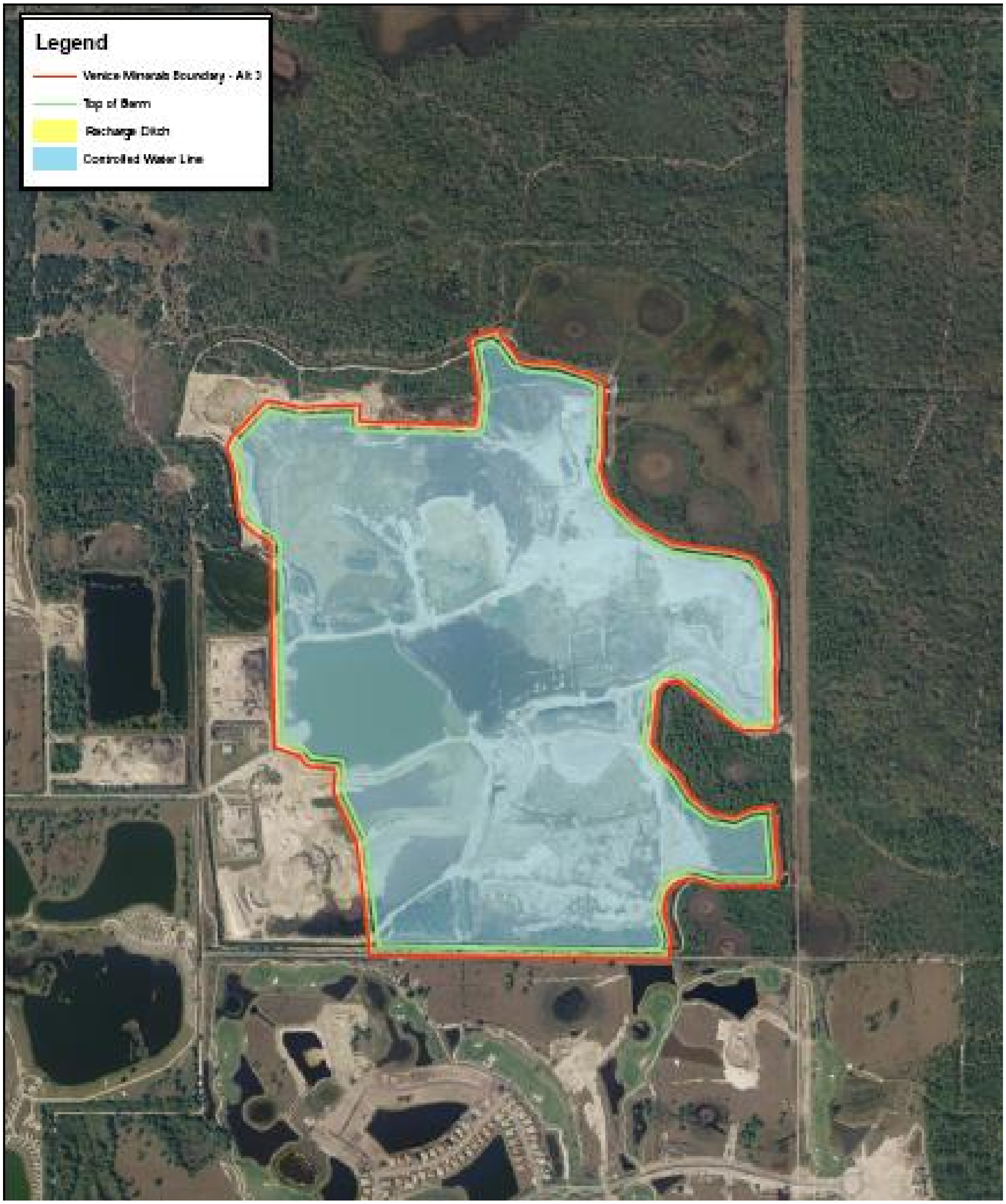
Figure 7 – Venice Minerals, Alternative 1

- Alternative 2 (refer to Figure 8) proposes to impact the four (4) southern, disturbed wetlands.



Alternative 8 – Venice Minerals, Alternative 2

- Alternative 3 (refer to Figure 9) proposes no wetland impacts.



Alternative 9 – Venice Minerals, Alternative 3

Table 8 summarizes the environmental rankings associated with each alternative for the Venice Minerals site.

Alternative	Alternative Detail	Environmental Cost Ranking	Overall Ranking
1	Impact all wetlands	medium ($148,280	low
2	Impact wetlands 1C to 4C	low ($152,069)	high
3	Impact no wetlands	high ($0)	medium

Table 8 - Venice Minerals Alternatives Ranking

Based solely on the estimated cost of mitigation per unit functional gain or loss (Environmental Cost), the alternatives would be ranked as follows:

1. Alternative 1
2. Alternative 2
3. Alternative 3

Based on Technical Memorandum 4.2.2.1 – Evaluation of Surface Storage (Venice Minerals Site), which includes a quantification of storage capacity and environmental costs, the alternatives would be ranked according to the cost/benefit analysis as follows:

1. Alternative 1
2. Alternative 2
3. Alternative 3

Wetland	Wetland Acreage	Functional Loss Units[1]	Alternative 1	Alternative 2
1A	0.68	(0.54	(0.54)	
2A	1.00	(0.80)	(0.80)	
3A	1.20	(0.96)	(0.96)	
1B	12.90	(9.89)	(9.89)	
2B	1.10	(0.88)	(0.88)	
3B	2.20	(1.76)	(1.76)	
4B	0.40	(0.29)	(0.29)	
1C	1.70	(1.13)	(1.13)	(1.13)
2C	0.20	(0.12)	(0.12)	(0.12)
3C	0.20	(0.10)	(0.10)	(0.10)
4C	0.20	(0.10)	(0.10)	(0.10)
Total (FL) [2]		**(16.57)**	**(16.57)**	**(1.45)**
Total BRA-estimated mitigation acreage*			39	3.5
Total BRA-estimated cost**			$2,457,000	$220,500
Cost per Functional Unit***			$148,280	$152,069

Table 9 - Venice Minerals UMAM Functional Loss Units

* Based on projected UMAM scores of "8" for location/landscape, hydrology, and species composition for the value of the created mitigation area

**Total Estimated Cost = (restoration/enhancement acreage X $60,000) + (creation acreage X $63,000)

***Cost per Functional Unit = Total Estimated Cost/Total FL or FG

[1] Total Functional Loss units if wetland is impacted in its entirety.

[2] Functional Loss

2.2 Conclusion

The results of the mitigation alternatives ranking for the Albritton, West Pinelnads, Myakka Connector, and Venice Mienrals sits are summarized in Table 1. However, the environmental benefit ranking is only one consideration necessary to determine the final design for each site.

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DONA BAY WATERSHED MANAGEMENT PLAN:
Salinity Targets for Watershed Management in Dona and Roberts Bays and their Tributaries

SARASOTA COUNTY – KIMLEY HORN AND ASSOCIATES
MASTER AGREEMENT FOR CONTINUING PROFESSIONAL SERVICES
TASK 3: WATERSHED GOALS
TASK 4.1.1.1: LIFE HISTORY REQUIREMENTS
TASK 4.1.1.2: OYSTER SURVEY
(INDIVIDUAL PROJECT ORDER NUMBER 1)

JULY 5, 2006

Submitted to:

MIKE JONES
SARASOTA COUNTY ENVIRONMENTAL SERVICES
2817 CATTLEMEN ROAD
SARASOTA, FLORIDA 34232

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INTRODUCTION

The Dona Bay Watershed Management Plan (DBWMP) is a regional initiative that promotes and furthers the implementation of the Sarasota County Comprehensive Plan, Comprehensive Conservation and Management Plans of the Sarasota Bay and Charlotte Harbor National Estuary Programs, and the Southwest Florida Water Management District's Southern Coastal Comprehensive Watershed Management Plan.

Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan and projects for the Dona Bay watershed to achieve the following general objectives: provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay; provide a more natural hydrologic regime for the Dona Bay watershed; protect existing and future property owners from flood damage; protect and/or improve existing water quality, and develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

The DBWMP is being developed by a team of six organizations, including Mote Marine Laboratory, led by Kimley-Horn and Associates in coordination with Sarasota County Environmental Services. Nine tasks or phases comprise the technical elements of the DBWMP. The second technical task for Mote Marine Laboratory is contributing to the development of watershed goals for the Dona Bay watershed. This report specifically outlines a rationale and method for the use of estuarine information in the establishment of watershed goals, and provides relevant estuarine resource targets. An Appendix reports on findings of a new oyster study in Dona Bay and Shakett Creek.

In May 2006, Sarasota County authorized that the geographic scope of the Dona Bay watershed study be expanded to include Roberts Bay and Curry Creek. This report contains new information on Roberts Bay and Curry Creek and supplants Mote Marine Laboratory Technical Report No. 1090.

ENVIRONMENTAL SETTING

Not counting basin alterations and augmented stream flows, the salinity trend of the Dona and Roberts Bays (DARB) study area during the past few centuries and especially the 20th Century has been one of increase. Sea level rise, the natural opening of Midnight Pass, construction of the Intracoastal Waterway, and Venice Inlet stabilization have been working to increase the reach of tides into and influence of salt waters upon the Bay. The increased connection has influenced water levels and circulation, sedimentation, salinity, and the numbers and kinds of plants and animals inhabiting the study area. In this context the stabilization and maintenance of the inlet may be viewed as consistent with natural trends. During this period, the major source of natural variation was probably related to the incidence and severity of tropical storms and hurricanes.

Without the influence of humans, freshwater inflows would have remained the same. Although an increase in rainfall and runoff might be expected during warmer climate periods, there is no local evidence for trends in increasing rainfall in the area beyond those attributable to known cyclicity. Four principal human actions have caused freshwater inflows to increase: diversion of Cow Pen Slough from the Myakka River; inland expansion of the effective watershed of Cow Pen Slough through man-made drainage diversion; connection of Curry Creek to the Myakka River via Blackburn Canal, and transformation of natural land cover to land uses with heightened runoff in both watersheds. The timing of inflows has been changed by these practices and also by instream structures that generally suppress the local surficial water table and shorten recovery times after storm events.

Increased flows and flow rectification are significant departures from "natural" conditions insofar as the creek and bay are concerned, and have de-stabilized the marine environment. When coupled with natural and cultural forces raising salinity in DARB, the combination of increased inflows and marine effects has created a strong salinity gradient over a relatively short distance, and a local area capable of rapid, high-amplitude oscillations in salinity.

RATIONALE AND METHOD

A Valued Ecosystem Component (VEC) approach is employed to develop management targets for Dona Bay. A VEC is a population, species, community, habitat, or an ecosystem function, recognized as a natural and desirable element of a given management domain (forest, lake, estuary, etc.). Valued ecosystem components are chosen when sufficient data exist within the domain, or in other settings where data are transferable to the domain, to support the establishment of environmental targets for restoration.

By this method,

1. Valued ecosystem components are identified for DARB and their tributaries;
2. Desired spatial distributions for each VEC are determined;
3. Environmental variables that regulate VEC distributions are identified;
4. Target values for environmental variables are recommended, and
5. Historical and modern hydrological studies are made to assess the ability to achieve and/or adjust the range of target values.

This report addresses steps one through four with the expectation that each step will be refined as the DBWMP progresses. Ongoing studies by other members of the project team will contribute to these recommendations. Once target values for environmental variables are refined, their practical feasibility under various watershed and stream management scenarios can be evaluated by engineering and hydrological studies.

GEOGRAPHICAL DEFINITIONS

The Dona Bay study area is defined as extending from Venice Inlet to US 41. The Shakett Creek study area is defined as extending from US 41 to the downstream-most control structure on Cow Pen Slough. The Roberts Bay study area is defined as extending from Venice Inlet to US 41. The Curry Creek study area is defined as extending upstream from US 41 (Mike Jones, personal communication).

VALUED ECOSYSTEM COMPONENTS IDENTIFIED FOR DONA BAY

Four VECs are employed for DARB– location and size of tidal fresh waters; submerged vascular aquatic vegetation (seagrasses), the hard clam *Mercenaria campechiensis*, and the American oyster, *Crassostrea virginica*. Additional information is provided for three valued fish species common in Sarasota County waters.

DESIRED SPATIAL DISTRIBUTIONS

A. Tidal Fresh Water: Based on historical information and data from other tidal streams in southwest Florida,

> Tidal fresh waters will persist during all times, except during extended natural droughts, in Shakett Creek upstream of Fox Creek, and in Curry Creek upstream of the confluence of the historic headwaters of Curry Creek with Blackburn Canal.

B. Seagrasses: Based on their known past and modern distributions,

> *Ruppia maritima* (widgeongrass) and *Halodule wrightii* (shoalgrass) will be the principal SAV species east of US 41, in both systems. Their cover and relative abundances will alternate depending on seasonal and annual variations in stream flow and salinity, and *Halodule* may also occur west of US 41 in wet periods.
>
> *Syringodium filiforme* (manatee grass) and *Thalassia testudinum* (turtle grass) will be the principal submerged aquatic vegetation (SAV) species in the lower (western) reaches of Dona and Roberts Bays. Their cover and relative abundances will alternate depending on seasonal and annual variations in salinity and water clarity, and both may also occur in middle and upper DARB in dry periods.

C. Hard Clams: Based on their known past and modern distributions,

> *Mercenaria campechiensis* will persist in subtidal and low intertidal beds of *Syringodium* and *Thalassia*. Hard clams will recruit into middle DARB in dry periods.

D. Oysters: Based on their known past and modern distributions,

> *Crassostrea virginica* will persist as living oyster reefs in lower Shakett and Curry Creeks and extend as living reefs west into middle Dona and Roberts Bays.

ENVIRONMENTAL VARIABLES REGULATING DARB VECS

This report focuses on the role of salinity in regulating seagrasses, hard clams, and oysters. As findings by other team members become available the roles of hydrologic regimes, water clarity, dissolved oxygen, or other variables may be considered in addition to salinity. The following sections are adapted from Estevez (2000) and Estevez and Marshall (1993).

A. Tidal Freshwaters

Tidal fresh water reaches of coastal streams provide habitat for the larval and juvenile stages of numerous valued species, and also support a unique flora and fauna. Although the historic location of altered urban streams is often unknown, studies of relatively unaltered coastal streams have identified proxy records for the upstream extent of saltwater encroachment. Estevez, Edwards and Hayward (1991) reported that the transition of bankside soils from alluvial to tidal, as depicted in first generation USDA soil surveys, correspond to long-term surface salinity means of less than 2.0 ppt. The 1959 Soil Survey for Sarasota County depicts the upstream extent of tidal soil in Shakett Creek at a point approximately 2,000 ft upstream of its confluence with Fox Creek, leaving a relatively short and shallow reach of "Salt Creek" as usually fresh in nature. The Soil Survey depicts the upstream extent of tidal soil in Curry Creek at a point upstream of Albee Farm Road, leaving a relatively short and shallow reach of "Historic Curry Creek" as usually fresh in nature.

Surface and bottom salinity where Fox Creek enters Shakett Creek should average less than 2.0 ppt.

Surface and bottom salinity where Historic Curry Creek enters Blackburn Canal should average less than 2.0 ppt.

B. Seagrasses

Seagrasses found near Dona Bay include *Halodule wrightii*, *Thalassia testudinum*, *Syringodium filiforme*, and possibly *Ruppia maritima*. *Ruppia* is not a true marine plant but it often occurs in low salinity waters.

Using available SWFWMD aerial photography of seagrasses in the region, approximately 36% of Dona Bay's total surface area has seagrass. Compared to Roberts Bay (43% seagrass) and Lyons Bay (75% seagrass), Dona Bay has the lowest seagrass coverage of Venice inland waters.

Seagrass beds have a variety of functions within estuarine habitats (Wood et al., 1969). They are important as a structural habitat for juveniles and adults of many animal species. Seagrasses anchor sediments and slow water currents to the point at which part of the water column sediment load settles to the bottom (Ward et al., 1984). Nutrients carried by these sediments are utilized directly by the seagrass plants and indirectly by the grazers and detritus feeders within the seagrass beds. Reductions in seagrass bed coverage usually result in drastic shifts in community composition. Major seagrass losses typically change the nature of or cause large decreases in the productivity of fisheries within the affected areas (Livingston, 1987). A study in northeastern Florida Bay (Montague et al., 1989) demonstrated that seagrasses and benthic fauna were much less abundant where bottom salinities were highly variable. Montague et al. (1989) stated that:

> "Submerged vegetation found in small quantity at the upstream stations...are known to thrive elsewhere at salinities comparable to the mean salinities found at those stations. Frequent, large, and sudden variations in salinity at a station...might reset succession, preventing good development of any one benthic community."

In a rule-based ecological model of an estuarine lake, Starfield et al. (1989) concluded that the abundance of underwater plant biomass was sensitive to the rate of change of salinity rather than the salinity level *per se*, but these model outputs have not yet been confirmed. Fears (1992) tested the effects of salinity shocks of various intensities and durations on the growth rate and survival of *Thalassia*, *Halodule*, and *Syringodium*. His experimental design did not mimic situations where drastic salinity changes occur on tidal, daily, weekly, or longer temporal cycles. Extreme variation in salinities in and near Dona Bay (Jones, 2004) may be a major cause of SAV limitation.

Ruppia maritima

Wigeongrass is often found with the seagrasses but is not a true marine plant; it is considered a freshwater species with a pronounced salinity tolerance. It behaves as an annual in habitats subject to drought, lethal increases in salinity, or other extremes, or as a perennial in deeper, more stable environments, and has specialized features enabling survival under varying salinities and high temperature beyond those tolerated by other submersed angiosperms. *Ruppia* usually occurs at low intertidal elevations in estuaries, but mixes with true seagrasses up to at least 1.5 km offshore in large oceanic bays.

Widgeongrass has been observed in a wide range of salinities from fresh water to hypersaline waters (Kantrud, 1991), however, a re-analysis of distributional data by Estevez (2000) shows that particular *Ruppia* populations grow in comparatively narrow salinity ranges. It has not been reported from Shakett Creek but grows in tidal freshwater reaches of the Myakka River.

Halodule wrightii

In an early study (McMahan, 1968) pots of *Halodule* maintained vigorous growth in salinities from 23 to 37 ppt, for 5 weeks, and it survived in salinities up to 60 ppt. In a separate experiment an attempt was made to grow *Halodule* at salinities ranging from 0 to 87 ppt. It survived for 6 weeks in salinities ranging from 3.5 to 52.5 ppt. After 2 weeks at salinities under 9 ppt *Halodule* began to show adverse effects. Fears (1993) demonstrated that *Halodule* could tolerate short term, to 24 hrs duration, salinity shocks in fresh water. He warned that longer duration exposures or repeated shocks could kill this seagrass. Field data on *Halodule* distribution near river mouths and on tidally exposed sandbars also suggest that it can tolerate wide salinity fluctuations.

No information is available on the reproduction and germination of this seagrass under artificially manipulated salinity regimes. *Halodule* flowers have been reported to occur in various areas at temperatures between 22 ^{o}C and 26 ^{o}C and in salinities ranging from 26.0 ppt to 36.0 ppt (Moffler and Durako, 1987).

Doering et al. (2002) report that "laboratory experiments indicated that (*Halodule*) mortality could occur at salinities < 6ppt, with little growth occurring between 6ppt and 12ppt. Field data indicated that higher blade densities (> 600 blades per square meter) tend to occur at salinities greater than 12ppt. Relationships between salinity in the estuary and discharge from the Caloosahatchee River indicated that flows > 8.5 m cubic meters per second would produce tolerable salinity (< 10ppt) for *V. americana* and flows < 79 cubic meters per second would avoid lethal salinities (< 6ppt) for *H. wrightii*."

Syringodium filiforme

Phillips (1960) summarized observations related to salinity effects on the distribution of *S. filiforme*. His summary suggested that *Halodule* is more tolerant of low salinities. Phillips reported dense beds of *Syringodium* in the Indian River Lagoon in salinities of 22 - 35 ppt. He suggests that an optimum salinity level to support *Syringodium* should exceed 20 - 25 ppt.

Fears' (1993) results showed that *Syringodium* growth rates were not noticeably affected by salinity shocks (= submergence in water of low or zero salinity) until they were placed in freshwater for 24 hrs. Less harsh treatment did not result in noticeable growth rate decreases for this species.

Syringodium is rarely seen in flower in Florida waters (Phillips, 1960) and therefore no information exists on the effects of salinity on the processes of reproduction and seed germination.

Thalassia testudinum

A dominant species throughout its range, *Thalassia* nonetheless constitutes a relatively minor element of Dona Bay's seagrass cover. The paucity of *Thalassia* may be explained by the Bay's extensive history of dredging and spoiling, coupled with extremes in freshwater inflow. *Thalassia* is intolerant of low salinity (Fears, 1993), and is a slow spreading, poor colonizer among seagrass species. These characteristics give *Thalassia* a low recovery rate during favorable salinity periods. The areal extent of *Thalassia* suggests that modern *Thalassia* beds are not very old.

Many species of seagrasses seem to disappear soon after the introduction of large freshwater inflows (Bellan, 1972), or species diversity among seagrasses is reduced. Thereafter, salinity or other impacts become more difficult to observe because affected living resources left in the area tend to be eurytopic.

To create conditions favorable for *Ruppia* within its desired range, mean bottom salinity should be maintained near 5 ppt, with a standard deviation about the mean less than 10 ppt.

To restore and enhance *Halodule* within its desired range, mean bottom salinity should be maintained near 25 ppt, with a standard deviation about the mean less than 10 ppt.

To enhance the potential for *Syringodium* and *Thalassia* growth in their desired range, the duration of bottom salinities of zero ppt should be kept to less than 24 hours.

C. Hard Clams

Live hard clams occur in Lyons Bay but to date only dead clams have been collected from either Dona Bay or Roberts Bay (Estevez, 2005).

Adult hard clams survive short spells of lowered salinities by closing their valves, and stop pumping at salinities below 15 ppt (Eversole, 1987). Survival times under adverse environmental conditions are age/size dependent. Ambient temperatures and dissolved oxygen levels alter salinity tolerances and survival times. Larval and juvenile clams are more susceptible to low salinities because they lack the protection of the heavy, thick shells of older clams (Wells, 1957). Fishermen in the Indian River lagoon have noted that small clams can tolerate low salinity for 2 to 3 hours while adults may be able to withstand low salinity for several days.

Hard clams already stressed by other environmental factors may be more susceptible to salinity stress (Wells, 1957). High temperatures, for example, increase respiratory demands and decrease the length of valve closure periods (Barnes, 1987). Elevated summertime water temperatures and high biological oxygen demands, created by excess nutrient supplies, reduce dissolved oxygen availability (Windsor, 1985) below the metabolic needs of clams stressed by low salinities.

Sudden increases in salinity, exceeding 8 parts per thousand (ppt) are also lethal to hard clams (M. Castagna, Virginia Institute of Marine Science, personal communication). In fact, hard clams can tolerate a larger decrease -- drops of up to 15 ppt -- if the lowest salinities remain above seasonally changing and geographically variable lethal salinity limits.

Distributional patterns of *Mercenaria mercenaria* in several areas suggest that salinity has a strong influence either on recruitment or on subsequent post-recruitment survival and growth (Wells, 1957; Walker and Tenore, 1984; Craig et al., 1988). Physiological changes occur within clam tissues when exposed to low salinities. Clam tissues leak amino acids at salinities that truly euryhaline species, such as *Mytilus* and many others, can tolerate without amino acid losses (Rice and Stephens, 1988). Amino acid loss continued after a 5-day acclimation period, at 17.0 ppt, for adult *Mercenaria*. Net losses of amino acids can be used as an index of a species' ability to tolerate salinity fluctuations. Adult *Mercenaria* can tolerate long exposures to lowered salinities by tightly closing their thick valves (Wells, 1957), but the duration of the maximal period of closure is a function of temperature.

Patterns of shell growth in adult hard clams have been studied in 10 southeastern estuaries (Jones, et al. 1990). Florida clams have higher growth rates and shorter life spans than northern clams. Shells exhibit a bimodal growth pattern with peak rates of new shell deposition in the spring and late fall of the year. Shell growth is lowest in summer when temperatures are highest and salinities are lowest. Salinity data for three sites are available. At no time were monthly salinities below 10 ppt. In 3 months (8% of 36 station-months), salinities were lower than 15 ppt. Salinities were between 15 and 20 ppt during 33% of visits and salinities were greater than 20 ppt on more than half (56%) of the visits.

Salinity requirements of embryonic, larval, and juvenile clams change throughout development and early growth (Mulholland, 1984). Temperature has a complicating effect on the interpretation of salinity requirements of *Mercenaria mercenaria* and *M. campechiensis*. Female clams in spawning state were found to be almost continuously present in the Indian River near Melbourne (Hesselman et al., 1989). A strong biphasic period of spring (March - June) and fall (August - October) ripening and spawning of female littleneck hard clams in Wassaw Sound, Georgia, was reported by Pline (1964). There was a strong correlation between recruitment failure and depressed winter salinity (< 30 ppt) in winter. Hard clams postponed high experimental mortality in 10.0 ppt salinity by remaining tightly closed for 4 to 5 weeks, but eventually succumbed.

Studies of the salinity requirements of larval and juvenile clams find that the minimum tolerable salinity was 20 ppt or greater. Given that low-latitude clam populations encounter higher water temperatures, published salinity requirements of larval clams suggest that it would be advisable to avoid salinity decreases to levels below 20 ppt at least during spawning and preferably throughout the year.

Wells (1957) noted that few hard clams were found in parts of Chincoteague Bay where salinities often reached levels ranging from 13 to 21 ppt. The western and northern margins of the bay are affected by fresh water from creeks and rivers. Wells stated that productive clam beds in Chincoteague Bay are located near inlets in relatively saline waters. Further south in Georgia's Wassaw Sound, dense clam beds (with finds of >15/15 min effort) are mostly located in the shallow waters of the Sound within 6 km of coastal inlets.

Adult clams can, under certain conditions, tolerate low salinities for extended periods. Burrell (1977) found that oysters, although tolerant of lower salinities than clams, suffered much higher mortality during floodwater discharges from the Santee River system in South Carolina. Salinities remained below 10 ppt for 2 to 3-week periods. Oysters suffered mortalities ranging from 32% to 66% in various areas while clam mortality was less than 5%. Clam and oyster internal liquors remained at higher salinities than did their ambient environment. Hard clams can withstand direct exposures to fresh water for up to 114 hours (Pearse, 1936). Despite these extreme exposures, Eversole (1987) describes the hard clam as only moderately euryhaline and concludes, in reviewing the literature on clam responses to salinity, that optimum salinities for egg development, larval growth and survival, and adult growth are in the 24 to 28 ppt range.

In general, salinity below 15 ppt may be considered "low;" such salinities affect clam physiology, behavior, reproduction, and survival. Small clams may survive low salinities for hours while large clams may survive for days, or even weeks, but they do so under stressful conditions.

A bottom salinity of 20 ppt is recommended as the lowest average salinity genuinely suitable for hard clams in DARB. This value emerges from divergent studies of shell growth, spawning, larval growth, and field studies. In the spring and fall, when shell growth and spawning are normally at peak levels, salinities of 25 ppt or greater would be protective. With these as reference-points, salinity characteristics that may be recommended to maintain and enhance hard clam populations are that, within their desired range:

1. For a year as a whole, mean bottom salinity should be maintained at levels above 20 ppt.
2. The lower limit of bottom salinity should be 10 ppt and the upper limit can equal oceanic values.
3. In summer, mean bottom salinities should exceed 20 ppt and be associated with standard deviations not greater than 5 ppt. Excursions of summer-time salinity below 15 ppt should not persist for more than 1 week (7 days).
4. During other times of the year, mean bottom salinities should be equal to or exceed 25 ppt and be associated with standard deviations not greater than 5 ppt.
5. Successive high tide, bottom salinities should not increase by more than 5 ppt, and successive low tide, bottom salinities should not decrease by more than 10 ppt, beyond background rates as a result of surface water management operations.

D. Oysters

Oysters were once present in sufficient quantities to form significant archaeological formations at Venice. Jones (2005) reported a one year increase in percentages of live oysters and number of live oysters at fixed stations in DARB, significant improvements since 2003. All measures of oyster abundance and condition indicate that DARB and their tributaries experience intermittent conditions inimical to oyster success.

Oysters are immobile, after a larval stage, and are therefore subject to the permanent effects of salinity changes due to alterations of riverine inflow, ocean influence, or circulation. Low riverine flows of short duration result in high salinities in Apalachicola Bay and result in increased predation on newly settled spat; population sizes of adult, harvestable oysters are reduced 2 and 3 years later (Wilber, 1992). Wilber found little evidence that high flows of short duration (≤ 30 days) adversely affected oyster harvests for the same or subsequent years. Her analyses were based on river flow data (kept by the Northwest Florida Water Management District) and oyster harvest data from 1960 to 1981.

Oysters can avoid predation by tolerating salinity fluctuations that their natural predators cannot tolerate (Gunter, 1955). Low salinities kill oyster drills and starfish (Sellers and Stanley, 1984). Maintenance of salinities within ranges above the lower tolerance limits of oyster predators usually results in major declines in oyster abundance (Allen and Turner, 1989). Ortega and Sutherland (1992) found adequate spat settlement in both low salinity (< 15 ppt) and high salinity (> 20 ppt) reaches of Pamlico and Core Sounds, North Carolina. Algal turfs and poor sediment inhibited growth in low salinity areas and competition by fouling organisms retarded success in high salinity areas.

Salinity requirements of *Crassostrea virginica* are reviewed in Sellers and Stanley (1984). Adult oysters tolerate a salinity range of 5 to 30 ppt. They do best within a salinity range of 10 to 28 ppt (Loosanoff 1965a). Salinities below 7.5 ppt inhibit spawning. Maximum larval growth and survival occur above salinities of 12.5 ppt and maximum spat growth occurs between 15 and 20 ppt.

Oysters can tolerate salinities as low as 3.0 ppt for 14 days, and 6.0 ppt for up to 30 days (Loosanoff 1965b). When flood conditions persist for 30 days or more, oyster mortalities typically reach 100% (Allen and Turner, 1989). Sellers and Stanley (1984) reported major oyster mortalities in several areas that were affected by major floods when salinities remained below 2 ppt for extended periods.

On Louisiana's state seed grounds Chatry et al. (1983) found that salinity in the setting year is the prime determining factor for the production of seed oysters. Both high and low salinities resulted in poor seed production. Low salinities resulted in insufficient setting while the negative effects of high salinities were believed due to the effects of predation on oyster spat. The maintenance of optimum setting salinities was most critical from May through September. To optimize Louisiana spat production, Chatry et al. recommended May salinities between 6 to 8 ppt; salinities should average 13 ppt in June and July and not increase to greater than 15 ppt until late August, and September salinities should not average more than 20 ppt.

Volety et al. (2005) report that "oysters in the Caloosahatchee estuary spawn continuously from April to October, a period that coincides with freshwater releases into the estuary. Upstream, sub-tidal locations exhibited good spat recruitment, low disease intensity, and higher juvenile growth rates compared to downstream, intertidal sites. High freshwater flows during summer either flushes out oyster larvae and spat from areas with suitable cultch and/or reduce, salinities to levels that are unfavorable for spat settlement and survival. Freshwater releases in the range of 500 to 2000 CFS (cubic feet per second) will result in optimum salinities for oysters. Limited freshwater releases during winter coupled with decreased releases in summer should result in decreased *P. marinus* infections, suitable conditions for survival and enhancement of oyster reefs in the Caloosahatchee River."

Based on a review of oyster salinity requirements, to promote reefs in desired areas:

1. Salinities in areas where oyster bars are desired can be allowed to fluctuate broadly between 10 to 28 ppt, and these areas should possess strong longitudinal salinity gradients and mixing.
2. Lower salinities can be briefly tolerated by adult oysters. Salinities less than 6 ppt should not be allowed to persist longer than 2 weeks, nor should salinities lower than 2 ppt be allowed for longer than a week.
3. To protect recruitment, salinity during local spawning seasons should be above 10 ppt. Optimal larval and spat growth and survival can be obtained in salinities between 12.5 and 20 ppt.

Once salinity data have been analyzed by other members of the project team, these guidelines will need to be tested against new data for DARB oysters (Appendix 1).

E. Fish

Fish populations may be affected greatly by rapid salinity shifts. Spotted seatrout (*Cynoscion nebulosus*), snook (*Centropomus undecimalis*), and red drum (*Sciaenops ocellatus*) are common residents of Venice waters. They are variably affected by low salinities, and a single salinity regime may not be suitable for all three species. Additionally, these three fish are dependent on a rich and diverse invertebrate and fish-based food chain. Altered salinities can be predicted to have different effects on each of the prey species of the three carnivorous species. A study of salinity change effects on fish and invertebrate populations in the St. Lucie estuary (Haunert and Startzman, 1980), while informative, was concerned with short-term changes in fish and invertebrate populations. They did not consider the long-term biotic changes in this estuary that resulted from the permanent alteration of stream flow caused by the various water control structures upstream from the St. Lucie Estuary. Their study basically reported that animal communities which had already been affected by a long history of stream flow alterations were not significantly affected by a single test discharge.

Adults of the three species are mobile, and they have wide salinity tolerance ranges (Haunert and Startzman, 1980; Banks et al., 1991). Their larvae and juveniles are poor to weak swimmers and have more narrow salinity tolerance ranges. Adult snook, for example, spawn in inlets and spend much time in the vicinity of dams feeding on freshwater prey species that are stunned or killed by their passage over dams (Marshall, 1958; Seaman and Collins, 1983). Much of the following discussion centers on the salinity requirements of the larval and juvenile stages of these three fishes.

Spotted Seatrout

Banks et al. (1991) demonstrated that salinity tolerances of spotted seatrout are age-linked. Upper and lower tolerances changed during early growth. The results of this study were complicated by the fact that seatrout embryos -- acclimated to altered salinities -- produced larvae that were more tolerant of extreme salinities. The narrowest range of salinity tolerance, 6.4 to 42.5 ppt, occurred on day 3 after hatching. Feeding begins on day 3 after hatching; the change from dependency on yolk to exogenous foods and the immature state of the osmoregulatory system undoubtedly account for the higher sensitivity to salinity change. Salinity ranges for successful reproduction and larval survival of spotted seatrout were approximately 20 - 45 ppt and 10 - 40 ppt, respectively (Holt and Banks, 1989).

Seatrout spawn in deep channels adjacent to seagrass beds or in tidal portions of estuaries (Lorio and Perret, 1978). The Intracoastal Waterway in the vicinity of Dona Bay would fully fit this description of optimum spawning grounds. Florida's spotted seatrout spawn from April through September with peaks in late May or early June (Lorio and Perret, 1978). Salinity reductions, to levels below the tolerance limits of seatrout larvae (below 10 ppt), during this time could cause tremendous mortalities to occur among populations of recently hatched seatrout larvae.

Sudden, massive salinity reductions have been observed to cause either mass migrations from or mortalities of adult seatrout in Florida estuaries (Tabb, 1966). Adult seatrout are a truly euryhaline species, but they apparently cannot tolerate sudden salinity changes of the type that may occur during hurricanes or tropical storms.

Snook

Snook utilize a series of habitat types that are dependent upon the growth stage of this species (Gilmore et al., 1983). Juvenile snook, ranging from 11-156 mm SL (mean = 27.5 mm) reside for 10 to 70 days within the freshwater tributaries of the Indian River Lagoon. Larger juveniles, from 10-174 mm SL (mean = 67 mm) are found in marsh habitats where they remain from 60 to 90 days. Freshwater and marsh recruitment peak in summer and fall (Gilmore et al, 1983). Juvenile snook move from marshes to seagrass meadows after reaching lengths from 100 to 150 mm SL at ages of 4 months or more.

Snook diets change during juvenile growth and adult maturation. In freshwater, juveniles prey upon microcrustacea, palaemonid shrimp, and neonatal mosquitofish, *Gambusia affinis* (Gilbert et al, 1983). Saltmarsh juveniles prey upon sheepshead minnows (*Cyprinodon variegatus*), mosquito fish, palaemonid shrimp, and microcrustacea (mysids, copepoda, etc.). In seagrass beds, larger juveniles prey upon a variety of fish and penaeid shrimp (Gilbert et al., 1983). Adult snook switch diets as they move from areas of higher to lower salinity (Marshall, 1958).

Snook survive in freshwater but they cannot reproduce because their spermatozoa require activation by saltwater (Seaman and Collins, 1983). Large releases of freshwater into Shakett Creek probably do not compromise the osmoregulatory abilities of the common snook, but increased flows could wash weakly swimming juveniles and their prey from the preferred low-salinity habitats.

<u>Red Drum</u>

Red drum are tolerant of a wide range of salinities (reviewed by Reagan, 1985). Adults have been collected from areas of virtual freshwater (0.3 ppt in Louisiana) and from areas with salinities exceeding that of full strength seawater (40 - 50 ppt in Texas). Small fish are more common at low salinities, and large fish seem to prefer higher salinities (Yokel, 1966). Perret et al. (1980) summarized numerous studies from widely scattered areas to report that juvenile red drum have been captured at salinities ranging from 0 ppt to 30 ppt. Highest catches of small red drum in Mississippi occurred when salinities ranged from 20 to 25 ppt.

Red drum larvae have salinity tolerances of 15 - 35 parts per thousand, somewhat narrower than the salinity range tolerated by larval spotted seatrout (Holt and Banks, 1989). These authors found that salinities above and below these ranges significantly impaired all phases of reproduction and larval development in red drum.

Adult red drum are likely to swim away from areas with salinities above or below their preference range. Juveniles may be able to tolerate extremely low salinities, but their rates of acclimation to freshwater are not known. A sudden salinity shock could have a large negative impact on red drum juveniles.

Based on a review of seatrout, snook, and red drum salinity requirements:

1. Salinities must be held at seasonally appropriate levels within nursery grounds and spawning areas for each of these three species. When red drum and seatrout larvae are present the red drum larval tolerance range of 15 -35 ppt should not be exceeded.

2. Juvenile snook must have access to freshwater nursery areas such as those that exist in the upper reaches of Shakett and Curry Creeks. Salt-water should not be allowed to encroach on these areas due to its lethal effects on many of the prey species consumed by juvenile snook.

Existing flood control structures may block juvenile snook from a large part of their favored nursery habitat.

TARGET VALUES FOR SALINITY IN DONA AND ROBERTS BAYS

Ecological features of the DARB system and tidal coastlines generally are created through the action of geological, hydrological, chemical, and biological forces. The distribution, composition, abundance and condition of living resources along these coasts acquire common features and regionally unique features (Odum et al., 1975). Soils, wetlands, seagrass beds, oyster reefs, and other structural ecosystem features develop in analogous ways across estuaries within specific climatic zones. The relationship of these features to freshwater inflow, tidal amplitude, salinity and other dynamical features also follow regular patterns. Productivity of individual species is regulated by the overlap of structural and dynamic habitat (Browder and Moore, 1981). It follows from the regularity of these patterns and processes that salinity recommendations registered to major landscape features of the study area form an environmentally acceptable point of beginning.

In Dona Bay, major features include the downstream-most control structure of Cow Pen Slough; the canalized reach of Shakett Creek; the emergence of the canalized creek into the broader natural lower creek east of US 41; the highway and bridge at US 41; upper, middle and lower Dona Bay, and the ICW-Venice Inlet area. The entire area is tidally affected. The area and volume of tidal reaches increases logarithmically toward Venice Inlet.

In Roberts Bay, major features include the canalized reach of Blackburn Canal; remnants of Historic Curry Creek entering the canal upstream of Albee Farm Road; the emergence of the canalized creek into the broader natural lower creek east of US 41; the highway and bridge at US 41; upper, middle and lower Roberts Bay, and the ICW-Venice Inlet area. The entire area is tidally affected. The area and volume of tidal reaches increases logarithmically toward Venice Inlet.

A. Initial salinity targets (in parts per thousands) are established for these landscapes of Shakett Creek and Dona Bay:

Area	RK	Mean	Standard Deviation	Minimum	Maximum	Range
Control Structure	6.5?	0.5	<1.0	0.0	1.0	2.0
Fox Creek	5.5	1.0	<2.0	0.0	5.0	5.0
Middle Shakett Creek	3.0 to 4.5	5.0	10.0	0.0	15.0?	15.0?
Lower Shakett Creek	2.0 to 3.0	20.0	10.0	6.0	28.0	22.0
Upper Dona Bay	1.3 to 2.0	25.0	10.0	12.0	35.0	23.0
Lower Dona Bay	0.8 to 1.3	28.0	5.0	20.0	35.0	15.0

B. Initial salinity targets (in parts per thousands) are established for these landscapes of Curry Creek/Blackburn Canal, and Roberts Bay:

Area	RK	Mean	Standard Deviation	Minimum	Maximum	Range
Blackburn Canal	5.5	0.5	<1.0	0.0	1.0	2.0
Historic Curry Creek	5.0	1.0	<2.0	0.0	5.0	5.0
Middle Curry Creek	3.7 to 4.5	5.0	10.0	0.0	15.0?	15.0?
Lower Curry Creek	3.0 to 3.5	20.0	10.0	6.0	28.0	22.0
Upper Roberts Bay	2.3 to 3.0	25.0	10.0	12.0	35.0	23.0
Lower Roberts Bay	1.2 to 2.0	28.0	5.0	20.0	35.0	15.0

Additional Salinity Standards

Additional constraints on salinity can be placed on the landscape-level targets described above. Most involve bottom salinity, SAV, oysters, and hard clams. Most are also supportive of or consistent with targets listed above. One of the additions, the second oyster target, calls for the duration of salinities below 2 ppt to last no longer than 7 days.

Targets addressing the duration of limiting conditions cannot be assessed by spatially intensive but temporally practical sampling and measurement. In these cases, continuous recording instruments should be deployed at stations in the designated segments found to be representative of potentially critical conditions. Because the duration targets pertain to neighboring segments, it may be possible to employ just one such instrument in each creek, in the vicinity of the U.S. 41 bridge. Because the critical targets reflect summer and/or high discharge periods, instrument use could be restricted to times and conditions when duration limits were most likely to be exceeded.

Additional salinity (S) targets, in parts per thousand (ppt).

Target	Affected VEC
Mean bottom S = 25 ppt ± 10 ppt or less	*Halodule*
0 ppt duration at bottom < 24 hr.	*Syringodium and Thalassia*
Annual mean bottom S > 20 ppt.	*Mercenaria*
Minimum bottom S ≥ 10 ppt.	*Mercenaria*
Summer mean bottom S > 20 ppt ± 5 ppt or less	*Mercenaria*
Duration of summer mean bottom S < 15 ppt ≤ 7 days	*Mercenaria*

Non-summer mean bottom $S \geq 25$ ppt $\pm$ 5 ppt or less	*Mercenaria*
Duration of $S < 6$ ppt < 14 days	*Crassostrea*
Duration of $S < 2$ ppt < 7 days	*Crassostrea*

Rate Limits

We found very little useful information concerning the maximum rates of salinity change tolerable by estuarine or marine organisms. The only finding, for hard clams,

> Successive high tide, bottom salinities should not increase by more than 5 ppt, and successive low tide, bottom salinities should not decrease by more than 10 ppt, beyond background rates[1] as a result of surface water management operations,

requires explanation. Based on personal communications with scientists and fishermen in the clam industry, the amplitude of tolerable "sudden" salinity increases and decreases were trimmed and are expressed in terms of successive tides. This modification results in the fastest possible rate of salinity change that is measurable. Without better data on real-time rates of salinity change in lower DARB, we felt obligated to take the additional precaution of suggesting that the limits be contingent upon a comparison to "background" rates of change. A definition of background is offered but it does little to change our view that this target should be advisory rather than certain.

In the event that all salinity targets cannot simultaneously be met, the following priorities are suggested. Minimum targets are more important than maximum targets. In upstream waters, low mean salinities are more important than their variation. In marine waters, low variation is probably more important than the mean salinities they accompany.

1/ Defined as the rates of salinity change that would occur between reference tides in the absence of surface water management structures and operations.

REFERENCES

Arnold, W.S., Bert, T.M., Marelli, D.C., Cruz-Lopez, H., and Gill, P.A. 1996. Genotype-specific growth of hard clams (genus *Mercenaria*) in a hybrid zone: Variation among habitats. Marine Biology. Vol. 125, no. 1, pp. 129-139.

Bahr, L.M. and W.P. Lanier, 1981. The ecology of intertidal oyster reefs of the South Atlantic coast: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/15. 105 pp.

Banks, M.A., G.J. Holt, and J.M. Wakeman, 1991. Age-linked changes in salinity tolerance of larval spotted seatrout (Cynoscion nebulosus, Cuvier). J. Fish Biology 39: 505-514.

Barnes, R.D., 1987. Invertebrate Zoology, Fifth Edition. Saunders College Publishing, Philadelphia. 898 pp.

Bellan, G. 1972. Effects of an artificial stream on marine communities. Marine Pollution Bulletin 3:74-78.

Browder, J.A. and D. Moore, 1981. A new approach to determining the quantitative relationship between fishery production and the flow of fresh water to estuaries, pp. 403-430 in R. Cross and D. Williams (eds.), Proc. Nat. Symp. on Freshwater Flow to Estuaries. Vol. 1 FWS/OBS-81/04. U.S. Fish and Wildlife Service, Washington, D.C.

Burrell, V.G., 1977. Mortalities of oysters and hard clams associated with heavy runoff in the Santee River System, South Carolina in the spring of 1975. Proc. Natl. Shellfish. Assoc. 67: 35-43.

Chatry, M., R.J. Dugas, and K.A. Easley, 1983. Optimum salinity regime for oyster production on Louisiana's state seed grounds. Contrib. Mar. Sci. 26: 81-94.

Craig, M.A., T.J. Bright, and S.R. Gittings., 1988. Growth of Mercenaria mercenaria and Mercenaria mercenaria texana seed clams planted in two Texas bays. Aquaculture 71: 193-207.

Davis, H.C. 1958. Survival and growth of clam and oyster larvae at different salinities. Biol. Bull. (Woods Hole) 114: 296-307.

Dawson, C.E., 1955. A study of the oyster biology and hydrography at Crystal River, Florida. Contrib. Inst. Mar. Sci. Univ. Texas 4(1): 279-302.

Doering, P.H., Chamberlain, R.H., and Haunert, D.E. 2002. Using Submerged Aquatic Vegetation to Establish Minimum and Maximum Freshwater Inflows to the Caloosahatchee Estuary, Florida. Estuaries Vol. 25, no. 6B, pp. 1343-1354.

Estevez, E.D. 2000. Matching salinity metrics to estuarine seagrasses for freshwater inflow management, Ch. 22 in S. Bortone (ed.), Seagrasses: Monitoring, Ecology, Physiology and Management. CRC Press, Boca Raton.

Estevez, E.D. 2005. Molluscan bioindicators of the tidal Myakka River and Inshore Waters of Venice, Florida. Mote Marine Laboratory Technical Report No. 990.

Estevez, E.D., R.E. Edwards and D.M. Hayward. 1991. An ecological overview of Tampa Bay's tidal rivers, pp. 263-277 in S.F. Treat and P.A. Clark (eds.), Proceedings, Tampa Bay Scientific Information Symposium 2. Tampa Bay Regional Planning Council.

Estevez, E.D. and M.J. Marshall. 1992. Sebastian River Salinity Regime, Parts 3 and 4: Recommended Targets. Contract 92W-177 Report to St. Johns River Water Management District. Mote Marine Laboratory Technical Report No. 308. 171 p.

Eversole, A.G., 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic): Hard Clam. U.S. Fish and Wildlife Service Biological Report 82(11.75). 33 pp.

Fears, S. 1993. The role of salinity fluctuation in determining seagrass distribution and species composition. Master of Science thesis, Department of Environmental Engineering, University of Florida, Gainesville. 91 p.

Gilmore, R.G., C.J. Donohue, and D.W. Cooke, 1983. Observations on the distribution and biology of east-central Florida populations of the common snook, Centropomus undecimalis (Bloch). Fla. Sci. 46: 313-336.

Gunter, G., 1955. Mortality of oysters and abundance of certain associates as related to salinity. Ecology 36: 601-605.

Hesselman, D.M., B.J. Barber, and N.J. Blake., 1989. The reproductive cycle of adult hard clams, Mercenaria spp. in the Indian River Lagoon, Florida. J. Shellfish Res. 8: 43-49.

Holt, G.J. and M. Banks, 1989. II. Salinity tolerance in larvae of spotted seatrout, red drum, and atlantic croaker. pp. 46-81 in: Salinity requirements for reproduction and larval development of several important fishes in Texas estuaries. Final report to the Texas Water Development Board.

Jones, M. 2005. Dona and Robert's Bay Second Annual Watershed and Estuary Report. Sarasota County Environmental Services.

Jones, D.S., I.R. Quitmyer, W.S. Arnold and D.C. Marelli, 1990. Annual shell banding, age, and growth rate of hard clams (Mercenaria spp.) from Florida. J. Shellfish Res. 9:215-225.

Kantrud, H.A. 1991. Wigeongrass (*Ruppia maritima*): a literature review. USFWS, Fish and Wildlife Research 10, 58 p.

Livingston, R.J., 1987. Historic trends of human impacts on seagrass meadows in Florida. pp. 139-152 in M.J. Durako, R.C. Phillips, and R.R. Lewis (eds.). Proceedings of the Symposium on Subtropical-Tropical Seagrasses of the Southeastern United States. Fla. Mar. Res. Publ. No. 42., Florida Marine Research Institute, St. Petersburg, Florida.

Loosanoff, V.L., 1965(a). The American or eastern oyster. U.S. Fish. Wildlife Serv. Circ. 205. 36pp.

Loosanoff, V.L., 1965(b). Gonad development and discharge of spawn in oysters of Long Island Sound. Biol. Bull. 129: 546-561.

Lorio, W.J. and W.S. Perret, 1978. Biology and ecology of the spotted seatrout (Cynoscion nebulosus Cuvier). Proc. Red Drum and Seatrout Colloquium, Oct. 19-20, 7-13.

Marshall, A.R., 1958. A survey of the snook fishery of Florida with studies of the biology of the principal species, Centropomus undecimalis (Bloch). Fla. Board Conserv. Mar. Res. Lab. Tech Ser. No. 11. 37pp.

McMahan, C. A. 1968. Biomass and salinity tolerance of shoal grass and manatee grass in Lower Laguna Madre, Texas. J. Wildl. Manag. 32, 501-506.

Moffler, M.D. and M.J. Durako, 1987. Reproductive biology of the tropical-subtropical seagrasses of the southeastern United States. In: M.J. Durako, R.C. Phillips, and R.R. Lewis, III, (eds.) Proceedings of the Symposium on Subtropical-Tropical Seagrasses of the Southeastern United States, pp. 77-88. Florida Marine Research Publications Number 42, Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, Florida.

Odum, H.T., B.J. Copeland and E.A. McMahan, 1975. Coastal Ecological Systems of the United States. Conservation Foundation, Washington, D.C.

Pearse, A.S., 1936. Estuarine animals at Beaufort, North Carolina. J. Elisha Mitchell Sci. Soc. 52: 174-222.

Perret, W.S., J.E. Weaver, R.O. Williams, P.L. Johansen, T.D. McIlwain, R.C. Raulerson, and W.M. Tatum, 1980. Fishery profiles of red drum and spotted seatrout. Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi. 60 pp.

Pline, M.J., 1964. Reproductive cycle and low salinity stress in adult Mercenaria mercenaria of Wassaw Sound, Georgia. M.Sc. Thesis, Georgia Institute of Technology School of Applied Biology. 74 p.

Reagan, R.E., 1985. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico). Biological Report 82(11.36), TR EL-82-4, U.S. Fish and Wildlife Service. 16 pp.

Seaman, W., Jr. and M. Collins, 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Florida)--Snook. U.S. Fish Wildl. Serv. FWS/OBS-82/11.16. U.S. Army Corps of Engineers, TR EL--82-4. 16 pp.

Sellers, M.A. and J.G. Stanley, 1984. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic) -- American oyster. U.S. Fish Wildl. Serv. FWS/OBS-82/11.23. U.S. Army Corps of Engineers, TR EL--82-4. 15pp.

Starfield, A.M., B.P. Farm and R.H. Taylor, 1989. A rule-based ecological model for the management of an estuarine lake. Ecol. Modeling 46: 107-119.

Tabb, D.C., 1966. The estuary as a habitat for spotted seatrout, Cynoscion nebulosus. Am. Fish. Soc. Spec. Publ. 3: 58-67.

Volety, A.S., Tolley, G., Savarese, M., and Winstead, J.T. 2004. Role of anthropogenic and environmental variability on the physiological and ecological responses of oysters in southwest Florida. Journal of Shellfish Research. Vol. 23, no. 1, pp. 315-316.

Volety, A.K., Tolley, S.G., Savarese, M., Rsanake, E., Haynes, L., Winstead, J.T., Barnes, T. and Doering, P.H. 2005. The role of oysters and adaptive resource management in setting restoration targets for southwest Florida estuaries. Journal of Shellfish Research Vol. 24, no. 1, p. 338.

Walker, R.L. and K.R. Tenore., 1984. The distribution and production of the hard clam, Mercenaria mercenaria in Wassaw Sound, Georgia. Estuaries 7: 19-27.

Ward, L.G., W.M Kemp, and W.R. Boynton, 1984. The influence of waves and seagrass communities on suspended particulates in an estuarine embayment. Marine Geology 59:85-103.

Wells, H.W., 1957. Abundance of the hard clam Mercenaria mercenaria in relation to environmental factors. Ecology 38, 123-128.

Wilber, D., 1992. Associations between freshwater inflows and oyster productivity in Apalachicola Bay, Florida. Estuarine, Coastal and Shelf Science 35: 179-190.

Windsor, J.G., 1985. Nationwide review of oxygen depletion and eutrophication in estuarine and coastal waters: Florida region. Florida Institute of Technology, Melbourne.

Wood, E.J.F., W.E. Odum, and J.C. Zieman, 1969. Influence of seagrasses on the productivity of coastal lagoons. Lagunas Costeras. pp. 495-502 in Proc. UN Symposio Mem. Simp. Intern. UNAM-UNESCO, Mexico, D.F. Nov. 1967.

Yokel, B.J., 1966. A contribution to the biology and distribution of the red drum, Sciaenops ocellata. M.S. Thesis, Univ. Miami, Coral Gables: 160pp.

APPENDIX 1: A STUDY OF OYSTERS IN DONA AND ROBERTS BAYS

BACKGROUND

Sarasota County has embraced the use of American oysters as bioindicator organisms in Dona and Roberts Bays, and their tributaries. Jones (2004) used 1948 and ground-truthed 2001 aerial photographs to depict historic and modern reef distributions, and modern live:dead ratios and spat settlement. About ten percent of historic oyster cover has been lost. Lyon's Bay had the most live and percent live oysters. Few live oysters were found upstream of US 41 in Shakett or Curry creeks and oysters in Dona Bay were mostly dead. The most live beds and robust oysters occurred between RK 2.1-3.3 on Shakett Creek.

Jones (2005) found that oysters in Shakett and Curry creeks and their respective bays generally improved during the following year, while Lyons Bay oysters were unchanged. In Shakett Creek, live oysters upstream of US 41 increased from <50% in 2003 to >75% in 2004. Percent live oysters also increased in Dona Bay. The 2003 mortality event was attributed to an abnormally wet, rainy season.

Also in 2004, Estevez (2005) surveyed mollusks at half-kilometer intervals in Dona Bay and Shakett Creek, from Venice Inlet to the Cow Pen Slough control structure near RK 6.0. Oyster was the dominant species and it with another 9 species comprised 90% of the collection. Oyster range was greater for dead material than live and more live oyster was found intertidally than in the subtidal. Jones (2004) and Estevez (2005) also probed sediments in Dona Bay and Shakett Creek for buried, relict reefs. There is evidence that historic oysters occurred farther upstream than modern ones in Curry Creek, but habitat alterations associated with channelization of Cow Pen Slough prevent a similar conclusion for Shakett Creek.

Other oyster-related investigations are underway or recently finished. As part of the DBWMP, the USF Department of Geology has conducted a study of sediments and sedimentation in the larger DARB study area. Field work for that effort is complete and a report is forthcoming. Also, SCG is implementing a county-wide oyster monitoring program that will occupy existing stations in DARB.

As part of the development of resource management targets for the DBWMP, Mote Marine Laboratory performed another oyster survey. Originally intending to use oyster epibiont and predator damage as a proxy record for historical salinities in Dona Bay and Shakett Creek, preliminary sampling found that shell damage was insufficient for use as a salinity proxy. Also, concerns for sampling buried reefs so as to address time-averaging issues discussed by Lindland et al. (2001) could not be addressed within the present scope of study.

In order to further the development of ecological targets for the study area, a related study of oyster condition, defined as largest live and largest dead shells, was undertaken. This metric was developed in the Loxahatchee River and has been applied in SWFWMD minimum flows and levels studies of the Alafia River (Estevez 1990; Culter et al., 2001).

METHODS

Intertidal reefs in Dona Bay and Shakett Creek were visited in March 2006. Intertidal reefs in Roberts Bay and Curry Creek were visited in June 2006. At each site, fifteen oyster clumps were haphazardly collected across the reef and along the perimeter of the reef. Each clump was dissected and the height of the largest living and largest dead oyster was measured to the nearest millimeter.

Oysters do not grow as reefs at RK 0.5 near Venice Inlet. There, oysters were located by snorkeling and wading along boulder rip-rap and mangrove shorelines and measurements were made on oysters encountered at mid to low intertidal elevations.

RESULTS

Figures A1 and A2 depict Shakett Creek and Dona Bay means and standard deviations of live and dead oyster heights, and box-and-whisker plots of data distributions, respectively.

Mean heights are lowest at RK 0.5 near Venice Inlet, and at RK 3.5 to 4.3 in Shakett Creek (Figure A1). Mean values are highest at RK 1.0 to 2.5 but differ between live and dead material. Largest dead oysters occur from RK 1.0 to 3.0 whereas largest live oysters occur over a shorter range, from RK 1.0 to 2.5 with a peak value at RK 2.0. More large dead oysters occur farther upstream in Shakett Creek, than do large live ones.

Figure A2 depicts data distribution as percentiles-- 5^{th}, 10^{th}, 25^{th}, 50^{th} (median), 75^{th}, 90^{th}, and 95^{th}.

Figures A3 and A4 depict Curry Creek and Roberts Bay means and standard deviations of live and dead oyster heights, and box-and-whisker plots of data distributions, respectively.

Mean heights are lowest at RK 0.5 near Venice Inlet, and at RK 1.5 in Roberts Bay (Figure A3). Mean values are highest at RK 2.0 to 3.0 with little difference between live and dead material. More large dead oysters occur farther upstream in Curry Creek, than do large live ones. Largest dead oysters occur at RK 3.5, than live oysters, signifying that favorable conditions for growth have occurred at some earlier time.

Figure A4 depicts data distribution as percentiles-- 5^{th}, 10^{th}, 25^{th}, 50^{th} (median), 75^{th}, 90^{th}, and 95^{th}.

DISCUSSION

Oyster sizes assessed by this method tend to identify upstream and downstream reaches where suboptimal oyster conditions exist. In high salinity water near Venice Inlet, small oyster size may be related to limited food supply, higher salinity, and mortality caused by marine parasites, diseases, and predators. In low salinity reaches, small oyster size may be caused by mortality resulting from prolonged exposure to fresh water, oxygen stress, or poor recruitment.

In Shakett Creek, the RK "footprint" of large dead oysters is larger than for live oysters, signifying that favorable conditions for oysters have existed over a longer reach of the study area than has existed for the few years since the largest living oysters have matured. Jones (2004) observed that the most live beds and robust oysters of 2003 occurred between RK 2.1-3.3, which includes part of but was also upstream of the optimal zone identified in the 2006 survey. This difference is consistent with the finding that larger dead oysters occurred farther upstream than live ones in 2006.

CONCLUSION AND RECOMMENDATION

The present study adds spatial detail to the organization and condition of oyster resources in the DARB study area. The pattern of largest live and dead oyster heights is comparable to that seen in other coastal rivers sampled by the same method, and depicts two common findings: that a central reach of largest oysters occurs between reaches with smaller animals; and that the reach of large dead material is longer than that for large live material. Over an antecedent period of unknown length, and also for the past few years, conditions conducive to oysters have occurred between RK 1.0 to 3.0 in Shakett Creek/Dona Bay, and between RK 2.0 to 3.0 in Curry Creek/Roberts Bay.

Further study of surface water quality data near and upstream of RK 3.0 in both streams should be undertaken by other members of the DBWMP team to identify conditions that may be depressing oyster success.

REFERENCES

Culter, J.K., Estevez, E.D., Sprinkel, J., Leverone, J., Baird, A., Osterhoudt, J. and D. Ingrao. 2001. An investigation of relationships between freshwater inflows and benthic macroinvertebrates in the Alafia River estuary. Mote Marine Laboratory Technical Report no.773.

Estevez, E.D. 1990. Environmental studies of the tidal Loxahatchee River / Palm Beach and Martin Counties, Florida. Mote Marine Laboratory Technical Report no. 181.

Estevez, E.D. 2005. Molluscan Bioindicators of the Tidal Myakka River and Inshore Waters of Venice, Florida. Mote Marine Laboratory Technical Report no. 990.

Jones, M. 2004. Dona and Robert's Bay Estuary Analysis. Sarasota County Environmental Services.

Jones, M. 2005. Dona and Robert's Bay Second Annual Watershed and Estuary Report: 2004. Sarasota County Environmental Services.

Lindland, E., C. Burt, J. Edlin, M. Elkins, J. Leavor, J. Mallon, M. Myers, S. Obley, M. Savarese, and G. A. Goodfriend. 2001. Time averaging on oyster reefs: implications for environmental reconstruction and historical change. Geological Society of America 33(2):A74.

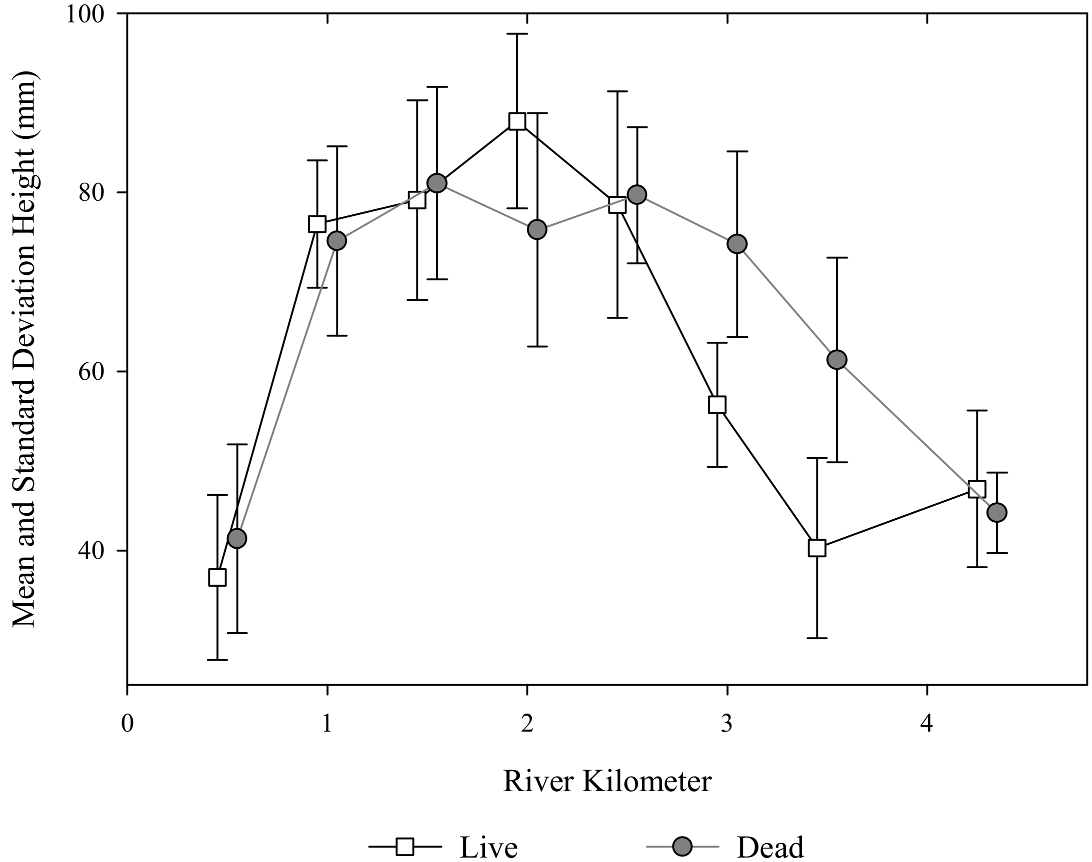


Figure A1. Mean and standard deviation of oyster shell height for live and dead material in Shakett Creek and Dona Bay.

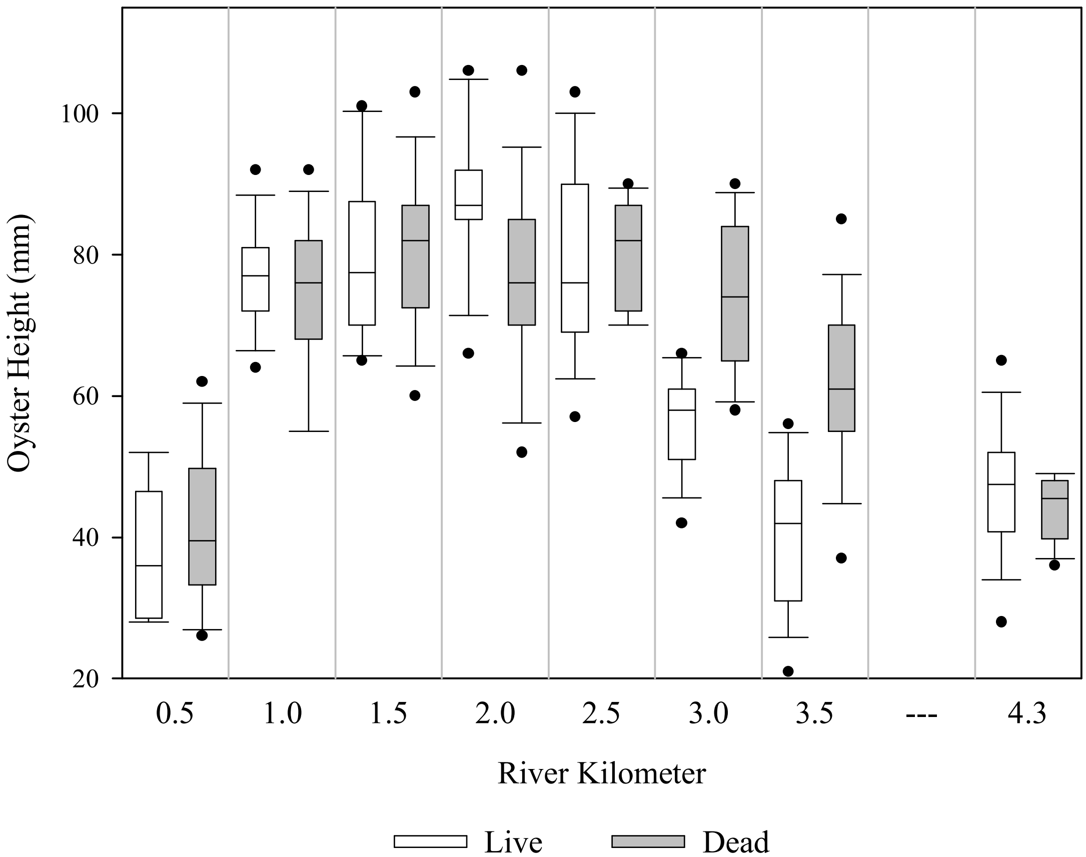


Figure A2. Live and dead oyster heights in Shakett Creek and Dona Bay, with data distributions as percentiles-- 5th, 10th, 25th, 50th (median), 75th, 90th, and 95th.

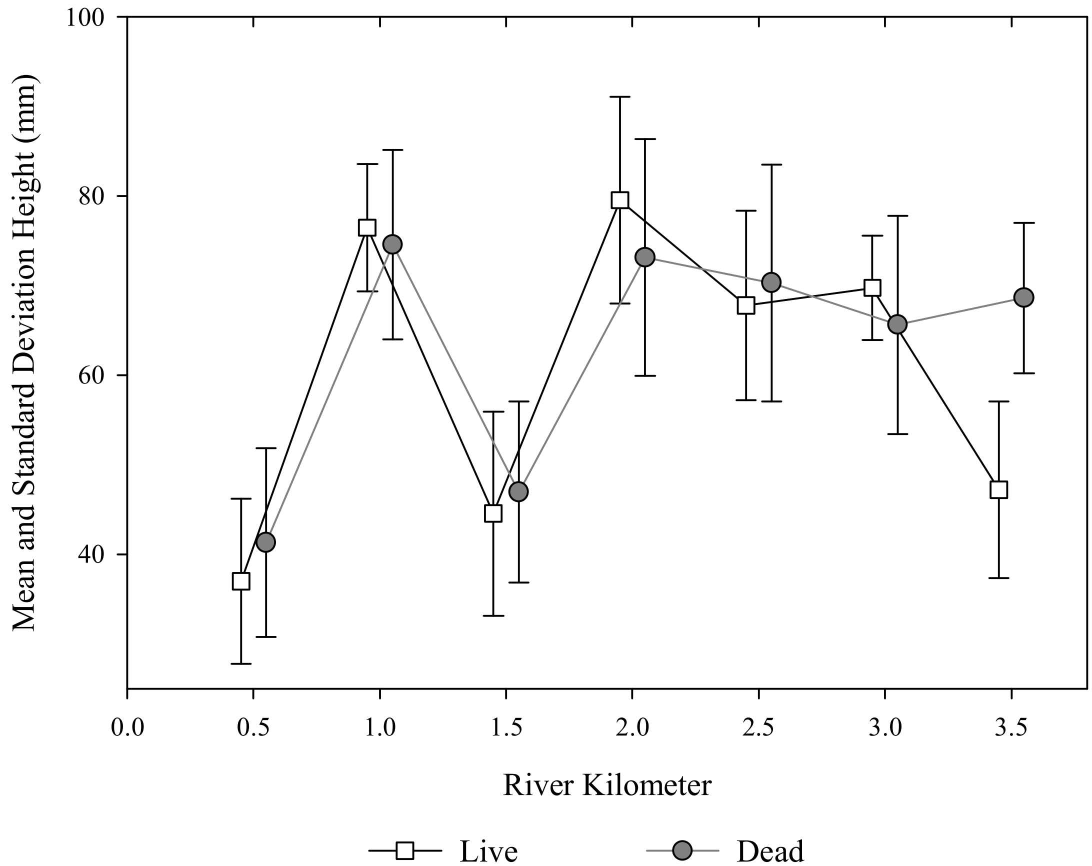


Figure A3. Mean and standard deviation of oyster shell height for live and dead material in Curry Creek and Roberts Bay.

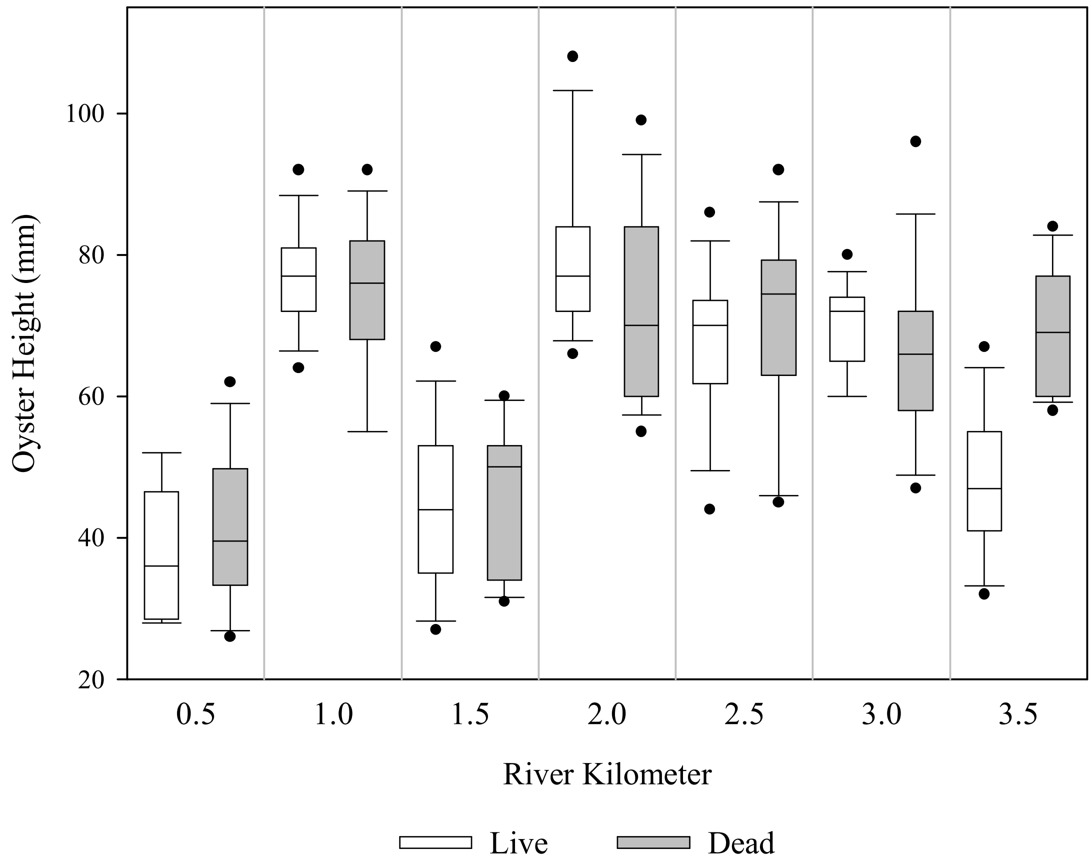


Figure A4. . Live and dead oyster heights in Curry Creek and Roberts Bay, with data distributions as percentiles-- 5th, 10th, 25th, 50th (median), 75th, 90th, and 95th.

Chapter 4 - Water Supply Appendices

Photo of Cow Pen Canal
Lower Water Level Control Structure

TM 4.2.1. – WATER QUALITY ANALYSIS AND WATER TREATEMENT OPTIONS ANALYSIS

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

Pursuant to Task 4.2.1 of the DBWMP contract, PBS&J prepared this technical memorandum to present the results of a review of existing water quality data to determine if additional sampling and testing is needed for evaluation of water treatment alternatives and to present an evaluation of alternatives for a water treatment facility using surface water from the Dona Bay watershed as a raw water source.

2.0 WATER TREATMENT ALTERNATIVES

The water in the Cow Pen Canal is similar to typical Florida streams, with high color and dissolved organic carbon, and seasonal variations in quality with changes in rainfall amounts. The alternatives for treatment of the water to drinking water standards include conventional treatment processes and more recently developed membrane technology. Four treatment alternatives using conventional and membrane systems were evaluated and compared.

3.0 WATER QUALITY

Cow Pen Canal, the primary tributary to Dona Bay, is a Class III stream (fishing and recreation) and is not protected for the purpose of providing a potable water source. The Dona Bay watershed is primarily undeveloped, with citrus groves, pasture, and other agriculture being the predominant land uses. However, the conversion of agricultural property to residential development will likely influence the future water quality in the watershed.

Sarasota County completed a year long sampling and testing program in 2003 to evaluate the water quality in the Cow Pen Canal and the potential for use of the water for irrigation or as a potable water source. The sampling program included monthly testing for pollutants listed in the National Primary and Secondary Drinking Water Regulations and selected additional parameters. The National Primary and Secondary Drinking Water Standards were established by the Environmental Protection Agency for all public potable water supply systems and relate to the finished water distributed to users. It should be noted that the test results are for a raw water source prior to treatment.

With the exception of pathogens, none of the contaminants exceeded the primary drinking water standards. Total coliform and fecal coliform counts exceeded the Criteria for Surface Water quality in several of the samples. The parameters that exceeded the Secondary Drinking Water Standards and Surface Water Quality Standards are aluminum, iron, color, odor, and bacteria. Pesticides were found to be present in minor concentrations in three of the samples, but did not exceed the maximum contaminant level (MCL) required by the drinking water standards.

The high color level suggests a high dissolved organic carbon content which increases the likelihood of disinfection bi-product (DBP) formation unless removed prior to application of chlorine based disinfectants.

This water source has the potential for blue-green algae growth. Blue-green algae, echnically known as **cyanobacteria**, are microscopic organisms that are naturally present in lakes and streams. While normally present in low numbers, blue-green algae can become very abundant in warm, shallow, undisturbed surface water receiving sunlight. Blue-green algae are easily controlled by applying oxidizing biocides to the water. However, as the blue-green algae die they produce geosmin and MIB (2-methylisoborneol). These compounds are responsible for creating earthy, musty odors and tastes in water. Geosmin can be sensed by the nose at very low concentrations (on the order of 10 parts per trillion). The effects of MIB and Geosmin are controlled by application of additional oxidants and/or activated carbon (granular or powdered).

The hardness of the water varies seasonally from soft to very hard dependent upon the percentage of the flow resulting from groundwater infiltration into the stream. Hard water requires more soap and synthetic detergents for home laundry and washing, and contributes to scaling in boilers and industrial equipment. Hardness is caused by compounds of calcium and magnesium, and by a variety of other metals. General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard.

The Langelier Saturation Index (LSI; also called Langelier Stability Index) is a calculated number used to predict the calcium carbonate stability of water. Langelier developed a method for predicting the pH at which water is saturated in calcium carbonate (called pHs). The LSI is expressed as the difference between the actual system pH and the saturation pH or:

LSI = pH – pHs

The water's calcium hardness, alkalinity, temperature and dissolved solids content are used to calculate LSI.
If the actual pH of the water is less than the calculated saturation pH, the LSI is negative and the water has a very limited scaling potential and may actually dissolve calcium carbonate deposits. If there are no calcium carbonate deposits to dissolve, the water will begin dissolving iron from the pipe walls. If the actual pH exceeds pHs, the LSI is positive, and being supersaturated with $CaCO_3$, the water has a tendency to form scale. At increasing positive index values, the scaling potential increases.

A target LSI for the treated water delivered to the system is general in the range of 0 to <+0.5; a negative LSI is not desirable.

4.0 TREATMENT REQUIREMENTS

Table 1 summarizes the water quality parameters that were identified in the Cow Pen Water Quality Monitoring Report that are of concern.

Pollutant	Tested	Exceeds MCL	Comment
Pesticides	Y	N	Present in 3 samples
Iron	Y	Y	
Color	Y	Y	
Odor	Y	Y	
Hardness	Y		High
Coliforms	Y	Y	Present
Giardia	Y		Present
Cryptosporidium	Y		Present

Table 1: Cow Pen Water Quality Concerns

Pathogens, such as *Giardia* and *Cryptosporidium*, can cause gastrointestinal illness (e.g., diarrhea, vomiting, cramps) and other health risks, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients). *Cryptosporidium* is a significant concern in drinking water because it contaminates surface waters used as drinking water sources, it is resistant to chlorine and other disinfectants, and it has caused waterborne disease outbreaks.

Current regulations require filtered water systems to reduce source water *Cryptosporidium* levels by 99 percent (2-log). Recent data on *Cryptosporidium* indicate that this treatment is sufficient for most systems, but additional treatment is necessary for certain higher risk systems. These higher risk systems include filtered water systems with high levels of *Cryptosporidium* in their water sources and all unfiltered water systems, which do not treat for *Cryptosporidium*.

The treatment process must reduce these parameters to acceptable levels or remove them. The microorganisms, *Giardia* and *Cryptosporidium* have been found to be present in the Dona Bay watershed. The drinking water standards require that the treatment technology must remove or inactivate the microorganisms.

Softening of the water to remove hardness may be required to provide aesthetically acceptable water. Because the source water is coming from a drained watershed with many potential sources of pollution, the level of total suspended solids (TSS) and total organic carbon (TOC) are assumed to be high for the purpose of this evaluation and must be reduced by any alternative processes. The current and future drinking water requirements will mandate that the treatment technology:

- Meet primary and secondary drinking water standards
- Provide multiple barriers to pathogens
- Minimize the interaction of organic carbon compounds with chlorine disinfectant in the treatment of water and in the treated water
- Provide disinfection of pathogens in the treatment process and residual disinfection in the drinking water distribution system
- Provide an aesthetically satisfactory water for consumption

5.0 TREATMENT PROCESSES

The following water treatment unit processes were evaluated for treatment of surface water from the Dona Bay watershed.

5.1 Rapid Rate Mixed Media Filtration

Filtration is a physical process that removes impurities from water by percolating it downward through a filter media such as garnet, sand, and anthracite installed in layers. The water flows through the media and particulates are entrapped and removed from the water. The treated water is then disinfected. Filtration is the next to last process in the traditional water treatment train. It is generally effective in removing particles 10 microns and larger as well as pathogens.

5.2 Coagulation/Precipitation/Clarification (Lime Softening)

Coagulation/Flocculation/Precipitation is a process of adding chemicals to water to produce a chemical reaction which forms particles. After the chemical coagulant is added, the water is gently agitated to cause the particles to collide and form larger particles. Following the agitation, the water enters a quiescent zone and the particles settle out (clarification) due to the difference in specific gravity between the solid particles and the water.

Lime softening is a variation of this process that uses a strongly basic chemical such as lime or caustic to precipitate calcium carbonate and magnesium hydroxide. This process is general used as an initial treatment stage in a traditional water surface treatment train and is effective in the removal of hardness, alkalinity, suspended solids, and pathogens from the source water.

5.3 Ion Exchange

Ion exchange is a reversible, solution phase chemical reaction where an ionic constituent (i.e. either an atom or molecule with either a positive or negative electrical charge) is exchanged for a similarly charged ion attached to an immobile solid particle. These solid ion exchange particles may be either a naturally occurring inorganic zeolite or synthetically produced organic resin. The synthetic organic resins were developed to mimic the natural zeolites with improved performance and are the predominant type used today because their characteristics can be tailored to specific applications.

An organic ion exchange resin is composed of high-molecular-weight polymer that can exchange their mobile ions for ions of similar charge from the solution. These resins are generally made from a styrene-divinylbenzene co-polymer but acrylic polymers are also used in certain situations. Each resin has a distinct number of ion exchange sites that set the maximum quantity of exchanges per unit of resin. Once a resin is exhausted it is chemically regenerated for reuse.

Cation exchange resins have an affinity for ions with a positive charge such as calcium, magnesium, sodium and potassium. Anion exchange resins have an affinity for ions with a negative change such as bicarbonate, chloride, sulfate, and ortho-phosphate. Anion exchange resins will also remove dissolved organic carbon (DOC) from water. In pure water applications, organic loading is not desired as it reduces the ion exchange capacity of the resin.

However, this phenomenon is a useful unit process for reducing the DOC content from a water supply if disinfection byproducts are a concern. When an anion resin is used to remove DOC it is referred to as an organic trap and is regenerated with a dilute caustic (≈2%) and salt (≈10%). Organic traps are most commonly housed in pressure vessels. The MIEX process uses a proprietary acrylic anion resin that is smaller than standard to improve reaction kinetics. The resin is impregnated with iron to make it magnetic. Because of this feature, the resin beads behave as small magnets and assists in the resin recovery stage of the process. Additional details of this process will be found further within this section.

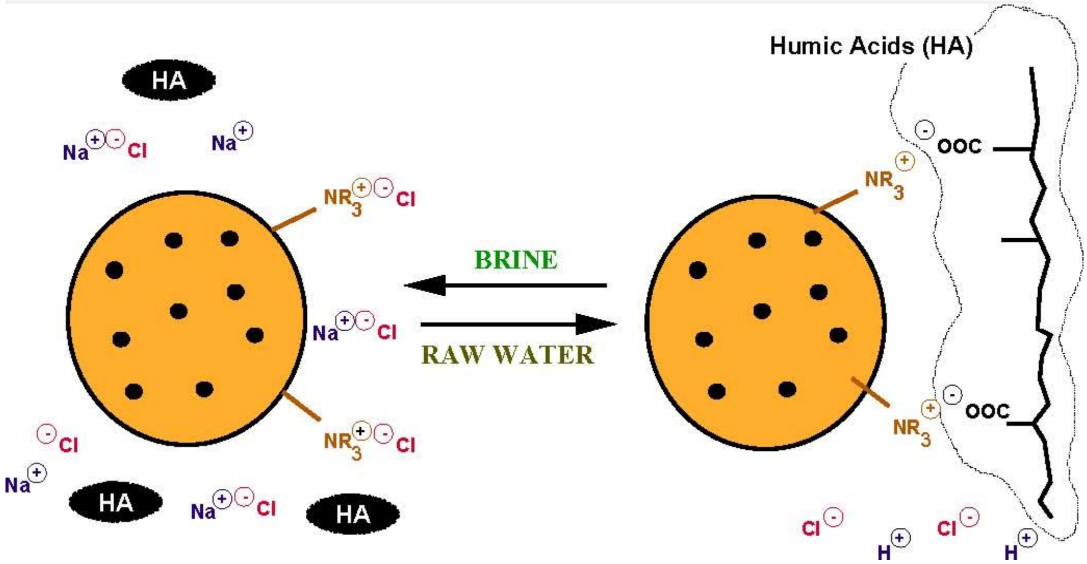


Figure 1 - DOC Removal by Ion Exchange

5.4 Activated Carbon

Granular and powdered activated carbon removes taste and odor producing substances through similar chemistry. Granular activated carbon (GAC) is typically used in gravity filter beds or pressure filter columns and is sometimes incorporated in mixed media filters as a replacement for anthracite. Powdered activated carbon (PAC) is generally fed into the raw water stream as it enters the mixing tanks at the start of the treatment process. The PAC is removed in the coagulation/sedimentation process. The effectiveness of the process depends on "adsorption", a process where a particle or molecule adheres to the surface of a substance, usually due to molecular-level electrical forces. Because the adsorption process depends on surface area, the more surface area the carbon has the more contaminants it can adsorb. A contaminant that is highly soluble in water tends to stay in the water and avoids adsorbing onto the activated carbon particles. Activated carbon filtration is very effective at removing many, but not all, organic molecules, such as fuels, pesticides, and solvents. It is also effective at removing some non-organic compounds and metals from water, such as chlorine, arsenic, chromium, and mercury. GAC must be replaced or regenerated periodically as the media loads and adsorption efficiency of the particles decreases.

5.5 Membrane Treatment

Membrane technology utilizes a semi-permeable membrane for the separation of suspended and dissolved solids from water. The process uses hydraulic pressure to force water molecules through the semi-permeable membrane. Impurities are retained and concentrate in the feed water, which becomes the reject water or concentrate stream. Permeate the water that passes through the membrane, is recovered as product water. Membrane technologies in order of decreasing permeability are:

- Microfiltration (MF)

- Ultrafiltration (UF)
- Nanofiltration (NF)
- Reverse Osmosis (RO)

The range of sizes of selected constituents in water and the performance capabilities of the different membranes are illustrated in Figure 2.

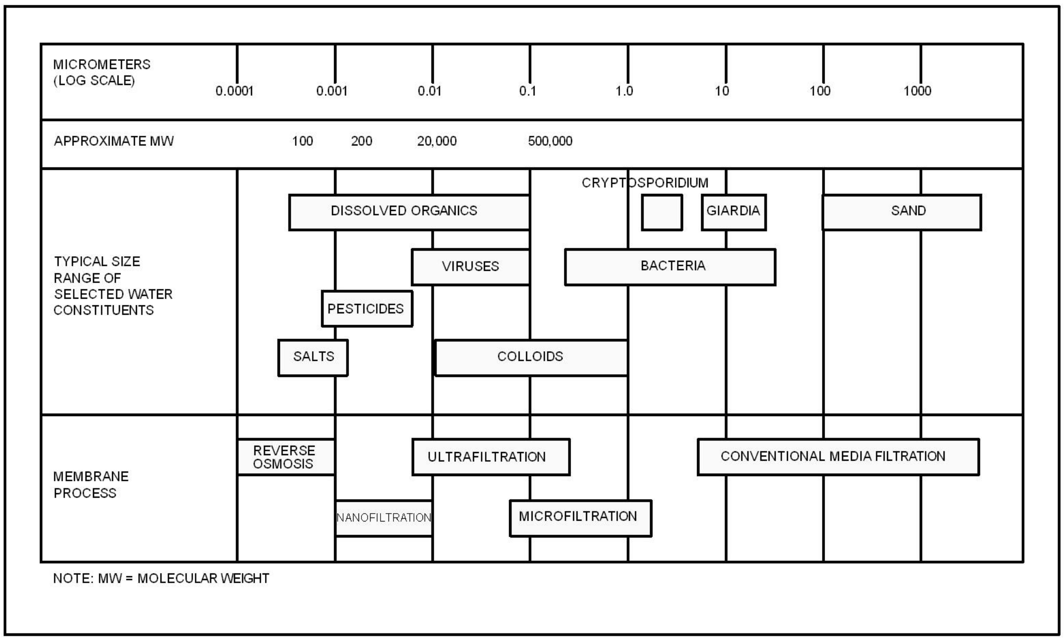


Figure 2 – Filtration Spectrum

Microfiltration (MF) and ultrafiltration (UF) are used to remove larger particles, colloids, and many microorganisms. MF performs as a semi-permeable barrier to reduce turbidity and some types of colloidal suspensions. UF offers higher removals than MF, but operates at higher pressures. Nanofiltraton (NF) technology is positioned between reverse osmosis and ultrafiltration and is applicable where the level of dissolved solids removal is less than the levels normally encountered with brackish water or seawater sources. NF is used to remove pesticides and other organic contaminants, hardness, bacteria and viruses, and organic-related color. Membranes of varying permeability are available to match the type and level of contaminants that must be removed.

Also, membrane filtration systems provide a physical barrier that removes Cryptosporidium, Giardia, bacteria, and viruses.

5.6 ACTIFLO (Ballasted Clarification)

ACTIFLO is a trade name for a proprietary ballasted Coagulation/Precipitation /Sedimentation process that utilizes microsand (100 to 150 µm particle size) to add weight to chemically formed flocculation particles in conjunction with lamella settling tubes to aid in clarification. There are similar products available from other manufacturers. This is not a filtration process and must be followed by filtration. The greatest advantage of the ACTIFLO system is that it requires much less space than conventional coagulation-sedimentation, which makes it useful for sites with limited space or for increasing the capacity of existing facilities that have limited area for construction. The smaller footprint is due to reduced rapid mix and flocculation residence time. Also, the clarifier section operates at much higher overflow rates than conventional clarifiers. Exceptions to the Ten State requirements would be required during the permitting process.

5.7 Oxidation Pre-Treatment

This unit process would begin the oxidation of organic compounds by applying a powerful oxidant and disinfectant to the raw water. Oxidants that could be used in this step are chlorine dioxide (ClO_2), potassium permanganate ($KMnO_4$), ozone (O_3), or hydrogen peroxide (H_2O_2). $KMnO_4$ is a solid and must be mixed with water prior to application. H_2O_2 s a liquid and would be diluted with water prior to application. ClO_2 and O_3 must be generated near the point of application. All of these are effective against pathogens and effective in removing taste, odor, and color from water. These oxidants will oxidize iron and manganese aiding in their removal from the water. They also break down the organic precursors to trihalomethanes (THM) and haloacetic acids (HAAC).

5.8 Disinfection

The disinfection of drinking water prior to distribution is achieved through the use of a form of chlorine. Chlorine is an element found combined in nature and is associated with many manufactured products. When in a free state, it is a powerful disinfectant, effective in destroying many types of pathogens. The advantage of chlorine disinfectant is the presence of a chlorine residual in the distribution system. Because chlorine reacts with organic carbon compounds to form disinfection byproducts which have been identified with some health concern, most treatment plants that have surface water sources use a combination of chlorine and ammonia to minimize the formation of these compounds. In the chloramination process, stoichiometric ratios of ammonia and chlorine are mixed to promote the formation of monochloramine (NH_2Cl). It is very important to control the ratios to prevent the formation of dichloramine ($NHCl_2$) and trichloramine (NCl_3) as they may cause odor issues. Ultraviolet (UV) light is effective in the deactivation of *Giardia* and *Cryptosporidium* and should be considered as an additional treatment for alternatives that do not have a positive barrier.

6.0 TREATMENT ALTERNATIVES

The traditional process for water treatment is coagulation, clarification, filtration, and disinfection. Because of the presence of pathogens, pesticides, dissolved organic compounds, color, and odor, additional treatment processes will be required. The traditional process for water treatment is generally credited with a 2.5 log removal of pathogens, which is not sufficient for the source water being used. Because of the quality of the source water, additional treatment processes would be required to supplement the traditional process.

Using various combinations of the unit treatment processes described above, four alternatives were developed to meet the requirements for treatment of water from the Dona Bay watershed for use as a potable water supply.

6.1 Alternative 1 - Lime Softening/Filtration

Under this alternative, lime is used as to precipitate hardness and as a coagulant to form particles that by settling, physically remove suspended solids, hardness, and pathogens. Pre-oxidation treatment is included to oxidize organic compounds that are precursors to disinfection byproducts, and to break down organic compounds that cause taste and odor problems. Mixed media filtration is utilized to remove particulate matter, including suspended solids and pathogens. A granular activated carbon filter could be added to absorb organic compounds and pesticides or powdered activated carbon could be used following the pre-oxidation. The disinfection process is used to kill pathogens and provide a disinfection residual in the drinking water. UV treatment is included to provide deactivation of *Giardia* and *Cryptosporidium*. Table 2 provides the treatment effectiveness of Alternative 1. Figure 3 provides a schematic of Alternative 1.

Parameter	Tested	Exceeds MCL	Comment	Pre-oxidaton	Coagulation/Precipitation (Lime Softening)	Rapid Rate Mixed Media Filtration	Granular-activated Carbon	Disinfection	Check
Pesticides	Y	N					X		X
Color	Y	Y		X			X		X
Odor	Y	Y		X			X		X
Hardness	Y		High		X				X
Coliforms	Y	Y	Present	X	X	X		X	X
Giardia	Y		Present	X	X	X		X	X
Cryptosporidium	Y		Present	X	X	X		X	X
TSS	N				X				X
DOC/TOC	N			X			X		X

Table 2 – Lime Softening/Filtration

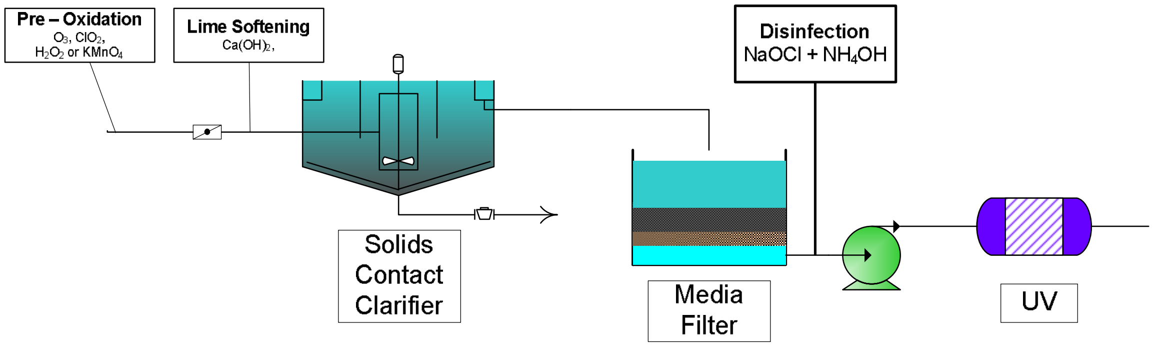


Figure 3 – Lime Softening and Filtration Schematic

6.2 Alternative 2 - Ballasted Clarification/Filtration

This alternative is similar to Alternative 1 except that the coagulation, precipitation, clarification process uses the ballasted clarification system. The remaining processes are the same as in Alternative 1. As in Alternative 1, pre-oxidation would be the first step in the process. Table 3 provides the treatment effectiveness of Alternative 2. Figure 4 presents a schematic of the Actiflo Process/Filtration clarification process. Figure 5 presents a schematic of the clarified water.

Parameter	Tested	Exceeds MCL	Comment	Pre-Oxidation	ACTIFLO (Ballasted Clarification)	Rapid Rate Mixed Media Filtration	Granular-activated Carbon	Disinfection	Check
Pesticides	Y	N					X		X
Color	Y	Y		X			X		X
Odor	Y	Y		X			X		X
Hardness	Y		High		X				X
Coliforms	Y	Y	Present	X	X	X		X	X
Giardia	Y		Present	X	X	X		X	X
Cryptosporidium	Y		Present	X	X	X		X	X
TSS	N				X				X
DOC/TOC	N			X			X		X

Table 3 – Actiflo Clarification/Filtration

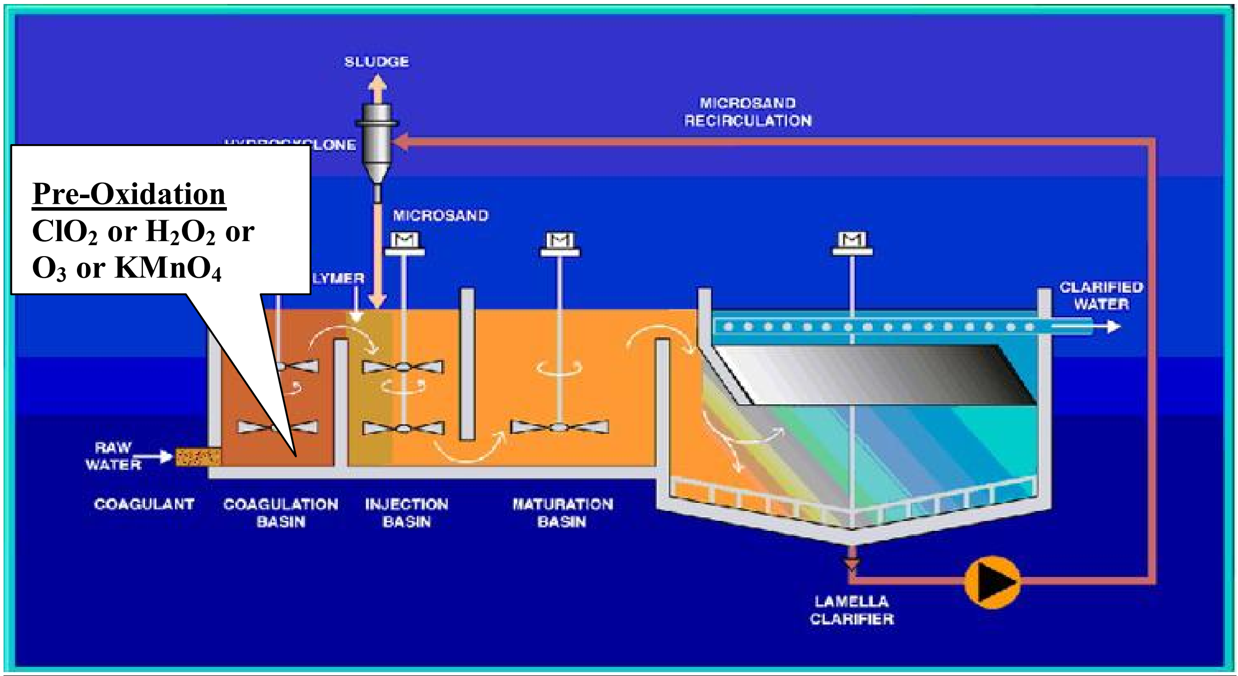


Figure 4 – Actiflo Process/Filtration Schematic

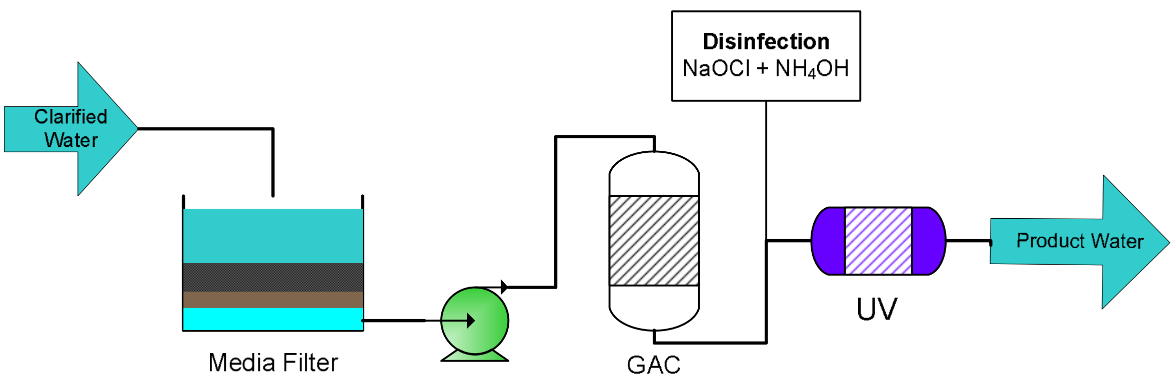


Figure 5 – Ballasted Clarification/Filtration Schematic

A strong oxidizing agent is used for pre-oxidation to start the destruction of disinfection byproducts. The ballasted clarification process will remove raw water turbidity, color, TOC, algae, cryptosporidium, iron, manganese, arsenic and other typical undesirable water contaminants. The mixed media filtration is utilized to remove particulate matter from the water, including suspended solids and pathogens that are not captured in the clarification process. The granular activated carbon is utilized to absorb organic compounds and pesticides. The disinfection process using chloramination is used to kill pathogens and provide a disinfection residual in the drinking water.

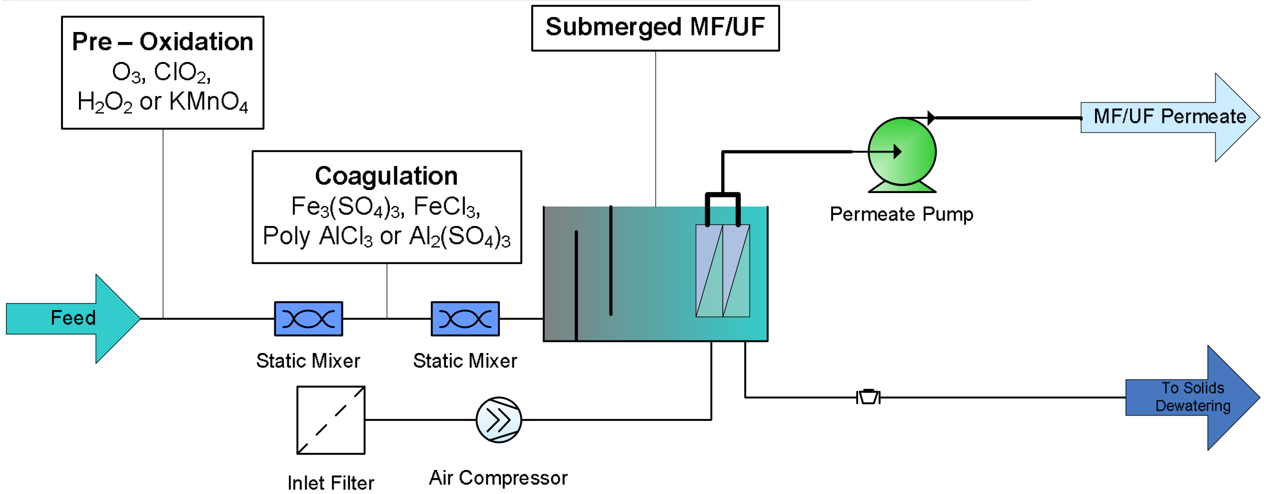
Solids produced during the ballasted sand process will be dewatered with the solids being disposed of in an approved landfill.

6.3 Alternative 3 - Combined Membrane Treatment

Under this Alternative, chemicals are added to precipitate suspended solids, calcium, magnesium and other ions into small particles. The microfiltration membrane is utilized to separate particles that are in the macro molecular range, 0.1 to 1 micrometers, which would include bacteria and Giardia cysts as well as suspended solids. The nanofiltration membrane is utilized to separate molecules and particles in the molecular range, 0.01 to 0.001 micrometers, from the water. Molecules and particles in this size range would include viruses and pesticides, hardness and sulfates. If RO is selected, a portion of the MF/UF permeate will bypass the RO to blend with the RO permeate. The blend ratio will be selected to achieve a high quality drinking water. The chloramination disinfection process is used to kill pathogens and provide a disinfection residual in the drinking water. Table 4 provides the treatment effectiveness for Alternative 3. Figure 6 presents a schematic of the Alternative 3 treatment process.

Parameter	Tested	Exceeds MCL	Comment	Pre-Oxidation	Chemical Precipation	Microfiltation Membrane Treatment	Nanofiltration Membrane Treatment	Disinfection	Check
Pesticides	Y	N					X		X
Color	Y	Y		X			X		X
Odor	Y	Y		X			X		X
Hardness	Y		High		X	X	X		X
Coliforms	Y	Y	Present	X	X	X	X	X	X
Giardia	Y		Present	X	X	X	X	X	X
Cryptosporidium	Y		Present	X	X	X	X	X	X
TSS	N				X	X	X		X
DOC/TOC	N			X		X	X		X

Table 4 – Combined Membrane Treatment



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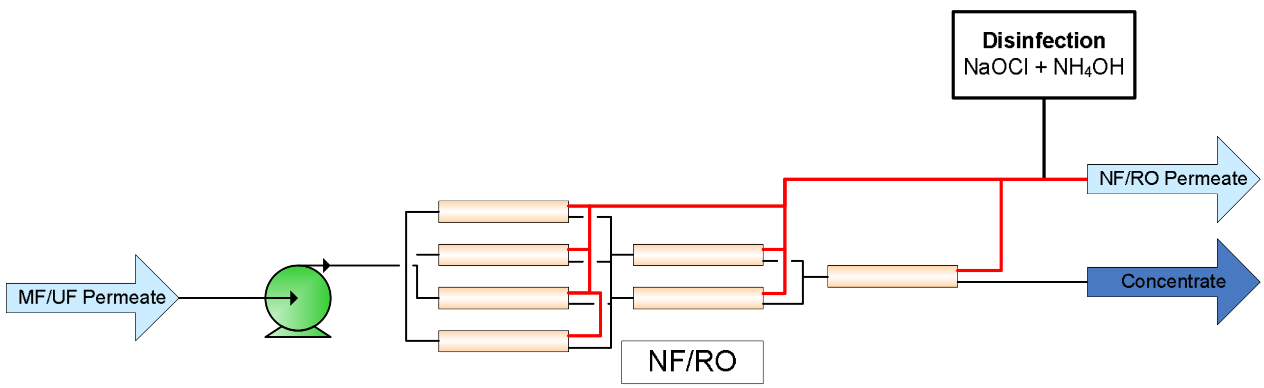

Figure 6 – Combined Membrane Treatment Schematic

6.4 Alternative 4 - Ballasted Clarification/Membrane

Pre-oxidation followed by the ballasted clarification process is utilized to remove turbidity (high and low), color, TOC, algae, particle counts, cryptosporidium, iron, manganese, arsenic and other typical undesirable water contaminants. The nanofiltration membrane is utilized to separate molecules and particles in the molecular range, 0.01 to 0.001 micrometers, which would include viruses and pesticides. The chlorine disinfection process is used to kill pathogens and provide a disinfection residual in the drinking water.

The ballasted clarification process is utilized to remove raw water turbidity, color, TOC, algae, particle counts, cryptosporidium, iron, manganese, arsenic and other typical undesirable water contaminants. Dual media filtration is required to reduce the suspended solids levels further before application on the nanofiltration membrane. The nanofiltration membrane is utilized to separate molecules and particles in the molecular range, 0.01 to 0.001 micrometers, from the water. Molecules and particles in this size range would include viruses and pesticides. The disinfection process is used to kill pathogens and provide a disinfection residual in the drinking water. Table 5 provides the treatment effectiveness of Alternative 4. Figure 7 presents a schematic of the Actiflo Process/Filtration clarification process. Figure 8 presents a schematic of the treatment process for the clarified water.

TM 4.2.2 – WATER QUANTITY | WATER BUDGET APPROACH

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and SWFWMD are currently completing the necessary, pre-requisite data collection and analysis as well as comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marin Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the Southwest Florida Water Management District (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by KHA to present analyses of historical hydrologic data collected in the Cow Pen Canal, Blackburn Canal and Myakka River watersheds, consistent with Task 4.2.2 of the DBWMP contract. Specifically, hydrologic data bases have been developed to reflect current conditions for the Dona Bay and Roberts Bay watersheds. These data bases will then be used to develop existing water budget estimates for natural systems, water quality, and alternative water supply scenario analyses for the Dona Bay watershed.

2.0 DONA BAY AND COW PEN SLOUGH

2.1 Historical Perspective

As reflected on the 1847 survey of Sarasota County and presented on **Figure 1**, a large slough once dominated the landscape in Sarasota County west of the Myakka River. This slough ran from north to south and eventually turned eastward to the Myakka River. Since this large slough was dependent upon the Myakka River for drainage, it receded very slowly. During the dry season, it likely became a large isolated retention area below a certain elevation and receded primarily by evapotranspiration.

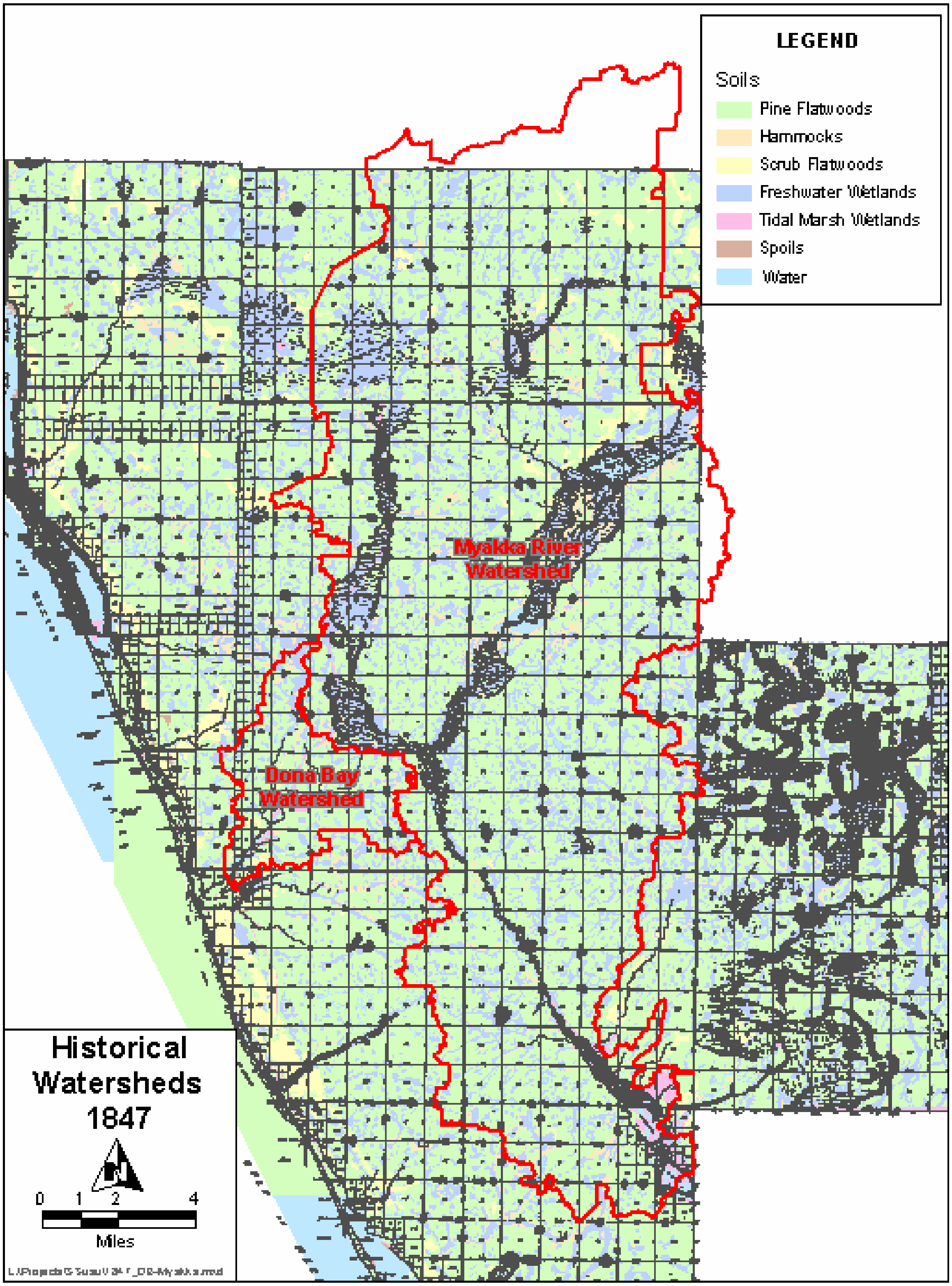

Figure 1 - 1947 Land Survey of Sarasota County

Between 1916 and 1920, as part of the Sugar Bowl Drainage District, a drainage ditch was cut through this slough. This man-made ditch was then extended south of the slough where it was connected to a small tidal creek, known as Salt Creek. Salt Creek meandered southwest where it subsequently enters Shakett Creek and Dona Bay. These activities initiated the diversion of approximately 37,453 acres from the Myakka River watershed to Dona Bay. Presumably performed for mosquito control and/or pasture conversion, this work effectively drained and diverted flows from the Myakka River to Dona Bay. However, this area was also still very prone to flooding following large storm events. Around 1950, a group of nine ranchers, with technical assistance from the Soil Conservation Service, constructed 7.5 miles of channel excavation along the lower reaches of Cow Pen Slough.

In 1961 the Sarasota Soil Conservation District, Sarasota County, and the Manatee River Soil Conservation District, with assistance from the Soils Conservation Service, developed the "Watershed Work Plan for the Sarasota West Coast Watershed". Areas that once drained to the Myakka River via Cow Pen Slough had already been drained and diverted to Phillippi Creek by the Sarasota Fruitville Drainage District in the 1920's and put into vegetable production. However, these vegetable producing areas were still subject to flooding during large events. The objectives of the 1961 Plan were: (1) to reduce flood damage frequency in the vegetable producing area to about once in 10 years; and (2) to provide adequate drainage and flood protection in the pasture lands to permit the production of improved pastures in the lower-lying areas along the stream channels. As a result, a larger canal was excavated through the slough, extended west of the "old cow pen slough" ditch through an upland ridge, and connected directly to Shakett Creek. In addition to the canal work, three large water level control structures were constructed. Only two of these structures are still operational. **Figure 2** presents a map from the original Work Plan.

Due to environmental concerns relative to changes in freshwater volumes being diverted to Dona Bay, upon completion of the first and second phases of the Plan in 1964 and 1966, respectively, the work was halted. The third phase which included a pumping station to divert addition flows from Phillippi Creek to the Cow Pen Canal (and Dona Bay) was not initiated. The 1961 Plan was formally abandoned in 1979, although the objective of reducing flood damage to the vegetable production areas was not accomplished. Much of the historical Cow Pen Slough has been converted and used for either pasture or citrus production. However, much of the historical slough signature still exists. **Figure 3** presents the natural and man-made drainage system as it exists today in dark blue with the historical wetland and slough systems identified in light blue.

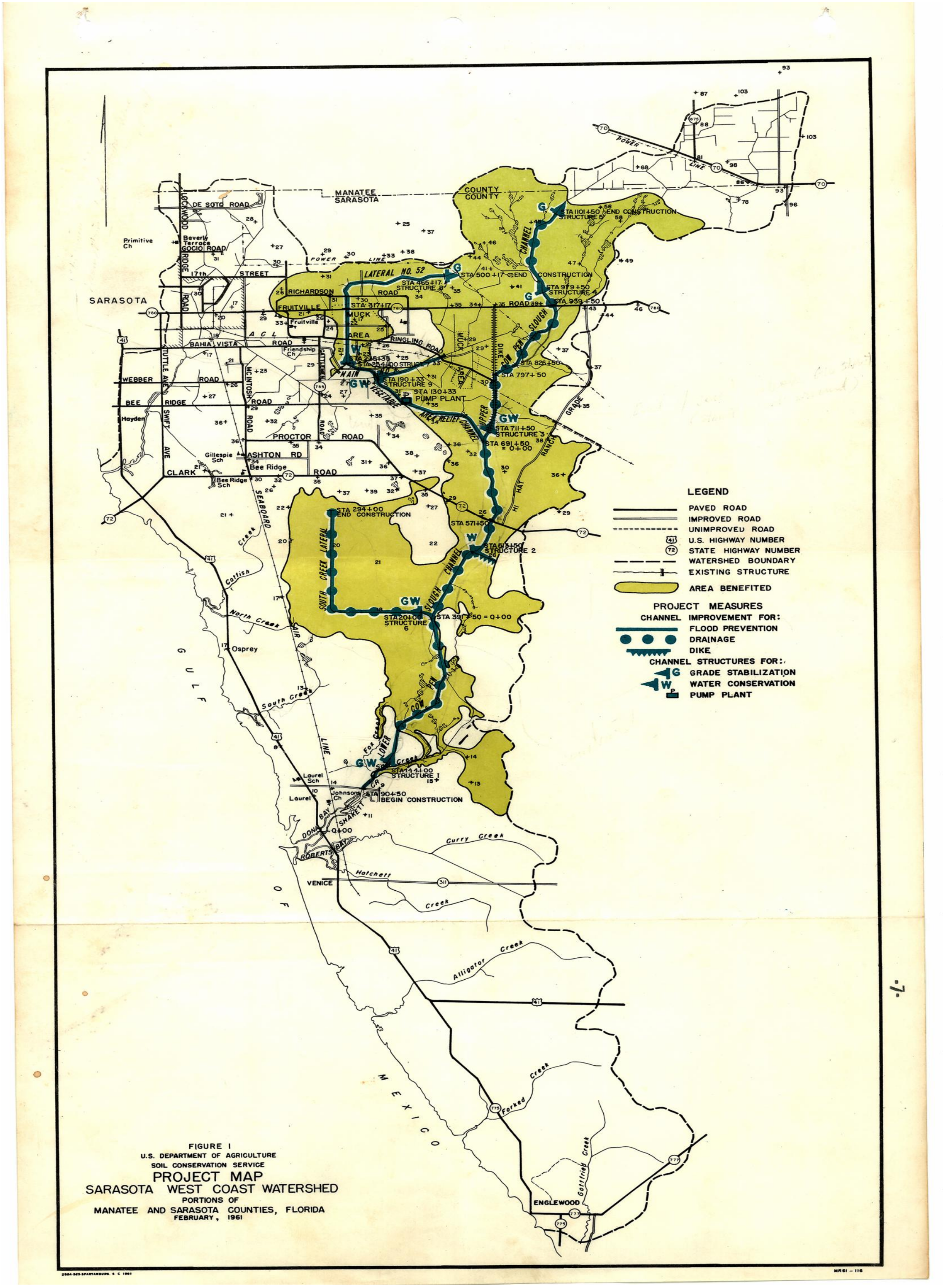

Figure 2 – 1961 Cow Pen Slough Work Plan

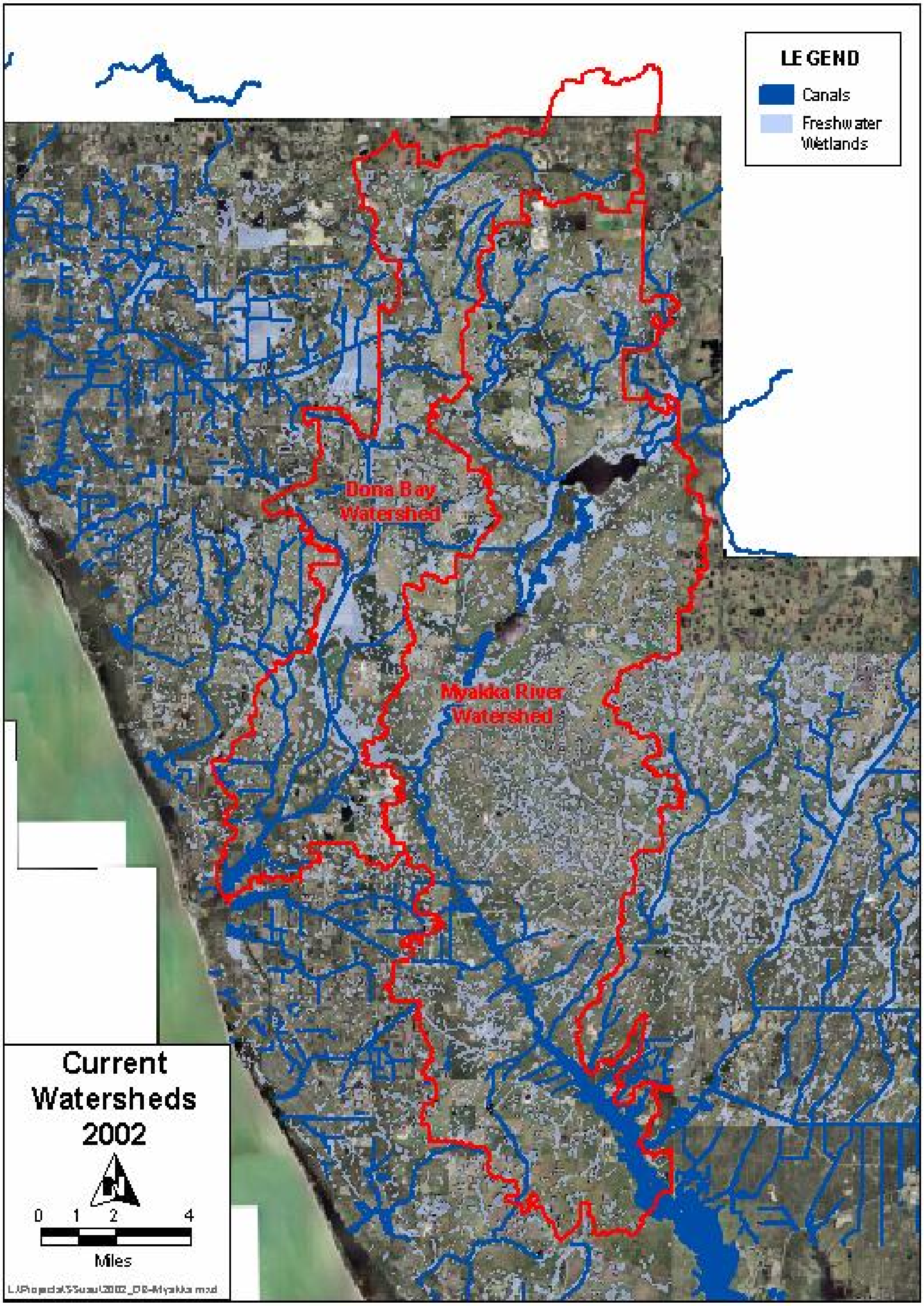

Figure 3 – Existing Drainage Network in Sarasota County

With the public acquisition of the Pinelands Reserve and the Albritton tract, much of the historical slough is currently under public ownership. Portions of the historical slough in the southern portion of the Pinelands Reserve have already been restored to some degree through re-hydration. In addition, SCG in cooperation with SWFWMD is monitoring stream stages and flows at both operable weirs on the canal. Rating curves have been developed by Hydrologic Data, Inc. and KHA has reduced the flow data from 2003 through 2005 to develop monthly, seasonal, and annual water budgets.

Flood stages determined by the USGS at the historical confluence of the Cow Pen Slough with the Myakka River are 13.6, 14.7, 15.4, 16.0, 16.1, 16.4, 16.7, and 17.1 NGVD, for the 2, 5, 10, 25, 50, 100, 200, and 500 year floods, respectively. Under current conditions, the 10-year or greater floodplain associated with the Myakka River extends westward into the Cow Pen Slough watershed when flood stages exceed 15.0 NGVD.

2.2 Determination of Existing Cow Pen Canal Water Budget

The approach for determining the amount of "excess" surface water diverted to Dona Bay by the Cow Pen Canal is consistent with that presented in the report prepared by KHA entitled "*Dona Bay Watershed Management Plan - Determination of Excess Runoff and Development of Water Budgets for 2003 and 2004"*. The Dona Bay monthly water budgets for 2005 has been completed and incorporated into the updated report prepared by KHA entitled "*Dona Bay Watershed Management Plan - Determination of Excess Runoff and Development of Water Budgets for 2003 and 2005"*. **Table 1** provides a summary of the 2005 water budget for Dona Bay, upstream of the Cow Pen diversion canal.

	2005 DONA BAY WATER BUDGET				
	1	2	3	4	5
	MEAN	2005	2005	R/P	2005
2005	RAINFALL	RAINFALL	RUNOFF		ET + STORAGE
MONTH	Inches	inches	inches		Inches
JAN	2.38	2.16	0.45	0.21	1.71
FEB	2.67	3.81	0.42	0.11	3.39
MARCH	3.01	4.37	3.03	0.69	1.34
APRIL	2.42	2.74	0.44	0.16	2.30
MAY	2.94	3.78	0.23	0.06	3.55
JUNE	7.16	15.44	6.98	0.45	8.46
JULY	8.04	7.45	4.19	0.56	3.26
AUG	8.56	3.36	0.83	0.25	2.53
SEPT	7.93	3.28	0.17	0.05	3.11
OCT	3.34	7.91	0.62	0.08	7.29
NOV	1.89	3.11	0.50	0.16	2.61
DEC	2.07	0.72	0.17	0.24	0.55
TOTAL	52.41	**58.10**	**18.03**	**0.31**	**40.07**

Table 1 – 2005 Dona Bay Water Budget Summary

Where:

1 = Mean Annual Rainfall for Southern Coastal Watershed (SWFWMD)
2 = Average Rainfall from Lower and Upper Weir Monitoring Sites for 2005
3 = Average Runoff from Lower and Upper Weir Monitoring Sites for 2005
4 = Average Runoff divided by Rainfall (Column 3 divided by Column 2)
5 = Evapotranspiration plus Change in Storage (Column 2 minus Column 3)

2.3 Development of Long-Term Flow Data for Cow Pen Slough

Other than the hydrologic data recently collected in Cow Pen Slough by SCG from 2003 though 2005, the only other available flow information is from USGS gaging station 02299700 recorded between 1963 and 1966. Therefore, a continuous, long-term data base does not exist for the Cow Pen Slough watershed. However, in 1980 transfer equations were developed to relate average daily flows from the Myakka River at USGS gaging station 02298830 (1936 to present) to average daily flows in Cow Pen Slough using the data period common to both sites (i.e. 1963 through 1966). In so doing, the entire data base at the Myakka River site can theoretically be transferred to generate a continuous, long-term data base for Cow Pen Slough. These previous transfer equations were developed by Hydroscience Research Group, Inc. for the Manasota Basin Board of the Southwest Florida Water Management District in 1980 and are contained in the report entitled *Preliminary Evaluation of the Surface-Water Supplies in the Cow Pen Slough Area*. These original transfer equations are provided in **Table 2**.

Myakka River Average Daily Flow (cfs)	Cow Pen Slough (transferred) Average Daily Flow (cfs)	Transfer Equation
0.00	0.00	
0.10	0.25	y = 0.4000x^0.20412
1.00	0.40	y = 0.4000x^0.20412
10.00	0.70	y = 0.4000x^0.24304
21.90	1.10	y = 0.1856x^0.57658
36.30	2.00	y = 0.02855x^1.1831
66.10	4.00	y = 0.03141x^1.1565
100.00	6.50	y = 0.02934x^1.1727
219.00	18.00	y = 0.01638x^1.2994
468.00	60.00	y = 0.003505x^1.5854
646.00	92.00	y = 0.01726x^1.3261
1000.00	180.00	y = 0.004439x^1.5360
1570.00	340.00	y = 0.01060x^1.4099
2130.00	614.00	y = 0.0002184x^1.9376
8750.00	4550.00	y = 0.01175x^1.4175

Table 2 – Transfer Equations (based upon Hydroscience, 1980)

The transfer equations presented in **Table 2** were applied to the entire Myakka River data base from USGS gage site 02298830. To verify the current applicability of the transfer equations, the transferred results were converted to monthly inches of runoff and compared to the actual monthly inches of runoff measured in Cow Pen Slough from January 2003 through December 2005. A summary of the results are presented graphically in **Figure 4**.

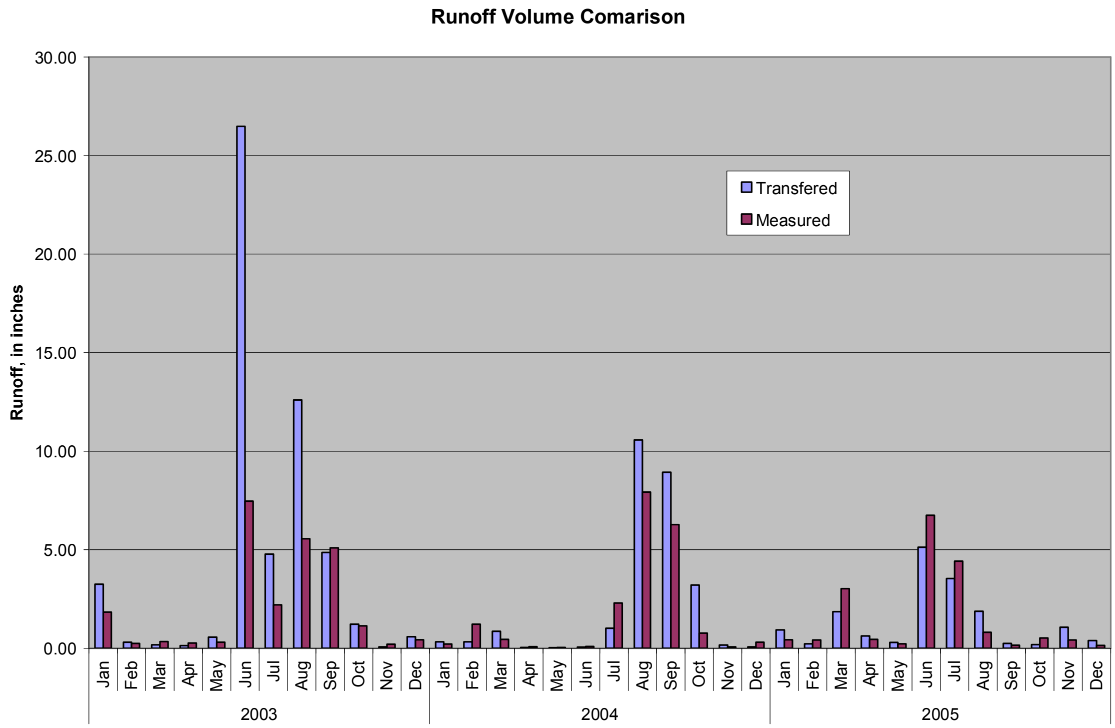

Figure 4 – Transferred and Measured Flows in Cow Pen Slough (2003- 2005) (based upon original transfer equations)

A comparison of the transferred and measured data revealed a couple of items of note. First, both the transferred and measured runoff exceeds the transferred and measured rainfall for January 2003. A review of antecedent conditions indicates that this can be explained by the fact that much of this runoff occurred at the beginning of January as a result of rainfall at the end of December.

The second anomaly is not as easy to explain. Specifically in June of 2003, the transferred runoff volume of 26.48 inches is significantly greater than the actual measured runoff volume in the Dona Bay watershed of 8.14 inches. This can be partially explained in that the 22.73 inches of total rainfall in June from the transferred watershed (Myakka River) exceeds that in the measured watershed (Dona Bay) of 16.54 inches. But the fact that the transferred runoff is greater than the transferred rainfall indicates that the transfer equations themselves may be problematic during periods of high flow. In fact the original transfer equations developed for various flow regimes, include a single equation for high daily flows (i.e. between 2,130 cfs and 8,750 cfs). Not only is this a large spread to be represented by a single transfer equation, but a review of the mean daily flows in late June indicate that they actually exceeded the upper range of the transfer equation (i.e. 8,750 cfs) for 2 days. In addition, the mean daily flows exceeded 2,130 cfs for 9 days. This period is responsible for 99% of the transferred runoff volume for June and is the most pronounced example of monthly flow deviations between the transferred and measured data during periods of high flows/rainfall. Therefore, it was concluded that the transfer equations do not perform accurately during periods of high flows conditions. Since subsequent water budget and flow diversion analyses will be dependent upon the long term transfer data set, this anomaly bears further consideration.

On the one hand, periods of high flow may not have a significant impact on water withdrawal predictions since excess water will by-pass or overflow the storage systems and withdrawal capacity will be limited. However, an over-estimate of high flows will likely result in an overestimate of freshwater entering Dona Bay. Therefore, it was considered worthwhile to reconcile the transferred and measured data sets during high flow regimes. Because of rainfall variations between the 2 watersheds during 2003-2005, a direct correlation and development of a new transfer equation(s) for high flows was not expected to be practical. An alternative approach was selected that involved simulating one or more of the high flow storms in the Dona Bay watershed with the 2003 Myakka River rainfall. Comparison of the measured Myakka River flows to the simulated Dona Bay flows for the same rainfall event(s) could provide the basis for the development of a new transfer equation(s) for high flow regimes.

Table 3 presents the rainfall gages in the upper Myakka River where daily rainfall totals were reviewed to develop a representative rainfall volume and duration for the June 2003 storm event. Also included in **Table 3** are the rainfall totals at each gage site for the 3-day, 7-day, and 10-day durations. For the purposes of the transfer analysis, the 3-day and 7-day rainfall events were simulated. The 10-day event was not considered since the incremental increase in the rainfall volume at sites 409 and 490 between the 7-day and 10-day periods was not significant. In fact, sites 409 and 490 actually reported more rainfall in the 7-day period than was reported at sites 194 and 336 in the 10-day period. In addition, sites 409, 490 and 507 are located upstream of the Myakka River USGS stream flow station and sites 409 and 490 had relatively comparable rainfall distributions. Therefore, the total 3-day and 7-day rainfall totals at sites 409, 490 and 507 were averaged as 14.32 inches and 16.92 inches, respectively, for use in the simulation. By way of comparison, the maximum 3-day and 7-day rainfall totals measured in Cow Pen Slough during this period were only 7.76 inches and 11.22 inches, respectively.

Rainfall Site	3-day Rainfall	7-day Rainfall	10-day Rainfall
194	10.79 inches	13.78 inches	16.70 inches
336	10.91 inches	13.93 inches	16.73 inches
409	15.03 inches	17.57 inches	17.70 inches
490	14.82 inches	17.33 inches	17.69 inches
507	13.07 inches	15.86 inches	17.63 inches

Table 3 – Myakka River Rainfall in June 2003

The dimensionless rainfall distributions for the 3-day and 7-day storms were developed from NOAA hourly rainfall data in the upper Myakka River (Myakka River at Myakka City FL, MKAF1 and Myakka River at Myakka State Park near Myakka City, MKCF1 - http://precip.fsl.noaa.gov/hourly_precip.html) and are presented in **Table 4** and **Table 5,** respectively. The 3-day rainfall distribution was compiled in 4 hour increments from hour 20 on June 19, 2003 through hour 20 on June 22, 2003. The 7-day rainfall distribution spanned from hour 0 on June 16, 2003 through hour 24 on June 23, 2003.

Time (hrs)	Time (dimensionless)	Rainfall (dimensionless)
0	0.000000	0.000000
4	0.055556	0.028592
8	0.111111	0.030021
12	0.166667	0.030021
16	0.222222	0.034310
20	0.277778	0.072194
24	0.333333	0.150822
28	0.388889	0.335239
32	0.444444	0.461758
36	0.500000	0.468906
40	0.555556	0.468906
44	0.611111	0.497498
48	0.666667	0.583274
52	0.722222	0.850608
56	0.777778	0.861330
60	0.833333	0.861330
64	0.888889	0.861330
68	0.944444	0.923517
72	1.000000	1.000000

Table 4 – 3 Day Distribution

Time (hrs)	Time (dimensionless)	Rainfall (dimensionless)
0	0.000000	0.000000
8	0.047619	0.000000
16	0.095238	0.000000
24	0.142857	0.016718
32	0.190476	0.019195
40	0.238095	0.019195
48	0.285714	0.019195
56	0.333333	0.024768
64	0.380952	0.025387
72	0.428571	0.065635
80	0.476190	0.113313
88	0.523810	0.133746
96	0.571429	0.158514
104	0.619048	0.159752
112	0.666667	0.196285
120	0.714286	0.424149
128	0.761905	0.539938
136	0.809524	0.564706
144	0.857143	0.870588
152	0.904762	0.879876
160	0.952381	0.933746
168	1.000000	1.000000

Table 5 – 7 Day Distribution

Figure 5 presents the 7 day dimensionless rainfall distribution developed for the upper Myakka River. In addition, cumulative dimensionless daily rainfall totals from the Cow Pen Slough watershed are plotted on **Figure 5** for comparison. This comparison of dimensionless rainfall distributions during June 2003 indicates that the rainfall in the Cow Pen Slough watershed was generally more gradual and that the majority of the rainfall in the upper Myakka River watershed occurred in the last 3 days of the 7 day period.

Figure 6 presents the hydrographs from the 3-day and 7-day rainfall events corresponding to the upper Myakka River rainfall, simulated in the Cow Pen Slough watershed. As indicated in **Figure 6**, the 7-day rainfall duration consistently resulted in a larger magnitude hydrograph and was therefore used to develop average daily flow estimates for comparison and correlation to the Myakka River average daily flows.

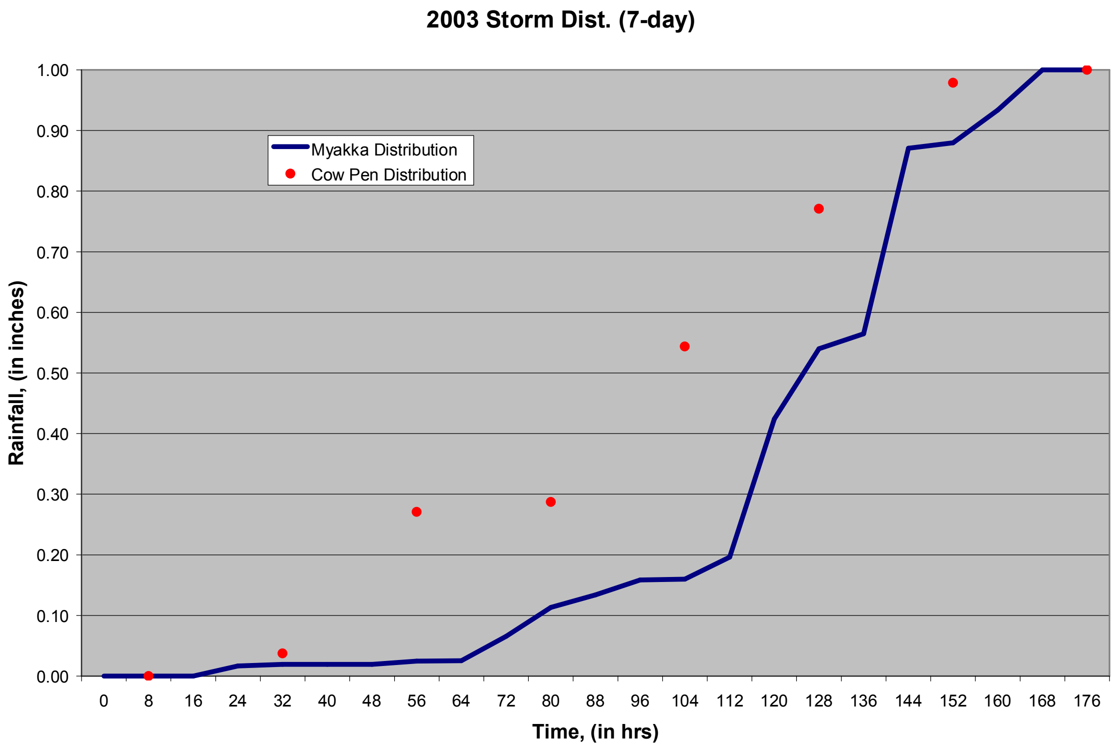

Figure 5 – Comparison of Dimensionless Rainfall Distributions

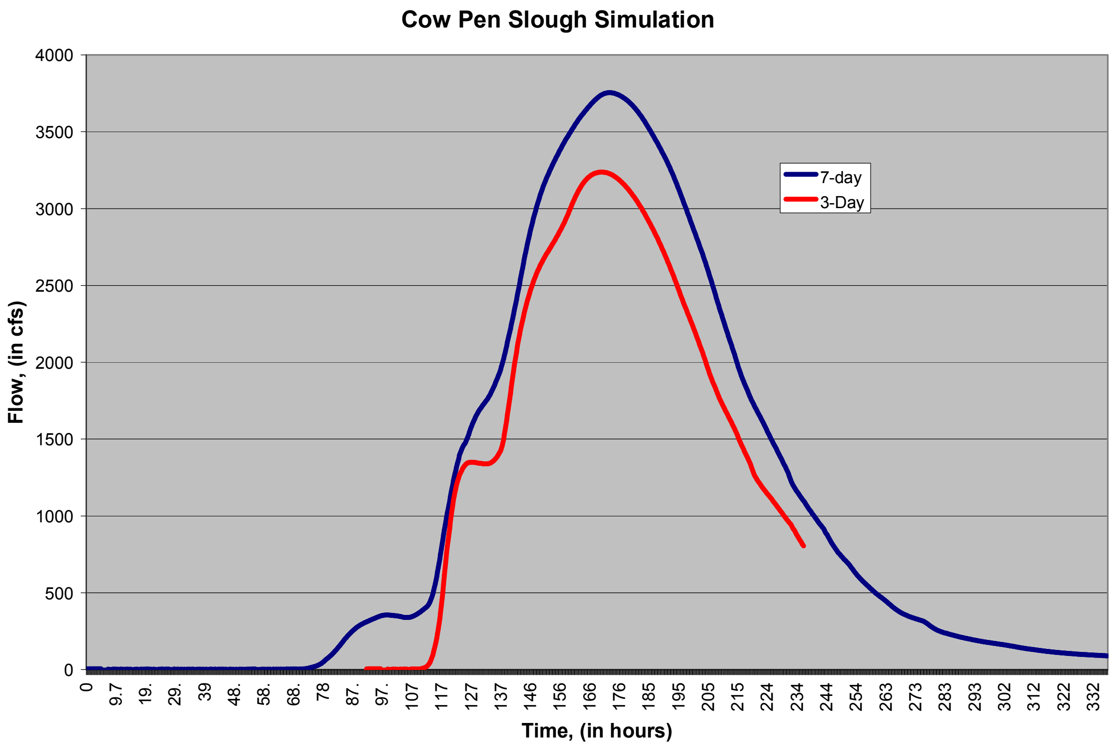

Figure 6 – Comparison of 3-day and 7-day Rainfall Durations

Table 6 compares the average daily flows generated from the 7-day duration storm event simulation for Cow Pen Slough to those measured at the Myakka River USGS gage site 02298830. **Figure 7** presents a graph of the average daily flows based upon the original transfer equations (in red) and those values presented in **Table 6** (in blue). A linear equation shown as a dashed line was fitted to the "blue" points and intersects the original transfer equations around a flow rate of 2000 cfs for the Myakka River.

Date	Myakka River (Average Daily Flow)	Cow Pen Slough (Average Daily Flow)
June 20, 2003	482 cfs	174 cfs
June 21, 2003	1120 cfs	483 cfs
June 22, 2003	3910 cfs	1841 cfs
June 23, 2003	8700 cfs	3335 cfs
June 24, 2003	10800 cfs	3598 cfs
June 25, 2003	9540 cfs	2590 cfs
June 26, 2003	7490 cfs	1391 cfs
June 27, 2003	5820 cfs	667 cfs
June 28, 2003	4530 cfs	301 cfs
June 29, 2003	3630 cfs	166 cfs
June 30, 2003	2850 cfs	105 cfs

Table 6 – Comparison of Average Daily Flows

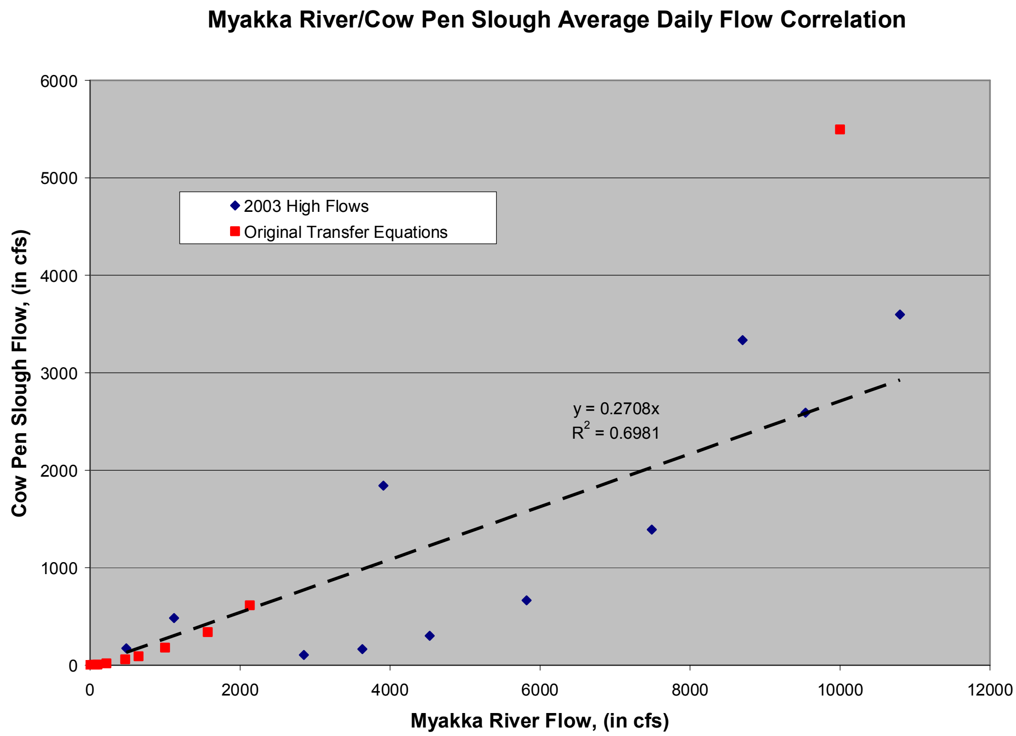

Figure 7 – Myakka River/Cow Pen Slough Flow Correlation

In terms of the validity of the remainder of the transferred data during the 2003 to 2005 period, deviations in runoff generally tracked deviations in rainfall. An attempt was made to compare transferred and measured data on a monthly basis. This information is summarized in **Table 7** through **Table 10**.

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
2003	0.11	1.37	2.16	3.52	3.61	22.73	4.76	12.50	8.08	0.79	0.98	5.09	65.70
2004	2.02	4.32	0.89	2.80	0.79	7.73	11.36	11.90	9.10	1.81	1.28	3.74	57.74
2005	2.51	3.80	4.42	3.61	3.47	11.93	9.30	4.09	2.16	6.32	3.68	0.57	55.85
Ave	**1.55**	**3.16**	**2.49**	**3.31**	**2.62**	**14.13**	**8.47**	**9.50**	**6.45**	**2.97**	**1.98**	**3.13**	**59.76**

Table 7 – Upper Myakka River (Transferred) Rainfall (in inches)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
2003	3.11	0.30	0.17	0.14	0.55	15.69	4.16	11.02	4.79	1.14	0.07	0.62	41.76
2004	0.31	0.39	0.80	0.04	0.03	0.06	1.11	9.92	8.12	2.91	0.15	0.09	23.92
2005	0.93	0.21	1.89	0.59	0.30	5.17	3.60	1.78	0.23	0.24	1.02	0.38	16.36
Ave	**1.45**	**0.30**	**0.96**	**0.25**	**0.29**	**6.97**	**2.96**	**7.57**	**4.38**	**1.43**	**0.41**	**0.36**	**27.35**

Table 8 – Cow Pen Slough Transferred Runoff (in inches)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
2003	0.15	0.91	1.46	2.96	4.58	16.54	5.56	15.93	11.23	1.43	0.72	5.21	66.67
2004	1.76	4.22	0.62	4.36	0.97	5.81	5.58	9.76	5.38	2.29	1.67	3.44	45.85
2005	2.16	3.81	4.37	2.74	3.78	15.44	7.45	3.36	3.28	7.91	3.11	0.72	58.10
Ave	**1.36**	**2.98**	**2.15**	**3.35**	**3.11**	**12.60**	**6.20**	**9.68**	**6.63**	**3.87**	**1.83**	**3.12**	**56.87**

Table 9 – Cow Pen Slough Measured Rainfall (in inches)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
2003	1.84	0.25	0.34	0.27	0.31	8.14	2.58	6.18	4.97	1.09	0.34	0.36	26.67
2004	0.17	1.05	0.46	0.09	0.06	0.12	2.18	7.75	6.25	0.91	0.09	0.27	19.39
2005	0.45	0.42	3.03	0.44	0.23	6.98	4.19	0.83	0.17	0.62	0.50	0.17	18.03
Ave	**0.82**	**0.57**	**1.28**	**0.27**	**0.20**	**5.08**	**2.98**	**4.92**	**3.80**	**0.87**	**0.31**	**0.27**	**21.36**

Table 10 – Cow Pen Slough Measured Runoff (in inches)

Figure 8 provides an updated graph comparing the transferred and measured runoff in Cow Pen Slough between 2003 and 2005 based upon the updated transfer method.

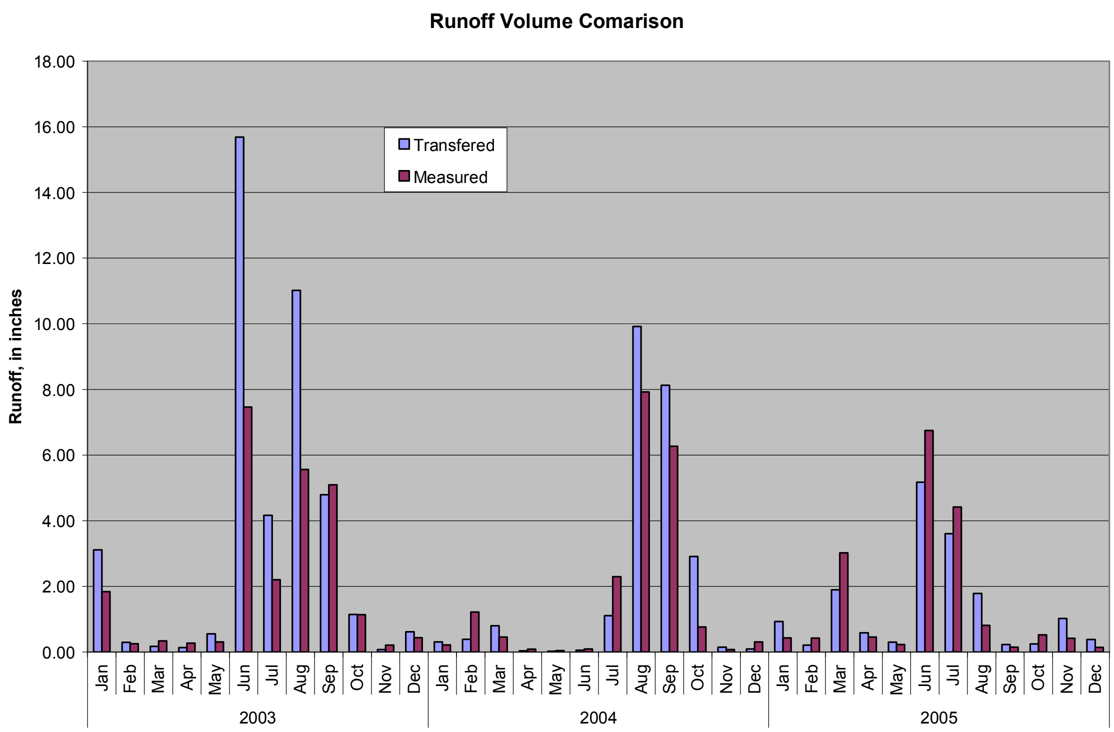

Figure 8 – Transferred and Measured Flows in Cow Pen Slough (2003- 2005) (based upon updated transfer method)

Next, the measured data was evaluated to determine if monthly runoff prediction was possible, given monthly rainfall. However with only 3 years of measured data points for each month, it was not possible to reach any definitive conclusions relative to the relationship between rainfall and runoff. While comparing transferred and measured data on an annual basis may be too broad of a time period, making such a comparison on a monthly basis may be too narrow of a window.

Recent work conducted by the Southwest Florida Water Management District on the Upper Myakka River identified three seasonal blocks that may be better suited for comparing the hydrologic trends and therefore the transferred and measured data. These three seasonal blocks periods are defined as:

Block 1 – April 20th through June 24th
Block 2 – October 28th through April 19th
Block 3 – June 25th through October 27th

A comparison of the measured and transferred seasonal block analyses are summarized in **Table 11** and **Table 12,** respectively. As indicated in the cells highlighted in red (corresponding to seasonal block periods with complete rainfall and runoff data records) in **Table 11** and **Table 12**, the measured and transferred runoff-to-rainfall ratios are very comparable. In fact, the transferred ratios are consistently slightly below the measured or actual ratios, so that the transferred data should provide a slightly conservative estimate of actual flows. This may be desirable since the transferred data is to be used to predict the reliability of available water.

Block 2			
2003	Rainfall (inches)	Runoff (inches)	%
Block 1	21.88	6.26	0.29
Block 3	14.05	17.18	1.22
Block 2	15.80	2.43	0.15
Total	**51.73**	**25.87**	**0.50**
2004	Rainfall (inches)	Runoff (inches)	%
Block 1	8.56	0.18	0.02
Block 3	25.30	17.07	0.67
Block 2	17.23	4.66	0.27
Total	**51.09**	**21.91**	**0.43**
2005	Rainfall (inches)	Runoff (inches)	%
Block 1	16.72	6.35	0.38
Block 3	23.48	6.64	0.28
Block 2			
Total			

Table 11 – Block Analysis Summary (Measured)

Block 2	16.58	7.13	0.43
2003	Rainfall (inches)	Runoff (inches)	%
Block 1	28.53	7.30	0.26
Block 3	30.58	30.07	0.98
Block 2	15.58	2.23	0.14
Total	**74.69**	**39.60**	**0.53**
2004	Rainfall (inches)	Runoff (inches)	%
Block 1	7.82	0.08	0.01
Block 3	35.91	21.99	0.61
Block 2	17.68	3.87	0.22
Total	**61.41**	**25.94**	**0.42**
2005	Rainfall (inches)	Runoff (inches)	%
Block 1	15.92	5.17	0.32
Block 3	22.58	6.06	0.27
Block 2			
Total			

Table 12 – Block Analysis Summary (Transferred)

2.4 Estimation of Excess Freshwater Volume to Dona Bay from the Cow Pen Canal

To estimate the magnitude of additional freshwater that has been added to the Dona Bay estuary by the Cow Pen canal diversion, the estimated natural water budget for the historical Dona Bay watershed contained in Technical Memorandum 4.1.2 was compared with the flows projected by the transfer equations. Although earlier drainage works began diverting flows from the Myakka River to Salt Creek and Dona Bay in the early 1900's, the primary canal diversion by the SCS was not completed until 1966. Therefore for sake of comparison, only the area diverted by this later project and this date were considered to illustrate the beginning of the introduction of additional flows. The estimated amount of historical and existing freshwater runoff from the Cow Pen Canal to Dona Bay are presented on **Figure 9**. The historical estimates are based upon the seasonal block analyses presented in TM 4.1.2. The additional runoff estimates are based upon the transferred data for Cow Pen Slough aggregated by month. Therefore, to approximate the historical time frames, the monthly Cow Pen Slough data was summed for May through June (Block 1), July through October (Block 3), and November through April (Block 2). To provide a more direct comparison, a cumulative volume comparison was also prepared and is provided in **Figure 10**.

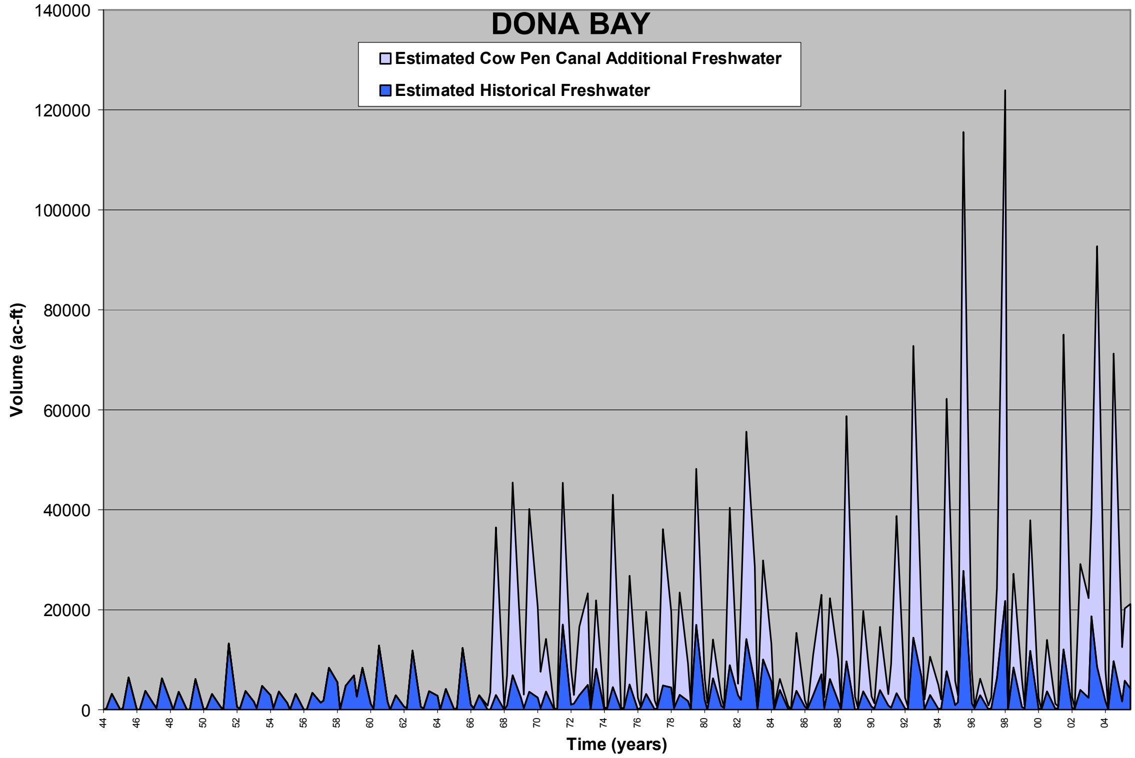

Figure 9 – Dona Bay, Estimated Historical and Excess Freshwater

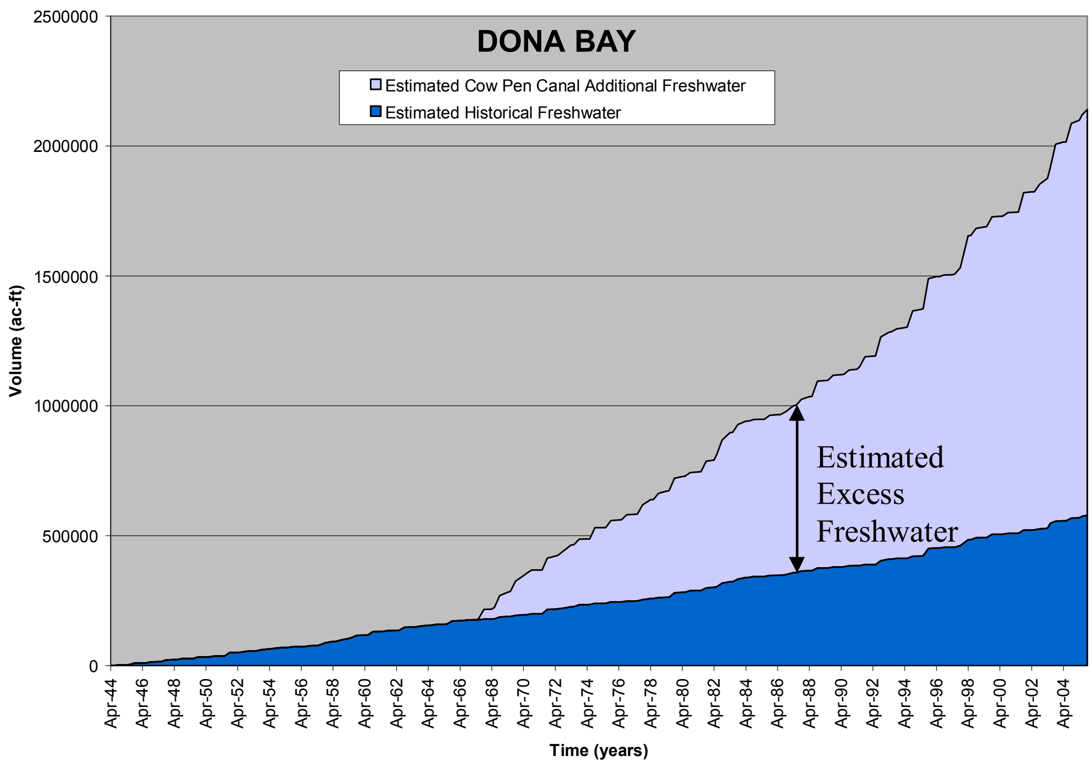

Figure 10 – Dona Bay, Estimated Historical and Excess Freshwater (Cumulative)

2.5 Alternative Water Supply Options for Dona Bay

Using the transferred data for Cow Pen Slough, an analysis was performed for the three (3) phases presented in Technical Memorandum 4.2.7. Generally, Phase 1 includes the utilization of the Venice Minerals site as a gravity fed surface water supply reservoir pursuant to Alternative 2 of Technical Memorandum 4.2.4.1. Phase 2 includes Venice Minerals plus the Albritton site as a gravity fed surface water supply reservoir pursuant to Alternative 3 of Technical Memorandum 4.2.4.2. Phase 3 adds an intake pumping facility to provide additional above ground storage in the Albritton site pursuant to Alternative 5 of Technical Memorandum 4.2.4.2.

Each phase was evaluated by creating monthly water budgets using the transferred runoff data base (70 years). Monthly rainfall was taken from the SWFWMD web site for the Myakka River. Monthly ET is based upon published potential evapotranspiration rates for southwest Florida by the University of Florida, Institute of Food and Agricultural Sciences (IFAS). Based upon the net monthly inflow (inputs minus outputs), the monthly reservoir storage was adjusted and excess water accounted for as outflow.

A range of yields were considered and corresponding reliabilities were determined. The reliability is defined as the estimated percentage of the time that the source water would be sufficient to meet the corresponding yields. It is calculated as the time that the supply is sufficient to meet the associated yield divided by the entire time period of the analysis. **Table 13** provides the yields and associated reliabilities for each phase.

Phase 1 Yield	Reliability	Phase 2 Cumulative Yield	Reliability	Phase 3 Cumulative Yield	Reliability
5 mgd	100 %	10 mgd	99.2 %	15 mgd	97.8 %
6 mgd	99.3 %	11 mgd	98.7 %	16 mgd	97.3 %
7 mgd	98.4 %	12 mgd	97.7 %	17 mgd	95.7 %

Table 13 – Phase Yields and Reliabilities

Based upon these evaluations, it is estimated that each of the 3 phases could yield an increment of 5 mgd, for a total of 15 mgd.

2.6 Dona Bay Water Supply Options on Reducing Excess Freshwater

To estimate the potential ability of each of phase of the Dona Bay Water Supply Option presented in Section 2.5 to reduce excess freshwater volumes to Dona Bay, the period of flow from 1966 to present was considered. **Figure 11** illustrates the cumulative reduction of excess freshwater in 5 mgd increments, corresponding to each potential phase. If all phases consisting of 15 mgd had been implemented, over 40% of the excess freshwater diverted by the Cow Pen canal could theoretically be reduced. Although what has occurred in the past cannot be undone, this analysis does indicate what could be expected in the future if the water supply option was implemented as part of the DBWMP.

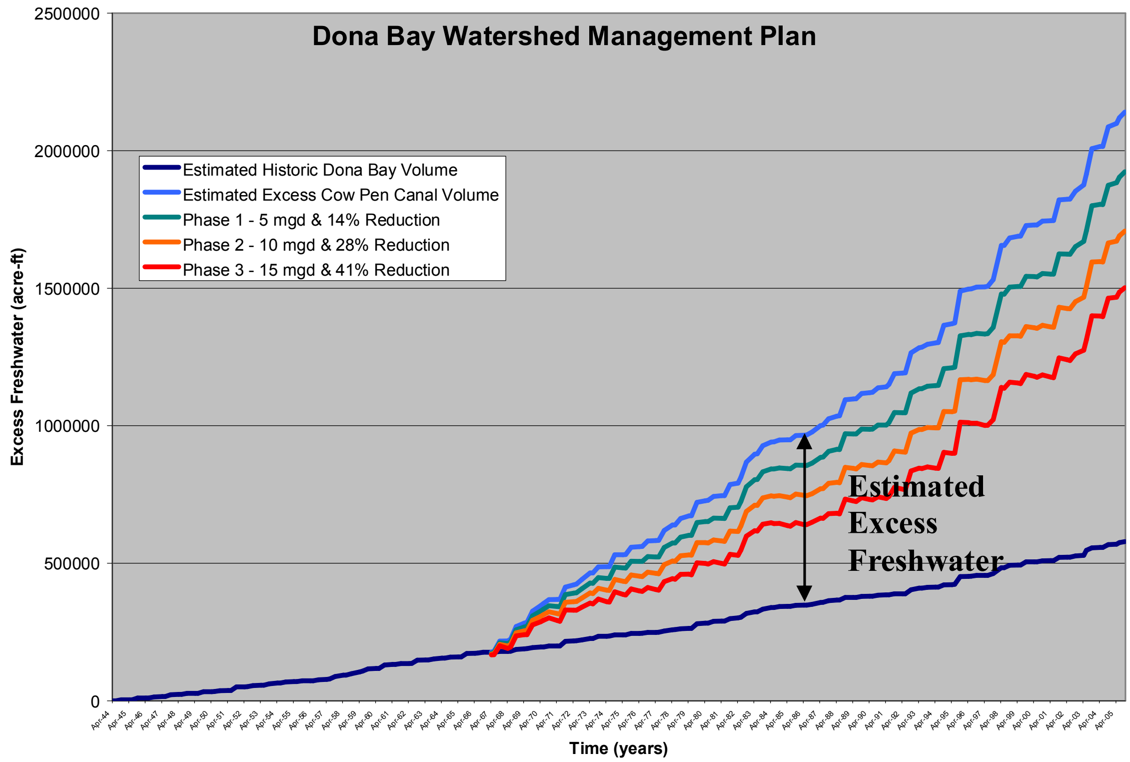

Figure 11 – Potential Benefit of Water Supply Options on Reducing Cumulative Excess Freshwater to Dona Bay

3.0 ROBERTS BAY AND BLACKBURN CANAL

3.1 Historical Perspective

The Blackburn Canal was constructed in the late 1950's and early 1960's by private property interests to relieve flooding on the Myakka River. Blackburn Canal intercepts the Myakka River between the present day Border Road and I-75 bridges. It extends approximately 6 miles from its confluence with the Myakka River to Roberts Bay and according to the original engineering report prepared by DeLew, Cather, and Brill, the Blackburn Canal was designed to convey approximately 800 cfs for the 50-year frequency flood event. This canal was excavated at or below sea level from the Myakka River, west to Curry Creek. Curry Creek, once a relatively short, natural coastal creek, was straightened and deepened to provide for an adequate hydraulic connection with the Blackburn Canal. **Figure 12** shows the east end of the Blackburn Canal at its confluence with the Myakka River.

The USGS has estimated flood stages at the confluence of the Myakka River and Blackburn Canal of 5.8, 7.9, 9.2, 10.4, 11.2, 11.9, 12.5, and 13.0 msl for the 2, 5, 10, 25, 50, 100, 200 and 500-year frequency flood, respectively. Since it is excavated at or below sea level for its entire length, this canal has the potential to accept a portion of all freshwater flows from the Myakka River.

Figure 12 – Blackburn Canal at Confluence with Myakka River

3.2 Development of Long-Term Flow Data for Blackburn Canal

In previous work performed by KHA in association with the Curry Creek Floodplain Study Update, it was estimated that approximately 7% of the freshwater flows by volume in the Myakka River were diverted to Curry Creek and Roberts Bay by the Blackburn Canal. With a contributing area of approximately 278.2 square miles and an average annual runoff of 15.26 inches, the estimated average annual volume of freshwater diverted to Roberts Bay from the Myakka River would be 15,851 acre-feet. However, as is the case with rainfall, this annual runoff volume may vary significantly from year to year.

The USGS began monitoring flows in Blackburn Canal at Jackson Road in 2004. This information was reviewed to verify the actual flow volumes diverted by Blackburn Canal. The measured flows in Blackburn Canal were plotted against the corresponding flows in the Myakka River and USGS gage 02298830 and are presented in **Figure 13**. The data presented in **Figure 13** plots the average daily flows measured by the USGS between March 6, 2004 and October 1, 2005. Based upon these measurements, the actual volume of runoff diverted from the Myakka River by Blackburn Canal during this period of record equated to 55,830.84 acre-feet.

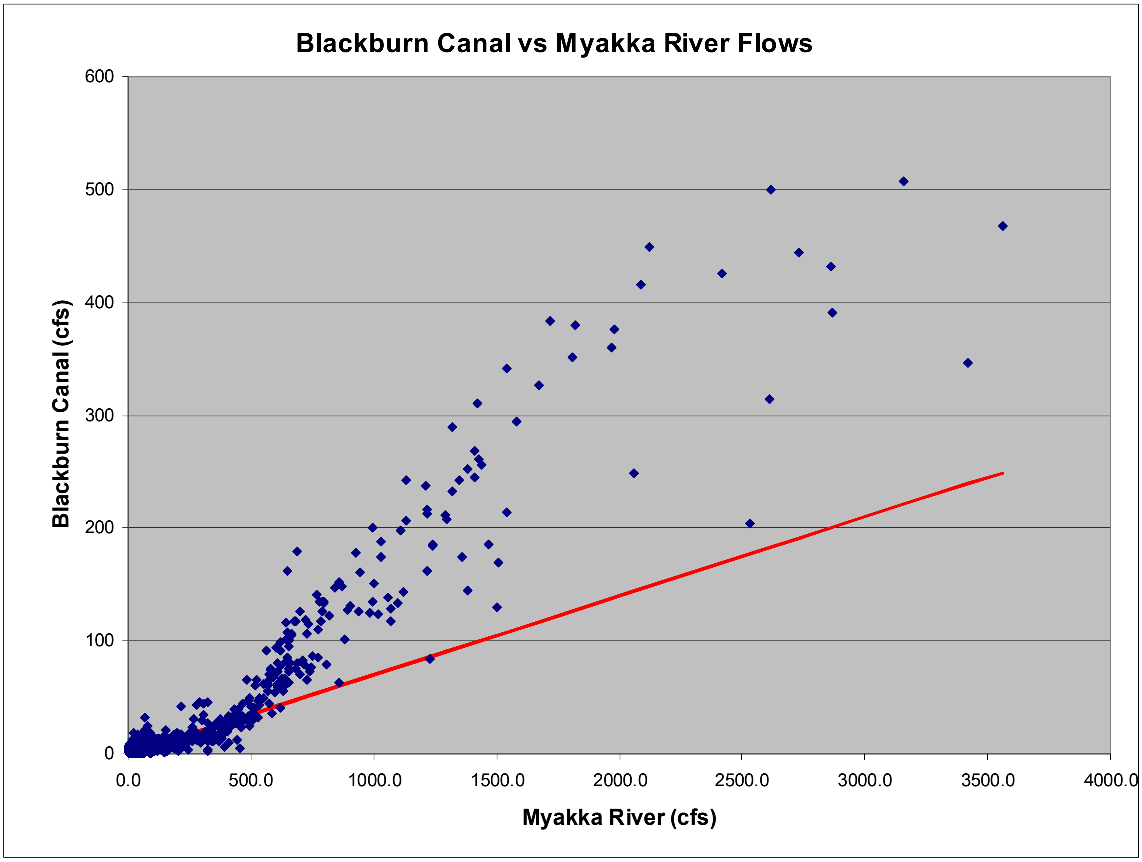

Figure 13 – Myakka River vs. Blackburn Canal (measured flows)

A line corresponding to 7% of the Myakka River flows is also presented on **Figure 13** and indicates that flows in Blackburn Canal correspond to approximately 7% of the flow in the Myakka River at USGS gage 02298830 up to approximately 500 cfs. However, when flows in the Myakka River exceed 500 cfs, flows in Blackburn Canal are consistently above the 7% line. For the period of actual flow measurements (March 6, 2004 through October 1, 2005), 7% of the total runoff volume from the Myakka River would have equated to 30,822.20 acre-feet or only 55% of the actual runoff volume.

Figure 14 presents the same Myakka River/Blackburn Canal flow data set fitted with a 4th order polynomial curve having an R "squared" of 0.93. However, during the period of record (March 6, 2004 through October 1, 2005) high flows in the Myakka River did not exceed 3560 cfs. In order to develop a flow relationship between the Myakka River and Blackburn Canal when flows in the Myakka River exceed 3500 cfs, the flood flows developed by the USGS in their 1977 report entitled *Magnitude and Frequency of Flooding on the Myakka River, Southwest Florida* were considered. This report provided the flood flow relationships between the Myakka River (at the State Park) and Blackburn Canal as presented in **Table 14**. Interestingly, it is noted that with the exception of the 2-year frequency event, flood flows in the Blackburn Canal are consistently 8% of those in the Myakka River. For the 2-year frequency event, the Blackburn Canal flood flow is only 4% of that in Myakka River.

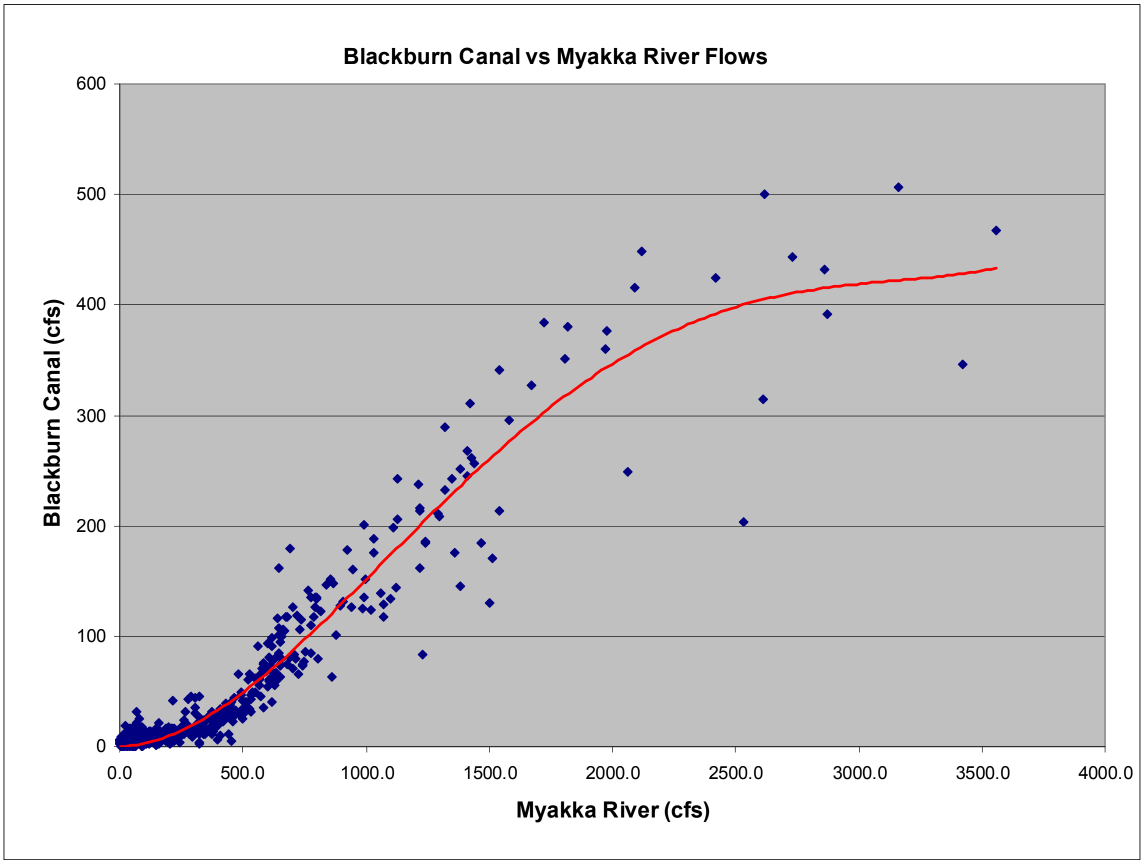

Figure 14 – Myakka River vs. Blackburn Canal (measured flows)

Site	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	25-yr (cfs)	50-yr (cfs)	100-yr (cfs)	200-yr (cfs)	500-yr (cfs)
Myakka	2070	3480	4640	6340	7750	9350	11200	13500
Blackburn	86	270	361	494	609	735	882	1085

Table 14 – Myakka River & Blackburn Canal Flood Flow Relationship (based upon USGS, 1977)

As previously indicated, the USGS report provides a relationship between flood discharges. **Table 15** provides a comparison between these flood discharges and the measured average daily discharges where an overlap between the data sets exist. This comparison indicates that where an overlap exists, the flood discharges are consistently less than the measured average daily discharges. However, lacking actual flow measurements in excess of 3560 cfs, the flood flow relationship appears reasonable, with the possible exception of the 2-year flood flow relationship.

Myakka River - Average Daily Flow	Blackburn Canal - Average Daily Flow
2060 cfs	249 cfs
2070 cfs	**86 cfs**
2090 cfs	416 cfs
2120 cfs	449 cfs
2420 cfs	425 cfs
2530 cfs	204 cfs
2610 cfs	314 cfs
2620 cfs	500 cfs
2730 cfs	444 cfs
2860 cfs	432 cfs
2870 cfs	391 cfs
3160 cfs	507 cfs
3420 cfs	346 cfs
3480 cfs	**270 cfs**
3560 cfs	468 cfs
4640 cfs	**361 cfs**

Table 15 – Comparison of Average Daily and Flood Discharges

Figure 15 presents a graph the flow relationship using both the average daily and instantaneous flows for the Myakka River and the Blackburn Canal (with the exception of the 2-year flood flow) when flows in the Myakka River exceed 1000 cfs. A 4^{th} order polynomial equation with and R "squared" of 0.86 was also fitted to this high flow data set. **Table 16** presents the flow regime equations developed to define the relationship between flows in the Myakka River and Blackburn Canal. Since 1400 cfs resulted in comparable flows in Blackburn Canal using both equations, it was used to form a smooth transition between these 2 equations. Application of these flow regime equations to the measured data set (March 6, 2004 through October 1, 2005) yielded a total runoff volume of 52,660.30 acre-feet, or 94% of that actual runoff volume. These flow regime equations were applied to the entire USGS average daily flow data set for the Myakka River (September 1936 through December 2005). However, it should be noted that Blackburn Canal was not constructed until the late 1950's, or early 1960's.

Flow Regime	Regression Equation	R "squared"
$0 < y < 1400$ cfs	$y = 0.00000000001127x^4 – 0.000000095x^3 + 0.000229x^2 + 0.0063x$	0.93
$y > 1400$ cfs	$y = -0.00000000001201x^4 + 0.000000004x^3 – 0.000043x^2 + 0.2245x$	0.86

Table 16 – Myakka River/Blackburn Canal Flow Relationship Equations

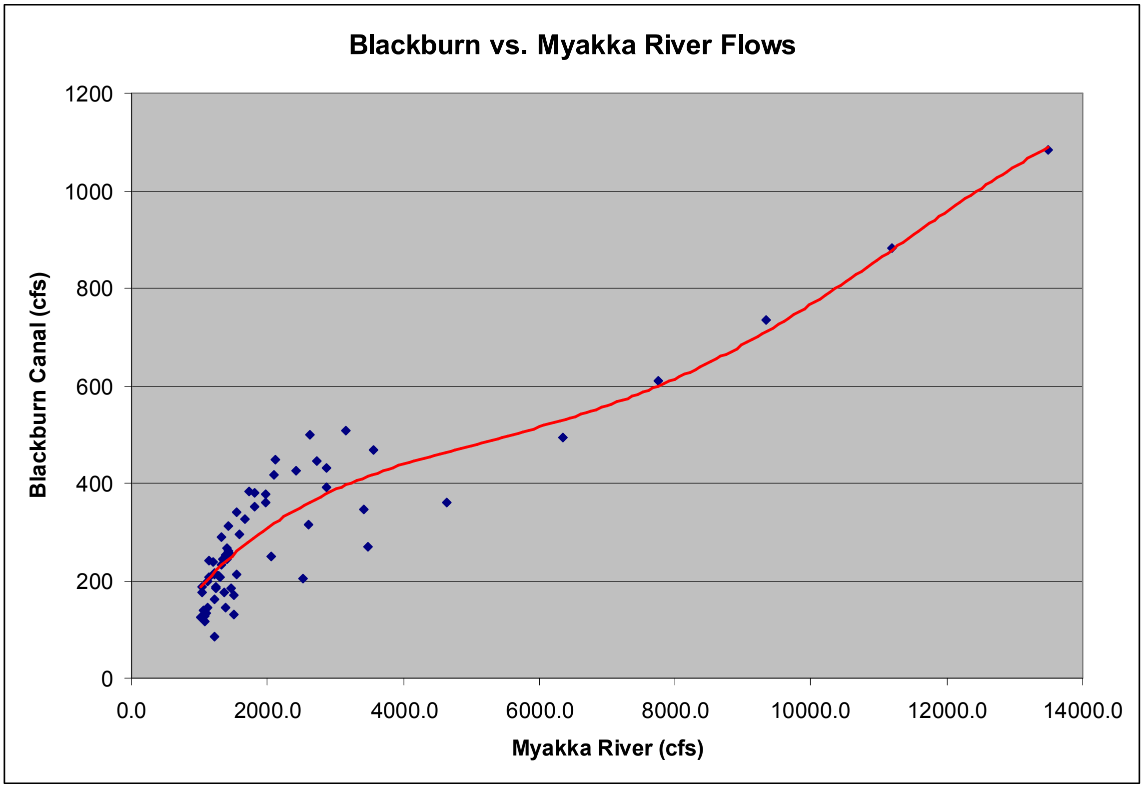

Figure 15 – Myakka River vs. Blackburn Canal (measured flows w/high flows)

3.3 Estimation of Excess Freshwater Volume to Roberts Bay from Blackburn Canal

To estimate the magnitude of additional freshwater that has been added to the Roberts estuary by the Blackburn Canal diversion, the estimated natural water budget for the historical Roberts Bay watershed contained in Technical Memorandum 4.1.2 was compared with the with the flows projected by the equations contained in Table 16. Based upon the original engineering report, it was assumed that the Blackburn Canal was completed by 1960. Therefore for sake of comparison, this date was used to illustrate the beginning of the introduction of additional flows. The amount of estimated historical and existing freshwater runoff to Roberts Bay is presented on **Figure 16**. The historical estimates are based upon the seasonal block analyses presented in TM 4.1.2. The additional runoff estimates are based upon the monthly volume estimates developed for Blackburn Canal. Therefore, to approximate the historical time frames, the monthly Blackburn Canal data was summed for May through June (Block 1), July through October (Block 3), and November through April (Block 2). To provide a more direct comparison, a cumulative volume comparison was also prepared and is provided in **Figure 17**.

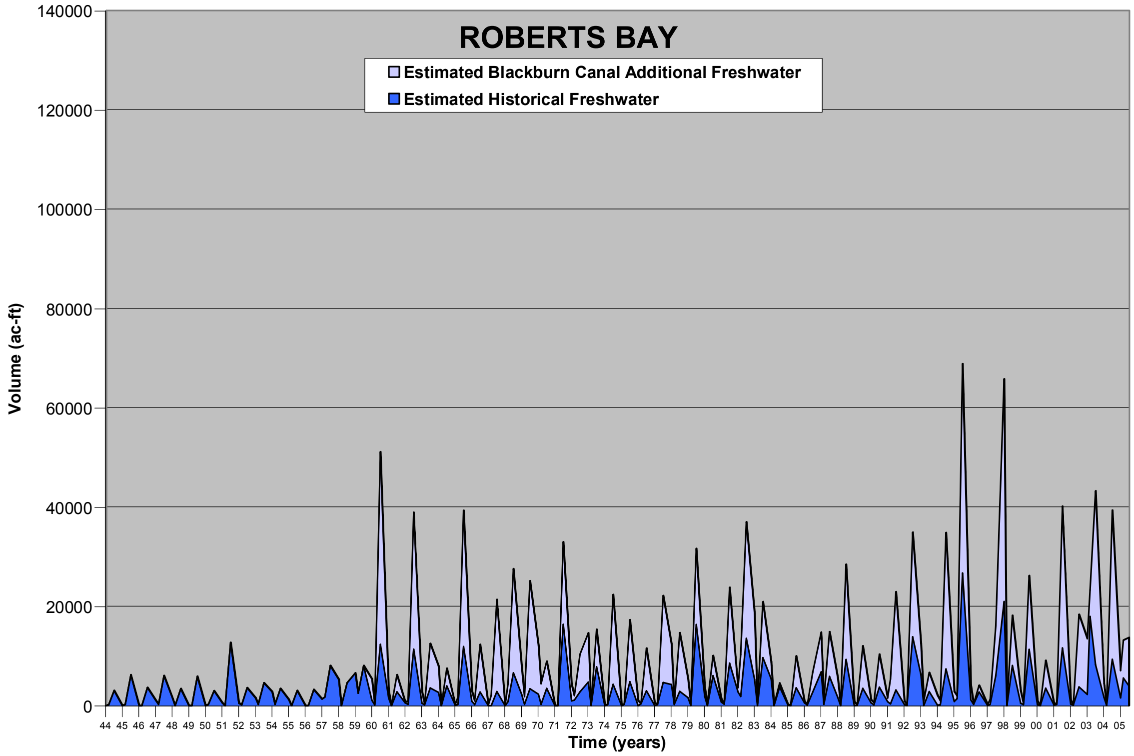

Figure 16 – Roberts Bay, Estimated Historical and Excess Freshwater

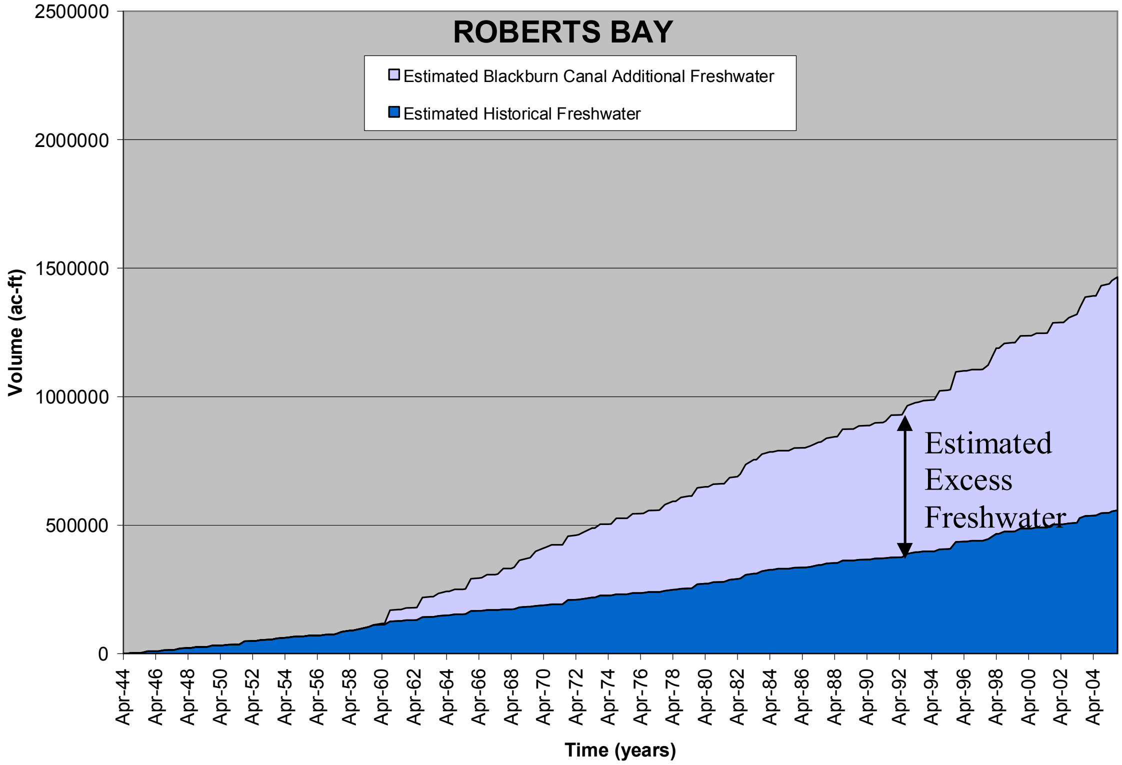

Figure 17 – Roberts Bay, Cumulative Historical and Excess Freshwater

3.4 Roberts Bay Low Head Weir Impact on Reducing Excess Freshwater

To estimate the potential impact of a low head weir in Blackburn Canal on reducing excess freshwater flows to Roberts Bay, it was first necessary to establish a stage-discharge relationship for the Blackburn Canal. Stage-discharge information collected by the USGS between March 6, 2004 and August 29, 2005 was analyzed. **Figure 18** provides a plot of the reported stage-discharge information for the Blackburn Canal.

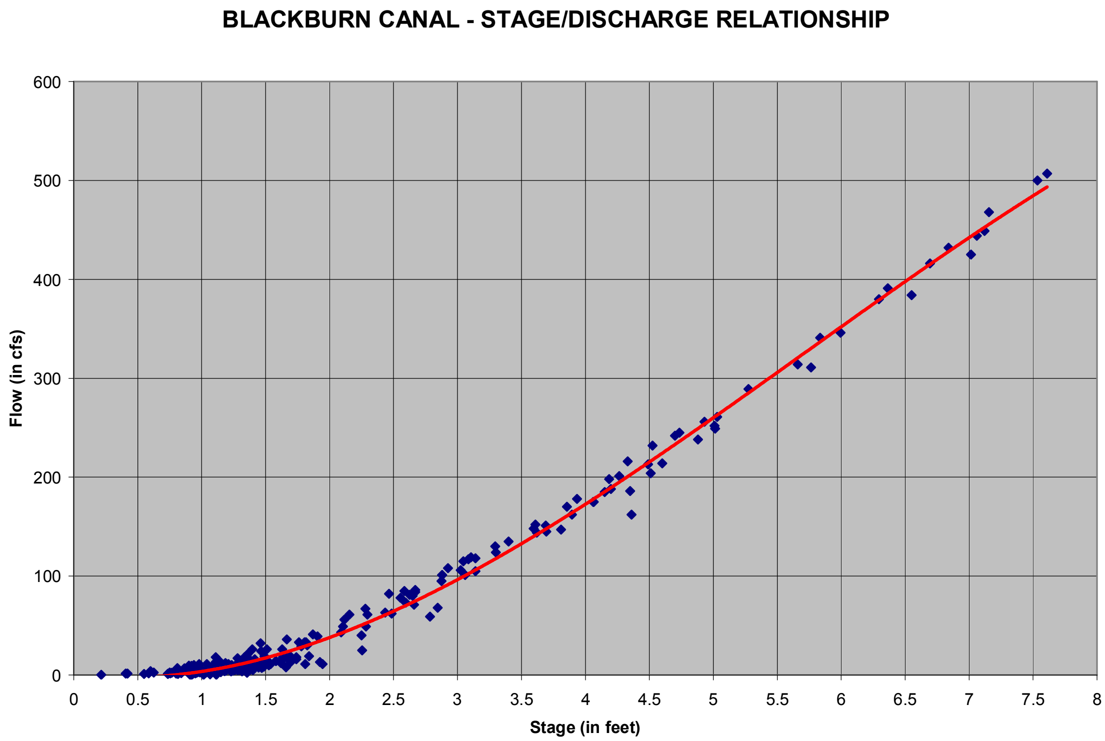

Figure 18 – Blackburn Canal Stage/Discharge Relationship

A third order polynomial equation with an R "squared" of 0.99 was fitted to the stage-discharge data and is provided in **Table 17**.

Blackburn Canal Stage-Discharge Regression Equation	R "squared"
$y = -1.0885x^3 + 18.644x^2 - 14.005x$	0.99

Table 17 – Blackburn Canal Stage/Discharge Equation

The potential impact on reduction of cumulative excess freshwater flows to Roberts Bay from Blackburn Canal was evaluated using three (3) low head weir elevations: 2.0, 2.5, and 3.0 ngvd. Based upon the stage-discharge regression equation, the corresponding discharges for weir inverts of 2.0, 2.5, and 3.0 are approximately 38 cfs, 64.5 cfs, and 96 cfs, respectively. The long-term Blackburn Canal discharge data base was then evaluated relative to the potential reduction in discharges to Roberts Bay for each low head weir option. Using the cumulative flow analyses presented in Figure 17, **Figure 19** illustrates the theoretical effectiveness of each low head weir in reducing excess freshwater flows to Roberts Bay if they had been installed when the Blackburn Canal was constructed.

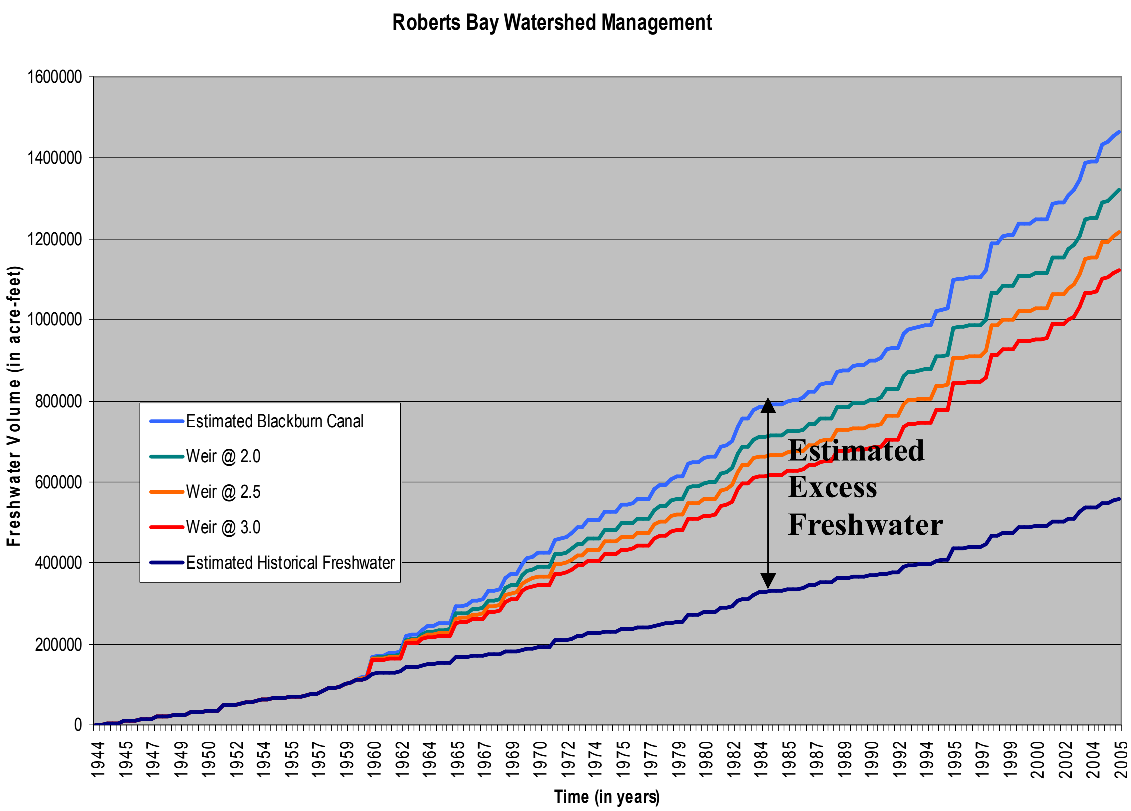

Figure 19 – Potential Cumulative Excess Freshwater Reduction to Roberts Bay

Although what has occurred in the past cannot be undone, this analysis does indicate what could be expected in the future if a low head weir was installed in Blackburn Canal east of Jackson Road. Of course, assurance would need to be provided that a low-head weir would not adversely increase flood stages in the Myakka River.

TM 4.2.3 – WATER QUANTITY | FLOW DIVERSION APPROACH

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBS&J to present a summary of efforts to develop a statistically robust and scientifically valid flow diversion and system reliability analysis. This effort is consistent with Task 4.2.3 of the DBWMP contract.

2.0 INTRODUCTION AND DATA SOURCES

The objective of the flow diversion analysis was twofold: (1) to estimate the sustainable amount of water that would be available for water supply, and (2) to assess the characteristics of the Cow Pen Canal flows in the area of the upper water level control structure, as well as at those occurring at the lower water level control structure that discharges to Shakett Creek and Dona Bay.

The two factors that determine flow availability are total water demand and system reliability. Total water demand was defined as the maximum daily average amount of water that could be withdrawn from the reservoir for a given reliability. Reliability is the percent of time that the system would be able to deliver a given water demand.

The analysis was conducted to assess the 3 project phases described in TM 4.2.7 – Development of Phasing Plan. The geometric characteristics of the reservoir (area and volume) associated with each project phase are listed below:

Project Phase	Reservoir Area (acres)	Reservoir Volume (acre-ft)
1	388	5,634
2	978	11,488
3	978	17,342

Table 1 – Reservoir Characteristics

In addition to reservoir geometry, the input data used in the analysis included flow, precipitation, and potential evapotranspiration. Sources are described below.

- Flow data was derived from Myakka River to Cow Pen Slough transfer equation analysis, as discussed in Technical Memorandum 4.2.2. Transfer data were available from 1936 to the present.
- Daily precipitation data was available from USGS Station 349. This station is located approximately 2.2 miles from the reservoir site and includes the longest set of continuous daily rainfall records in the area from 1956 to 2004.
- Potential evaporatranspiration (PET) data based upon "Potential Evapotranspirtion Probabilities and Distributions in Florida" published by the University of Florida, Institute of Food and Agricultural Sciences.

3.0 FLOW DIVERSION AND SYSTEM RELIABILITY ANALYSIS

The flow diversion and reliability analysis was conducted using a spreadsheet model that performed the calculations based on the following equation:

$S_F = S_I + Q + P – E – D - E_x$

Where:
$S_F =$ Final storage volume
$S_I =$ Initial storage volume
Q = Runoff
P = Direct precipitation on the reservoir area
E = Evaporation losses
D = Water demand
$E_x =$ Reservoir excess (overflow continuing downstream)

The model was setup to assess system performance using a 49-year period of flow, precipitation and evaporation records (January 1, 1956 and December 31, 2004). That period was selected because it is the longest available for daily input of all variables. System reliability was calculated as the ratio (in percent) of days when the water demand would be met during the period of analysis to the total number of days in that simulation period.

4.0 SIMULATION MODEL RESULTS

A number of scenarios were simulated assuming flow diversions of 10, 30, 50 and 100 percent of the total flow into the reservoir. The model simulates the system performance on a daily basis over the simulation period (January 1, 1956 to December 31, 2004). Results are shown in Figures 1 through 3. The water demands associated with the alternative flow diversion amount for 90 and 95-percent system reliabilities are shown below. Reliability is calculated as the percent of the time in days that the system is capable of meeting the water demand. The 90 and 95-percent reliabilities are generally considered acceptable range of minimum values for appropriate operation of the water withdrawal system. An 85 percent flow diversion scenario was also considered for the Phase 3 analysis as an additional piece of information because the 15^{th} percentile flow is often used to represent minimum flow conditions for minimum flows and levels analysis.

Flow Diversion	Water Demand (mgd) for 90-Percent Reliability			Water Demand (mgd) for 95-Percent Reliability		
(%)	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
10	2.5	2.8	2.9	2.2	2.2	2.3
30	5.6	7.1	7.6	4.7	6.2	6.7
50	7.5	10.1	11.7	6.3	8.6	10.3
85	9.7	13.6	16.5	8.0	11.5	14.2
100	10.4	15.0	18.2	8.6	12.6	15.4

Table 2 – Flow Diversion / Reliability

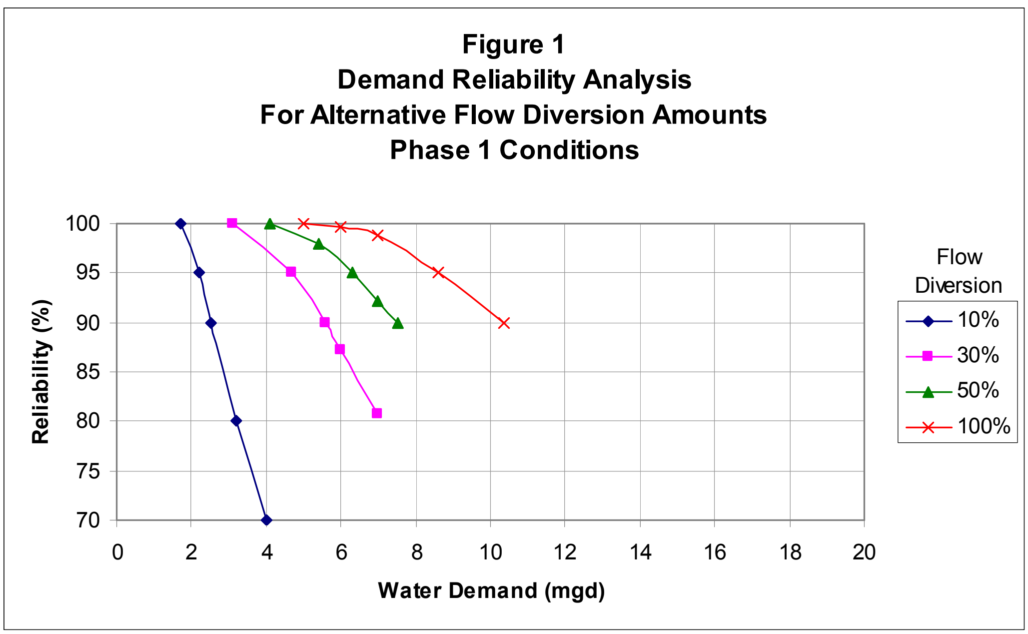

Figure 1 – Phase 1, Demand vs. Reliability

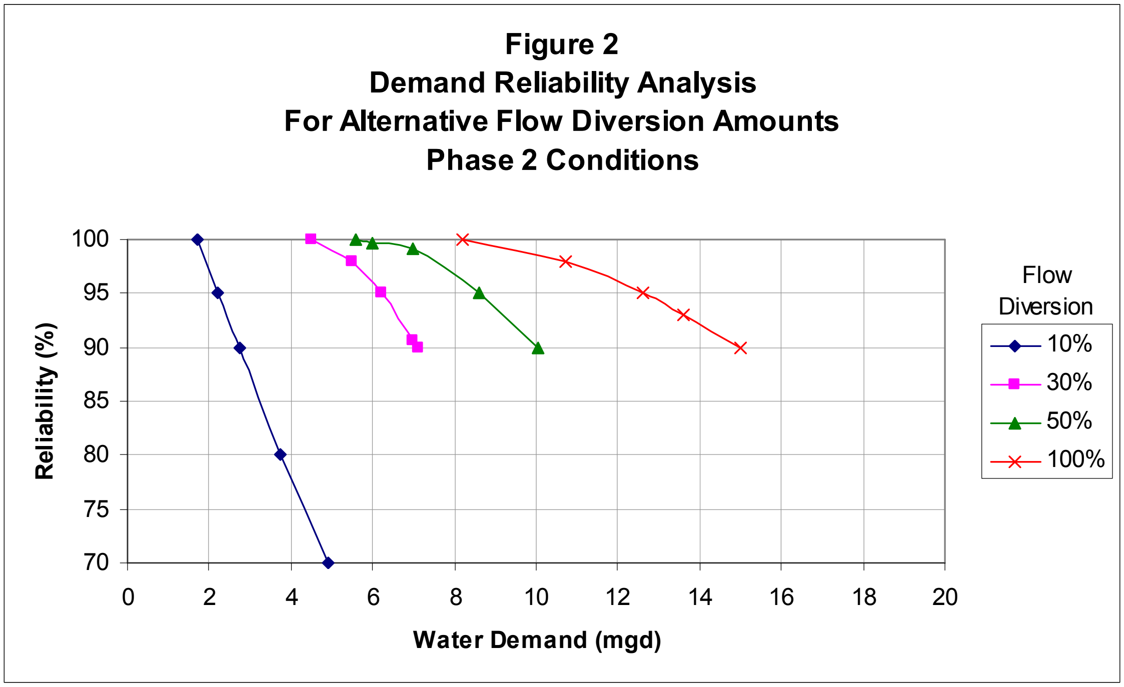

Figure 2 – Phase 2, Demand vs. Reliability

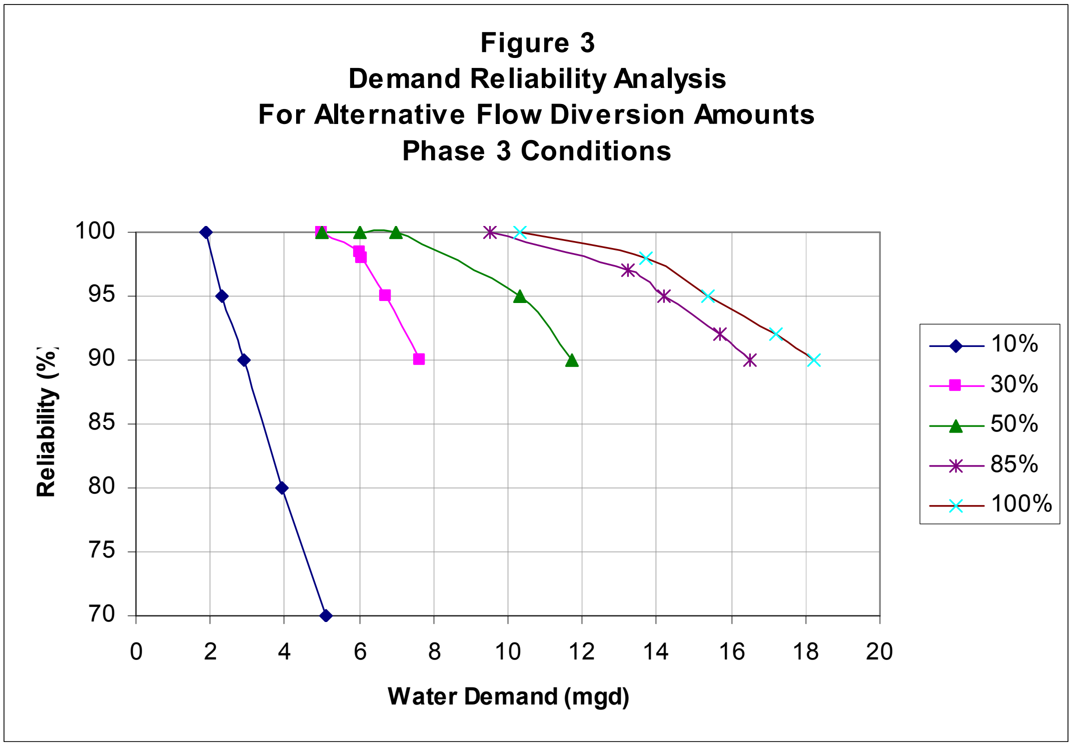

Figure 3 – Phase 3, Demand vs. Reliability

5.0 FLOW CHARACTERISTICS DOWNSTREAM OF THE PROPOSED RESERVOIR

Excess flows that either overflow or bypass the reservoir would continue downstream to the lower water level control structure on the Cow Pen Canal. An assessment of the quantity of these flows is necessary to help assess potential benefits in terms of flow reductions to Dona Bay. These flow quantities were determined at two locations in the watershed, downstream of the reservoir and between the upper and lower water level control structures. This quantity represents the reduced flows from the Cow Pen Canal discharging to Shakett Creek and Dona Bay resulting from the various watershed/hydrologic restoration plans corresponding to Phases 1 through 3.

Two water withdrawal scenarios were considered for this assessment, both associated with Phase 3 of the project plan.

1. A 100-percent flow diversion at a water demand of 15 mgd and 95% reliability
2. A 100-percent flow diversion at a water demand of 18 mgd and 90% reliability

Figure 4 shows the flow characteristics associated with both existing conditions and the two scenarios in the area immediately downstream from the proposed reservoir. As shown, both scenarios result in capturing all the available flow (88.5 percentile for Scenario 1 and 90.5 percentile for Scenario 2). Both proposed scenarios are believed to better represent historical characteristics of the watershed in terms of freshwater volumes to Dona Bay.

Figure 5 shows the estimated flow characteristics at the lower water level control structure where the Cow Pen Canal discharges to Shakett Creek and Dona Bay. The location considered in Figure 5 reflects the addition discharges from the watershed located between the upper and lower water level control structures. Due to the lack of measured data, flows from this portion of the watershed were estimated by a simple ratio of drainage areas. As the area downstream of the reservoir is approximately 20 percent of the area upstream of the reservoir, the total daily flow at the Dona Bay discharge for existing conditions was calculated as 120 percent of the flow indicated by the Myakka River/Cow Pen Slough transfer equations. For the two water withdrawal scenarios, the flow was calculated as 20 percent of the transfer equations flow plus the reservoir excess determined from the spreadsheet model. Both scenarios reflect an average reduction of fresh water discharges of about 77 percent and a median reduction of 83 percent. Those reductions are believed to be consistent with restoration goals.

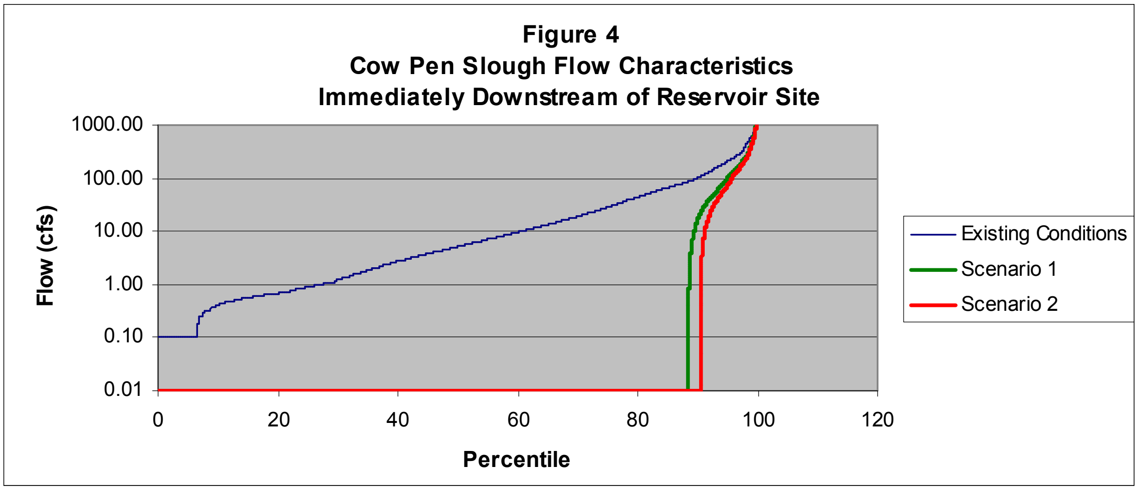

Figure 4 – Upstream Flow Percentiles

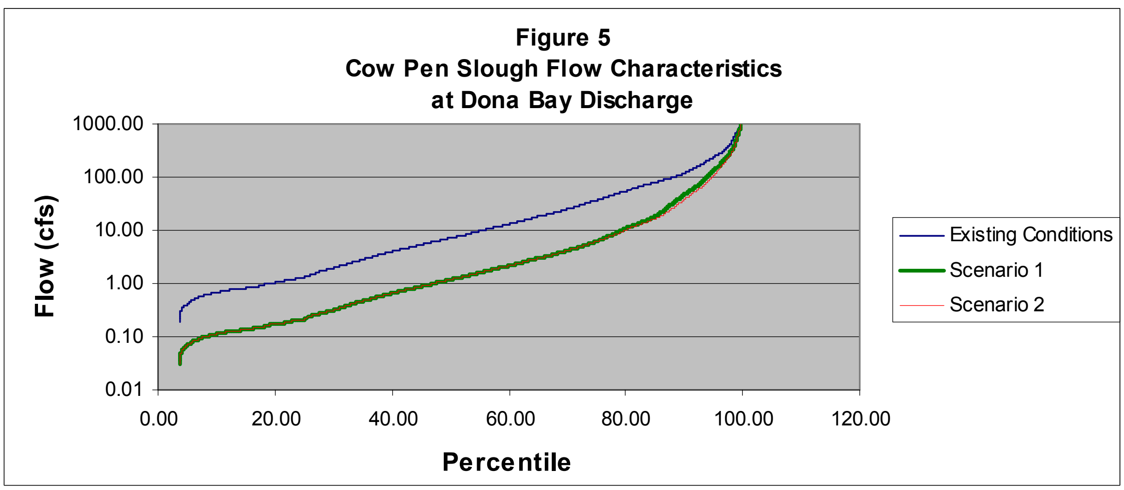

Figure 5 – Downstream Flow Percentiles

TM 4.2.4.1 – EVALUATION OF SURFACE STORAGE (Venice Minerals Site)

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and SWFWMD are currently completing the necessary, pre-requisite data collection and analysis as well as comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marin Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the Southwest Florida Water Management District (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by KHA to provide a preliminary storage evaluation for the Venice Minerals site, consistent with Task 4.2.4 of the DBWMP contract. In addition a comparison of yields and opinions of probable capital costs are provided for three conceptual surface storage configurations.

2.0 DESCRIPTION OF VENICE MINERALS SITE

In 2004, Sarasota County purchased approximately 548 acres from Venice Minerals and Mining LLC (VM). In turn, Sarasota County leased approximately 402 acres back to VM to complete the on-going mining of sand, shell, and rock. The on-going mining operation is expected to be complete in 2 to 3 years.

The remaining un-mined 146 acres consists of natural and man-made wetlands as well as pine flatwoods. This area was acquired by Sarasota County's Environmentally Sensitive Lands Protection Program (ESLPP).

For the purpose of this analysis, the Venice Minerals site was evaluated in conjunction with the Albritton facility. However, it is anticipated that it may even be used in conjunction with other storage components in the Dona Bay watershed or within the Peace River Manasota Regional Water Supply Authority's (Authority) integrated regional water supply system. Such an integrated system would likely provide greater reliability than that available as a stand alone system.

3.0 ESTIMATE OF POTENTIAL YIELD

3.1 Alternatives Evaluated

Preliminary evaluations of three (3) surface water storage alternatives were performed for the Venice Minerals site. For the purposes of this analysis, it was assumed that the reservoir would be used in conjunction with the Albritton Site and filled by gravity to an elevation of approximately 18 NGVD with a total operating range of approximately 15 feet.

Each of the alternatives would have the following common features:

- A berm constructed to approximately elevation 28.0 NGVD around the entire reservoir.
- An emergency overflow to the historical Cow Pen Slough located in the northeast corner of the reservoir
- An additional setback from the east and south property lines to accommodate the existing recharge/drainage ditch.
- A freeboard of 10 feet above the maximum operating range.

Alternative 1 - Alternative 1 considered using the entire 548 acre area footprint (mining operation and the un-mined area) for a water storage reservoir (see **Figure 1**). This alternative assumed a top of berm elevation of 28 NGVD and is intended to provide an operating range of approximately 15 feet with a total surface area of approximately 490 acres.

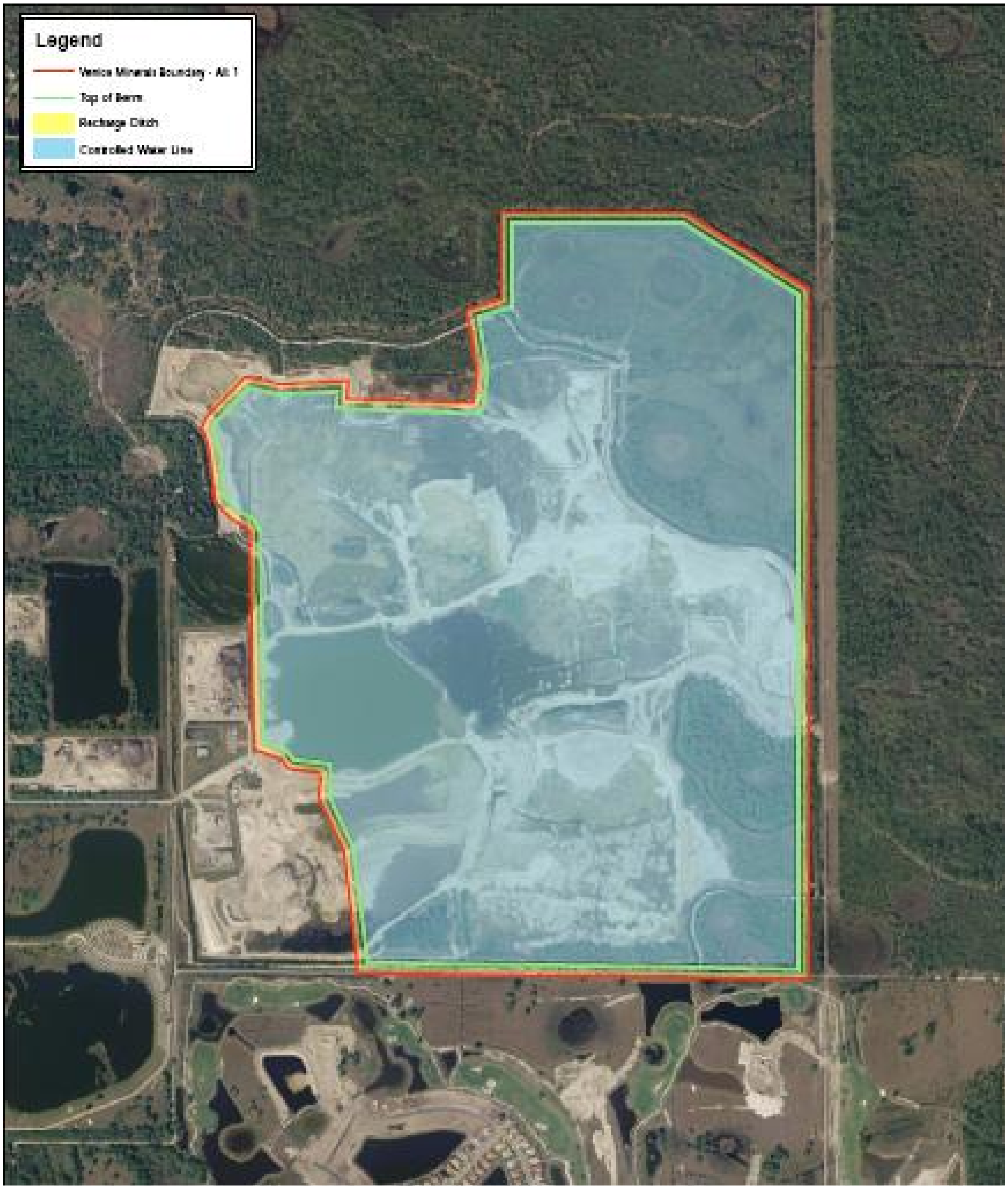

Figure 1 – Venice Minerals, Alternative 1

Alternative 2 - Alternative 2 considered using the existing 402 acre mining area as well as approximately 34 of the 146 acres of un-mined area located along the southeast boundary of the mining operation (see **Figure 2**). This alternative assumed a top of berm elevation of 28 NGVD and is intended to provide an operating range of approximately 15 feet with a total surface area of approximately 388 acres.

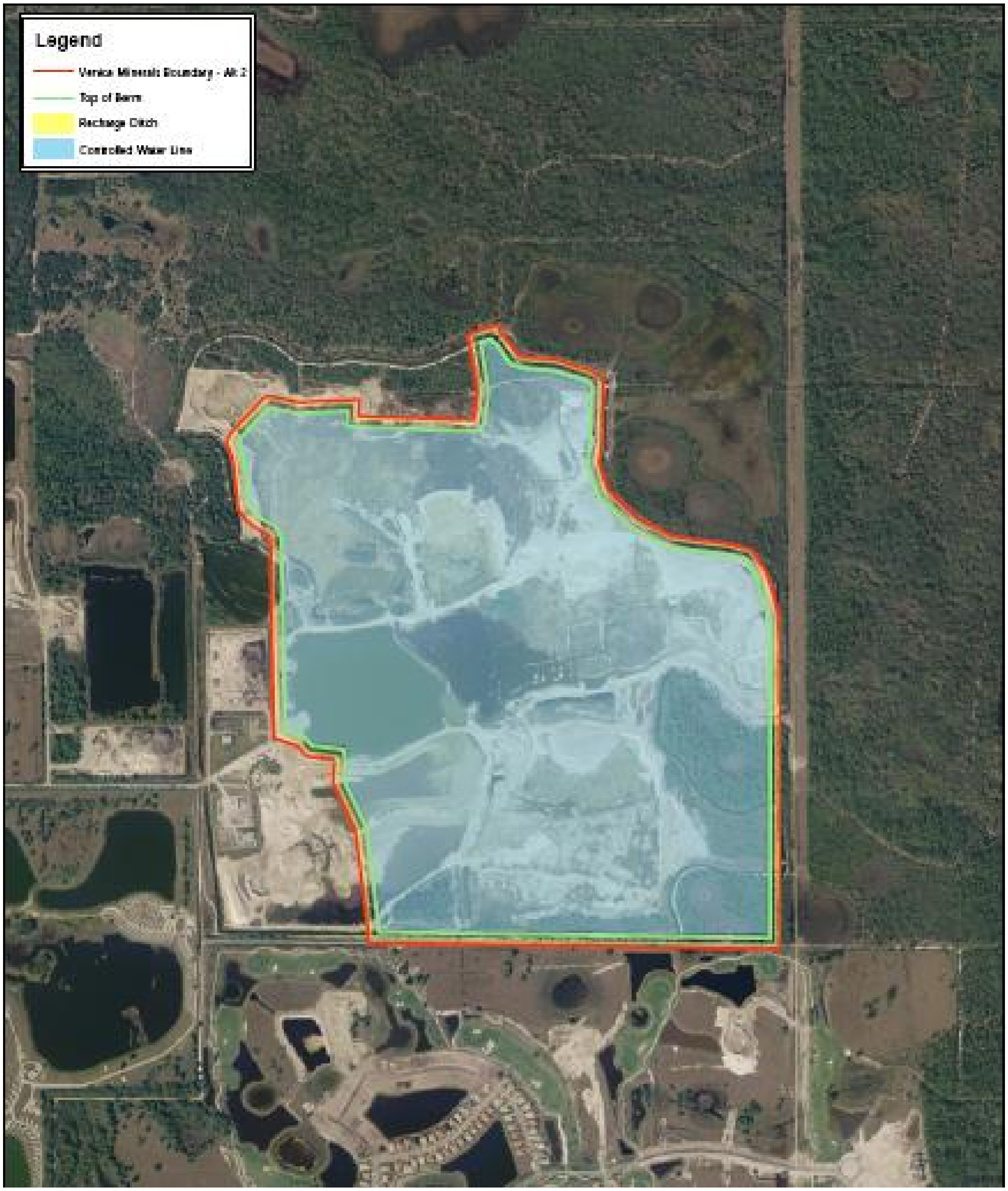

Figure 2 – Venice Minerals, Alternative 2

<u>Alternative 3</u> – Alternative 3 considered using only the 402 acre existing mining operation area (see **Figure 3**). This alternative assumed a top of berm elevation of 28

NGVD and is intended to provide an operating range of approximately 15 feet with a total surface area of approximately 345 acres.

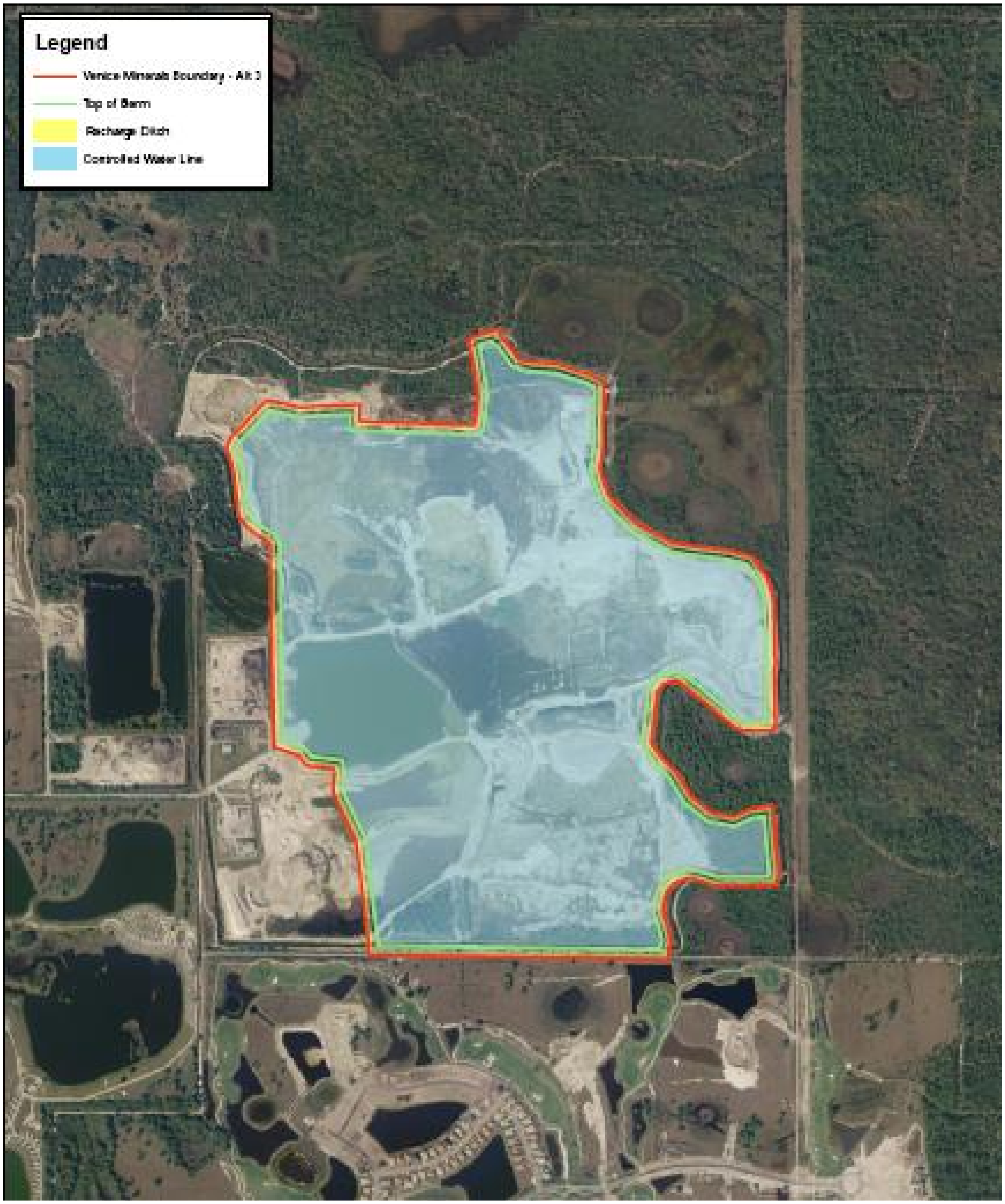

Figure 3 – Venice Minerals, Alternative 3

3.2 Preliminary Berm Sections

The preliminary berm section provides for retainage of the existing perimeter recharge ditch along the west and south property boundary (although it may need to be relocated or reconfigured). **Figure 4** provides a typical section assumed for the perimeter berms and recharge/drainage ditch, as applicable. The berm section was incorporated into digital topographic maps based upon 2004 LiDAR information provided by Sarasota County. It should be noted that the Venice Minerals mining operation has been on-going since 2004, but the 2004 LiDAR represent the best available information at the current time. More recent topographic information should obtained for final design.

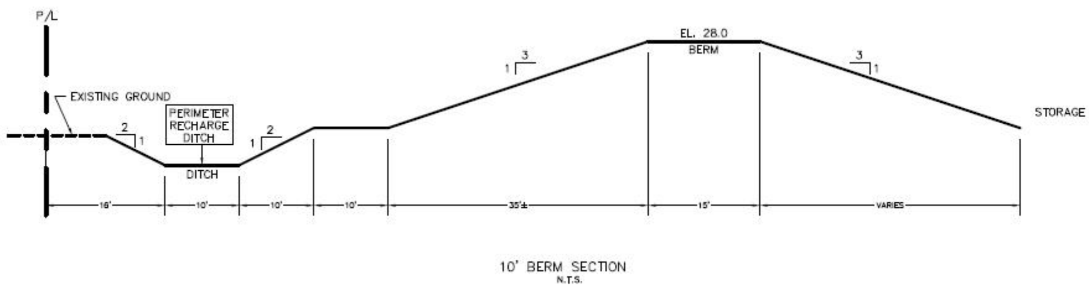

Figure 4 – Typical Berm Section

3.3 Preliminary Yield Evaluations

For the purpose of this preliminary evaluation, a design drought period of at least 250 days was assumed and evaporation loses were not considered. In general, annual evaporation approximates annual rainfall, but during a drought, it could exceed rainfall by approximately 40 inches. The design drought period will be fine tuned through the course of this project based upon other on-going and concurrent analyses. Results of the preliminary evaluations for each alternative are provided in **Table 1** through **Table 3**. For each depth of storage (represented as the operating range) the corresponding storage in both acre-feet (ac-ft) and million gallons (mg) are provided as well as the number of days it would take to deplete the available reservoir storage corresponding to various withdrawals (yield). The yield, operating range and time to deplete the storage are highlighted in the tables.

Venice Minerals		Alternative 1 - 490 acres				
Operating	Storage		Yield			
Range (ft)	Ac-Ft	mg	9 mgd	10 mgd	11 mgd	12 mgd
1	475.98	155	17	16	14	13
5	2379.88	775	86	78	70	65
6	2855.86	931	103	93	85	78
7	3331.83	1086	121	109	99	90
10	4759.76	1551	172	155	141	129
14	6663.66	2171	241	217	197	181
15	7139.64	2326	258	233	211	194

Table 1 – Alternative 1 Preliminary Storage Evaluation

Venice Minerals		Alternative 2 - 388 acres				
Operating	Storage		Yield			
Range (ft)	Ac-Ft	mg	7 mgd	8 mgd	9 mgd	10 mgd
1	375.58	122	17	15	14	12
5	1877.89	612	87	76	68	61
6	2253.47	734	105	92	82	73
7	2629.05	857	122	107	95	86
9	3380.21	1101	157	138	122	110
10	3755.79	1224	175	153	136	122
15	5633.68	1836	262	229	204	184

Table 2 – Alternative 2 Preliminary Storage Evaluation

Venice Minerals		Alternative 3 - 345 acres				
Operating Range (ft)	Storage		Yield			
	Ac-Ft	mg	5 mgd	6 mgd	7 mgd	8 mgd
1	330.59	108	22	18	15	13
5	1652.97	539	108	90	77	67
6	1983.56	646	129	108	92	81
8	2644.75	862	172	144	123	108
10	3305.94	1077	215	180	154	135
11	3636.53	1185	237	197	169	148
12	3967.12	1293	259	215	185	162
14	4628.31	1508	302	251	215	189
15	4958.90	1616	323	269	231	202

Table 3 – Alternative 3 Preliminary Storage Evaluation

Preliminary estimated yields for each alternative are summarized in **Table 4** below.

Alternative	Approximate Yield	Operating Range	Drought Period	Volume of Storage
1	9 mgd	15 feet	258 days	2.3 bg
2	7 mgd	15 feet	262 days	1.8 bg
3	6 mgd	15 feet	269 days	1.6 bg

Table 4 - Estimated Yield for each Alternative

4.0 BASIS FOR OPINION OF PROBABLE COST

To further evaluate each alternative, preliminary engineer's opinions of probable cost were developed. To develop these estimates, opinions of probable cost from the Authority's proposed reservoir expansion were reviewed as a recent and comparable example. As a basis of comparison, many of the design features of the Peace River reservoir were conservatively considered applicable to the design of the Venice Minerals reservoir. Other than the unit costs for earthwork which are discussed separately, unit costs for Venice Minerals were increased 10% over those used for the Peace River reservoir. Continued value engineering through the final design process should be undertaken. Components of the Peace River reservoir not included at this time in the opinions of probable cost included the intake and outlet piping and professional design services. The opinions of probable cost for each alternative are provided at the end of this report.

4.1 Earthwork

One of the primary capital cost considerations is earthwork. Approximate estimates of fill volumes needed for each alternative are provided in **Table 5**. Each volume has been increased by 10% to account for shrinkage of borrow material.

Alternative	Top of Berm Elevation	Berm Perimeter	Approximate Fill for Berm
1	28 NGVD	20,567 feet	760,701 cy
2	28 NGVD	18,692 feet	740,228 cy
3	28 NGVD	20,960 feet	1,173,193 cy

Table 5 - Approximate Estimate of Fill Needed

Based upon information provided by Venice Minerals (VM) in April of 2006, there are approximately 740,800 cubic yards of remaining sand/fill material. VM representatives also estimate 212,000 cubic yards of shell currently remaining on-site. It may also be possible to mix some of the shell material as well as an un-quantified amount of screened organic material with the 740,800 cubic yards of fill material for the berm construction. For purposes of this evaluation, it is assumed that there are only approximately 740,800 cubic yards of fill material that that could be available on-site for the construction of the berm.

There is also material situated along the perimeter of the site that would need to be reserved from being "mined" to provide the base for the berm construction. As additional surveying is completed to quantify the potential perimeter reservation, the opinion of probable cost can be updated.

VM has also indicated that they would consider selling on-site fill material to the County for approximately $2.00 per ton. Based upon the Geotechnical Engineering Services Report prepared by Professional Services Industries, Inc. (PSI), a unit weight of 100 pcf was assumed for material in this area. This would result in an equivalent unit price of $2.70/cubic yard (cy). While this price is still negotiable, it was used for this evaluation. For alternatives that were estimated to have a shortage of on-site fill, it may be more economical to purchase available on-site fill as opposed to hauling in fill material from off-site.

Under Alternatives 1 and 2, fill for the berm was presumed to be generated by excavation associated with the inclusion of the ESLPP lands to the depths and quantities specified in the PSI report. A preliminary fill balance for each alternative is provided in **Table 6**, respectively.

Alternative	Fill Needed	ESLPP Lands (based PSI report)	Purchased from VM	Balance
1	760,701 cy	1,300,000 cy	0 cy	539,299 cy
2	740,228 cy	475,000 cy	265,228 cy	0 cy
3	1,173,193 cy	0 cy	740,800 cy	(432,393) cy

Table 6 – Preliminary Fill Balance

The opinions of probable earthwork cost for each alternative were determined based upon the following assumptions:

On-site material purchase price = $2.70/cy
On-site handling costs = $3.00/cy
Excavation and handling of ESLPP fill material = $3.00/cy
Hauling and handling of off-site material = $10.00/cy (assumes material is free from another County source such as the Celery Fields or Albrittons)

Other earthwork elements included in the opinion of probable cost include slope protection, and filer drains. 2004 unit prices for the Authority reservoir were adjusted (increased) for the Venice Minerals reservoir.

4.2 Mitigation

Alternatives 1 through 4 would require off-site wetland mitigation. The acreage and limits of wetlands in the non-mined areas has been field determined and quantified as follows:

Wetlands within ESLLP (total) = 22 acres
Wetlands within ESLLP (southern parcels only) = 2.3 acres

In addition, the non-mined lands would need to be acquired from the ESLPP. The purchase price of these lands was assumed to be equal to the original price of $2,795/acre and the creation of off-site mitigation was considered at a cost of $60,000/acre (based upon input from Biological Research Associates, Inc.)

4.3 Seepage Control

Consistent with the Peace River reservoir project, seepage control design features were considered in the preliminary opinion of probable cost estimate for Venice Minerals. Specifically, a soil-bentonite slurry wall to an average depth of 45 feet was considered reasonable for preliminary purposes. At the time of final design, the actual needed depth for the slurry wall can be determined. In addition, a 60 mil polyethylene, geosynthetic membrane was also included as a necessary component in the opinion of probable cost.

4.4 Water Quality Control Features

Similar to the Peace River reservoir, aeration towers and a bubbler system were included in the preliminary opinion of probable cost to address potential water quality issues associated with stratification.

4.5 Mobilization/Demobilization

Based upon a review of the Peace River reservoir estimates for mobilization/demobilization, the Opinion of Probable Cost for the VM reservoir was estimated at 5% of the reservoir costs for all alternatives.

4.6 Site Preparation

To estimate clearing and grubbing, acreages used included both the non-mined area (where applicable) and the area around the perimeter where the berm is to be placed. In addition, for the non-mined area, it was assumed that 50% of the area would need tree clearing.

4.7 Care and Handling of Water

Since the existing mining area has already been excavated, only the non-mined areas (where applicable) were considered as requiring dewatering during excavation activities. However, water treatment for sediment control during construction activities was considered applicable for all alternatives.

4.8 Additional Minor Items and Contingency

To account for additional minor items that might be identified during the final design stage, a 10 percent allowance was added to the total of the reservoir item costs.

In addition, a 16% contingency was added to the total capital opinion of probable cost.

5.0 RESULTS

In order to estimate the relative cost effectiveness of each alternative, opinions of probable cost were divided by the approximate estimated yield. Results are summarized in **Table 7**. In addition, opinions of probable cost for each alternative were divided by the estimated storage associated with the estimated yields. This information is presented in **Table 8**.

Alternative	Opinion of Probable Cost	Approximate Yield	Yields/Cost
1	$19,746,484	9 mgd	$2.19/gal
2	$16,376,697	7 mgd	$2.34/gal
3	$24,523,839	6 mgd	$4.09/gal

Table 7

Alternative	Opinion of Probable Cost	Storage	Yields/Cost
1	$19,746,484	7,140 acre-feet	$2,766/ac-ft
2	$16,376,697	5,640 acre-feet	$2,904/ac-ft
3	$24,523,839	4,965 acre-feet	$4,939/ac-ft

Table 8

Based upon the above analysis, Alternative 1 would be the most cost effective. Alternative 1 includes the incorporation of the entire ESLPP lands with a 15 ft. operating range. The estimated yield is 9 mgd for a design drought period of approximately 258 days.

6.0 RECOMMENDATIONS

The following recommendations are provided as next steps to further the design of the Venice Mineral reservoir site:

- Install continuous stage recorders at the two outfall weirs. Field survey the dimensions and inverts of the existing weirs.
- Quantify the amount of on-site material that should be reserved around the perimeter of the Venice Minerals property.
- Obtain recent a topographic survey for the Venice Minerals property.
- In coordination with the PRMRWSA, explore pertinent design considerations and feasibility analyses related to the potential integration of the Venice Minerals site and the Dona Bay Watershed project into the regional system.

Venice Minerals Reservoir – Alternative 1
Preliminary Opinion of Probable Cost

ITEM:	UNIT	UNIT PRICE	QUANTITY	TOTAL PRICE
RESERVOIR				
Mobilization/Demobilization	LS	$ 665,000	1	$ 665,000
Site Preparation: Clearing & Grubbing	AC	$ 5,280	204	$ 1,077,120
Stripping	CY	$ 1.21	123,420	$ 149,338
Care and Handling of Water				
Control of Groundwater	AC	$ 1,760	146	$ 256,960
Water Treatment for Sediment Control	LS	$ 275,000	1	$ 275,000
Earthwork				
Fill Placement	CY	$ 3.00	760,701	$ 2,282,103
Bedding, Filters and Drains	CY	$ 28.60	45,250	$ 1,294,150
Second Stage Drains	CY	$ 49.50	11,800	$ 584,100
Slope Protection - Soil Cement	CY	$ 38.50	88,750	$ 3,416,875
Seepage Control				
Cut Off Slurry Wall	SF	$ 3.08	925,515	$ 2,850,586
Geomembrane Composite Lining	SF	$ 0.55	461,000	$ 253,550
Reservoir Water Quality Features				
Aeration Towers & Bubbler System	LS	$ 860,000	1	$ 860,000
Additional Minor Items	LS	10%	1	$ 1,329,978
Subtotal Reservoir:				**$ 15,294,761**
MITIGATION				
Mitigation	LS	$ 1,728,070	1	$ 1,728,070
Subtotal Mitigation:				**$ 1,728,070**
SUBTOTAL - CAPITAL COSTS				**$ 17,022,831**
Contingency		16%		**$ 2,723,653**
TOTAL COST WITH CONTINGENCY				**$ 19,746,484**

Venice Minerals Reservoir – Alternative 2
Preliminary Opinion of Probable Cost

ITEM:	UNIT	UNIT PRICE	QUANTITY	TOTAL PRICE
RESERVOIR				
Mobilization/Demobilization	LS	$ 604,000	1	$ 604,000
Site Preparation: Clearing & Grubbing	AC	$ 5,280	73	$ 385,440
Stripping	CY	$ 1.21	44,165	$ 53,440
Care and Handling of Water				
Control of Groundwater	AC	$ 1,760	34	$ 59,840
Water Treatment for Sediment Control	LS	$ 275,000	1	$ 275,000
Earthwork				
On-Site Borrow Purchase	CY	$ 2.70	265,228	$ 716,116
Fill Placement	CY	$ 3.00	740,228	$ 2,220,684
Bedding, Filters and Drains	CY	$ 28.60	41,150	$ 1,176,890
Second Stage Drains	CY	$ 49.50	10,700	$ 529,650
Slope Protection - Soil Cement	CY	$ 38.50	80,660	$ 3,105,410
Seepage Control				
Cut Off Slurry Wall	SF	$ 3.08	841,140	$ 2,590,711
Geomembrane Composite Lining	SF	$ 0.55	418,700	$ 230,285
Reservoir Water Quality Features				
Aeration Towers & Bubbler System	LS	$ 730,000	1	$ 730,000
Additional Minor Items	LS	10%	1	$ 1,207,347
Subtotal Reservoir:				**$ 13,884,812**
MITIGATION				
Mitigation	LS	$ 233,030	1	$ 233,030
Subtotal Mitigation:				**$ 233,030**
SUBTOTAL - CAPITAL COSTS				**$ 14,117,842**
Contingency		16%		**$ 2,258,855**
TOTAL COST WITH CONTINGENCY				**$ 16,376,697**

Venice Minerals Reservoir – Alternative 3
Preliminary Opinion of Probable Cost

ITEM:	UNIT	UNIT PRICE	QUANTITY	TOTAL PRICE
RESERVOIR				
Mobilization/Demobilization	LS	$ 919,200	1	$ 919,200
Site Preparation: Clearing & Grubbing	AC	$ 5,280	57	$ 300,960
Stripping	CY	$ 1.21	34,485	$ 41,727
Care and Handling of Water				
Water Treatment for Sediment Control	LS	$ 275,000	1	$ 275,000
Earthwork				
On-Site Borrow Purchase	CY	$ 2.70	740,800	$ 2,000,160
Fill Placement	CY	$ 3.00	740,800	$ 2,222,400
Off-Site Borrow, Placement and Hauling	CY	$ 10.00	432,393	$ 4,323,930
Bedding, Filters and Drains	CY	$ 28.60	46,150	$ 1,319,890
Second Stage Drains	CY	$ 49.50	12,000	$ 594,000
Slope Protection - Soil Cement	CY	$ 38.50	90,450	$ 3,482,325
Seepage Control				
Cut Off Slurry Wall	SF	$ 3.08	943,200	$ 2,905,056
Geomembrane Composite Lining	SF	$ 0.55	469,500	$ 258,225
Reservoir Water Quality Features				
Aeration Towers & Bubbler System	LS	$ 660,000	1	$ 660,000
Additional Minor Items	LS	10%	1	$ 1,838,367
SUBTOTAL - CAPITAL COSTS				**$ 21,141,240**
Contingency		16%		**$ 3,382,598**
TOTAL COST WITH CONTINGENCY				**$ 24,523,839**

TM 4.2.4.2 – EVALUATION OF SURFACE STORAGE (Albritton Site)

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and SWFWMD are currently completing the necessary, pre-requisite data collection and analysis as well as comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marin Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the Southwest Florida Water Management District (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBSJ to provide preliminary storage evaluation for the Albritton site, consistent with Task 4.2.4 of the DBWMP contract. In addition a comparison of yields and opinions of probable capital costs are provided for five conceptual surface water configurations.

2.0 DESCRIPTION OF ALBRITTON SITE

In 2004 Sarasota County purchased 1,000 acres of property to the north of the Central County Solid Waste Disposal Complex (CCSWDC) for the purpose of obtaining cover material for the landfill. The CCSWDC landfill will require approximately 12 million cubic yards of material for daily cover, closure, and construction of new cells over the remaining life of the landfill. The Albritton site will provide that quantity of material. Sarasota County Solid Waste Department obtained a permit for the excavation of a shallow borrow pit in the southwest area of the property and has excavated approximately 90,000 cubic yards of material to date. A permit has been secured for a second phase borrow pit, which will also be shallow so that de-watering is not required for the excavation.

The purpose of this preliminary storage evaluation is to evaluate alternatives for excavation of the borrow pit to allow the site to be used for storage of surface water. Although the Albritton site is evaluated as a stand alone facility in this analysis, storage on this site may be used in conjunction with previously excavated borrow pits on the landfill site and the Venice Minerals site to the south.

3.0 ESTIMATE OF POTENTIAL YIELD

Five alternatives were evaluated for the configuration of a water storage reservoir on the Albritton property. The alternatives included variations in the area excavated, the operating range of the storage reservoir, and the construction of berms around the excavated area.

3.1 Alternatives Evaluated

The alternatives considered included three plans for the borrow pit and resulting reservoir that provided for storage of the water below the existing grade of the site. The assumed operating range for the three reservoirs would be 10 feet. Two additional alternatives would have an operating range that would extend from 10 feet below grade to 10 feet above grade.

Each of the alternatives provided for water to enter the site from Cow Pen Canal at the northwest corner of the property. This is immediately adjacent to the upper water level control structure in the canal. This structure controls the water elevation at 18 feet in the dry season and 14 feet in the wet season. For the three alternatives that store water below grade an operating range of 10 feet will allow the reservoir to be filled by gravity. Pumping will be required for an operating range that extends above existing grade. Each of the initial alternatives included excavation of the entire area of the borrow pit to a depth of 15 feet below existing grade.

Common features of the four alternatives are:

- An emergency overflow to return water to Cow Pen Slough located in the southwest corner of the reservoir
- A setback from the east and south property line to allow for a future roadway
- A recharge ditch on the north, east, and south boundaries to limit impacts to the groundwater elevation on adjacent property
- Provisions for transporting off-site stormwater runoff around the site
- Continued flow into the old Cow Pen Slough ditch to maintain wetland areas
- A freeboard of 10 feet above the maximum operating range

Alternative 1 – Alternative 1 (see Figure 1) includes a settling pool and biological filtration area to remove some of the suspended solids and other pollutants as water enters the reservoir. If the volume of water removed from the Cow Pen Canal during peak flow periods is maximized, the effectiveness of the treatment zones may be limited. The potential effectiveness of these treatment areas will be evaluated as the design proceeds.

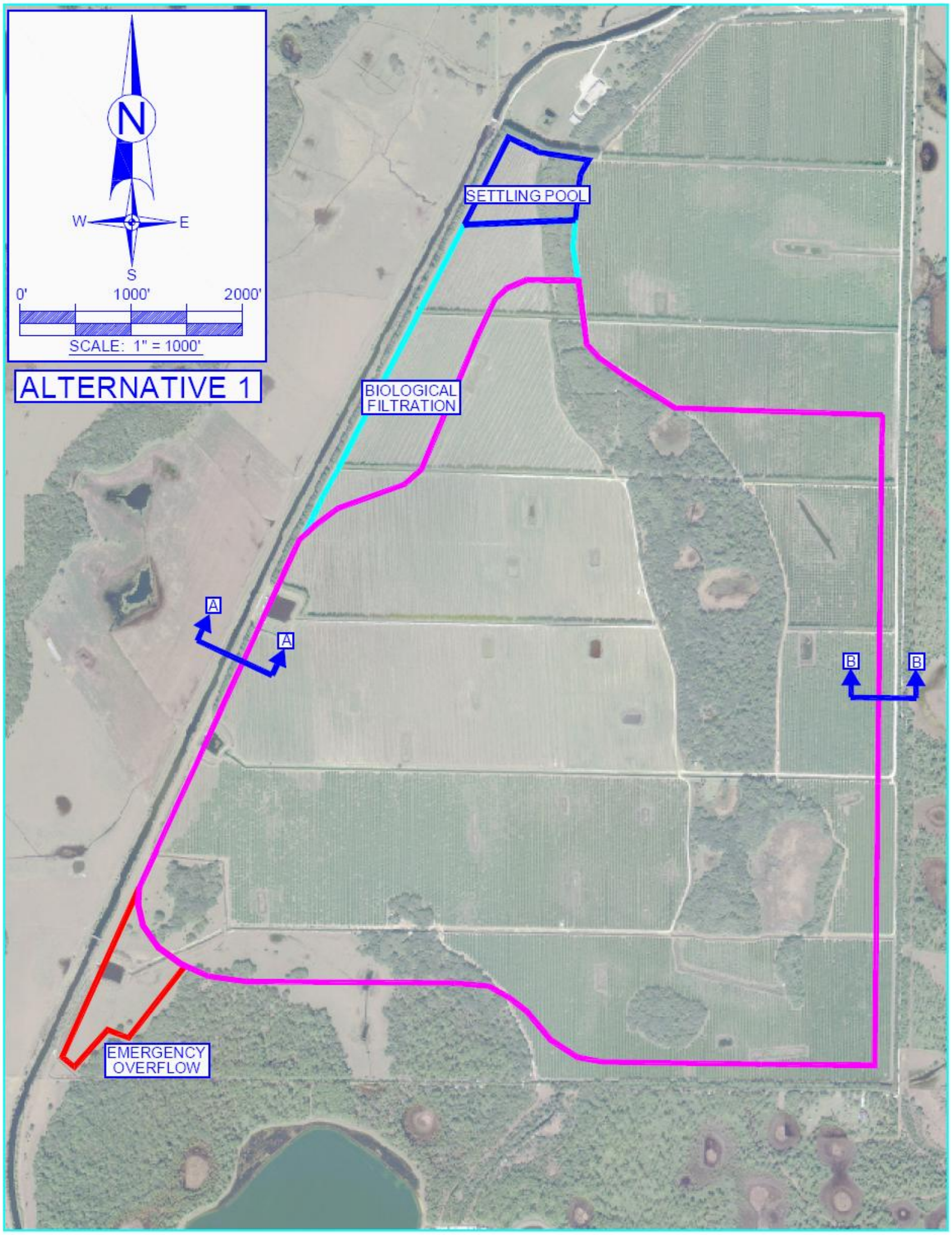

Figure 1 – Alternative 1

Alternative 2 – The Albritton site has a hammock area that extends from the north to the southeast across the site. The hammock is approximately 150 acres and includes herbaceous wetlands. Alternative 2 has the same outside boundary as Alternative 1 but excludes the hammock area from the reservoir excavation (see Figure 2). A recharge ditch around the hammock area will be required to maintain groundwater conditions and the hydroperiod for the wetlands. The reservoir berm will not extend around the limits of the hammock area. Since the normal operating range for the reservoir will be below the existing grade at the hammock, the hammock should not be inundated except in large storm events.

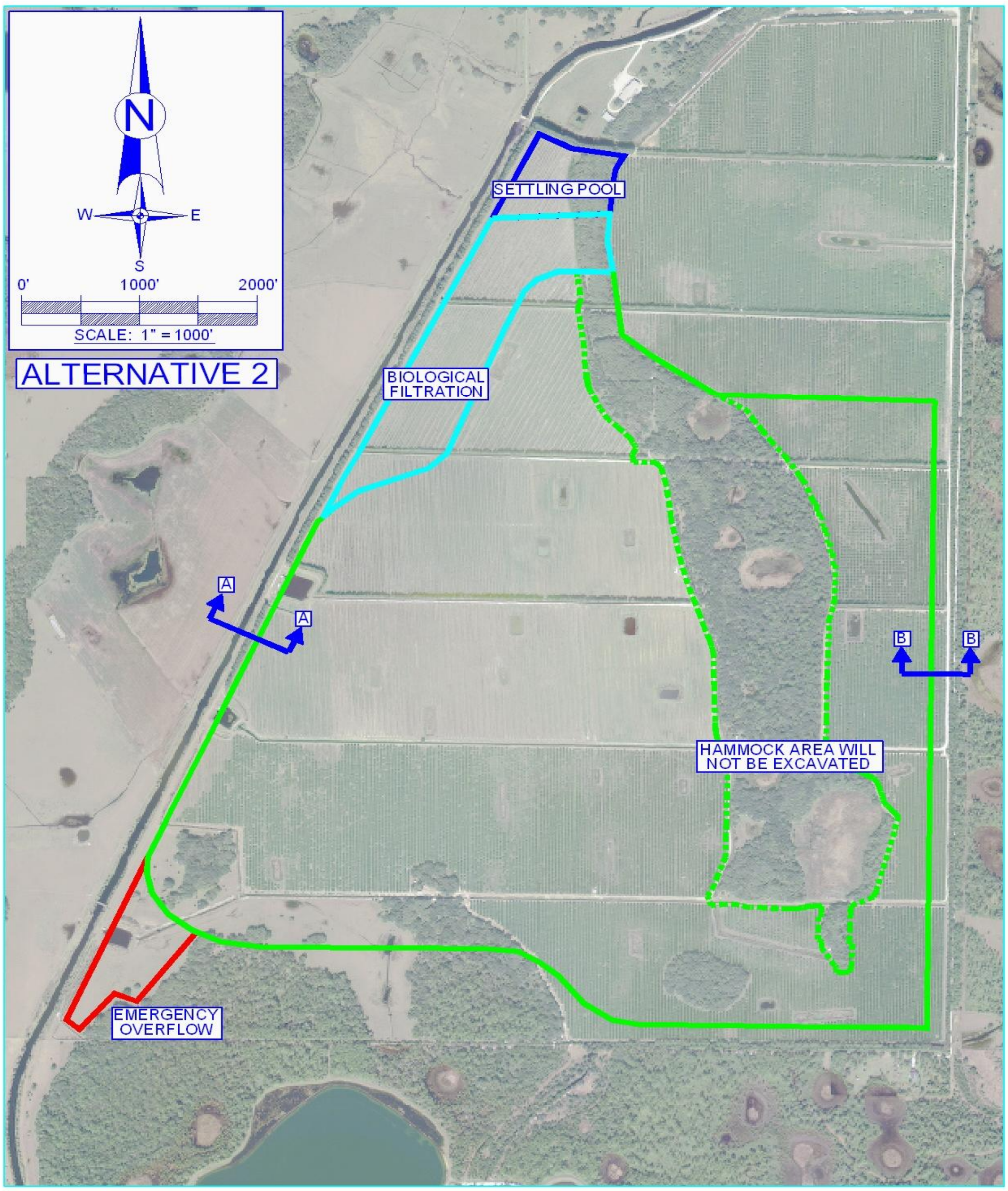

Figure 2 – Alternative 2

Alternative 3 – Alternative 3 (Figure 3) includes construction of marsh areas on the south side of the reservoir area. The marsh areas could serve as mitigation for environmental impacts and would improve water quality flowing into the downstream areas. One drawback of this borrow pit plan is that the soils in the southeast part of the site designated as marshland are some of the better quality soils on the property.

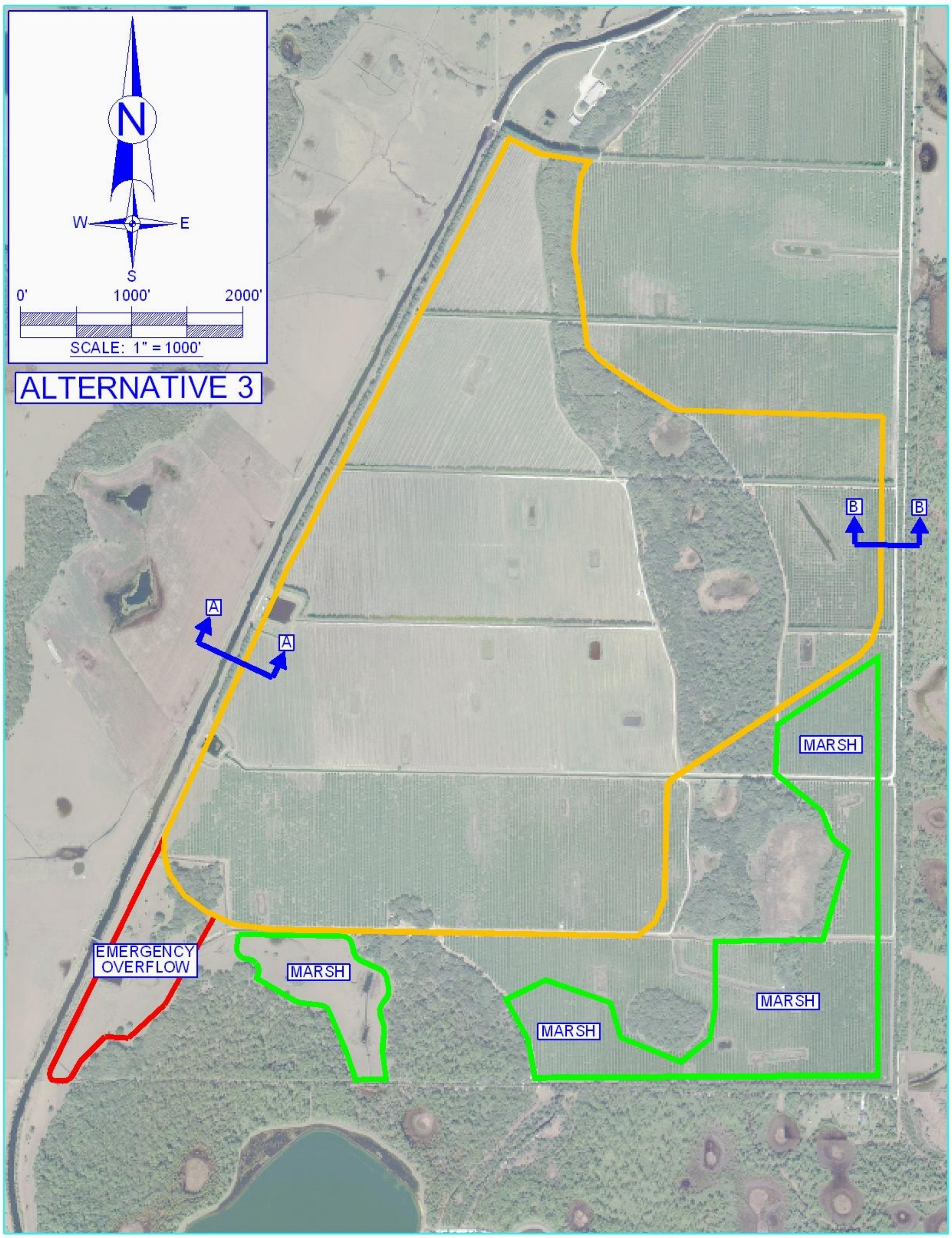

Figure 3 – Alternative 3

Alternative 4 – Alternative 4 provides for an operating range in the reservoir from 10 feet below grade to 10 feet above grade. The configuration of the berms are the same as Alternative 1 without the settling pond and biological filtration zones (see Figure 4). The treatment zones within the reservoir would be difficult to construct with the greater operating range in this alternative. The control structure for diverting water into the reservoir will allow water to fill the reservoir by gravity up to elevation 18.0. Water stored above that elevation will have to be pumped into the reservoir.

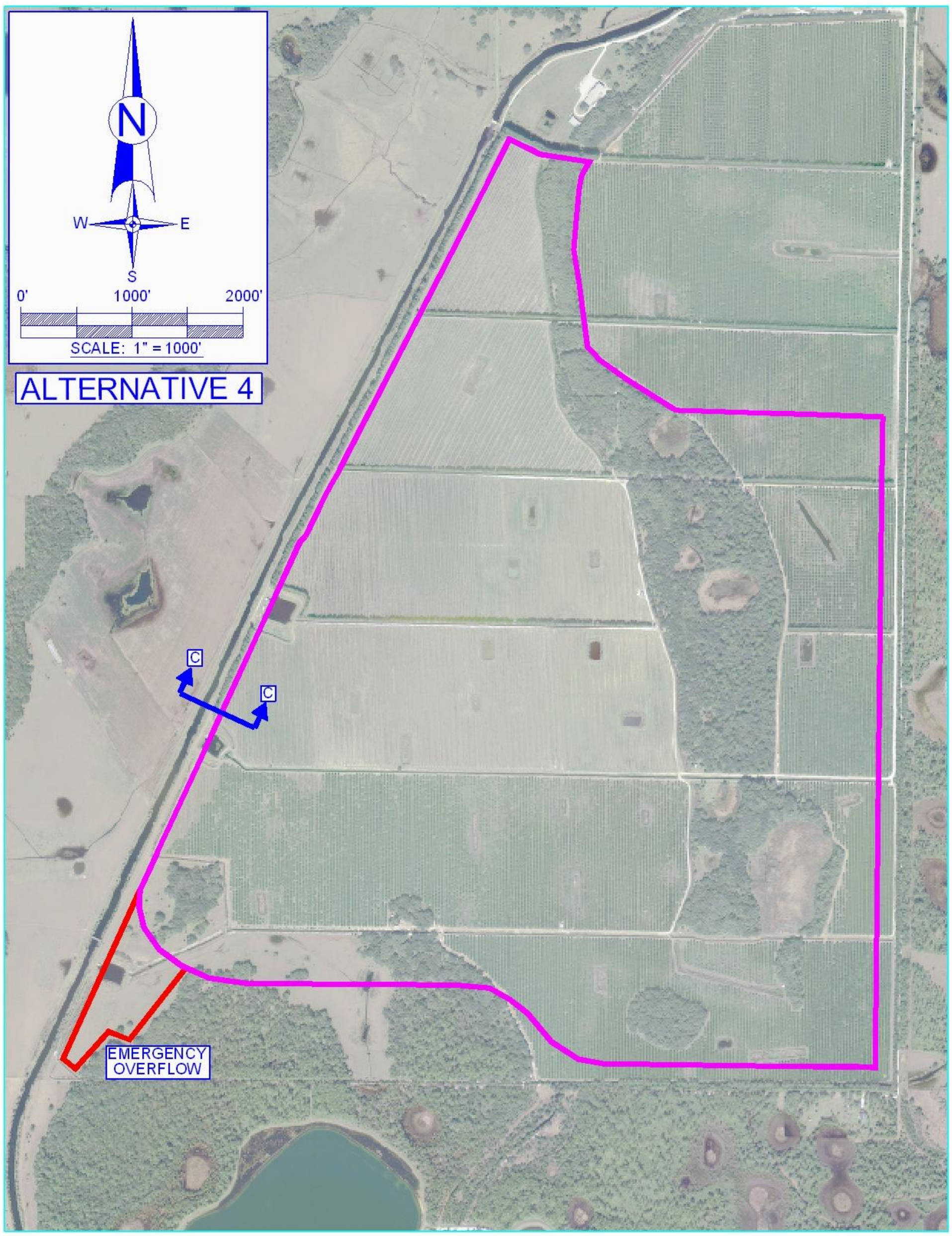

Figure 4 – Alternative 4

Alternative 5 – Alternative 5 uses the same footprint for the reservoir as Alternative 3 and provides for an operating range in the reservoir from 10 feet below grade to 10 feet above grade. As in Alternative 4, the control structure for diverting water into the reservoir will allow water to fill the reservoir by gravity up to elevation 18.0. Water stored above that elevation will have to be pumped into the reservoir.

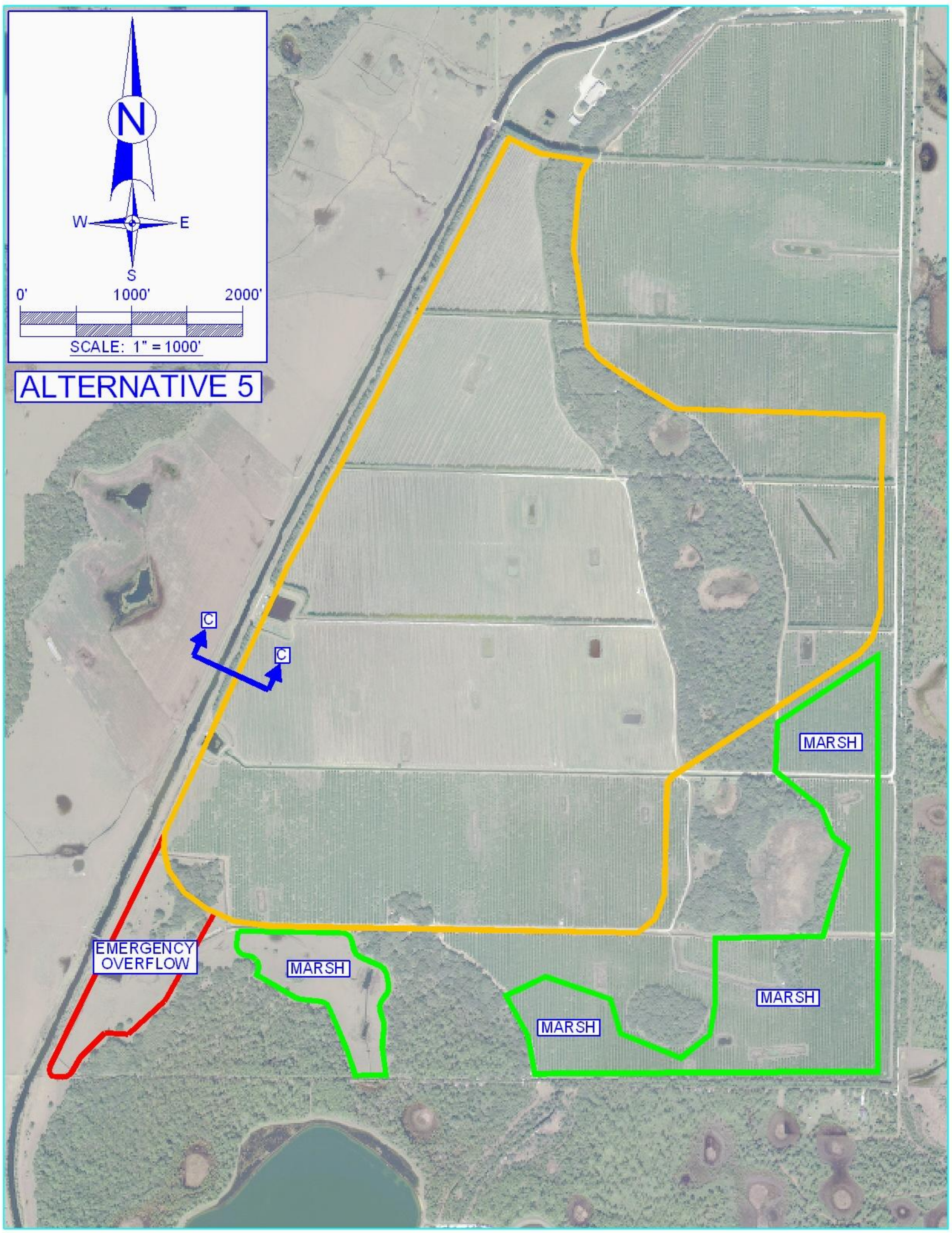

Figure 5 – Alternative 5

The volume of borrow material that would be excavated, the surface area of the reservoir, and the water storage capacity that would be created in each alternative are shown in Table 1. The estimated volumes of borrow material are based upon excavation of the entire site within the reservoir boundaries to a depth of 15 feet below existing grade. The borrow material within the site varies in quality and will need to be handled carefully to segregate good fill material from clayey soils. Since only 12 million cubic yards of material is needed for the remaining life of the landfill, each of the alternatives fulfills the landfill needs and could provide surplus material. The excavation of the material should be monitored closely to segregate the better material from the less desirable soil.

Alternative	Average Reservoir Area, ac	Operating Range, ft	Water Storage, acre-ft	Available Borrow Material, cy[1]
1	735	10	7,265	18.6 million
2	580	10	5,677	14.9 million
3	580	10	5,714	13.7 million
4	772	20	15,458	17.8 million
5	580	20	11,272	12.9 million

Table 1 – Alternatives Borrow Volumes and Reservoir Areas

[1]Total available borrow material less the volume needed to construct a berm around the reservoir.

3.2 Preliminary Berm Sections

Section A-A in Figure 5 is the berm along the Cow Pen Canal for Alternatives 1, 2, and 3. The water elevation in the canal is controlled by a weir structure located downstream of the site. The overflow elevation of the weir is at elevation 7.0 during the wet season and at elevation 11.0 during the dry season. The canal has a berm along both sides that was created when the canal was excavated. The berms are used for maintenance access by county vehicles. The elevation of the western side of the Albritton site adjacent to the maintenance berm varies from elevation 14.0 to elevation 18.0. In order to provide for an operation range of up to 18.0 and a freeboard of 10.0 feet a new berm would be constructed to an elevation of 28.0.

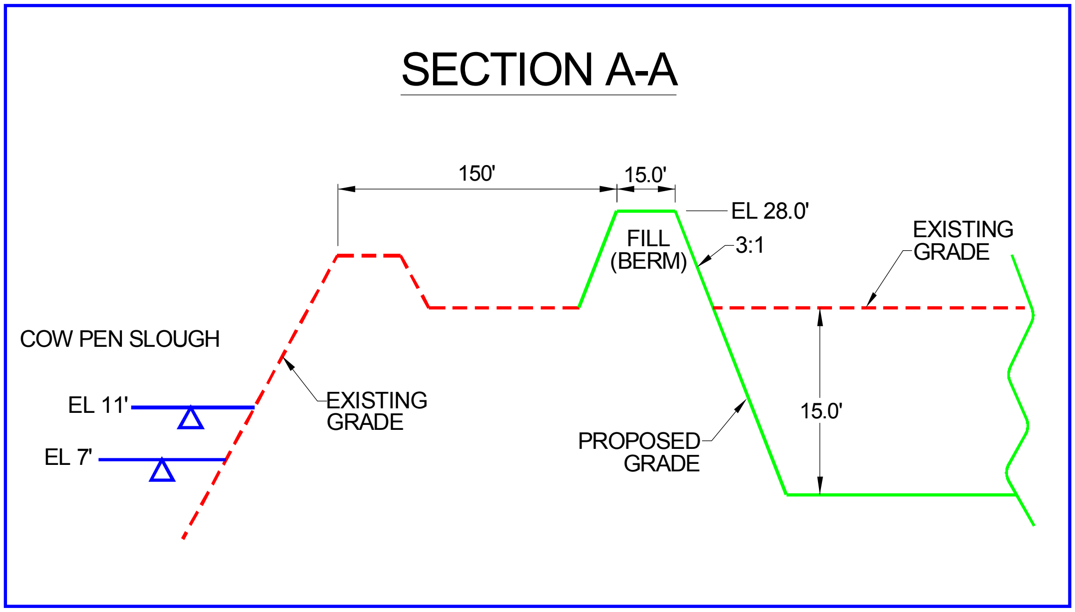

Figure 5 – Typical Berm Section

Section B-B shown in Figure 6 is the east and south boundaries of the property for Alternatives 1, 2 and 3. The section includes space for a future four-lane roadway, a recharge ditch, and a stormwater ditch to intercept offsite drainage. The existing grade along the east property boundary is approximately elevation 21.0.

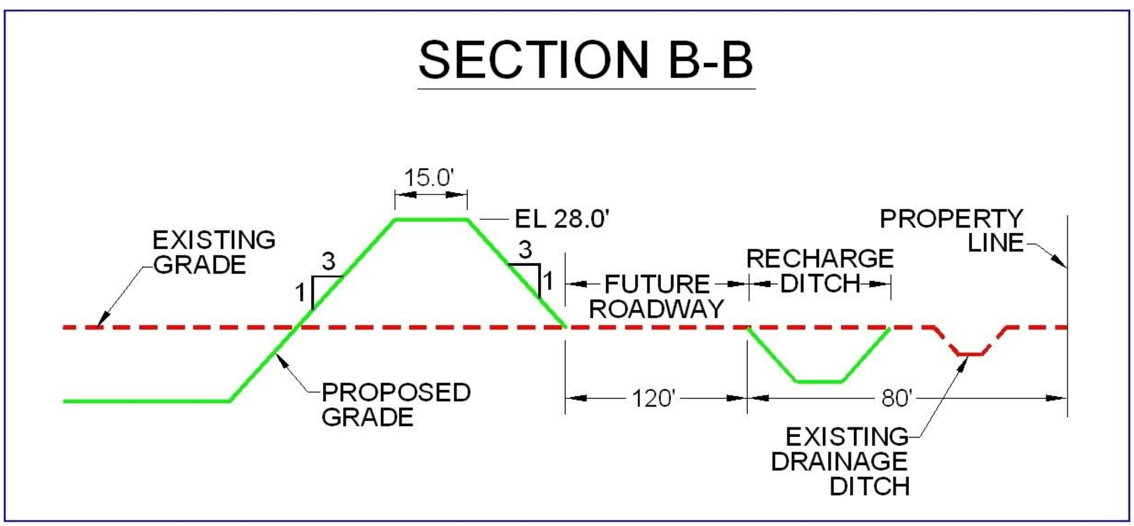

Figure 6 - Typical Berm Section

The preliminary design for the higher berm for Alternatives 4 and 5 is shown in Section C-C. (Figure 7). The berm for this alternative is approximately 18 feet above existing grade on the west side of the site.

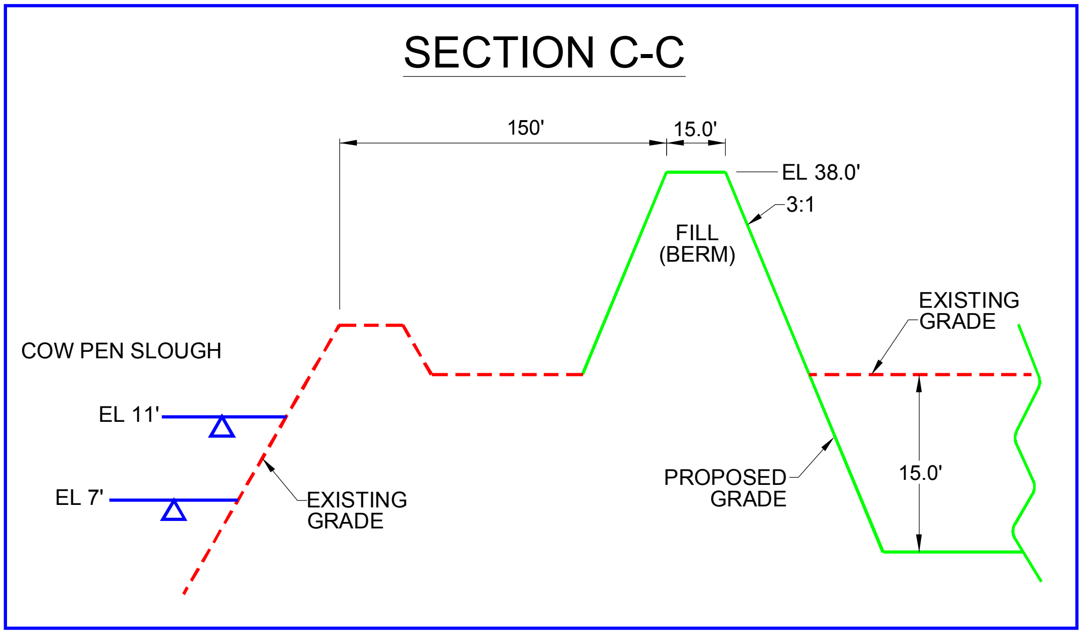

Figure 7 – Typical Berm Section

3.3 Preliminary Yield Evaluations

The basis for calculation of the preliminary design yield for the Venice Minerals site was followed for the five alternatives evaluated for the Albritton property, and a design drought period of 250 days was used. Tables 2 through 6 show the time required to deplete the storage for each operating range at the withdrawal rates or yield rates indicated.

OPERATING RANGE	STORAGE		YIELD			
(FT)	(AC-FT)	(MG)	(7 MGD)	(8 MGD)	(9 MGD)	(10 MGD)
2	1,443	470	67	59	52	47
4	2,888	941	134	118	105	94
6	4,341	1,414	202	177	157	141
8	5,799	1,889	270	236	210	189
10	7,265	2,366	338	296	263	237

Table 2 – Alternative 1 Preliminary Storage Evaluation

OPERATING RANGE	STORAGE		YIELD			
(FT)	(AC-FT)	(MG)	(5 MGD)	(6 MGD)	(7 MGD)	(8 MGD)
2	1,120	365	73	61	52	46
4	2,244	731	146	122	104	91
6	3,378	1,100	220	183	157	138
8	4,523	1,473	295	246	210	184
10	5,677	1,849	370	308	264	231

Table 3 – Alternative 2 Preliminary Storage Evaluation

OPERATING RANGE	STORAGE		YIELD			
(FT)	(AC-FT)	(MG)	(5 MGD)	(6 MGD)	(7 MGD)	(8 MGD)
2	1,133	369	74	62	53	46
4	2,269	739	148	123	106	92
6	3,411	1,111	222	185	159	139
8	4,559	1,485	297	248	212	186
10	5,714	1,861	372	310	266	233

Table 4 – Alternative 3 Preliminary Storage Evaluation

OPERATING RANGE	STORAGE		YIELD			
(FT)	(AC-FT)	(MG)	(5 MGD)	(10 MGD)	(15 MGD)	(20 MGD)
2	1,517	494	99	49	33	25
4	3,038	990	198	99	66	49
6	4,566	1,487	297	149	99	74
8	6,101	1,987	397	199	132	99
10	7,643	2,490	498	249	166	124
12	9,192	2,994	599	299	200	150
14	10,748	3,501	700	350	233	175
16	12,311	4,010	802	401	267	201
18	13,881	4,521	904	452	301	226
20	15,458	5,035	1007	504	336	252

Table 5 – Alternative 4 Preliminary Storage Evaluation

OPERATING RANGE	STORAGE		YIELD			
(FT)	(AC-FT)	(MG)	(10MGD)	(12 MGD)	(14 MGD)	(16 MGD)
2	1,102	359	36	30	26	22
4	2,208	719	72	60	51	45
6	3,319	1,081	108	90	77	68
8	4,437	1,445	145	120	103	90
10	5,561	1,811	181	151	129	113
12	6,691	2,179	218	182	156	136
14	7,827	2,549	255	212	182	159
16	8,969	2,921	292	243	209	183
18	10,117	3,296	330	275	235	206
20	11,272	3,672	367	306	262	230

Table 6 – Alternative 5 Preliminary Storage Evaluation

Table 7 is a summary of the preliminary estimates of yield for each alternative for a drought period of 250 days.

Alternative	Approximate Yield	Operating Range	Drought Period	Volume of Storage
1	9 mgd	10 feet	250 days	2.4 bg
2	7 mgd	10 feet	250 days	1.8 bg
3	7 mgd	10 feet	250 days	1.9 bg
4	20 mgd	20 feet	250 days	5.0 bg
5	14 mgd	20 feet	250 days	3.7 bg

Table 7 – Estimated Yield for Each Alternative

4.0 OPINION OF PROBABLE COST

Estimates of probable costs for each alternative are included at the end of this memorandum.

4.1 Earthwork

The Albritton site was purchased for the purpose of providing approximately 12 million cubic yards of cover material for the landfill. The most economical process for excavation of the borrow pit for the landfill operation is to mine the material over the remaining life of the landfill as it is needed. In order to excavate the material over a short time frame to create the reservoir, the material will have to be excavated and stored offsite. An evaluation of alternatives for excavation of the borrow pit and storage of the soil demonstrated that 12.0 million cubic yards of soil could be stored on the landfill site and used from the stockpile as needed. The stockpile on the landfill could be designed to be consumed as the landfill is expanded. The capital cost for the excavation would be incurred in a short period of time rather than spread over many years.

Alternatives 1, 2, and 3 each have the same preliminary design for the berm around the reservoir. The only variables are the length of the berms and the existing grade along the alignment of the berms. Alternatives 4 and 5 require a berm approximately 29 feet above existing grade and a much greater quantity of fill. Table 8 is a summary of the quantities available for each alternative. The available quantity is the total volume that could be excavated less the amount of material that would be required for construction of the berms.

Alternative	Average Berm Height, ft.	Berm Perimeter, ft.	Approximate Berm Fill, cy	Available Borrow Material, cy[1]
1	8.8	23,800	437,000	18.6 million
2	8.8	23,800	426,000	14.9 million
3	8.7	23,100	303,000	13.7 million
4	18.9	26,150	1,311,000	17.8 million
5	18.7	23,800	1,132,000	12.9 million

Table 8 – Estimate of Berm Fill Needed and Borrow Material Available

[1] Total volume of material that could be excavated less the material required for berm construction.

The projected quantity of cover and construction soil needed for the remaining life of the landfill is approximately 12.0 million cubic yards. Each of the alternatives will provide more soil than needed if the excavation is to a depth of 15 feet below existing grade. The quantity of soil in excess of the landfill needs could be sold or the depth of the excavation can be reduced to limit the volume of soil removed. The depth of the excavation can be reduced without reducing the water storage capacity of the reservoir. Another option is to limit the excavation to the areas that have the better soils for landfill uses.

The opinion of probable cost for earthwork is based upon the following unit costs:

On-site material handling costs = $3.00/cy
Excavation and hauling to a stockpile on the landfill = $5.00/cy

Other earthwork costs include slope protection, dewatering, filter drains, etc. The unit costs for these items are based upon costs estimated for the Peace River Manasota Regional Water Supply Authority reservoir, with an adjustment of 10% for inflation.

4.2 Mitigation

Alternatives 1, 3, 4 and 5 each will require mitigation for wetland and hammock impacts. Alternative 2 leaves the existing hammock area and wetlands in place, and will require less mitigation. There may be sufficient area within the county owned property to mitigate by creating new areas or enhancing existing environmental areas. An estimated cost of $50,000 per acre was used for determining probable mitigation costs.

4.3 Other Costs

Other costs included in the opinion of probable costs for the reservoir construction are:

Site preparation – Clearing and grubbing
Sodding – Cover of disturbed areas and outside face of the berm
Seepage control – A soil-bentonite slurry wall to an average depth of 45 feet
Water quality control - Aeration towers and bubbler system for mixing
Mobilization/demobilization – 5% of probable construction cost
Dewatering – Removal and sediment control for the borrow pit mining operation

5.0 RESULTS

Table 9 is a comparison of the opinion of probable cost for construction of the reservoir divided by the approximate yield for each alternative based upon a drought period of 250 days and Table 10 is the probable cost divided by the volume of storage provided for each alternative. Based upon these comparisons, Alternative 4 is the least cost per gallon for construction of the reservoir and the least cost per unit of storage.

However, Alternative 4 includes an operating range that extends above grade. The probable cost for that alternative does not include a pumping system to transport water from Cow Pen Slough into the reservoir or any modifications to the existing weir structure in the slough. Alternative 4 also involves the construction of a large storage reservoir above grade, which creates a public safety concern. The design of the above grade storage will have to meet stringent requirements.

Alternative	Probable Cost	Approximate Yield, MGD	Cost/Gal
1	$ 25,435,000	9	$ 2.83
2	$ 22,915,000	7	$ 3.27
3	$ 22,277,000	7	$ 3.18
4	$ 31,312,000	20	$ 1.57
5	$ 26,127,000	14	$ 1.87

Table 9

Alternative	Probable Cost	Storage, acre-feet	Cost/Ac-ft
1	$ 25,435,000	7265	$ 3,501
2	$ 22,915,000	5677	$ 4,036
3	$ 22,277,000	5714	$ 3,899

4	$ 31,312,000	15458	$ 2,026
5	$ 26,127,000	11272	$ 2,318

Table 10

Albritton Site Reservoir – Alternative 1
Preliminary Opinion of Probable Cost

ITEM	UNIT	UNIT PRICE	QUANTITY	TOTAL AMOUNT
MOBILIZATION/DEMOBILIZATION	LS	5%		$ 940,317
RESERVOIR				
Earthwork				
Clearing and grubbing	AC	$ 5,280.00	760	$ 4,012,800
Stripping	CY	$ 1.21	459,800	$ 556,358
Dewatering	AC	$ 1,760.00	735	$ 1,293,600
Sediment control	LS	$ 990,809	1	$ 990,809
Fill placement for berms	CY	$ 3.00	436,659	$ 1,309,977
Bedding, filters, and drains	CY	$ 28.60	52,363	$ 1,497,582
Second stage drains	CY	$ 49.50	13,655	$ 675,917
Slope protection - soil cement	CY	$ 38.50	102,701	$ 3,953,986
Slurry wall	SF	$ 3.08	952,023	$ 2,932,231
Geomembrane liner	SF	$ 0.55	533,466	$ 293,406
Aeration towers and bubbler system	LS	$ 1,290,000	1	$ 1,290,000
Additional Minor Items	LS	10%	1	$ 1,880,667
Subtotal Reservoir:				**$ 20,687,000**
MITIGATION	LS	$ 300,000.00	1	**$ 300,000**
SUBTOTAL - CAPITAL COSTS				**$ 21,927,000**
Contingencies	LS	16%	1	$ 3,508,000
SUBTOTAL RESERVOIR CONSTRUCTION				**$ 25,435,000**
EXCAVATION/HAULING TO LANDFILL	CY	$ 5.00	18,608,341	**$93,041,705**
TOTAL PROBABLE COST				**$ 118,476,705**

Albritton Site Reservoir – Alternative 2
Preliminary Opinion of Probable Cost

ITEM	UNIT	UNIT PRICE	QUANTITY	TOTAL AMOUNT
MOBILIZATION/DEMOBILIZATION	LS	5%		$ 854,502
RESERVOIR				
Earthwork				
Clearing and grubbing	AC	$ 5,280.00	605	$ 3,194,400
Stripping	CY	$ 1.21	366,025	$ 442,890
Dewatering	AC	$ 1,760.00	580	$ 1,020,800
Sediment control	LS	$ 781,863	1	$ 781,863
Fill placement for berms	CY	$ 3.00	426,189	$ 1,278,567
Bedding, filters, and drains	CY	$ 28.60	52,363	$ 1,497,582
Second stage drains	CY	$ 49.50	13,655	$ 675,917
Slope protection - soil cement	CY	$ 38.50	102,701	$ 3,953,986
Slurry Wall	SF	$ 3.08	952,023	$ 2,932,231
Geomembrane liner	SF	$ 0.55	533,466	$ 293,406
Aeration towers and bubbler system	LS	$1,017,959	1	$ 1,017,959
Additional Minor Items	LS	10%	1	$ 1,708,960
Subtotal Reservoir:				**$ 18,799,000**
MITIGATION	LS	$100,000	1	**$ 100,000**
SUBTOTAL - CAPITAL COSTS				**$ 19,754,000**
Contingencies	LS	16%	1	$ 3,160,640
SUBTOTAL RESERVOIR CONSTRUCTION				**$ 22,915,000**
EXCAVATION/HAULING TO LANDFILL	CY	$ 5.00	14,900,000	**$ 74,500,000**
TOTAL PROBABLE COST				**$97,415,000**

Albritton Site Reservoir – Alternative 3
Preliminary Opinion of Probable Cost

ITEM	UNIT	UNIT PRICE	QUANTITY	TOTAL AMOUNT
MOBILIZATION/DEMOBILIZATION	LS	5%		$ 821,907
RESERVOIR				
Earthwork				
Clearing and grubbing	AC	$ 5,280.00	605	$ 3,194,400
Stripping	CY	$ 1.21	366,025	$ 442,890
Dewatering	AC	$ 1,760.00	580	$ 1,020,800
Sediment control	LS	$ 781,863	1	$ 781,863
Fill placement for berms	CY	$ 3.00	303,500	$ 910,500
Bedding, filters, and drains	CY	$ 28.60	50,779	$ 1,452,277
Second stage drains	CY	$ 49.50	13,242	$ 655,469
Slope protection - soil cement	CY	$ 38.50	99,594	$ 3,834,369
Slurry wall	SF	$ 3.08	923,222	$ 2,843,525
Geomembrane liner	SF	$ 0.55	517,328	$ 284,530
Aeration towers and bubbler system	LS	$ 1,017,959	1	$ 1,017,959
Additional Minor Items	LS	10%	1	$ 1,643,858
Subtotal Reservoir:				**$ 18,082,000**
MITIGATION	LS	$ 300,000	1	**$ 300,000**
SUBTOTAL - CAPITAL COSTS				**$ 19,203,907**
Contingencies	LS	16%	1	$ 3,072,625
SUBTOTAL RESERVOIR CONSTRUCTION				**$ 22,277,000**
EXCAVATION/HAULING TO LANDFILL	CY	$ 5.00	13,700,000	$ 68,500,000
TOTAL PROBABLE COST				**$ 90,777,000**

Albritton Site Reservoir – Alternative 4
Preliminary Opinion of Probable Cost

ITEM	UNIT	UNIT PRICE	QUANTITY	TOTAL AMOUNT
MOBILIZATION/DEMOBILIZATION	LS	5%		$ 1,160,543
RESERVOIR				
Earthwork				
Clearing and grubbing	AC	$ 5,280.00	797	$ 4,208,160
Stripping	CY	$ 1.21	482,185	$ 583,444
Dewatering	AC	$ 1,760.00	772	$ 1,358,720
Sediment control	LS	$ 1,040,686	1	$ 1,040,686
Fill placement for berms	CY	$ 3.00	1,311,400	$ 3,934,200
Bedding, filters, and drains	CY	$ 28.60	57,533	$ 1,645,453
Second stage drains	CY	$ 49.50	15,003	$ 742,656
Slope protection - soil cement	CY	$ 38.50	112,842	$ 4,344,400
Slope protection - lower slope	SF	$ 1.10	413,223	$ 454,545
Slurry wall	SF	$ 3.08	1,046,025	$ 3,221,758
Geomembrane liner	SF	$ 0.55	586,140	$ 322,377
Aeration towers and bubbler system	LS	$ 1,354,939	1	$ 1,354,939
Additional Minor Items	LS	10%	1	$ 2,321,134
Subtotal Reservoir:				**$ 25,532,000**
MITIGATION	LS	$ 300,000	1	**$ 300,000**
SUBTOTAL - CAPITAL COSTS				**$ 26,993,000**
Contingencies	LS	16%	1	$ 4,318,880
SUBTOTAL RESERVOIR CONSTRUCTION				**$ 31,312,000**
EXCAVATION/HAULING TO LANDFILL	CY	$ 5.00	17,838,000	$ 89,190,000
TOTAL PROBABLE COST				**$151,814,000**

Albritton Site Reservoir – Alternative 5
Preliminary Opinion of Probable Cost

ITEM	UNIT	UNIT PRICE	QUANTITY	TOTAL AMOUNT
MOBILIZATION/DEMOBILIZATION	LS	5%		$ 966,227
RESERVOIR				
Earthwork				
Clearing and grubbing	AC	$ 5,280.00	605	$ 3,194,400
Stripping	CY	$ 1.21	366,025	$ 442,890
Dewatering	AC	$ 1,760.00	580	$ 1,020,800
Sediment control	LS	$ 781,863	1	$ 781,863
Fill placement for berms	CY	$ 3.00	1,311,800	$ 3,395,400
Bedding, filters, and drains	CY	$ 28.60	50,779	$ 1,452,277
Second stage drains	CY	$ 49.50	13,242	$ 655,469
Slope protection - soil cement	CY	$ 38.50	99,594	$ 3,834,396
Slope protection - lower slope	SF	$ 1.10	364,710	$ 401,182
Slurry wall	SF	$ 3.08	923,222	$ 2,843,525
Geomembrane liner	SF	$ 0.55	517,328	$ 284,530
Aeration towers and bubbler system	LS	$ 1,017,959	1	$ 1,017,959
Additional Minor Items	LS	10%	1	$ 1,932,466
Subtotal Reservoir:				**$ 21,257,000**
MITIGATION	LS	$ 300,000	1	**$ 300,000**
SUBTOTAL - CAPITAL COSTS				**$ 22,523,000**
Contingencies	LS	16%	1	$ 3,603,680
SUBTOTAL RESERVOIR CONSTRUCTION				**$ 26,127,000**
EXCAVATION/HAULING TO LANDFILL	CY	$ 5.00	12,900,000	$ 64,500,000
TOTAL PROBABLE COST				**$116,754,000**

TM 4.2.4.3 – EVALUATION OF SUBSURFACE STORAGE

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

Reducing the amount of surface water flow in the Cow Pen Canal will reduce overall freshwater discharge quantities to Dona Bay and provide an alternative raw water supply that can be used to supplement regional water supply. The key components for this new alternative water supply will be withdrawal location and diversion intake options, source water quality, storage, piping and water treatment. As part of the storage component, both above ground reservoirs and underground storage using Aquifer Storage and Recovery (ASR) are being evaluated. This Technical Memorandum (TM) focuses on ASR as a storage component while taking into consideration the impacts of the aforementioned key components of the new surface water supply. A review of the Stormwater Resource Feasibility and Site Screening Analysis prepared by ASR Systems in 2004 will be discussed as it relates to the current project. In addition, a review of the hydrogeologic framework in Sarasota County will be summarized and evaluated in regards to ASR regulatory and operational constraints. Preliminary estimates of probable cost for the ASR storage option will be presented.

2.0 ASR CLASSIFICATION AND REGULATIONS

ASR in the State of Florida is regulated by the Florida Department of Environmental Protection (FDEP) under the Underground Injection Control (UIC) program. The rules and regulations governing the permitting, construction and operation of ASR wells are primarily contained in Chapter 62-528 of the Florida Administrative Code (FAC). In addition, the Southwest Florida Water Management District (SWFWMD) is also responsible for the issuance of well construction permits for ASR well facilities and issuing water use permit (WUP's) for the source water allocation and operation of ASR wells. In some cases, the local Department of Health also is responsible for the issuance of well construction permits.

3.0 CLASS V ASR WELL

Class V, Group 7 ASR wells are designed and permitted for the subsurface storage, and later recovery, of partially treated surface water. The ASR systems primary function is to store excess surface water, in subsurface formations, during periods when it is available, and later recover that same water, from the same well, to provide an alternative water supply during periods when there are customer demands. ASR systems are essentially a cost effective subsurface storage mechanism that can be utilized to extend total production capabilities beyond the design treatment capacity of a water treatment plant.

ASR wells also require a subsurface injection zone that demonstrates hydraulic characteristics (transmissivity) capable of accepting injection rates and volume, and providing acceptable recovery rates. In the west central portion of Florida, typically recharge and recovery rates are on the order of 1 to 2 million gallons per day per ASR well, however can be higher based on the hydraulic characteristics of the targeted storage zone. The current rules allow for the injection of partially treated surface water directly into aquifers with ambient total dissolved solids (TDS) concentrations in the receiving zone are at or above 1,000 mg/L. Partial treatment requires filtration and high level disinfection. Surface water that receives treatment at a water treatment plant with an FDEP operating permit can be injected into aquifers with ambient TDS concentration less than 1,000 mg/L.

Each ASR facility will also require the construction of a comprehensive monitoring well system to monitor operations and ensure injection operations are in compliance with the rules and regulations governing injection wells as well as being in compliance with individual injection well permit stipulations. These wells monitor the storage zone at two separate locations, and selected units immediately overlying the storage zone and are monitored for water level and selected water quality parameters, which are used to evaluate injection well operations and compliance.

Recharged water quality for Class V ASR wells essentially needs to meet all Federal and State primary and secondary drinking water standards (PDWS) along with supplemental minimum water quality criteria established by FDEP. There is some regulatory relief in the form of a Water Quality Criteria Exemption (WQCE) for secondary standards, which are not health based but aesthetic in nature. This is a separate permit application and processing fee and is issued for each constituent receiving a WQCE. A WQCE is issued for each constituent and is good for the duration of the Class V operating permit (typically for a five year period). The WQCE will require renewal along with the operating permit. There is no regulatory relief for primary standards. Recharge water for ASR wells (Class V) must meet Federal and State Primary's at all times.

It should be noted that data collected from some reclaimed water ASR facilities under construction and operational testing have raised regulatory concerns and issues regarding water quality changes that occur following recharge, specifically the occurrence of arsenic in the groundwater regime. The occurrence of arsenic in groundwater is further complicated by EPA reducing the arsenic standard from 50 ppb to 10 ppb, which took effect in January of 2006. The FDEP elected to implement the new standard a year earlier, in January of 2005.

This is currently being studied by a multitude of agencies; however, the outcome is uncertain at this time as to how the regulatory agencies will deal with some of the current regulatory hurdles. Previously, FDEP issued a position paper (white paper) indicating that through extensive monitoring to ensure no migration of arsenic off site and post treatment to remove arsenic from recovered water, a facility could continue to operate while investigating arsenic generation and remedial activities. That position is no longer held by FDEP. Most recently, FDEP stated that any ASR facility (under a construction and testing permit or operational permit) that has a chronic occurrence of arsenic will be required to enter into a consent order (CO) with FDEP. The CO will not be punitive in nature but will establish a plan and timeline to address the arsenic generation and bring the facility back into compliance.

It should be noted that each reclaimed water ASR facility is reviewed on a case by case basis. In some cases, additional monitor wells are required to observe and monitor water quality changes in the formation as a result of ASR operations. There are some ASR facilities that do not have water quality issues. A pilot study has been proposed for the removal of DO at a potable water ASR facility in Manatee County. Funding has been requested and is currently being considered by the SWFWMD. However; as of December 2006 no funding has been allocated. Other operational approaches, such as Targeted Storage Volume (TSV), are also being considered to address arsenic generation. The TSV approach is currently being reviewed and discussed in Tallahassee by FDEP to determine if this is a viable operational approach in dealing with arsenic.

4.0 PERMITTING

The FDEP is the lead permitting agency for Class V injection wells although SWFWMD issues some well construction permits and requires water use permits for ASR wells (Class V). The time required for permitting varies greatly depending on Districts, project location, available supporting data and type of injection facility (surface water, groundwater or reclaimed water). In some cases, the FDEP may require a feasibility study or an exploratory drilling program, prior to any permitting efforts, especially in those areas where insufficient hydrogeologic data exists or in areas where FDEP may have some environmental or regulatory concerns. This could lengthen the permitting process and subsequently the overall project duration.

Normally 6 to 12 months are required to complete the permitting process to secure a well construction and testing permit which allows for the construction and testing of the ASR facility. The construction permit is issued for a five year period during which the facilities are constructed and cycle tested under FDEP-approved operational cycle testing scenarios. An ASR operating permit is issued following successful demonstration of cycle testing which typically encompasses 4 to 5 separate recharge and recovery events over a two year period. The permitting sequence for the construction permit typically follows the sequence below and encompasses the entire 5 year permit window:

- Pre-application meeting to solicit input from the regulatory agencies for incorporation into the permit application package
- Preparation of the permit application package, supporting documentation and application process fee (application fee for Class V--$750.00)
- Issuance and response to Requests for Additional Information (RAI’s) issued by FDEP to address questions or concerns.
- FDEP issues a notice of draft permit (requires publication)
- FDEP issues a notice of intent to issue a construction and testing permit and a notice of a public hearing to address the permit (requires publication)
- FDEP issues a construction and testing permit along with all of the permit conditions and stipulations
- Final design completed on the ASR facility, technical specification and bidding package prepared and issued for bid
- Construction and testing of the ASR well facility under taken and completed.
- Engineering report prepared summarizing construction and testing completed on the wells and proposed cycle testing plan. Engineering report submitted to FDEP for approval
- Cycle testing initiated following approval of the engineering report. Cycle testing of the ASR well system can be conducted for a period of two or more years (but not beyond the construction permit duration without applying for another construction and testing permit).

- Cycle testing report completed summarizing all testing activities, analysis and providing appropriate recommendations. This report is submitted as part of the operating permit application package.
- In conjunction with an operating permit obtained from FDEP, a water use permit will be required in order to allow withdrawal of the source water and to monitor for environmental impacts caused by groundwater pumping during ASR recovery.

The sequence described above encompasses a 5 year period and does not take into consideration possible public or private opposition to the project. In the event that opposition is encountered during the initial permitting process, permitting and/or project completion could be delayed from months to years depending on the degree of opposition and if an administrative hearing is conducted.

5.0 HYDROGEOLOGIC FRAMEWORK

The hydrogeologic system in Sarasota County consists of a thick sequence of carbonate rocks overlain by clastic deposits. Beds of carbonate rock units dip to the south and thicken to the southwest. Freshwater bearing units are approximately 2,000 feet thick in the eastern portion of the County. Below 2,000 feet, evaporites occur which restrict groundwater flow resulting in degraded groundwater quality. In areas approaching the coastline (western portion of the County), the bottom extent of freshwater occurs at shallower depths due to saltwater intrusion resulting from lateral and vertical groundwater movement.

Permeable formations that comprise the fresh-water bearing units within the hydrogeologic framework in Sarasota County in descending order are the surficial deposits, Hawthorn Formation, Tampa Limestone, Suwannee Limestone, Ocala Limestone, and the Avon Park Formation (SWFWMD, GWRAI, 1988). Groundwater in Sarasota County is obtained from the Surficial Aquifer System, the Intermediate Aquifer System, and the Floridan Aquifer System. The Surficial Aquifer System is composed of sand, phosphorite, and undifferentiated deposits and is mainly used for lawn irrigation and livestock watering. Individual well yields from the Surficial Aquifer are less than 50 gallons per minute which is not sufficient to pursue as a storage zone for ASR. The Intermediate Aquifer System lies below the Surficial Aquifer and consists of discontinuous sand, gravel, shell and limestone, and dolomite beds. Three separate water permeable zones, PZ-1, PZ-2, and PZ-3 occur in the Intermediate Aquifer System. Groundwater from the Intermediate Aquifer System is generally potable, but TDS concentrations increase in the western parts of the County. The permeability of PZ-3 may be sufficient to sustain an operating ASR well; however, PZ-3 has not been utilized for ASR in west-central Florida primarily due to heavy competition of other PZ-3 irrigation wells, water quality concerns related to Arsenic generation and public perception.

The Floridan Aquifer System (FAS) is the most productive aquifer in Sarasota County and includes carbonates below the Intermediate Aquifer System. The FAS is divided into upper and lower permeable units separated by a middle confining unit. The Upper Floridan Aquifer (UFA) is used for water supply. In Sarasota County, the top of the UFA generally occurs at the top of the Suwannee Limestone and extends through the Ocala Limestone and Avon Park Formation. TDS and sulfate generally exceed potable use limits in the UFA throughout the entire County; however, can be treated to drinking water standards and/or agricultural irrigation standards. Within the study area, TDS concentrations are typically between 1,000 and 10,000 mg/L in the Suwannee Limestone and Ocala Limestone. The Avon Park Formation contains TDS concentrations that exceed 10,000 mg/L and even approach sea water quality in coastal areas. Due to the very high hydraulic permeability and TDS concentrations encountered, which would likely result in low recovery efficiencies of ASR wells, the Avon Park Formation has not been actively pursued for ASR well development. The Ocala Limestone typically has low permeability, which has also limited ASR well development of this unit throughout west-central Florida. The Suwannee Limestone typically has the proper combination of hydraulic permeability and ambient groundwater quality that can sustain a 1 to 2 mgd ASR well with recovery efficiencies greater than 70%. An ASR test well was recently constructed into the Suwannee Limestone at the Sarasota County Central Water Reclamation Facility located several miles west of the CPSC. Hydrogeologic data from this ASR test well indicates that the Suwannee Limestone can sustain a flow rate of approximately 2 mgd with ambient groundwater quality of approximately 2,000 mg/L TDS.

6.0 WITHDRAWAL LOCATIONS & DIVERSION INTAKE OPTIONS

As part of the Stormwater Resource Feasibility and Site Screening Analysis Study (Site Screening Study), four sites (Fox Creek, Albritton, Myakka and Pinelands) were identified from which up to 20 to 25 mgd freshwater could be diverted. As part of the current study, the focus of surface water diversion was further limited to the CPC, which further limited the study area to two diversion/storage sites: Fox Creek and Albritton (northward extension of the Pinelands site). According to a review of flow data presented in the Site Screening Study, there was 25 mgd of surface water available for diversion at the Fox Creek site for at least 102 days and 20 mgd at the Albritton site for at least 97 days. Based on our review of flow data, both sites have sufficient quantities of surface water available to sustain a surface water ASR system of at least 10 ASR wells. However, since some of the water upstream will be stored in the proposed surface storage reservoirs, these flow quantities may be reduced appropriately. There is sufficient land available to construct as many as 10 ASR wells apiece at both sites at a spacing of approximately 300 to 400 feet apart. Final ASR well spacing will be dependent upon results of cycle testing of the initial ASR test well and groundwater modeling if required by regulatory agencies.

The Site Screening Study identified two primary methods of surface water diversion, these being a diversion intake structure and bank filtration utilizing deep trench horizontal wells or horizontal directionally drilled wells. Large diameter and relatively shallow Ranney Wells have also been used successfully with bank filtration technology.

Selection of a particular surface water diversion method for a potential ASR site is influenced heavily by the fact that filtration and high level disinfection is a requirement of state regulations for the storage of surface water in an ASR well. Additionally, Federal and State Primary Drinking Water Standards also have to be met prior to injection at the ASR well. A discussion of specific water quality data is included in the following section.

Diversion intake structures are common throughout the United States and Florida with various design types based primarily on the quantity of water to be diverted, depth of the water body, existing flow rates in the water body and proximity of water diversion area to treatment/storage point. Intake structures may be driven by gravity flow but in most settings are associated with a pumping system, especially those systems requiring the movement of up to 25 mgd of water. Construction permitting of intake structures located on non-navigable waterways such as the CPC is less complex than intake structures on navigable waterways. The ability to withdraw water from a diversion intake structure is permitted by SWFWMD through issuance of a water use permit.

Bank filtration wells are constructed near the banks of rivers and canals at relatively shallow depths to pump and supply large amounts of surface water. The pumping action of these wells creates a pressure head difference between the canal and the shallow aquifer with the higher head at the canal ("Riverbank Filtration", 2003). The higher head of the river/canal water and lower head in the aquifer induces the canal water to flow downward through the porous sands into the pumping wells. The water from these wells is a combination of groundwater originally present in the shallow aquifer and filtered surface water from the canal. Ideally, bank filtration wells will pull >50% of water from the canal with the remaining portion contributed by groundwater. During movement of this water through the canal bed sediments, dissolved and suspended contaminants plus various pathogens are reduced or removed due to the combination of physical, chemical, and biological processes. Some European countries use this technology to augment the removal of natural organic matter (NOM), organic contaminants, and pathogenic microbes from as much as 80% of their drinking water. Outside of Europe, bank filtration systems are not widespread because surface water and groundwater of adequate quality are readily available (Environmental Science and Technology, 2002). However, recent and forthcoming changes to state and federal rules regulating drinking water supplies have made bank filtration technology a more viable alternative to conventional intake and treatment systems.

Construction and water use permitting for bank filtration wells is more complex than diversion intake structures. Due to inclusion of groundwater into the supply of diverted water, potential environmental impacts caused by the bank filtration wells will need to be addressed as part of the SWFWMD permitting and compliance process.

A detailed evaluation to determine which type of diversion intake option is feasible or would be recommended for either the Fox Creek or Albritton sites was not performed for this study, although a diversion intake structure can likely be constructed at either of the two sites for relatively the same costs (to be discussed in later section of TM). Site specific pilot testing and data evaluation is necessary to confirm the feasibility of using bank filtration or any of the horizontal or directionally drilled ASR well technology at either of the project sites.

7.0 SOURCE WATER QUALITY

As previously stated in this TM, all water stored in an ASR well must meet primary drinking water standards with some regulatory relief available for secondary drinking water standards. The Site Screening Study presented monthly water quality data from the Cow Pen Slough Water Quality Monitoring Study for the period between February and July, 2003. For this study, monthly water quality data from the CPC collected between February and December, 2003 and a single event in June 2006 were reviewed. These water samples were collected from the CPC in close proximity to the Albritton site and upstream of the Fox Creek site.

A review of all the water quality data indicates that there were no exceedances of any primary drinking water standards and therefore, no fatal flaws are identifiable in terms of the feasibility of storing CPC water underground in an ASR well. As many as four secondary drinking water standards (iron, color, odor and aluminum) were detected in water samples from multiple sampling events. Iron concentrations regularly exceeded the state standard of 0.3 mg/L and ranging up to 2.0 mg/L. Color levels also regularly exceeded the state standard of 15 color units ranging up to 400 color units with levels generally between 70 and 140 color units. Odor was detected above the state standard of 3.0 units in four samples ranging up to 40 units. Aluminum concentrations were detected above the state standard of 0.2 mg/L in 4 samples ranging up to 0.42 mg/L.

For ASR well systems, compliance with secondary drinking water standards is based on a rolling annual average, thus, aluminum is not likely to exceed the state standard limitations. Also, ambient groundwater within the Suwannee Limestone is likely to contain odor levels greater than the annual average odor level detected in the CPC and therefore, compliance with the state standard will not be required. Regulatory relief in the form of the WQCE will likely be required for iron and color.

The water quality parameters, total suspended solids (TSS) and total organic carbon (TOC) which were analyzed in the June 2006 water sample. In addition to the color analyses addressed previously, have significant implications to the treatment requirements for an ASR well system. The TSS concentration of 8.89 mg/L indicates that the design of an aboveground filtration system or a bank filtration system must be effective in lowering the TSS concentration to less than 5.0 mg/L as part of the regulatory requirement for filtration. The TOC concentration of 12.9 mg/L is consistent with surface water sources and suggests that if chlorine disinfection were to be used as part of the treatment process, disinfection byproducts such as total trihalomethanes (THMs) and haloacetic acids could be generated at levels exceeding the primary drinking water standards, which would then preclude injection into an ASR well. Color impacts the ability to provide effective ultraviolet disinfection of the source water and pilot testing of ultraviolet treatment systems is recommended to determine the disinfection system requirements.

8.0 PIPING & WATER TREATMENT

Piping systems as related to piping material types generally do not directly impact ASR feasibility determination. However, due to the high cost of piping water from one location to another, piping and associated pumping costs on both the recharge and discharge side of the ASR well do affect overall ASR project feasibility. For the purpose of comparing the Fox Creek and Albritton sites as part of this study, it is assumed that the potential ASR wells at both sites will be located in relatively close proximity (less than 2,500 feet) to the potential diversion intake along CPC. Discharge side piping size and lengths are dependent upon the ultimate location of the ASR recovered water, which has not been clearly defined for the purpose of this ASR feasibility study. Therefore, piping and pumping systems were not evaluated as part of this study.

For a diversion intake structure, typically filtration would be provided through an aboveground treatment system such as a sand filtration media or high pressure disk filters. Either system can be effective for removal of particulates so that compliance with total suspended solids (TSS) limitations can be achieved. However, sand filtration, especially deep bed filters are more effective in the removal of pathogens and viruses which is becoming a more prominent issue in treatment system considerations. The primary options for high level disinfection of surface water for ASR well systems include chlorination, chloramination, ultraviolet radiation, and ozonation. Each disinfection system option is not without drawbacks that would make it exclusively preferable to the other listed disinfection systems when an ASR well system is involved. A detailed analysis of the potential treatment system options is beyond the scope of this limited ASR feasibility study, however, a brief synopsis of various pros and cons of each disinfection system is provided hereafter:

Chlorination – Use of a chlorination system tied directly to a conventional diversion intake structure and filtration system is not likely to be feasible based on the existing CPC water quality and the likely generation of disinfection by products. If bank filtration were utilized for source water supply and filtration, reduction in TOC may allow use of chlorine disinfection without generating levels of disinfection by products that would prohibit injection at an ASR well.

Chloramination – Is similar to a chlorination treatment system in design except uses the addition of ammonia to suppress the formation of disinfection by products. It is more labor intensive and costly than standard chlorine treatment systems and may not be as effective in the treatment of pathogens and viruses.

Ultraviolet Radiation – Is increasingly being used to provide disinfection at facilities ranging from large scale treatment plants down to inline treatment at individual ASR wellheads because disinfection by products are not generated. High color concentrations as those found in CPC can affect ultraviolet radiation system efficiency and ultimately costs. If bank filtration were utilized for source water supply and filtration, reduction in color may increase effectiveness of the ultraviolet radiation system and lower treatment costs.

Ozonation – A treatment process that uses ozone gas produced by subjecting oxygen molecules to electrical current in order to inactivate pathogens and naturally occurring bacteria. Disinfection by products such as THMs and haloacetic acids are not formed by this treatment process but the treated water stream contains elevated dissolved oxygen concentrations. Dissolved oxygen levels are suspected of causing water quality and geochemical changes in the storage zone of an ASR well, which may lead to further treatment and also regulatory compliance issues.

In addition to being a surface water diversion intake option, bank filtration offers the potential of meeting the state filtration requirements for surface water recharged to an ASR well. Bank filtration, as mentioned previously, can substantially improve source water quality that can make all of the above disinfection systems more effective and less costly. The effectiveness of a bank filtration system at either of the two potential ASR well sites needs to be verified through a comprehensive pilot testing program.

9.0 ESTIMATED ASR COSTS

For this study, a probable cost estimate for implementing the storage option of a surface water supply ASR well system has been prepared that is applicable to both the Fox Creek and Albritton sites. This cost estimate is tied specifically to the permitting of the ASR well system, well construction and ASR cycle testing and includes both engineering and construction costs. Costs related to the surface water diversion intake system, conveyance piping and aboveground pumping, water treatment systems and water use permitting are outside the scope of this study and not addressed in this TM.

Based on the evaluation performed as part of this study, a conceptual ASR well system has been developed consisting of a 17.5-inch (outer diameter) ASR well cased to the top of the Suwannee Limestone with approximately 100 feet of open borehole, two storage zone monitor wells that are 6-inches in diameter with casing and borehole depths similar to the ASR well and an upper zone monitor well with 6-inch casing completed into PZ-3 of the Intermediate Aquifer System. It is expected that a single ASR well completed into the Suwannee Limestone will accept and yield up to 2 mgd and that as many as 10 wells may be necessary to capture and store up to 20 mgd. The cost estimate is detailed in the table below with a breakdown of various tasks for completing one ASR well system and also for completing the remaining 9 ASR wells:

TASK	Cost for 1 ASR Well	Cost for 9 ASR Well
FDEP Construction/Testing Permit	$75,000	$100,000
Well Drilling	$1,200,000	$8,500,000
Wellhead Infrastructure	$800,000	$5,400,000
ASR Cycle Testing	$200,000	$400,000
ASR Operational Permit	$100,000	$200,000
Totals	**$2,375,000**	**$14,600,000**

Table 1

Note: Costs for the 9 ASR wells are based on a single permitting/construction effort which provides for economy of cost savings.

10.0 SUMMARY AND RECOMMENDATIONS

The following provides a summary of findings based on the available information reviewed to date. The findings are predicated on the current rules and regulations in place governing Class V ASR wells and are applicable to both sites

Findings

- The Suwannee Limestone of the UFA contains suitable transmissivity, storage capacity and confinement for ASR operations.
- Water quality in the Suwannee Limestone of the UFA is conducive to the permitting, construction and operational testing of an ASR system.
- There are current regulatory issues that may arise with the installation and testing of a Class V ASR well that could prevent the ASR facility from obtaining an operating permit in the future.
- The estimated probable cost for a 2 mgd ASR well system completed into the Suwannee Limestone is $2.375 million.

Recommendations

- The County should proceed with a preliminary design study for the surface water diversion intake system, treatment system and conveyance piping systems that should include pilot testing as is applicable for the selected site.

TM 4.2.5 - DETERMINATION OF SURFACE WATER TREATMENT PLANT LOCATION

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

Pursuant to Task 4.2.5 of the DBWMP contract, PBS&J has prepared this technical memorandum to present a comparison of possible water treatment plant locations. Specifically, the 3 locations considered include in the vicinity of the planned water storage reservoirs (Albritton borrow site and the Venice Minerals site) as well as the existing Carlton water treatment plant site.

2.0 WATER TREATMENT PLANT ALTERNATIVE LOCATIONS

Two large, publicly owned areas within the Dona Bay Watershed are currently being excavated. The Venice Minerals site is a sand and shell mining operation that was purchased by Sarasota County and leased back to Venice Minerals and Mining. Excavation by the lessee is expected to be completed in the next 2 to 3 years. The Albritton site was purchase by Sarasota County for cover material for their adjacent landfill operation. Excavation of this site was initiated in the past year and could continue for some time. Both sites provide opportunities to store excess surface water from the Cow Pen Canal to achieve the Dona Bay watershed objectives. Both of the excavations could be completed to form reservoirs for source water storage that could be subsequently treated to provide a potable water supply.

Since mining of the Venice Minerals site will be complete within a few years, it will likely be the first phase of development of the reservoir system. Water will be transported across the Albritton site through a surface channel into the existing borrow pits on the landfill site and may flow through an underground pipe to connect to the reservoir at the Venice Minerals site. Figure 1 shows the locations of the potential reservoir sites.

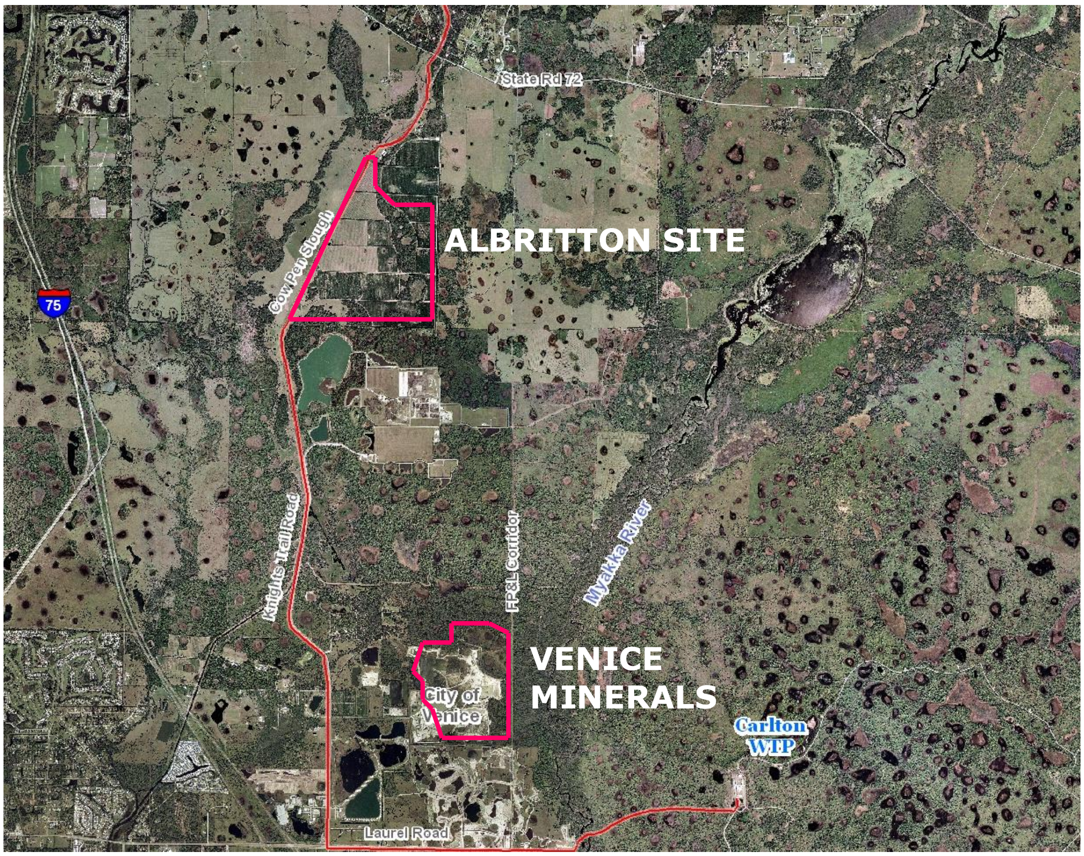

Figure 1 – Potential Reservoir Sites

Figure 2 shows the boundary of the property owned by Sarasota County at the Venice Mineral site. The excavation of the borrow pit will occupy almost all of the county-owned area, and there is not sufficient land available for construction of a new water plant. The purchase of additional property would be required, and the most favorable location would be southwest of the existing property on land currently occupied by the processing equipment for the borrow pit. This area is still owned by Venice Minerals and Mining and is located within the incorporated limits of the City of Venice.

Figure 2 – Venice Minerals Site

As previously indicated, the Albritton site was purchased to provide cover material for the adjacent landfill at the Central County Solid Waste Disposal Complex (CCSWDC). Excavation of the Albritton site has begun to provide the cover material needed on an annual basis and is planned to occur over the remainder of the life of the landfill. Excavation of the material could be accelerated and the material could be stored on the landfill to create a reservoir at an earlier date. Figure 3 shows the Albritton property and the surrounding area. The most efficient locations for a water treatment plant would be at the north end or at the south end of the site. The southwest corner of the property is preferable because it requires the least access road construction and is near a planned connection of the regional water transmission main and a planned County water transmission main extended from Preymore Street.

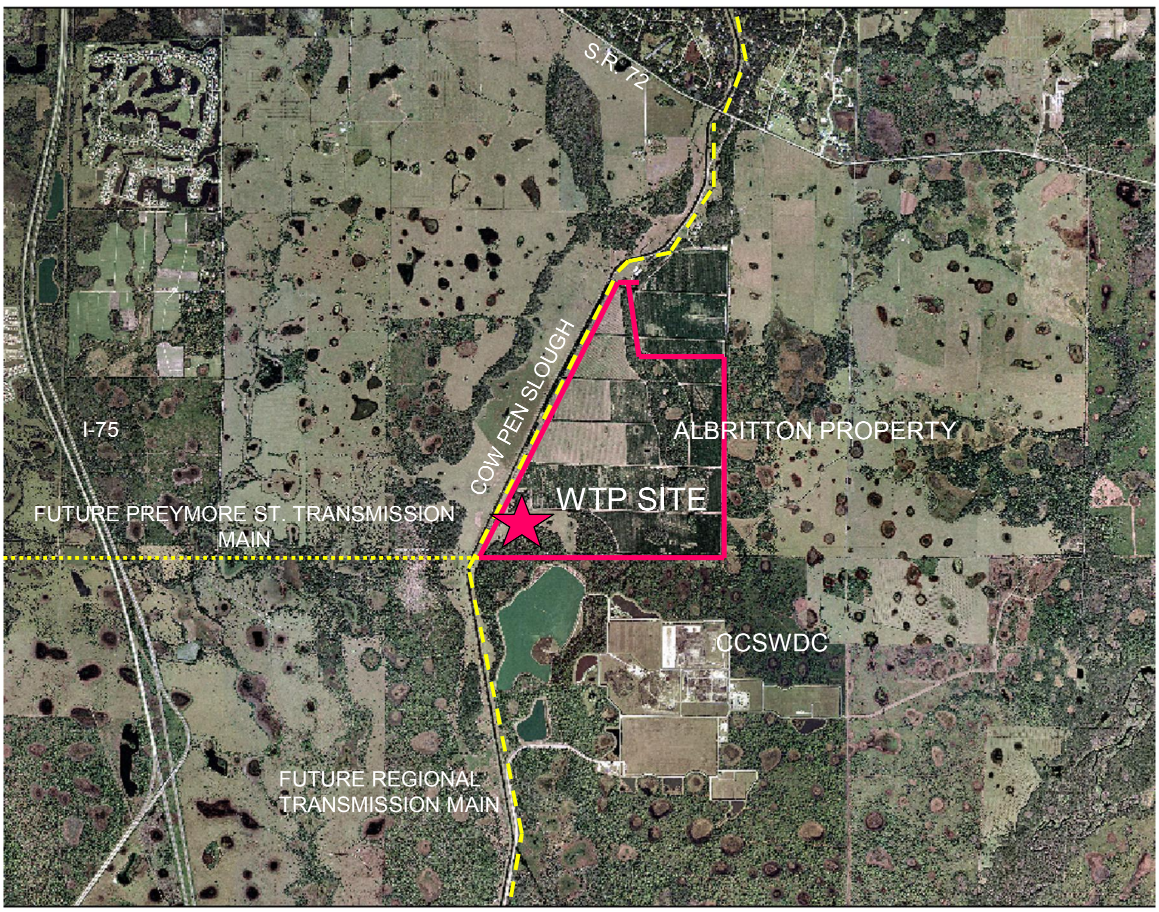

Figure 3 – Albritton Property

Construction of a water treatment plant at either of the borrow pit sites would place the facility near the source of water. A third possible site for a new water treatment plant is the existing Carlton Water Treatment Plant. This location offers a number of advantages, but would require the construction of a raw water main from the Venice Minerals site to the treatment plant (see Figure 4). Figure 4 shows the route of raw water across the Albritton site into the existing borrow pits and an underground pipe to connect to the Venice Minerals reservoir.

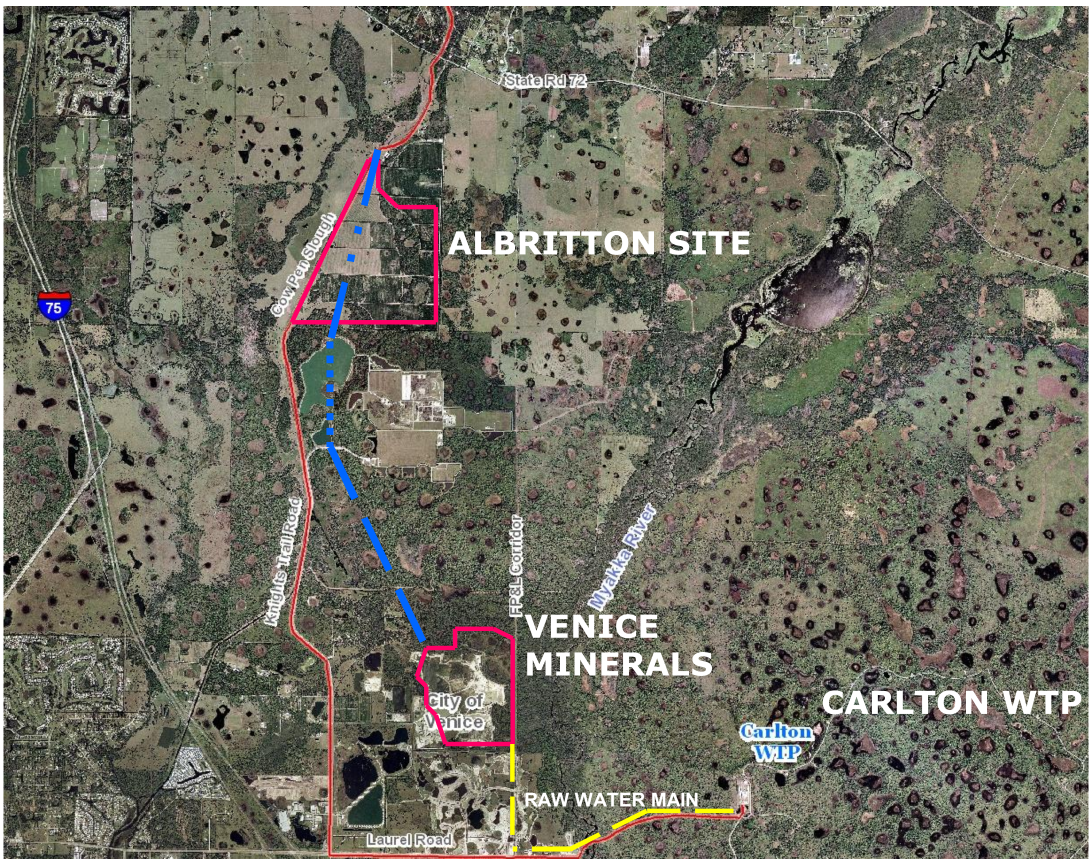

Figure 4 – Carlton WTP

Although most of the costs for construction of a water treatment plant generally will be the same for any of the three locations, there are items that will be specific to each location. The additional costs for the three locations are:

<u>Albritton Site</u>

This site does not have existing vehicular access. The probable cost for an access road to the site from Knights Trail Road is $4,888,000. The finished water from a treatment plant at this location could be pumped into the regional water transmission main that is planned to be adjacent to the site or into a County water transmission main planned to be constructed in an extension of Preymore Street.

Venice Minerals Site

The existing property owned by Sarasota County at the Venice Minerals site does not have vacant property that could be used for construction of a water treatment plant. The probable cost for 30 acres of additional property located to the southwest of the reservoir site, within the City of Venice, is $3,600,000, based upon an estimated value of $120,000/acre. The probable cost for a finished water main that would connect to the future regional water transmission main in Knights Trail Road is $655,000. If a connection to the existing County water transmission is required, a 24-inch pipe would be constructed to connect to the existing main in Laurel Road. The probable cost for a connection at Laurel Road is $1,747,200.

Carlton WTP

The probable cost for a 24-inch raw water main from the Venice Minerals site to the Carlton WTP is $3,400,000 including a crossing of the Myakka River.

3.0 CONCLUSIONS

The Carlton facility has the lowest probable cost for site specific features. In addition, construction of the new treatment plant adjacent to the Carlton facility offers the following advantages and is recommended:

- Water from the Peace River Water Authority is blended at the Carlton WTP with water produced at the site. Blending of water from a third source could be handled more effectively at the treatment plant.
- Coordination of treatment operations and high service pumping would be facilitated.
- Water could be pumped into the regional system to go north or south or could be pumped into the County's transmission system.
- Fewer additional operators likely would be needed.
- Security at the Carlton WTP is already in place.

TABLE 1 – ALTERNATIVE TREATMENT PLANT SITE LOCATIONS

	ALBRITTON SITE	VENICE MINERALS SITE	CARLTON WTP SITE
Coordination with phasing of development of reservoir system	• This location would be acceptable if it is the first phase of the reservoir	• This location would be acceptable if it is the first phase of the reservoir	• Could work with either phase • Raw water main required from reservoir • Shorter raw water line from Venice Minerals
Proximity to the water source	• Adjacent	• Adjacent	• Distance of 3.5 miles to the Venice Minerals site
Proximity to the planned regional water transmission system	• Adjacent • Near the planned connection to a Sarasota County transmission main in Preymore Street	• Distance 0.7 miles	• Adjacent
Proximity to the Sarasota County water transmission system	• Distance 5.4 miles to Laurel Road • Near the planned Preymore Street connection to the regional system	• Distance 2.0 miles to Laurel Road	• Adjacent
Power availability	• New service required	• Existing	• Existing
Vehicular access	• New access road required 1.3 miles	• Existing	• Existing
Available County-Owned property	• Existing	• Additional property required	• Existing
Staff requirements	• 24 hrs/7 days for capacity of 5.0 mgd or greater. Class A lead operator, Class C staff	• 24 hrs/7 days for capacity of 5.0 mgd or greater. Class A lead operator, Class C staff	• Existing staff could share responsibilities • Additional operators required
Coordination of operations with the Sarasota County water system and the regional water system	• Adds an additional facility to be operated and coordinated with the systems • Coordination of pumping, blending, timing of operations, etc. required	• Adds an additional facility to be operated and coordinated with the systems • Coordination of pumping, blending, timing of operations, etc. required	• Existing facilities are already a part of the systems • Provides capability of blending potable water from three sources
Coordination with planned modifications of the Carlton WTP	• Pumping and hydraulics • Chemical additions, disinfection, and corrosion control	• Pumping and hydraulics • Chemical additions, disinfection, and corrosion control	• The Dona Bay water source could be incorporated into the design of the modified Carlton process
Probable costs for site specific items	• Access Road - $4.9 million	• Property - $3,600,000 • Potable water main - $655,000	• Raw water main - $3.4 million

TM 4.2.7 – DEVELOPMENT OF PHASING PLAN

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by KHA to present a preliminary phasing plan to provide a logical implementation sequence for the Dona Bay comprehensive watershed management program elements, consistent with Task 4.2.7 of the DBWMP contract.

2.0 DESCRIPTION OF PROGRAM ELEMENTS

SCG in coordination with the SWFWMD, CHNEP, and the Peace River Manasota Regional Water Supply Authority (Authority) has embarked on the implementation of a comprehensive watershed management program for Dona Bay. As part of this program, SCG has acquired numerous sites that are strategically located for water resources and watershed management. SCG has also contracted with KHA and a team of subconsultants to evaluate alternatives and develop a program to restore natural system functions in Dona Bay and its watershed while protecting or improving water quality, maintaining or improving existing flood protection, and to the extent that it supports these program goals, develop alternative surface water sources for beneficial uses.

Key to the Dona Bay comprehensive watershed management program is the recognition that the volume of freshwater flow to the Dona Bay estuary has been dramatically altered by the diversion of approximately 37,453 acres from the Myakka River watershed with the construction of the Cow Pen Canal. Therefore, two effective management strategies include the restoration of watershed storage and the recycling of the excess surface water that could be stored in the strategic sites located in the watershed and owned by SCG. Additional opportunities exist on private properties that could be investigated as future public-private partnerships in watershed management. Based upon preliminary evaluations and an inventory of opportunities within the watershed, the a phasing plan has been developed that considers the incremental and gradual timing of restoration of the Dona Bay water budget and the estimated future demand for regional water supply. **Table 1** inventories the various potential program elements. **Figure 1** provides a map of the watershed which identifies the various potential program elements.

Element ID	Potential Site	Restoration	Preservation	Ownership
1	Fox Creek Site	X		SCG
2	West Pinelands	X		SCG
3	Venice Minerals	X		SCG
4	Pinelands Pits	X		SCG
5	Albritton Site	X		SCG
6	Gum Slough		X	SCG
7	LT Ranch Pasture	X		Private
8	Hi-Hat Old Grove	X		Private
9	Hi-Hat Floodplain		X	Private

Table 1 – Potential Dona Bay Watershed Management Program Elements

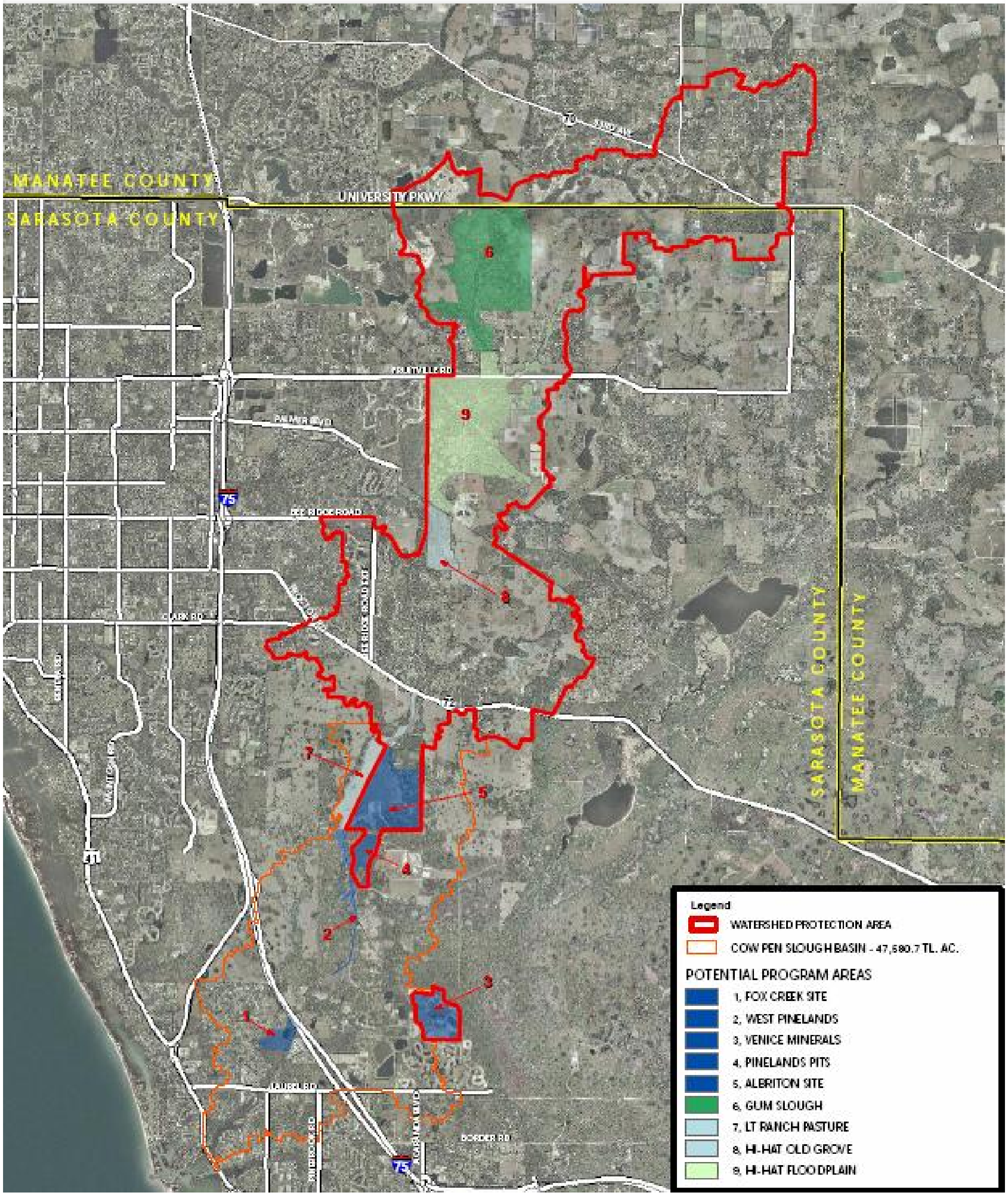

Figure 1 – Potential Watershed Management Sites

3.0 PHASE 1 CONFIGURATION

The initial phase of the Dona Bay Comprehensive Watershed Management program includes several elements that will initiate the restoration of the Dona Bay water budget, by increasing the watershed hydroperiod and storage capacity as well as enhancing water retention and stormwater attenuation. In the process, the volume of excess freshwater flow to Dona Bay will be reduced while providing wetland re-hydration and reservoir storage for approximately 5 mgd of alternative surface water supply. In addition, the timing of excess freshwater flows will be more naturally lagged by the diversion to the historical slough flow path. Pursuant to Technical Memorandum 4.2.2, this phase is estimated to reduce the excess freshwater currently being discharged from the Cow Pen Canal to Shakett Creek and Dona Bay by 14%. This initial phase will include comprehensive watershed program elements 2, 3, 4, and to some extent, 5. Specifically, the following program elements are proposed as part of the initial phase:

3.1 Element 2 – West Pinelands

This program element proposes to re-hydrate the historical cow pen slough corridor located adjacent to the canal within the public lands of the Pinelands reserve. This could be accomplished in a number of ways including raising the water level in the canal (not practical), lowering the historical slough corridor (costly), or recycling surface water from the canal to the historical slough corridor with pumping. Therefore, re-hydration of the west pinelands slough is proposed by using solar powered pump(s) to pump water from the adjacent Cow Pen Canal.

3.2 Element 3 – Venice Minerals

This program element proposes the completion of mining activities at Venice Minerals and the construction of perimeter ±15'high berms around the excavated borrow pit to create a reservoir for storage of excess freshwater flow from the Cow Pen Canal, as proposed under Alternative 2 of Technical Memorandum 4.2.4.1.

3.3 Element 4 – Pinelands Pits

This program element proposes (1) the construction of approximately 13,000 linear feet of 72" diameter (or hydraulic equivalent) gravity pipe from the southerly Pinelands borrow pit to Venice Minerals, (2) connection of the southern Pinelands borrow pit to the northern Pinelands borrow pit, and (3) connection of the northern Pinelands borrow pit to the southern property line of the Albritton tract to provide a system to transport water from the Albritton site to the reservoir created at the Venice Minerals site. However, the installation of a valve box or operable sluice gate between the Albritton site and the northern Pinelands borrow pit is also proposed to allow the hydrologic isolation during wet season and flood conditions when water levels in the Albritton site exceed elevation 18.0 ngvd. In addition, a grate box at an elevation of approximately 15.5 ngvd is proposed at the downstream end of the gravity pipe in the Venice Minerals reservoir to prevent the Pinelands pits from receding below 15.5. If determined at the design stage, it may also be advantageous to augment the Venice Minerals reservoir up to elevation 15.5 with a second gravity pipe (not shown) from the existing south Pinelands restoration area. The existing south Pinelands restoration area may in turn be enhanced by overflows from the Pinelands pits. The exact configuration can be finalized at the design stage.

3.4 Element 5 – Albritton Site

Element 5 includes the excavation of a ± 500 ft. wide waterway (with a 5 ft. minimum permanent pool depth) along the west side of the Albritton tract between the northwest portion of the site and the southern portion of the site, where it would tie into the northern Pinelands borrow pit. It is also proposed that the upper Cow Pen Canal water control structure, located at the northwest corner of the Albritton tract, would be reconfigured/reconstructed to have operable gates on both sides as well as the main canal gates (as is currently the case). The east side gates would allow the diversion of low and moderate flows into the Albritton tract while the main gates would serve as an emergency spillway to the downstream Cow Pen Canal. In the event that a future phase includes a private partnership with the LT Ranch, it is recommended that gates also be constructed but not operated on the west side of the reconfigured/constructed control structure and that an equalizer culvert be constructed beneath and parallel to the control structure spillway. The invert on the side gates when open would be at or below elevation 14.0 ngvd. The gates and spillway on the face of the reconfigured/reconstructed structure would allow for flows to discharge to the Cow Pen Canal when the Albritton or the LT Ranch Pasture sites were full.

To assure no adverse increase in flood stages on private properties adjacent to the Albritton site, the Phase 2 re-hydration area shown in the southeast portion of the Albritton site and perimeter berms may also be warranted in this initial phase. This can be determined and finalized at the design phase.

3.5 Alternative Water Supply Element

This water supply element would include construction of a surface water treatment plant at the existing Carlton Water Treatment Plant site as well as a pump station and 24-inch pressure pipe from the reservoir system to the treatment plant.

Using the long-term Cow Pen Canal flow data transferred from the Myakka River gage, monthly water budgets and routing analyses were performed for the Phase 1 configuration as presented in Technical Memorandum 4.2.2. As indicated in **Table 2**, the Phase 1 configuration is estimated to result in a yield between 5 mgd and 7 mgd with reliabilities between 100% and 98.4%, respectively. Reliability was determined as the estimated percentage of the time that the reservoir will be able to provide the specified yield.

Phase 1 - Yield	Reliability
5 mgd	100 %
6 mgd	99.3 %
7 mgd	98.4 %

Table 2 – Phase 1 Configuration, Estimated Yields and Reliability

Based upon the estimated 2 to 3 year completion date of the Venice Minerals excavation operations, it is estimated that the Phase 1 configurations could be completed as early as

2012, although it may not be needed until as late as 2025. The preliminary opinion of probable cost for the program elements in Phase 1 is estimated at $75,000,000. **Figure 2** provides a conceptual schematic of the phase 1 configuration.

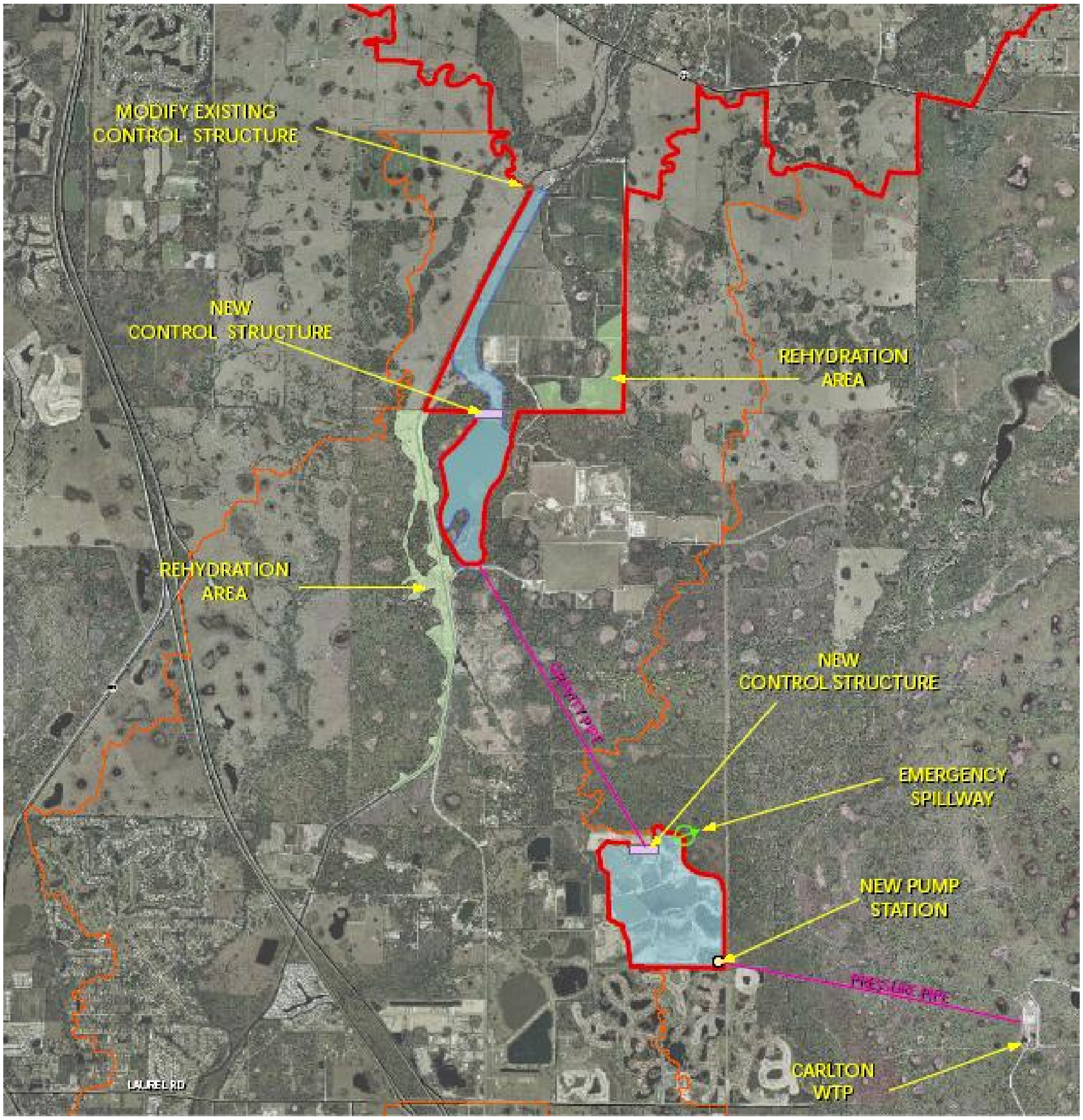

Figure 2 – Dona Bay Watershed Management Program, Phase 1 Configuration

4.0 PHASE 2 CONFIGURATION

The phase 2 configuration of the Dona Bay Comprehensive Watershed Management program will establish the framework for this and subsequent phases. This phase will further restore the Dona Bay water budget, by increasing the watershed hydroperiod and storage capacity as well as by enhancing water retention and stormwater attenuation. In the process, the volume of excess freshwater volume to Dona Bay will be reduced while providing wetland re-hydration and reservoir storage for an additional 5 mgd of alternative surface water supply. When combined with the program elements in the phase 1 configuration, this would provide a total of approximately 10 mgd of alternative surface water supply. In addition, the timing of freshwater flows will continue to be more naturally lagged by the creation of additional storage within the historical slough flow path. Pursuant to Technical Memorandum 4.2.2, this phase when combined with phase 1 configuration is estimated to result in a 28% reduction of the excess freshwater currently being discharged from the Cow Pen Canal to Shakett Creek and Dona Bay.

The phase 2 configuration will essentially include the ultimate excavation of the Albritton site (i.e. comprehensive watershed program element 5). Specifically, the following program elements are proposed as part of the phase 2 configuration:

4.1 Element 5 – Albritton Site

This program element proposes the completion of excavation activities at the Albritton site and construction of a 25' high perimeter berm around the resulting reservoir, presented as Alternative 3 in Technical Memorandum 4.2.4.2. Incidental to the construction of the berm should be the installation of the necessary conduit to accommodate a subsequent pump intake pipe proposed in Phase 3.

4.2 Alternative Water Supply Element

This program element proposes the expansion of the surface water treatment plant, presumably at the Cartlon Water Plant site as presented in Technical Memorandum 4.2.5.

Using the long-term Cow Pen Canal flow data transferred from the Myakka River gage, monthly water budgets and routing analyses were performed for Alternative 2 of the Venice Minerals site and Alternative 3 of the Albritton site. As indicated in **Table 3,** the program elements associated with the phase 2 configuration (inclusive of the phase 1 configuration) are estimated to result in a yield between 10 mgd and 14 mgd with reliabilities between 99.2% and 94.9%, respectively. Reliability was determined as the estimated percentage of the time that the reservoir will be able to provide the specified yield.

Phase 2 (inclusive of Phase 1) - Cumulative Yield	Reliability
10 mgd	99.2 %
11 mgd	98.7 %
12 mgd	97.7 %
13 mgd	96.4 %
14 mgd	94.9 %

Table 3 – Phase 2 Configuration, Estimated Yields and Reliability

Based upon meeting the medium to long range fill cover needs for the Central County Waste Disposal Complex (CCWDC), the second phase could be completed in the 2030 to

2035 timeframe. The preliminary opinion of probable cost for the program elements in the phase 2 configuration is estimated at $67,000,000. **Figure 3** provides a conceptual schematic of the phase 2 configuration.

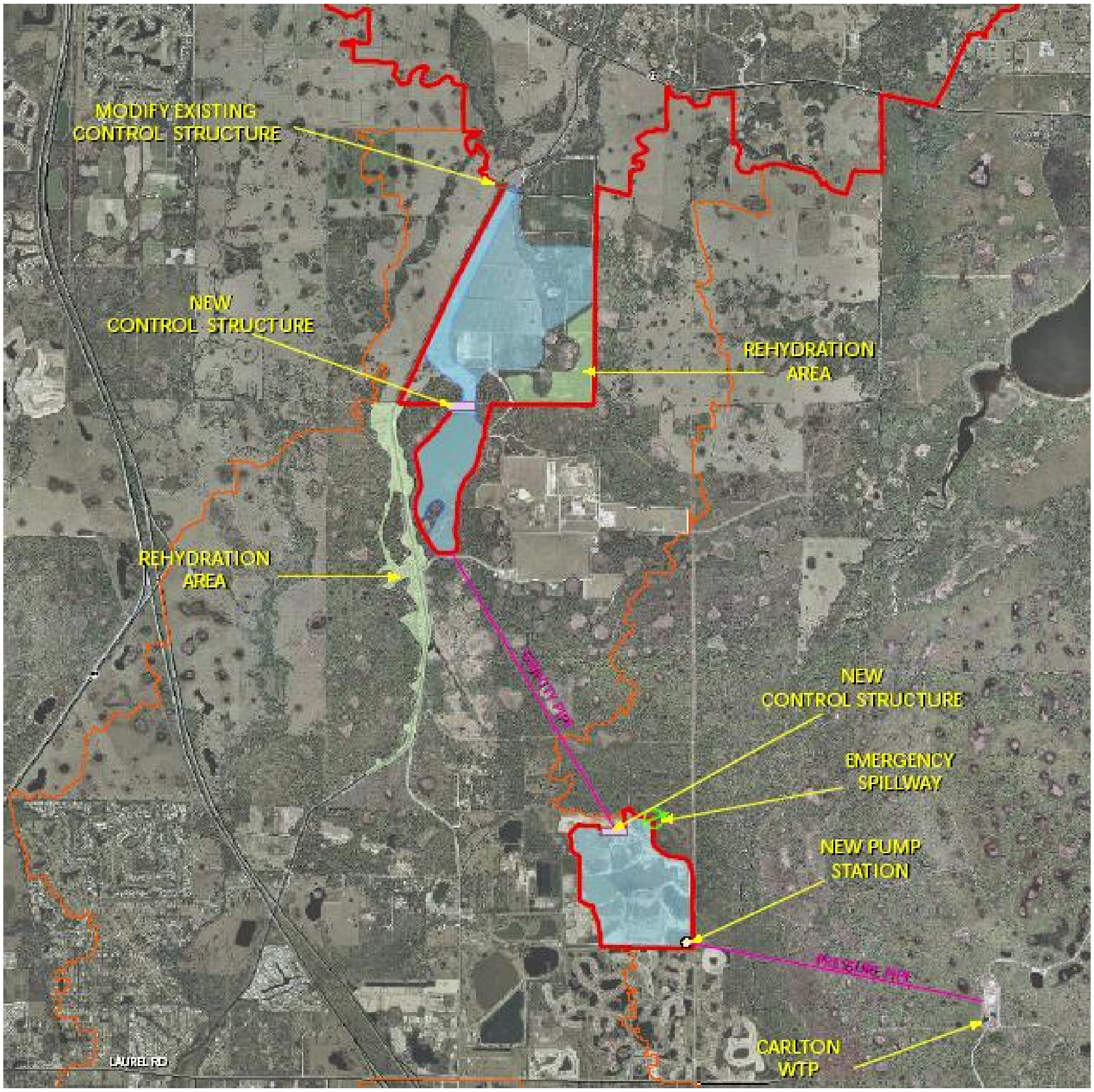

Figure 3 – Dona Bay Watershed Management Program, Phase 2 Configuration

5.0 PHASE 3 CONFIGURATION

The phase 3 configuration of the Dona Bay Comprehensive Watershed Management program would include utilizing the Albritton site for additional storage. While the first two phases rely upon gravity to fill and operate the reservoir storage, the phase 3 configuration would require a pump station located in the Cow Pen Canal, upstream or downstream of the upper control structure to obtain an additional 10 feet of vertical operating range above grade. Activities completed in the phase 1 configuration to hydraulically isolate the Albritton tract and in the second stage to build the perimeter berm to a height of 25 feet will facilitate the implementation of the phase 3 configuration. This subsequent phase will further restore the Dona Bay water budget, by increasing the watershed hydroperiod and storage capacity as well as enhancing water retention. Pursuant to Technical Memorandum 4.2.2, the phase 3 configuration (inclusive of phases 1 and 2) is estimated to result in a total reduction of 41% of the excess freshwater currently being discharged from the Cow Pen Canal to Shakett Creek and Dona Bay. However, it could result in a reduction of some of the storm attenuation gained through the first two phases.

In addition to reducing the volume of excess freshwater volume to Dona Bay, the phase 3 configuration would provide for an additional 5 mgd of alternative surface water supply. The phase 3 configuration, when combined with the phase 1 and 2 configuration, would provide a total of approximately 15 mgd of alternative surface water supply. Program elements included in the phase 3 configuration include the construction of a surface water pumping station in the adjacent Cow Pen Canal, as briefly described below:

5.1 Element 5 – Albritton Site

This program element proposes the construction of a surface water intake in the adjacent Cow Pen Canal and a pressure pipe to the Albritton site.

5.2 Alternative Water Supply Element

This program element proposes the expansion of the surface water treatment plant, presumably at the Cartlon Water Plant site as presented in Technical Memorandum 4.2.5.

Using the long-term Cow Pen Canal flow data transferred from the Myakka River gage, monthly water budgets and routing analyses were performed for Alternative 2 of the Venice Minerals site (refer to Technical Memorandum 4.2.4.1) and Alternative 5 of the Albritton site (refer to Technical Memorandum 4.2.4.2). As indicated in **Table 4**, the phase 3 configuration (inclusive of phase 1 and phase 2) is estimated to result in yields between 15 mgd and 20 mgd with reliabilities between 97.8% and 92.1%, respectively. Reliability was determined as the estimated percentage of the time that the reservoir will be able to provide the specified yield.

Phase 3 (Inclusive of Phase 1 and 2) - Cumulative Yield	Reliability
15 mgd	97.8 %
16 mgd	97.3 %
17 mgd	95.7 %
18 mgd	94.6 %
19 mgd	92.7 %
20 mgd	92.1 %

Table 4 – Phase 1, 2 and 3 Estimated Yields and Reliability

Based upon the long term water supply demands of the region, the phase 3 configuration could be completed in the 2035 timeframe. The preliminary opinion of probable cost for the program elements in Phase 3 is estimated at $34,000,000. **Figure 4** provides an conceptual schematic of the phase 3 configuration.

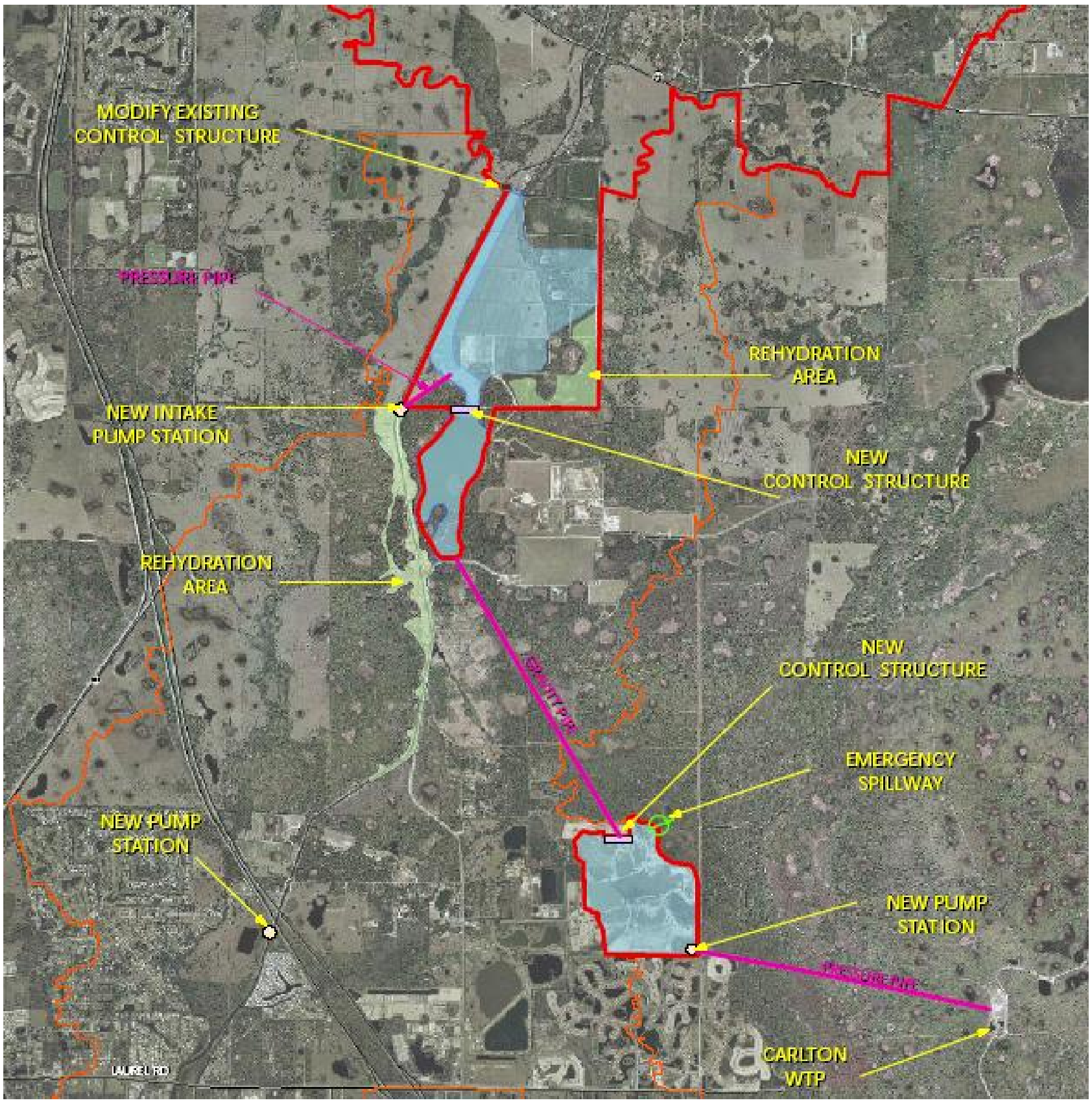

Figure 4 – Dona Bay Watershed Management Program, Phase 3 Configuration

6.0 FUTURE PHASES AND OPPORTUNITIES

Several additional potential program elements have been identified in **Table 1** and are discussed briefly in this section. Specifically, program element 1 could be investigated as an Aquifer Storage and Recovery (ASR) site since it is currently in public ownership and is strategically located adjacent to the lower control structure, where the Cow Pen Canal diversion ends and empties into the upstream tidal portion of Shakett Creek. Program Elements 7, 8, and 9 would require the voluntary partnership with private property interests. At this point, they are conceptual and their inclusion in the program is subject to additional investigations and discussions.

6.1 Element 1 – Fox Creek Site

This site is currently under public ownership and includes an existing borrow pit. It was acquired by SCG to serve as a regional mitigation site and has been designed and permitted accordingly. Among other things, this regional mitigation plan calls for the partial diversion of flows from the Cow Pen Canal, upstream of the lower control structure number to a network of created freshwater wetlands within the site. This partial diversion would occur through a proposed 18" diameter pipe when stages in the Cow Pen Canal exceed elevation 7.0 NGVD (invert of the pipe).

As part of a future phase that could provide additional excess freshwater flow reduction to the Dona Bay estuary as well as increased alternative water supply reliability, a pump station could be installed within the adjacent Cow Pen Canal to pump surface water to the existing borrow pit and into horizontal wells adjacent to the east and north sides of the borrow pit for pre-treatment. This is discussed in more detail in Technical Memorandum 4.2.4.3 – Evaluation of Subsurface Storage. It should be noted that the current state of the art for ASR technology and regulations continues to evolve. This evolution is expected to continue and should be tracked closely as it may cause current concepts to be rethought.

6.2 Element 4 – Pinelands Pits

If excess and/or unsuitable fill is available, it could be disposed of in the large northern borrow pit. If sufficient excess and/or unsuitable fill exists, the resulting depth in the existing borrow pit could be shallowed to have low water depths between 2 and 3 feet. Sump areas would need to remain at points of inflow and outflow.

6.3 Element 7 – LT Ranch Pasture

This program element would involve working with private property interests located on the west side of the Cow Pen Canal adjacent to the Albritton site. As such, it may require a public-private partnership. It is envisioned that this site of approximately 592 acres could be restored as a wetland marsh and may accept initial waters diverted from the upstream Cow Pen Canal as a pre-treatment facility prior to diverting water into the Albritton reservoir. It could also provide regional stormwater/mitigation and flood storage compensation for the LT Ranch and surrounding areas. Increasing the storage potential in this area could also off-set the otherwise resulting increase in local and regional flood stages associated with the transition of the Albritton site from a gravity to gravity/pumped storage facility. It is envisioned that funding assistance would be available from such programs as the United States Department of Agriculture - Natural Resources Departments' (USDA-NRCS) Wetlands Reserve Program.

6.4 Element 8 – Hi-Hat Old Grove

This program element would involve what is currently private property located within the Hi-Hat Ranch upstream of the Cow Pen Canal. The site is known as the Hi-Hat Old Grove and is approximately 421 acres that are currently in citrus production. However, it is strategically located such that it could be a potential regional stormwater management facility, further buffering the downstream Cow Pen Canal from upstream areas. It could also be constructed in association with the restoration of the non-operational water level control structure at the northern terminus of the Cow Pen Canal. Approximately 19,160 acres drain to this location. Although this area has been hydraulically altered, it is located in a historical low-lying area, making it strategically located to manage surface water. From a stormwater management perspective, it is also strategically located immediately upstream of numerous existing developments and downstream of the presently undeveloped lands in the Hi-Hat Ranch. Therefore, it could help fulfill the stormwater needs of future upstream development while assuring that flood stages are not adversely increased downstream.

6.5 Element 9 – Hi-Hat Floodplain

Sarasota County's 2050 Plan, if implemented would result in the permanent protection of the large natural floodplain area located south of State Road 780 within the Hi-Hat Ranch. This is an important watershed feature that should be protected. In the event that the 2050 Plan is not implemented, the County should prioritize protection of the area through a variety of means, including public acquisition through the County's Environmentally Sensitive Lands Protection Program.

Dona Bay Watershed Management Plan – Phase 1
Preliminary Opinion of Probable Cost

ITEM:	UNIT	UNIT PRICE	QUANTITY	TOTAL PRICE
Phase 1				
Element 2 – West Pinelands				
Solar Pumps	Each	$ 50,000.00	5	$ 250,000
Element 3 - Venice Minerals				
Reservoir	LS	$ 16,376,697	1	$ 16,376,697
Spillway	LS	$ 250,000	1	$ 250,000
Element 4 - Pinelands Pits				
72" Gravity Pipe	LF	$ 350	13,000	$ 4,550,000
Valve Box/Sluice Gate	LS	$ 100,000.00	1	$ 100,000
Miscellaneous	LS	$ 100,000.00	1	$ 100,000
Element 5 - Albritton Site				
On-Line Gated Control Structure	LS	$ 500,000.00	1	$ 500,000
Alternative Water Supply Element				
Water Treatment Plant	gpd	$ 5.00	5,000,000	$ 25,000,000
Pump Station to Water Treatment Plant	LS	1,000,000	1	$ 1,000,000
24" Pressure Pipe	*			$ 3,400,000
SUBTOTAL - CAPITAL COSTS				**$ 51,526,697**
Contingency		16%		$ 8,244,272
TOTAL				$ 59,770,969
Engineering, Administration		25%		$ 14,942,742
TOTAL COST WITH CONTINGENCY				**$ 74,713,711**

* - based upon probable cost (including Myakka River crossing) provided by PBSJ in Technical Memorandum 4.2.5 – Determination of Surface Water Treatment Plant Location

Dona Bay Watershed Management Plan – Phase 2
Preliminary Opinion of Probable Cost

ITEM:	UNIT	UNIT PRICE	QUANTITY	TOTAL PRICE
Phase 2				
Element 5 - Albritton Site				
Reservoir	LS	$ 26,127,000	1	$ 26,127,000
Alternative Water Supply Element				
Water Treatment Plant Upgrade	gpd	$ 4.00	5,000,000	$ 20,000,000
SUBTOTAL - CAPITAL COSTS				**$ 46,127,000**
Contingency		16%		$ 7,380,320
TOTAL				$ 53,507,320
Engineering, Administration		25%		$ 13,376,830
TOTAL COST WITH CONTINGENCY				**$ 66,884,150**

Dona Bay Watershed Management Plan – Phase 3
Preliminary Opinion of Probable Cost

ITEM:	UNIT	UNIT PRICE	QUANTITY	TOTAL PRICE
Phase 3				
Element 5 - Albritton Site				
Surface Water Intake Pump Station	gpd	0.70	5,000,000	$ 3,500,000
Alternative Water Supply Element				
Water Treatment Plant Upgrade	gpd	$ 4.00	5,000,000	$ 20,000,000
SUBTOTAL - CAPITAL COSTS				**$ 23,500,000**
Contingency		16%		$ 3,760,000
TOTAL				$ 27,260,000
Engineering, Administration		25%		$ 6,815,000
TOTAL COST WITH CONTINGENCY				**$ 34,075,000**

TM 4.2.8 – WATER SUPPLY WATERSHED PROTECTION PLAN (DRAFT)

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and SWFWMD are currently completing the necessary, pre-requisite data collection and analysis as well as comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marin Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the Southwest Florida Water Management District (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

As part of the formation of the Dona Bay Comprehensive Watershed Management Plan, the development of alternative surface water supply options was found to support other plan objectives relative to providing a more natural freshwater/saltwater regime in the tidal portions of Dona Bay. In the likely event that a surface water supply source is developed in the Dona Bay watershed, this Technical Memorandum was prepared to provide a Water Supply Watershed Protection Plan for the portion of Dona Bay that may contribute to surface water supply. Specifically, watershed goals within the Sarasota County Comprehensive Plan were reviewed relative to Water Supply. For those goals not currently regulated, incentive based protection mechanisms were identified that should be further developed through the watershed stakeholder group and public outreach. It is recognized that incentives may not be sufficient in all cases to address shortcomings in the regulations.

2.0 WATER SUPPLY WATERSHED PROTECTION AREA DELINEATION

At present, the contributing watershed located upstream of the likely reservoir locations(s) is primarily rural. Although development is occurring in Manatee County, it appears that the stream corridors have been set aside from the developed areas.

For the purposes of this effort, the Water Supply Watershed Protection Area (WSWPA) was delineated as the upstream watershed area that contributes to water supply reservoir(s). This WSWPA is presented on **Figure 1**. It essentially represents the entire watershed located upstream of the upper water level control structure for the Cow Pen Canal, the Albritton site, and the Venice Minerals site.

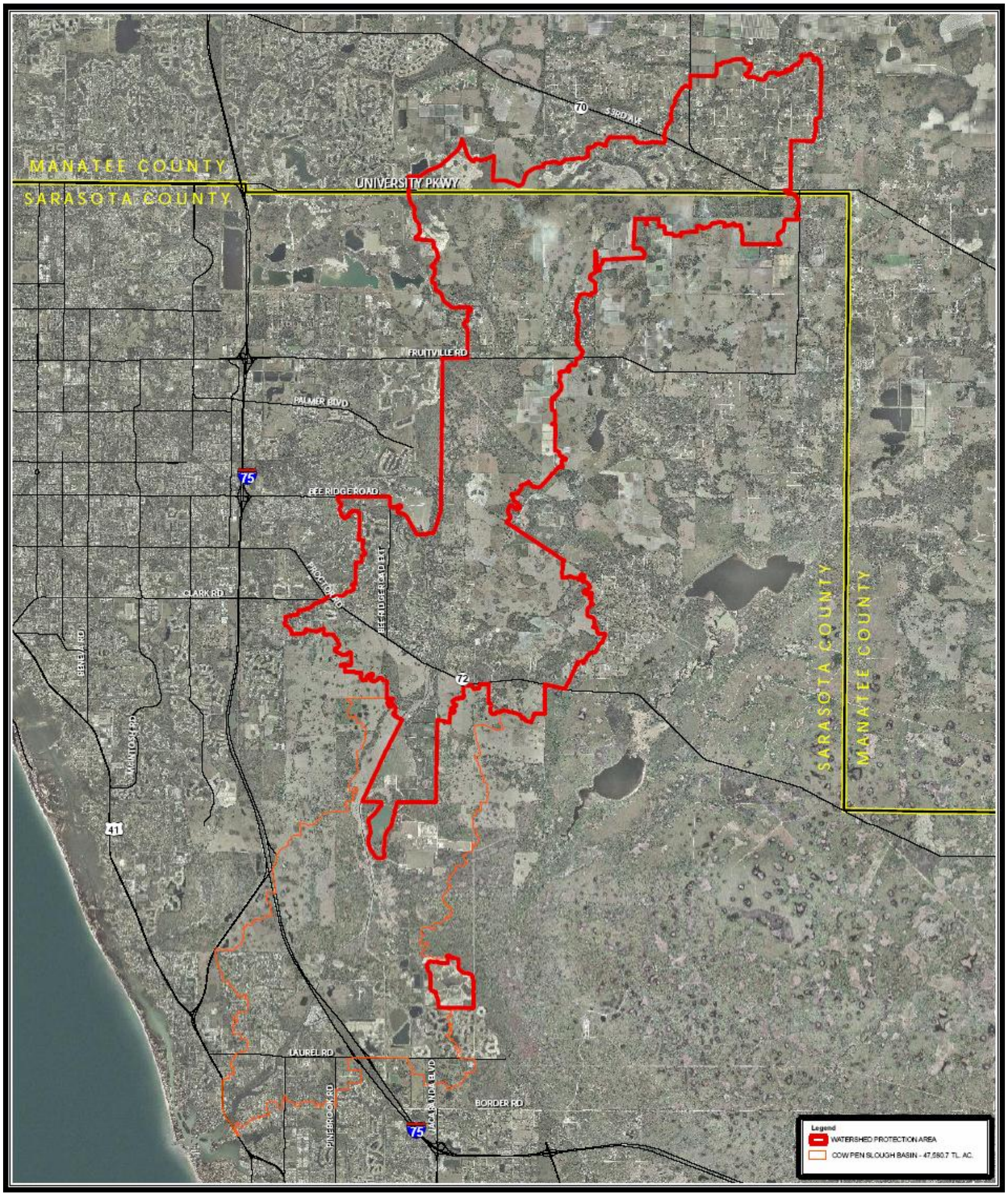

Figure 1 – Water Supply Watershed Protection Area

2.1 Existing and Future Land Use

Within Manatee County, the WSWPA consists primarily of older low density residential density suburban development. The recent moderate density subdivisions are located along the Sarasota-Manatee County line and have set backs from the headwaters tributaries that traverse through them and discharge to Sarasota County.

Within Sarasota County, the WSWPA is rural in nature consisting of agricultural uses and low density residential. The agricultural uses include some row crops as well as pasture (ranching). The low density residential areas are 5 to 10 acre lots with several golf course communities, including Misty Creek, Saddle Creek, Saddle Oaks Estates, Gator Creek, and Heritage Oaks.

Figure 2 provides the current Future Land Use Map for Sarasota County for the WSWPA. The current Future Land Use Map designates most of the lands within the WSWPA as rural. Current zoning within these rural designated areas are either Open Use Rural (OUR) or Open Use Estate (OUE) which allows 5 to 10 acre lots. Although these current zoning designations are all low density, they would result in the proliferation of domestic wells and on-site sewage treatment and disposal systems (septic tanks). In addition, lots developed under existing zoning designations could be platted over environmentally sensitive areas and floodplains.

However, any proposals to rezone existing areas to a more dense zoning classification (i.e. from 10 acre to 5 acre lots) if granted, would need to be developed as conservation subdivisions. Conservation subdivisions are required to cluster the granted density out of, and preserve environmentally sensitive areas. This would result in the density granted by 1 unit to 5 acres (or 1 unit to 10 acres), but the lots would not necessarily be 5 acres (10 acres) in size.

2.2 2050 Plan Overlay

Sarasota County recently established a Comprehensive Plan amendment known as the 2050 Plan. The 2050 Plan is intended to be an incentive-based, development option and contains several Resource Management Areas or RMAs. The Village and Greenway RMAs are intended to cluster "Villages" in compact upland areas and preserve large contiguous "Greenways" primarily centered on streams, rivers and watercourses. As currently proposed, these greenway areas would consist of named creeks and flow-ways, wetlands connected to those creeks and flow-ways, and an additional 500-foot buffer from the composite of these areas, or alternative greenway or buffer configuration that provide equivalent or greater net ecological benefit. Code requirements have included the AE flood zone as one of the key elements to be incorporated within the greenways. This is an important strategy as it is intended to prevent the encroachment of flood waters into homes and businesses by keeping the homes and businesses out of the floodplain, but it also provides for a valuable strategy for protecting the water courses.

Figure 3 provides the 2050 Plan within the WSWPA. From a water supply watershed protection perspective, the 2050 Plan overlay provides for numerous planning benefits from a watershed management perspective such as central water and wastewater, clustered and compact development, and permanent greenway/watercourse protection.

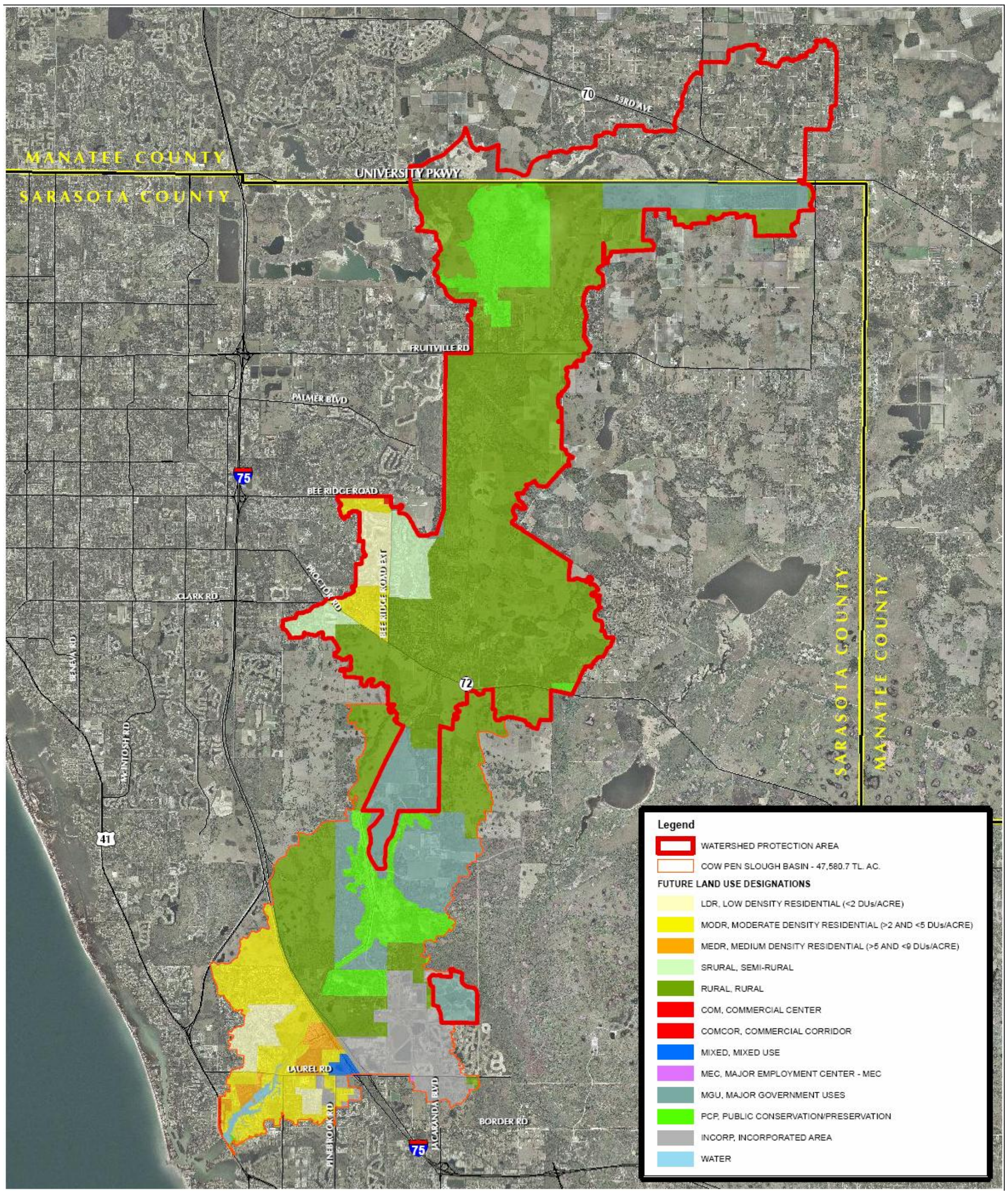

Figure 2 – Future Land Use Map

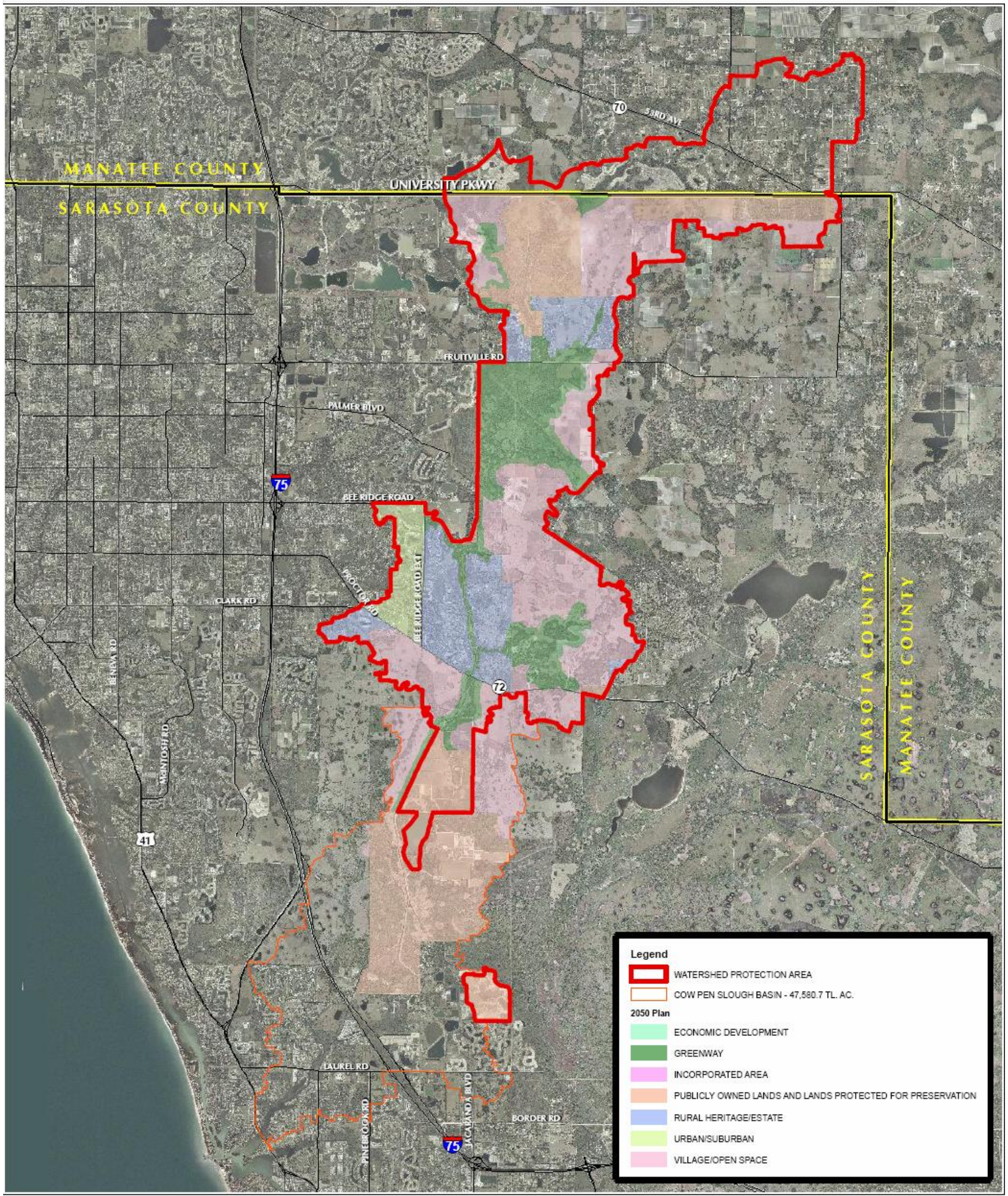

Figure 3 – Sarasota County 2050 Plan Overlay

Table 1 provides a matrix of entitlement and development requirements associated with three land use scenarios: (1) 10-acre lots, (2) 5-acre lots, and (3) the 2050 Plan overlay with villages and greenways resource management areas.

Land Use Scenario	Comp Plan Amendment Needed	Rezone Change Needed	Central Water	Central Wastewater	Clustered Development & Greenway
Existing Zoning	No	No	No	No	No
Rezoning to 5-acre and 10-acre lots	No	Yes	No	No	Yes
Village	Yes	Yes	Yes	Yes	Yes

Table 1 – Matrix of Land Use Scenarios in the WSWPA

3.0 NATIONAL WATER PROTECTION LEGISLATION

In 1972 the United States passed the Federal Clean Water Act, committing to achieve fishable and swimmable waters. Of specific relevance are Sections 303, 319 and 320 of the Clean Water Act.

Section 303(C)(1) defines water quality goals for a water body by designating the use of the water, setting criteria to protect those uses, and setting anti-degradation provisions for the water body. States must update their water quality standards every three years. New and revised water quality standards “shall be submitted” to EPA for review. Under Section 303(c)(2) of the Act, water quality standards “shall consist of” designated uses and water quality criteria. In setting water quality standards, states shall consider the use and value of public water supplies.

Section 303 also provides for apportioning pollutant loads among sources, where loadings must be reduced to achieve established water quality standards. This is currently being administered by the U.S. Environmental Protection Agency (EPA) as the Total Maximum Daily Load (TMDL) program in coordination with the Florida Department of Environmental Protection (FDEP). Section 319 serves to promote and financially support State programs to address diffuse pollution; the salient cause, from a national perspective of water quality degradation in the U.S. Finally, Section 320 establishes the National Estuary Program (NEP) to protect the nation’s estuaries. The WSWPA is located within the Charlotte Harbor NEP.

Public Law 92-500, the "Federal Water Pollution Control Act" was amended in 1987 to cover stormwater runoff into the Waters of the United States. In 1990 the Federal Environmental Protection Agency issued regulations for implementation of the amendment. Sarasota County was required to obtain a National Pollution Discharge Elimination System (NPDES) permit to discharge stormwater into Waters of the United States.

4.0 STATE OF FLORIDA – WATER PROTECTION LEGISLATION

Chapter 403, Florida Statutes, "Water Resources Act", provides the Department of Environmental Protection with the authority to establish water quality guidelines and recognizes stormwater runoff as an important resource. Chapter 17-25, Florida Administrative Code, "Regulation of Stormwater Discharge", implements this statute by providing minimum criteria for discharge into surface waters and groundwater of the State. The rule's basic objective is to achieve 80-90 percent removal of stormwater pollutants before discharging into receiving waters. The rule states that facilities must treat the runoff from the first one inch of rainfall, or as an option for projects with drainage areas less than 100 acres, the first one-half inch of runoff.

4.1 Water Quality Classifications

Florida's Water Quality Standards Program, the foundation of the state's program of water quality management, has five Water Quality Classifications based on designated use or functional classification:

- Class I - Potable water supplies
- Class II - Shellfish propagation or harvesting
- Class III - Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife
- Class IV - Agricultural water supplies (large agricultural lands, located mainly around Lake Okeechobee)
- Class V - Navigation, utility, and industrial use (there are no state waters currently in this class)

Class I waters generally have the most stringent water quality criteria and Class V the least. However, Class I, II, and III surface waters share water quality criteria established to protect recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife. All waters of the state are considered to be Class III, except for those specifically identified in Section 62-302.600, F.A.C. All waters of the state are required to meet the "Minimum Criteria for Surface Waters," as identified in Section 62-302.500, F.A.C.

The Cow Pen Canal is designated as a Class III water body and currently meets its use as a recreational (fishable and swimmable) water body. It is not classified as impaired according to the Impaired Waters Rule. The Florida Department of Environmental Protection (FDEP) issues permits for drinking water treatment facilities to draw water from Class III water bodies for potable water use so it is not necessarily required that waters in the WSWMA be designated as a Class I or II water body to be used as source water for potable water supply.

Sarasota County completed a year long sampling and testing program in 2003 to evaluate the water quality in the Cow Pen Canal and the potential for use of the water for irrigation or as a potable water source. The sampling program included monthly testing for pollutants listed in the National Primary and Secondary Drinking Water Regulations and selected additional parameters. The National Primary and Secondary Drinking Water Standards were established by the Environmental Protection Agency for all public potable water supply systems and relate to the finished water distributed to users. It should be noted that the test results are for a raw water source prior to treatment.

With the exception of pathogens, none of the contaminants exceeded the primary drinking water standards. Total coliform and fecal coliform counts exceeded the Criteria for Surface Water quality in several of the samples. The parameters that exceeded the Secondary Drinking Water Standards and Surface Water Quality Standards are aluminum, iron, color, odor, and bacteria. Pesticides were found to be present in minor concentrations in three of the samples, but did not exceed the maximum contaminant level (MCL) required by the drinking water standards.

Class I and Class III Standards for Total and Fecal Coliform are the same, except Class I sampling requirements are more stringent.

In Florida, the default Class III designation is commonly used as an example of the need for refinement. Class III is a broad brush category that applies equally to the diverse types of waterbodies in the state, including rivers, lakes, streams, springs, wetlands, estuaries, and marine waters. Though a distinction does exist between Class III freshwater and marine, the designation does not otherwise account for variations that may exist due to differences in physical, chemical, and biological characteristics between surface water types. These characteristics may affect the different uses that each water body type may support, both from human (e.g., different types of recreation) and aquatic life (e.g., different community types) perspectives.

If a potable water supply is developed from the excess freshwater in the WSWPA, re-designation of the source water from Class III to Class I should be considered for the WSWPA.

4.2 Stormwater Regulations

Chapter 17-25, Florida Administrative Code, emphasizes that "no discharge from a stormwater discharge facility shall cause or contribute to a violation of water quality standards in waters of the state" and continues by stating that erosion and sediment control "best management practices" shall be used as necessary during construction to retain sediment on-site. Further, stormwater discharge facilities which receive stormwater from areas which are a potential source of oil and grease contamination shall include mechanisms suitable for preventing the contaminants from leaving the stormwater discharge facility in concentrations which would cause or contribute to violations of applicable water quality standards in the receiving water. Chapter 17-3, Florida Administrative Code, "Water Quality Standards", provides minimum criteria which govern stormwater drainage necessary to protect the designated uses of State waters. This legislation provides detailed criteria for both surface water and groundwater protection.

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The responsibility for regulating stormwater from development activities was delegated to the SWFWMD in 1984. The Governing Board of the SWFWMD assumes its responsibilities as authorized in Chapter 373 and other chapters of the Florida Statutes by directing a wide-range of programs, initiatives, and actions. With respect to flood protection, water quality, and natural systems, respectively, SWFWMD's goals are:

To minimize the potential for damage from floods by protecting and restoring the natural water storage and conveyance functions of floodprone areas. The District shall give preference whenever possible to non-structural surface water management methods.

To protect water quality by preventing further degradation of the water resource and enhancing water quality where appropriate.

To preserve, protect and restore natural systems in order to support their natural hydrologic and ecologic functions.

Chapter 40D-2, Florida Administrative Code (FAC), "Basis of Review," includes stormwater system design criteria as well as technical and administrative information for applicants and permits.

Chapter 40D-4 and Chapter 40D-40 FAC, "Management and Storage of Surface Waters" (MSSW) states that the SWFWMD governs surface water permitting and stormwater runoff. Chapter 40D-4's Basis of Review specifies that post-development peak discharge rates for new development not exceed pre-development peak discharge rates for the 25-year, 24-hour event. In addition to regulating discharge, the District also restricts floodplain encroachment. District regulations require compensating storage be provided for fill placed within the 100-year floodplain. Rules also stipulate that activities affecting floodplains and floodways will not cause adverse impacts, i.e., increase flooding. Technical guidelines further clarify how to analyze and minimize impacts from activities in the floodplain.

5.0 SARASOTA COUNTY GOALS, OBJECTIVES, AND POLICIES

A review of the Watershed Management Goals, Objectives, and Policies contained in Sarasota County's Comprehensive Plan was performed relative to Water Supply Watershed Protection. Based upon this review, the following goals, objectives, and policies were selected and are reprinted from the Watershed Management Chapters for reference.

Watershed Management Goal 1 - Sanitary sewer service shall be provided to Sarasota County residents through the continual evolution of a centralized regional wastewater collection and treatment system, and shall be provided in a safe, clean, efficient, economical, and environmentally sound manner, concurrent with urban development.

Watershed Management Objective 1.1 - Continue to correct existing wastewater facility deficiencies, and coordinate the acquisition, extension, and construction of, or increase in the capacity of, facilities to meet future needs.

Watershed Management Policy 1.1.4 - The County shall continue implementation of the Franchise Acquisition, Consolidation, Implementation Plan - Wastewater Collection, Treatment, and Reuse Master Plan, which provides an engineered master plan for providing wastewater service to the unincorporated areas of Sarasota County concurrent with urban development and land use planning, a master priority listing and preliminary consolidation plan for the acquisition of private and franchised utilities, and an implementation plan for these activities. Priority shall be given to providing centralized service to areas experiencing septic tank failure and areas where water quality has been adversely affected by current disposal methods.

Watershed Management Policy 1.1.7 - The County shall prohibit the installation of onsite wastewater treatment and disposal systems in the areas designated as Urban Service Area and Barrier Island on the Future Land Use Map Series, unless the installation and use shall not adversely affect the quality of groundwater or surface water or adversely affect the natural function of floodplains as required by the provisions of the County Land Development Regulations (Ordinance No. 81-12, as amended); Ordinance No. 83-83 and Chapter 10D-6 F.A.C, regulating design, construction, installation, utilization, operation, maintenance and repair of individual onsite wastewater treatment and disposal systems, as amended; and any more stringent regulations applicable. Further, the County shall require that all buildings served by onsite wastewater treatment and disposal systems, except approved onsite grey water systems, connect to a publicly-owned or investor-owned sewerage system within one year of notification by the County that such a system is available as defined in Chapter 10D - Section 6.042, Florida Administrative Code. The County shall establish procedures for the notification of sewer availability.

Watershed Management Objective 1.2 - Maximize the use of existing and available central wastewater facilities and new facilities when they are constructed, and discourage urban sprawl.

Watershed Management Policy 1.2.1 - The County shall continue to require new development to connect to central wastewater systems consistent with the requirements contained in the Land Development Regulations based on the size of the development and distance to the existing system, the available capacity in the system, and the utility's rules allowing connection to the system.

Watershed Management Objective 1.3 - Continue to explore and use alternative and supplemental water resources to conserve and replace the use of traditional potable water supplies.

Watershed Management Policy 1.3.1 - The County shall continue implementation of the reuse component of the Franchise Acquisition, Consolidation, Implementation Plan - Wastewater Collection, Treatment, and Reuse Master Plan, which contains regulatory, engineering, public education and marketing, and financial strategies for the development of a regional distribution and storage system to provide reclaimed water and treated stormwater, to customers where it is needed and available in order to reduce the demand on potable water supplies and withdrawals from ground water aquifers.

Watershed Management Policy 1.3.3 - The County shall develop and adopt guidelines for the construction and management of golf courses to reduce or eliminate the use of sub-surface wells as irrigation sources and encourage the use of secondary treated wastewater for irrigation.

Watershed Management Objective 1.4 - Protect the functions of natural ground water recharge areas, natural drainage features, and surface water bodies.

Watershed Management Policy 1.4.2 - The County shall continue to provide a program to ensure that septage and sludge are received and disposed of in an environmentally sound manner.

Watershed Management Policy 1.4.4 - Sarasota County regulations for the disposal and use of septage and sludge shall provide for their efficient and beneficial use and prevent adverse environmental impacts. Land spreading and disposal of sludge shall be allowed only in areas that will not adversely impact groundwater resources and watersheds that drain into surface water supplies (which are used to meet potable water supply needs), recharge areas of a public water system and/or Outstanding Florida Waters. The land spreading of septage shall be prohibited within the County.

Watershed Management Policy 1.5.2 - Issuance of development orders for any site proposing to utilize an onsite wastewater treatment and disposal system shall be contingent upon demonstration of compliance with applicable federal, State and local permit requirements. Soil surveys shall be required for onsite wastewater treatment and disposal system permits. No individual onsite systems shall be permitted where soil conditions indicate that the system would not function without degrading water quality or where land alterations necessary to accommodate the system would interfere with drainage or floodplain functions.

Watershed Management Goal 2 - Sarasota County shall provide a Comprehensive Watershed Management (CWM) Plan which prevents and mitigates the losses, cost, and human suffering caused by flooding; protects natural and beneficial functions of the floodplain; protects water quality by preventing further degradation of the water resources; enhances water quality where appropriate; enhances, protects and conserves the hydrologic and ecological functions of natural systems including estuaries, freshwater and groundwater systems; and ensures safe, efficient, economical, and sustainable water supplies that provides customers the appropriate water quality for the intended use.

Watershed Management Policy 2.1.3 - The County shall continue to fund the continuous maintenance of watershed maps and models for each drainage basin in the County through the CWM Planning Program to provide a basis of review for new development and other watershed alteration proposals as well as assure that stormwater management facilities are developed to attain the adopted level of service. Implementation of all detailed master plans shall be completed by 2005. Each detailed master plan shall be developed, in accordance with the Basin Master Plan Schedule, as a Sarasota County inter-department effort to ensure consideration of natural drainage functions. Basin master plans shall be developed in cooperation with the municipalities and adjacent Counties to address stormwater quality and quantity problems in basins crossing more than one political boundary. Each plan shall be designed to protect downstream and estuarine water from degradation by stormwater runoff. Each basin plan shall define the level of service and a cost-effective capital improvements program shall be developed. As each basin plan is completed, the comprehensive plan, including the Capital Improvements Plan, shall be amended to incorporate and reflect the stormwater management facility improvements identified in the basin plan.

Watershed Management Policy 2.2.1 - The County shall implement its CWM Plan consistent with the National Pollutant Discharge Elimination System (NPDES) permit issued to the County by the U.S. Environmental Protection Agency. The Comprehensive Stormwater Quality Program shall provide for management and control of stormwater runoff to reduce pollution at the source and discharge of pollutants into receiving waters from the County's stormwater system to the maximum extent possible.

Watershed Management Policy 2.2.2 - The County shall require that the treatment of stormwater discharge meets standards which will ensure that there will not be adverse impacts on the quality of potable public surface water supplies.

Watershed Management Policy 2.2.3 - New development in the 100-year floodplains shall be consistent with all other Goals, Objectives, and policies of the Sarasota County Comprehensive Plan.

Watershed Management Objective 2.3 - To ensure that development and redevelopment provides for adequate stormwater management.

Watershed Management Policy 2.3.1 - No permit shall be issued for new development which will result in an increase in demand upon deficient facilities prior to the completion of improvements needed to bring the facility up to adopted level of service standards.

Watershed Management Policy 2.3.2 - Stormwater Level Of Service:

1) Stormwater Quality: no discharge from any stormwater facility shall cause or contribute to a violation of water quality standards in waters of the State as provided for in County Ordinances, Federal Laws and State Statutes. Water quality levels of service shall be set consistent with the protection of public health, safety and welfare and natural resources functions and values. To protect water quality and maintain stormwater quality level of service standards:

a) The County shall implement a CWM plan consistent with the federal NPDES requirements. The plan shall be adopted by the County after approval by the EPA.

b) New and existing industrial activities (as defined in the National Pollutant Discharge Elimination System regulations for storm water) shall develop and implement a Storm Water Pollution Prevention Plan (SW3P) for such activity.

c) No discharge from any stormwater facility shall cause or contribute to a violation of water quality standards in waters of the State as provided for in County Ordinances, Federal Laws and State Statutes. To meet this requirement:

(i) All stormwater systems for new development and re-development shall include features to minimize pollution from oil, suspended solids, and other objectionable materials. Such features shall be designed to treat the runoff resulting from the first one (1") inch of rainfall. Stormwater systems shall include additional measures designed to reduce floating and suspended solids to a minimum. Higher design criteria for water treatment shall apply if such criteria are necessary to meet and maintain the level of service or to protect water bodies (such as potable surface waters or Florida Outstanding Waters) which require higher levels of protection. The higher design criteria shall be based on a treatment system which treats 1.5 times the volume required for the selected treatment system or equivalent.

(ii) New development and re-development shall provide mitigation measures and best management practices to control pollutants specific to the pollutant characteristics of the proposed land use consisting of Best Management Practices shown to be effective in controlling the specific pollutants characteristic of the type of new development.

(iii) All development shall meet and be consistent with requirements in the Basin Master Plans.

(iv) Mitigation measures and best management practices relating to drainage shall be taken during construction activities to ensure that water quality is not degraded during the land clearing and construction of development. No cutting, clearing, grading or filling shall be accomplished on any site under development unless appropriate devices have been installed to minimize pollution from objectionable materials, to control erosion, and to remove sediment from surface water runoff. Appropriate techniques shall also be utilized to stabilize and revegetate disturbed areas as soon as possible.

d) Best management practices shall be encouraged for intensive agricultural land use practices that negatively impact water quality.

e) The County's Basin Master Plans shall include evaluation of pollutant loading.

2) Stormwater Quantity: Stormwater management systems shall provide for adequate control of stormwater runoff. The Stormwater Quantity Level of Service shall be …

The requirements to maintain stormwater quantity level of service standards are stated below:

a) New developments shall be designed to maintain the water quantity level of service standard and to minimize adverse stormwater impacts. Stormwater runoff shall not be diverted or discharged in such a way as to cause an adverse increase in off-site flood stages or have an adverse impact upon natural system values and functions. Stormwater management plan designs shall provide for the attenuation/retention of stormwater from the site. Water released from the site shall be in such a manner as to ensure that no adverse increases in off-site flood stages will result for up to and including a 100-year, 24-hour storm. The County shall pursue opportunities for off-site public or private regional stormwater attenuation/retention facilities to be used to accomplish stormwater attenuation requirements.

b) Until drainage improvements are made to upgrade the level of service, developments in basins identified through Basin Master Plans as not meeting the Level of Service shall limit the rate of runoff after development to the drainage system capacity by limiting the 100-Year, 24-Hour post-development runoff rates to the apportioned downstream flow capacities which do not cause flooding of residential structures.

c) Best management practices shall be encouraged for intensive agricultural land use practices which substantially increase runoff rates.

d) All new development and stormwater management systems shall meet and be consistent with the requirements in the Basin Master Plans, and ComprehensiveWatershed Management Plans.

e) By 2007, Sarasota County shall provide design standards for low impact design (LID) measures to mitigate the effect of impervious surfaces and stormwater pollutants on increased runoff volumes. LID design measures may include, but are not limited to, bio-retention areas, porous pavement, roof gardens, rainwater/stormwater recycling, etc.

Watershed Management Policy 2.3.2A - Consistent with the National Pollutant Discharge Elimination System (NPDES) permit, the County's Comprehensive Watershed Management Plan shall establish water quality design criteria for each drainage basin. In establishing these criteria, the County shall consider recommendations from the Sarasota Bay and Charlotte Harbor National Estuary Programs and the drainage basin pollutant load reduction goals to be established by the Southwest Florida Water Management District, and the State Surface Water Ambient Monitoring Program.

Watershed Management Policy 2.3.2B - The County shall work with the Southwest Florida Water Management District (SWFWMD) in an effort to coordinate approaches to planning and permitting of stormwater management and shall specifically request SWFWMD comment on a volume based approach to regulating stormwater management in addition to the common peak discharge rate approach.

Watershed Management Goal 3 - Potable water service shall be provided to Sarasota County residents through the continual evolution of a centralized regional supply, treatment, and distribution system, and shall be provided in a safe, clean, efficient, economical, and environmentally sound manner, concurrent with urban development.

Watershed Management Objective 3.1 - Continue to correct existing potable water facility deficiencies, and coordinate the acquisition, extension, and construction of, or increase in the capacity of, facilities to meet future needs.

Watershed Management Policy 3.1.1 - Sarasota County Utilities shall maintain up to date inventories indicating the available capacity and present demand for potable water facilities in the Sarasota County Utilities System service area.

Watershed Management Policy 3.1.5 - Continue to extend water lines to those portions of unincorporated Sarasota County developed with private wells utilizing the County's Line Extension Policy through the Sarasota County Utilities Capital Improvement Program and utilizing other mechanisms such as Municipal Service Benefit Unit non-ad valorem assessments.

Watershed Management Policy 3.1.6 – Sarasota County will continue to explore alternative water resources in cooperation with regional water supply authorities and other local entities. Additional water supply sources will need to be identified and developed to supplement the amounts from the T. Mabry Carlton Memorial Reserve, including wastewater and stormwater recycling systems developed by the County.

Watershed Management Policy 3.1.7 – As the County consolidates and develops potable water facilities, all facilities shall be developed with consideration for aesthetics and the possibility of incorporation into the County park system.

Watershed Management Objective 3.2 - Maximize the use of existing and available central potable water facilities and new facilities when they are constructed, and discourage urban sprawl.

Watershed Management Policy 3.2.1 - Until such time as the Sarasota County Utilities System can expand its distribution system to provide centralized potable water service, individually owned platted lots of record located within the designated Urban Service Area, as adopted pursuant to Sarasota County Ordinance No. 81-30, may be provided potable water with a private well provided all other legislative and regulatory requirements are met.

Watershed Management Policy 3.2.2 - The County shall mandate hookup to a centralized potable water system, where available, in accordance with State and County laws.

Watershed Management Policy 3.2.3 - The County shall continue to require new development to connect to central water systems consistent with the requirements contained in the Land Development Regulations, based on the size of the development and distance to the existing system, if the capacity is available in the system and the Utility's rules allow connection to the system.

Watershed Management Objective 3.3 - Continue to implement programs to conserve potable water resources.

Watershed Management Policy 3.3.1 - Sarasota County shall continue its efforts to implement water conservation programs, including such initiatives as the existing inverted water rate structure, low flow toilet rebates and showerhead exchange and outreach educational programs. Water conservation programs shall operate in cooperation with the Southwest Florida Water Management District, Manasota Basin Board, and other appropriate entities, both public and private.

Watershed Management Policy 3.3.2 - The County will continue to abide by the Southwest Florida Water Management District's (SWFWMD) emergency water shortage plan, and when necessary, the County may implement more restrictive water conservation measures, as may be required to protect and maintain the utility system.

Watershed Management Policy 3.3.3 - The County will continue, in partnership with the Southwest Florida Water Management District (SWFWMD) to ensure through a variety of educational and enforcement activities, the proper abandonment of unused water wells. SWFWMD Quality of Water Improvement (QWIP) incentive funding will be utilized to the greatest extent possible to realize the goal of measurable aquifer water quality upgrading.

Watershed Management Policy 3.3.4 - New development shall prioritize meeting irrigation needs through (1) demand management strategies, (2) reclaimed water, if available, (3) rain water or stormwater, and finally, (4) community ground water wells.

Watershed Management Objective 3.4 - Protect the functions of natural groundwater recharge areas and natural drainage features.

Watershed Management Policy 3.4.1 - Sarasota County will protect its potable water supply system, contributing recharge areas, and related open space benefits through implementation of its Wellhead Protection Ordinance which shall identify inappropriate land uses and facilities including, but not limited to, underground fuel storage tanks, landfills, hazardous materials storage, and certain commercial and industrial uses. The County's Wellhead Protection Ordinance will be amended, as needed, for consistency with the Florida Department of Environmental Protection's rule governing wellhead protection adopted in May 1995. The protection effort may include requests to the Southwest Florida Water Management District for cooperative funding or technical assistance to further identify zones of protection and cones of influence around individual wellheads or well fields.

Watershed Management Objective 3.5 - To ensure that the issuance of development permits shall be conditioned upon adequate potable water capacity.

Watershed Management Policy 3.5.2 - The County Public Health Unit shall enforce potable water quality standards in accordance with the Federal Safe Drinking Water Act, Chapter 403, Part VI, Florida Statutes, "Florida Safe Drinking Water Act", and Chapter 62-550, 62-551, 62-555, 62-560, or 10D-4, Florida Administrative Code, and as prescribed by the U.S. Environmental Protection Agency. However, the County may adopt more stringent standards if it deems necessary.

Watershed Management Policy 3.5.3 - Issuance of development orders will be contingent upon demonstration of compliance with applicable federal, State, and local permit requirements for onsite potable water systems.

Watershed Management Policy 3.5.4 - Potable Water Level Of Service:
1) System capacity shall be based on 250 gallons per Equivalent Dwelling Unit per day based on peak flow plus the maintenance of minimum fire flow standards.

2) Minimum potable water quality shall be as defined by the U.S. Environmental Protection Agency, except where the State or County may impose stricter standards.

Solid Waste Objective 2.3 - To protect the functions of natural groundwater recharge areas and natural drainage features.

Solid Waste Policy 2.3.1 - The Central County Solid Waste Disposal Complex shall minimize, to the greatest extent possible, potential environmental impacts consistent with the adopted stipulations contained within Ordinance No. 90-54 and Resolution No. 91-149. Development of the Central County Solid Waste Complex shall be consistent with the Land Management Plan, the "Principles for Evaluating Development Proposals in Native Habitats", and all other relevant policies in the Environment Chapter.

Solid Waste Policy 2.3.2 - All known public sanitary landfill sites, as determined by the Board of County Commissioners, shall undergo inspection and/or monitoring procedures to ensure that they do not create a public health hazard.

Solid Waste Policy 2.3.3 - The County shall support State legislation aimed at reducing the amount and toxicity of waste, such as limiting excess packaging, limiting the use of heavy metals in household batteries, reducing the level of pesticides, reducing mercury content in fluorescent bulbs, and the like.

Solid Waste Policy 2.3.4 - The County shall continue to seek mechanisms for the collection of domestic hazardous waste and transfer that waste to permitted hazardous waste disposal sites, thus avoiding disposal in the County's sanitary landfill. The program shall include public education about what hazardous waste should not be land filled.

Solid Waste Policy 2.3.5 - The disposal of hazardous waste generated by commercial entities shall remain the responsibility of said entities. The County shall assess and verify that such proper handling, storage, transportation, and disposal of hazardous waste by commercial entities occurs. The Florida Department of Health and Rehabilitative Services and the Florida Department of Environmental Protection shall regulate and be responsible for the proper handling, storage, transportation, and disposal of biomedical waste.

Solid Waste Policy 2.3.6 - The location of any new collection and/or storage areas for hazardous and acutely hazardous materials in commercial or industrial uses shall be prohibited within the 100 year floodplain of any in flowing watercourse within the watershed of an existing public potable surface water supply, or within 200 feet of the Florida Department of Environmental Protection jurisdictional line associated with any such in flowing watercourse, whichever is greatest. "Hazardous" and "acutely hazardous" materials shall be as defined and listed in 40 CFR 261, and as adopted within Chapter 1730, Florida Administrative Code, and Section 403.7, Florida Statutes.

Environmental Policy 5.2.4 - Mining activities (as defined by County Ordinance) are not permitted or permissible under the County zoning regulations within the designated areas of special environmental significance and/or sensitivity. The watersheds of Cow Pen Slough and the Myakka River, including the tributaries of the Myakka River, are designated areas of special environmental significance.

Based upon the review of relevant Comprehensive Plan Goals, Objectives, and Policies, the following potential sources were identified for consideration in the Water Supply Watershed Protection Plan: (1) reuse water, (2) stormwater runoff, (3) sludge, (4) mining, (5) on-site sewage treatment and disposal systems, and (5) other miscellaneous sources.

6.0 REUSE WATER

Reclaimed wastewater or reuse water is used throughout Sarasota County for residential, commercial and agricultural irrigation, including in the WSWPA. The EPA (Region 4), FDEP, the Florida Department of Health, SWFWMD and others issued a joint statement in support of water reuse that affirms that Florida's wastewater treatment standards and Florida's extensive experience with reuse ensure that Florida law and regulations are fully protective of public health and environmental quality. Sarasota County's Comprehensive Plan clearly promotes reuse as a key strategy to off-set potable water demands and as a sustainable disposal method for treated wastewater. However, there have been concerns relative to the application of reuse water in other nearby water supply watersheds that have prohibited its use. While there is little data to support the prohibition of reuse water, there has been recognition nationally that pollutants of "emerging" concern associated with pharmaceuticals and personal care products (PPCDs) are appearing in source water for water supply. These include an array of chemicals used internally or externally by humans as well as domestic animals and plants. As a result, it is expected that more stringent and expensive potable water treatment requirements will be mandated by EPA.

There are two primary recipients of reuse water land application in the WSWPA. These include the Hi-Hat Ranch which receives reuse water from the City of Sarasota. The other recipients are golf courses located in part or in total within WSWPA which receive reuse water from Sarasota County Utilities.

The Hi-Hat Ranch is located in the WSWPA, upstream of Clark Road and downstream of Fruitville Road. It also extends eastward into the Myakka River watershed. Pursuant to an agreement, the Hi-Hat Ranch has received reuse water from the City of Sarasota since 1990. The reuse water storage facility is located within the Myakka River watershed portion of the Ranch. In addition, most of the area where reuse water is applied is located in the Myakka River watershed portion of the Hi-Hat Ranch. There are four (4) areas within the Hi-Hat Ranch that receive the reuse water: (1) the Row and Furrow area, (2) the Old Grove, (3) the Utopia Grove, and (4) Site III. **Table 2** inventories the annual quantity of reclaimed wastewater applied in the Hi-Hat Ranch since 1990. **Figure 4** identifies the area within the Hi-Hat Ranch where reuse water is applied.

Year	Average Annual Reuse
1990	3.21 mgd
1991	3.34 mgd
1992	3.39 mgd
1993	2.39 mgd
1994	1.51 mgd
1995	0.82 mgd
1996	1.23 mgd
1997	1.30 mgd
1998	1.37 mgd
1999	1.34 mgd
2000	1.94 mgd
2001	2.15 mgd
2002	1.44 mgd
2003	1.28 mgd
2004	1.34 mgd

Table 2 – Hi-Hat Annual Average Reuse

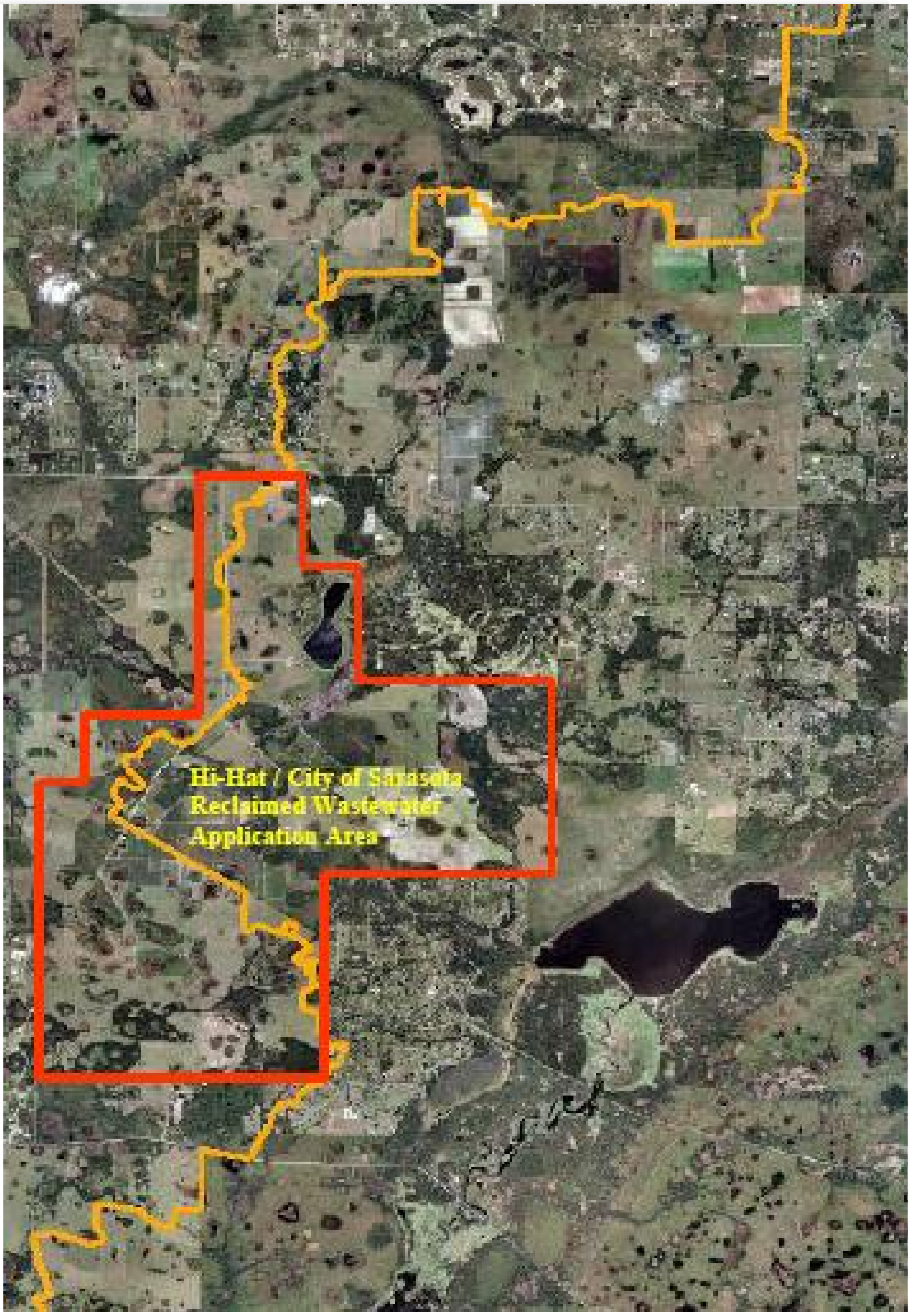

Figure 4 – Hi-Hat/City of Sarasota Reuse Water Application Area

In addition to the Hi-Hat Ranch, there are five (5) golf courses located totally or partially within the WSWPA that currently receive reuse water from Sarasota County for irrigation. **Table 3** lists the respective golf courses and their total average annual quantity of reclaimed wastewater. It should be noted that the Bent Tree golf course is primarily located in the adjacent Phillippi Creek watershed. Together, these golf courses average almost 1 million gallons of reuse water per day.

Golf Course Community	Average Annual Reuse
Bent Tree Country Club	194,423 gpd
Heritage Oaks Golf and Country Club	311,868 gpd
Misty Creek Country Club	139,869 gpd
Gator Creek Country Club	172,000 gpd
The Founder Club	178,515 gpd
Total	**996,675 gpd**

Table 3

Existing Sarasota County Watershed Management Goals/Policies relative to reuse water include: Policy 1.3.1, Policy 1.3.3, and Policy 3.3.4. These policies all promote the use of reclaimed or reuse water.

Relevant to the continued use of reuse water within the WSWPA, a distinction was made between potable and non-potable uses as well as between the existing/future land use plan and the 2050 plan overlay. First with respect to potable water, under the existing/future land use scenario, it is assumed that individual 5 and 10 acre lots would develop with individual wells for both domestic indoor and outdoor water use. Since these domestic wells would be used for individual irrigation, it is assumed that reuse water would not be used under the existing land use scenario, unless new golf courses were included.

On the other hand, if the 2050 plan is implemented, it is assumed that central water will be provided. In this case, it is also assumed that any surface water treatment will incorporate the latest technologies including those needed to address PPCDs. This assumption is made independent of whether or not reuse is used within the WSWPA and is considered even more likely if this alternative water supply becomes part of, or is incorporated into, the regional water supply system.

For the 2050 plan scenario, reuse was considered within the context of an irrigation strategy in the WSWPA. Given the need for the use of surface water as a source for potable water, it is recommended that the County consider the following irrigation hierarchy which would re-prioritize ground water over rain water or stormwater within the WSWPA.

(1) Demand Management – as a first priority, Sarasota County should implement incentives for state-of-the-art outdoor demand management and water conservations strategies, particularly for potential high water users.

(2) Reclaimed Water – as a second priority, Sarasota County should be willing to provide bulk service reuse water for irrigation needs. Reuse storage ponds

should be located at least 500 feet from any watercourse in the WSWPA and be designed to be self contained with liners.

(3) Community Wells – as a third priority, Sarasota County should support conducting necessary aquifer tests in coordination with private property owners and existing permit holders to determine a sustainable configuration and yield for a series of community wells in the Intermediate Aquifer System within the WSWPA. This aquifer investigation should characterize the Intermediate Aquifer System in the WSWPA in terms of quantity and quality as a function of depth. This effort could also look at the possibility of utilizing the Intermediate Aquifer as an augmentation to the potable supply for the region during droughts.

(4) Rain Water or Stormwater Recycling – since rain and stormwater is the source for the potable water supply in the WSWPA, this source should probably be the last source to be used to meet outdoor irrigation needs within the WSWPA.

7.0 STORMWATER RUNOFF

Stormwater runoff is the primary source of excess freshwater within the WSWPA. Accordingly, it can also be expected to be the primary source of pollutant loads, by volume. Stormwater runoff can carry litter, animal wastes, fertilizers, pesticides, heavy metals (e.g., chromium, cadmium, copper, lead, mercury, nickel, zinc), herbicides and synthetic organic compounds such as fuels, waste oils, solvents, lubricants and grease. Surface waters that receive runoff from agricultural areas often are subject to pollution associated with concentrations of fertilizers, pesticides, and animal wastes. As a result, water quality problems are often found in transmitting and receiving waters.

7.1 NPDES Program

Sarasota County received a National Pollution Elimination Discharge (NPDES) permit from the U.S. Environmental Protection Agency. The objective of this permit is to outline a Stormwater Management Program that will improve the quality of surface waters in Sarasota County by improving the quality of stormwater runoff through implementation of the many elements outlined as part of the plan. The Program Elements include (1) maintenance of structural controls, (2) development planning and regulations, (3) roadway maintenance, (4) management of discharges from municipal facilities, (4) reduction in the usage of pesticides, herbicides, and fertilizers, (5) inspection and enforcement, prioritize an inventory of all high-risk facilities, regulate erosion control for earth moving activities. The only known NPDES permit facilities in the WSWPA are the Verna Wellfield and the Venice Minerals operation.

This program is further supported by the following existing Sarasota County Watershed Management Goals/Policies: Policy 2.2.1 and Policy 2.3.2A.

7.2 Stormwater Regulations for New Development

Sarasota County Ordinance No. 81-12, as amended, "Land Development Regulations", provides regulations which guide development as it pertains to attenuation and treatment of stormwater runoff. These regulations require that off-site flood stages resulting from post-development conditions cannot exceed those under pre-development conditions for the 100-year, 24-hour design storm. Additionally, Ordinance No. 81-12, as amended, requires that new development provide for the treatment of the first 1" of runoff. These SCG regulations are more stringent then the State and SWFWMD regulations which only require flood attenuation for the 25-year, 24-hour storm and which only require the runoff from the first inch of rainfall to be treated. Both Sarasota County Government (SCG) and SWFWMD regulations are also intended to protect the values and functions of the 100-year floodplain. It is fortunate that much of the 100-year floodplain within the WSWPA has been determined and delineated so that its protection is covered by these regulations.

Although subdivisions platted prior to the adoption of Ordinance No. 81-12 were not bound to incorporate such mitigation techniques into their development, SCG has effectively been able to required stormwater management facilities for new development since the mid to late 1970's. As a result, even pre -1981 subdivisions such as Bent Tree and Gator Creek have stormwater management lakes.

Both SWFWMD and SCG impose an increase of 50% in the stormwater treatment volume if discharges are to areas designated by the State of Florida as Outstanding Florida Waters (OFW). SCG also requires a 50% increase in the stormwater treatment volume if the discharge is to saltwater tidal systems, bays, or the Gulf, even if they are not designated as OFW. It should also be noted that the Lakewood Ranch Development of Regional Impact (DRI) requires the treatment of an additional 50% of the volume as a means to protect the downstream Cooper Creek potable supply watershed.

While current Sarasota County regulations are probably very effective in addressing floodplain management issues, the current regulations for water quality treatment are currently being re-evaluated. The State of Florida through FDEP is in the process of updating the State Water Policy which is expected to result in significant changes in the treatment criteria of stormwater runoff. For example, it is expected that research conducted over the past several decades will be utilized to determine if stormwater treatment systems have been effective in achieving the required 80-90 percent removal of stormwater pollutants before discharging into receiving waters. If not, additional or alternative criteria may be required. In addition, it has been recognized that current SWFWMD and SCG stormwater do not address the total runoff volume which can also increase with land development and cause more subtle impacts to downstream water bodies. As a result SCG has recently adopted a Policy in their Comprehensive Plan to develop low impact development (LID) standards. LID strategies could typically include, but nor be limited to, bio-retention areas, roof gardens, porous pavement, swales, re-forestation, and rain water and stormwater recycling. It is expected that subsequent changes to State Water Policy may also promote if not stipulate the need for LID standards.

In the case of the Dona Bay WSWPA, the excess freshwater is the source of the alternative potable water supply. Therefore, LID should be promoted to more effectively remove pollutants at their source but not necessarily to reduce runoff volumes in the WSWPA.

Existing Sarasota County Watershed Management Goals/Policies that support these existing and proposed programs include Policy 2.1.3, Policy 2.2.2, Policy 2.2.3, Policy 2.3.2, and Policy 2.3.2B.

7.3 Agricultural Activities

Agricultural activities are currently a dominant land use within the WSWPA. Agricultural activities that cause pollution include poorly located or managed animal feeding operations; overgrazing; improper soil stabilization; and improper, excessive, or poorly timed application of pesticides, dipping vats, irrigation water, and fertilizer. Pollutants that result from farming and ranching include sediment, nutrients, pathogens, pesticides, metals, and salts. Impacts from agricultural activities on surface water and ground water can be minimized by using best management practices that are adapted to local conditions.

Additional Sarasota County Watershed Management Goals/Policies specific to managing stormwater discharges include Policy 2.3.2(1)(d) and Policy 2.3.2(2)(c). However, these are voluntary policies. As an additional incentive, it is recommended that SCG consider re-establishing a cooperative extension agent to coordinate the management of agricultural operations within the WSWPA. Another strategy that could be considered for the rural areas of the WSWPA, is for it to be a designated receiving area for water quality trading and watershed restoration. However, water quality or watershed restoration trading would only be suitable for pollutants or habitat for which there is a market (supply and demand) within the watershed. Watershed restoration and water quality enhancement activities within the WSWPA could also be funded through a surcharge on potable water rates.

7.4 Regional Stormwater Management Opportunities

As part of the Dona Bay Watershed Management Plan, several opportunities to provide regional stormwater at strategic locations in the watershed were considered. The results of this effort are provided within Technical Memorandum 4.4.3 – Regional Stormwater Feasibility Study. This effort indicates that the Albritton site (through the phase 2 configuration), the LT Ranch site (privately owned) and the Hi-Hat Old Grove area (privately owned) would all be very effective as regional stormwater facilities from a floodplain management standpoint. However based upon their strategic, on-line locations, it is anticipated that the LT Ranch site and the Hi-Hat Old Grove areas would also be very effective in pollutant removal by providing increased residence times. These opportunities should be explored as a partnership with the private property owners.

8.0 LAND SPREADING AND SLUDGE DISPOSAL

Sludge is the residual by-product of sewage treatment plants. This residual is primarily water and digested wastewater solids. The State of Florida regulates sludge according to the degree of stabilization, and the nitrogen and metals content. The standards of Chapter 62-640, Florida Administrative Code, regulate this residual product, and require all wastewater treatment plant residuals destined for disposal by landspreading in Sarasota County to meet Class B stabilization as defined in that Chapter. The sludge is required to meet minimum standards for pathogen and vector attraction reduction, and cannot exceed a certain level of heavy metal content as specified in Chapter 62-640, Florida Administrative Code. The regulations also include requirements for land spreading, which stipulate certain minimum setback distances from inhabited structures, surface-water bodies, and wells, and prohibit land application when the water table is less than 2 feet from the surface. There are also annual and lifetime caps on the amount of heavy metals that may accumulate on any parcel as a result of land application of sludge.

Existing Sarasota County Watershed Management Goals/Policies relevant to septage and sludge disposal include Policy 1.4.2 and Policy 1.4.4. In particular, Policy 1.4.4 would severely limit if not prohibit land spreading of septage and sludge within the WSWPA. There are currently no active sludge spreading sites within the WSWPA.

9.0 MINING OPERATIONS

Other than sand and shell excavation operations, there are no known mining operations in the WSWPA. Pursuant to the Sarasota County Comprehensive Plan, Environmental Policy 5.2.4, mining operations are not permitted or permissible in the Cow Pen Slough watershed, which includes the WSWPA.

10.0 ONSITE SEWAGE TREATMENT AND DISPOSAL SYSTEMS (OSTDS)

OSTDs including septic tanks are commonly used where providing central sewer is not available, such as in the majority of the WSWPA. When properly sited, designed, constructed, maintained, and operated, OSTDs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTD is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, OSTDs can be a source of nutrient (nitrogen and phosphorus), coliform bacteria, pathogens, and other pollutants to both ground water and surface water. OSTDs are typically associated with rural low density residential lots such as those that currently exist (and what could be expected under the Sarasota County future land use map) within the WSWPA.

The regulations that govern the installation of onsite sewage disposal systems were strengthened by amendments to Section 381.272, Florida Statutes, and Chapter 10D-6, Florida Administrative Code. These amendments, in conjunction with County regulations governing the installation and spacing of onsite sewage disposal systems adopted during the 1980s, have significantly strengthened the ability of the County to safeguard the environment from the adverse impacts of improperly constructed systems.

A continuing problem is the presence of existing areas served by aging onsite sewage treatment and disposal systems that were, in many cases, installed to lesser standards than are presently in effect. These systems are prone to malfunction, and have the potential for degrading surface and ground water supplies.

In 1997, the EPA recommended to Congress that state and local authorities should manage OSTDs based on performance goals. At the state level, the Florida Water Environment Association Utility Council (FWEAUC) has recommended that the Florida Department of Health should pursue legislative changes to increase its oversight of the performance of OSTDs by requiring performance-based operating permits for all systems.

Existing Sarasota County Watershed Management Goals/Policies relevant to OSTDs include: Policy 1.1.7, Policy 1.2.1, and Policy 1.5.2. Consistent with these existing policies, it is recommended that existing OSTDs in the WSWPA be monitored for failure rates. It may be necessary to expand central sewer services into areas along the western edge of the WSWPA if high OSTD failure rates are observed.

11.0 OTHER POTENTIAL SOURCES

11.1 Mosquito Control Spray Application Areas

Lyman Roberts, Ph.D., Director of the Sarasota County Mosquito Control District indicated that spraying is not conducted on a set schedule but by sampling the mosquito population with traps. When numbers of person-biting species exceed thresholds, the subject area is sprayed with Naled (Dibrom) or permethrin (Biomist 4-4). Naled is applied by air at 0.6 ounce per acre to rural areas east of I-75. This insecticide breaks down to undetectable levels within 7 hours. Permethrin is applied by truck at 0.00175 ounce of actual ingredients per acre and has a half life of about 6 hours.

11.2 Hazardous Waste/Spills

Because of its relatively rural nature, there is limited potential for sources of hazardous waste being generated within the WSWPA. However, there are three major roadways that currently traverse the WSWPA. State Road 70 in Manatee County traverses the watershed at its headwaters but doesn't cross a major stream or tributary. However, Sate Road 780 (Fruitville Road) which crosses a wide floodplain in the upper end of the watershed and State Road 72 (Clark Road) which crosses the Cow Pen Canal just upstream of the proposed Abritton storage area pose potential opportunities for hazardous spills to occur from vehicles traversing the watershed. These two latter crossings area both located in Sarasota County. It is recommended that Sarasota County consider providing adequate traffic barriers along each side of the roads at these two locations and that the roadside stormwater drainage should be crowned away from the canal.

In addition, University Parkway is to be extended eastward to State Road 70 by Manatee County just north of the County line. This alignment will cause significant impacts to the wide headwater tributaries in the WSWPA. It is recommended that Sarasota County engage Manatee County and property owners just south of the Manatee/Sarasota County line to see if the extension can be aligned to minimize the extent of the crossing of the headwater floodplain. Fortunately, there are no Interstate Highways that traverse the WSWPA.

Existing Sarasota County Solid Waste Goals/Policies that are relevant to hazardous waste include Policy 2.3.3, Policy 2.3.4, Policy 2.3.5, and Policy 2.3.6. In particular Policy 2.3.6 prohibits the location of any new hazardous collectionor storage areas within the 100 year floodplain within the watershed of a public potable surface water supply, or with 200 feet of the wetland jurisdictional line, whichever is greater.

11.3 Wastewater Treatment Facilities

There are no public or private wastewater treatment facilities in the WSWPA. However, Sarasota County's Bee Ridge Water Reclamation Facility (BRWRF) is located adjacent to the WSWPA, approximately 0.34 mile from the drainage way. The BRWRF is a 1.5 million gallon per day (mgd) wastewater treatment facility. It was placed in service in August 1995 and is adjacent to, and north of the Bee Ridge Landfill. It is located totally within the Phillippi Creek Watershed and it is likely that any spills would be contained on the parcel and not adversely impact water quality in the WSWPA.

Existing Sarasota County Watershed Management Goals/Policies that are relevant to wastewater treatment facilities include Objective 1.2. There are currently no wastewater treatment facilities in the WSWPA. Therefore, this objective and other related policies would likely only be applicable if a new wastewater treatment facility was constructed in the WSWPA in association with a 2050 Plan village.

11.4 Solid Waste Facilities

There are two solid waste facilities located just outside of the WSWPA. The first is the Sarasota County Bee Ridge Landfill which has been closed but is located just north of the Vegetable Relief canal and the WSWPA. The second site is the active Central County Solid Waste Disposal Complex on Knight's Road in the Pinelands Reserve. It is a Class I landfill that is situated outside of the WSWPA but geographically between the potential future reservoir sites for Albritton and the Venice Minerals.

Existing Sarasota County Solid Waste Goals/Policies that are relevant to solid waste facilities include Policy 2.3.1 and Policy 2.3.2. In particular Policy 2.3.1 addresses the adjacent Central County Solid Waste Disposal Complex. Policy 2.3.2 requires that all public landfill sites undergo inspection and/or monitoring. It is recommended that this is done routinely for both landfills that are adjacent to the WSWPA.

12.0 WATERSHED PROTECTION PROGRAMS

12.1 Protection and Restoration Projects

Protection and restoration projects refer to a suite of site-specific projects that protect and restore watersheds by conserving and enhancing existing watershed resources, or correcting specific problems identified through stream and upland assessments. Protection and restoration projects generally fall into the following categories: stormwater retrofit, stream repair, reforestation, wetland restoration, discharge prevention, pollution source control, municipal operations, sensitive area conservation, and agricultural best management practices. **Table 4** inventories the potential program elements being contemplated in the WSWPA (highlighted) and the lower Dona Bay watershed. **Figure 5** identifies the potential Dona Bay Watershed Management Program Elements.

Element ID	Potential Site	Restoration	Preservation	Ownership
1	Fox Creek Site	X		SCG
2	West Pinelands	X		SCG
3	Venice Minerals	X		SCG
4	Pinelands Pits	X		SCG
5	Albritton Site	X		SCG
6	Gum Slough		X	SCG
7	LT Ranch Pasture	X		Private
8	Hi-Hat Old Grove	X		Private
9	Hi-Hat Floodplain	X		Private

Table 4 – Potential Watershed Restoration Program Elements

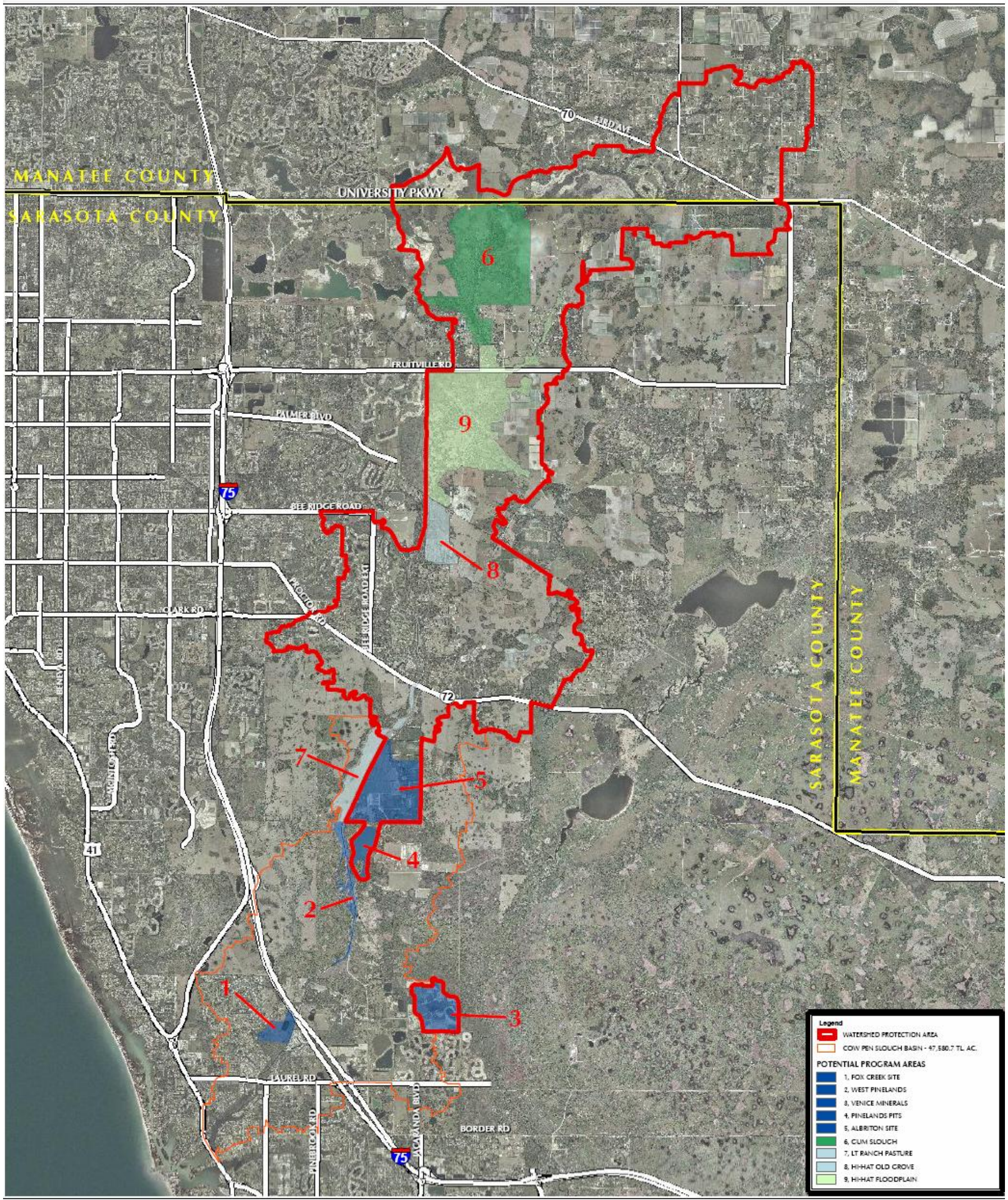

Figure 5 – Potential Dona Bay Watershed Management Program Elements

12.2 Land Use Planning

Land use planning may be the single most important tool in protecting the watershed for future generations. Florida state law requires cities and counties plan for the future by adopting comprehensive plans, which outline how they will manage the environmental, residential, economic, and transportation requirements as the communities change over time. In 1981, Sarasota County's adopted its first Comprehensive Plan which acknowledged the importance of maintaining the ecological integrity of the Cow Pen Slough Basin. The County prohibited mining activities within designated areas of special environmental significance and/or sensitivity. The watersheds of Cow Pen Slough, the Myakka River, and the Braden River are designated areas of special environmental significance.

In October 2000, the Board of County Commissioners, based on recommendations from the Urban Land Institute, called for crafting a growth management policy with a 50-year outlook.

The final product was the Sarasota 2050 plan. The plan establishes an incentive-based approach to managing growth within the WSWPA and across the unincorporated county during the next five decades.

Much of the WSWPA is designated within the Greenway Resource Management Area (RMA). This RMA designates a network of riverine systems, floodplains, native habitats, storm surge areas and uplands as priority resources for the County in order to implement programs, which are designed to protect these lands in perpetuity. The plan also identifies incentives for planners and decision-makers to use to ensure that both designated areas and private property rights are protected. These incentives provide for the purchase of development rights, the Transfer of Development Rights, the purchase of Conservation Easements and the protection of agricultural uses as appropriate.

12.3 Land Acquisition

Sarasota County has a voter-approved and taxpayer-funded *Environmentally Sensitive Lands Protection Program* (ESLPP). The program is designed to acquire and protect natural lands. Priority sites within the county are ranked on environmental criteria including connectivity, water resources, habitat rarity, diversity, and manageability. Areas within the designated Greenway RMA are automatically assigned a higher priority. The County coordinates and pursues joint programs with and seeks, where available, funding from regional, state and federal resources for the purchase of conservation lands. In addition, private not-for-profit entities such as the Nature Conservancy provide assistance in land acquisition.

In January 2004, Sarasota County acquired a 1,972 conservation easement from the Schroeder-Manatee Ranch that stipulates no future development on a parcel that is located at the headwaters of the WSWPA. The parcel is known as the Gum Slough site. The Nature Conservancy had acquired an adjoining 200-acre easement from a private landowner in 2000. These conservation easements will provide valuable wildlife habitat and help protect the water resources of Cow Pen Slough. **Figure 6** identifies all lands currently under public ownership or private protection within the Dona Bay watershed.

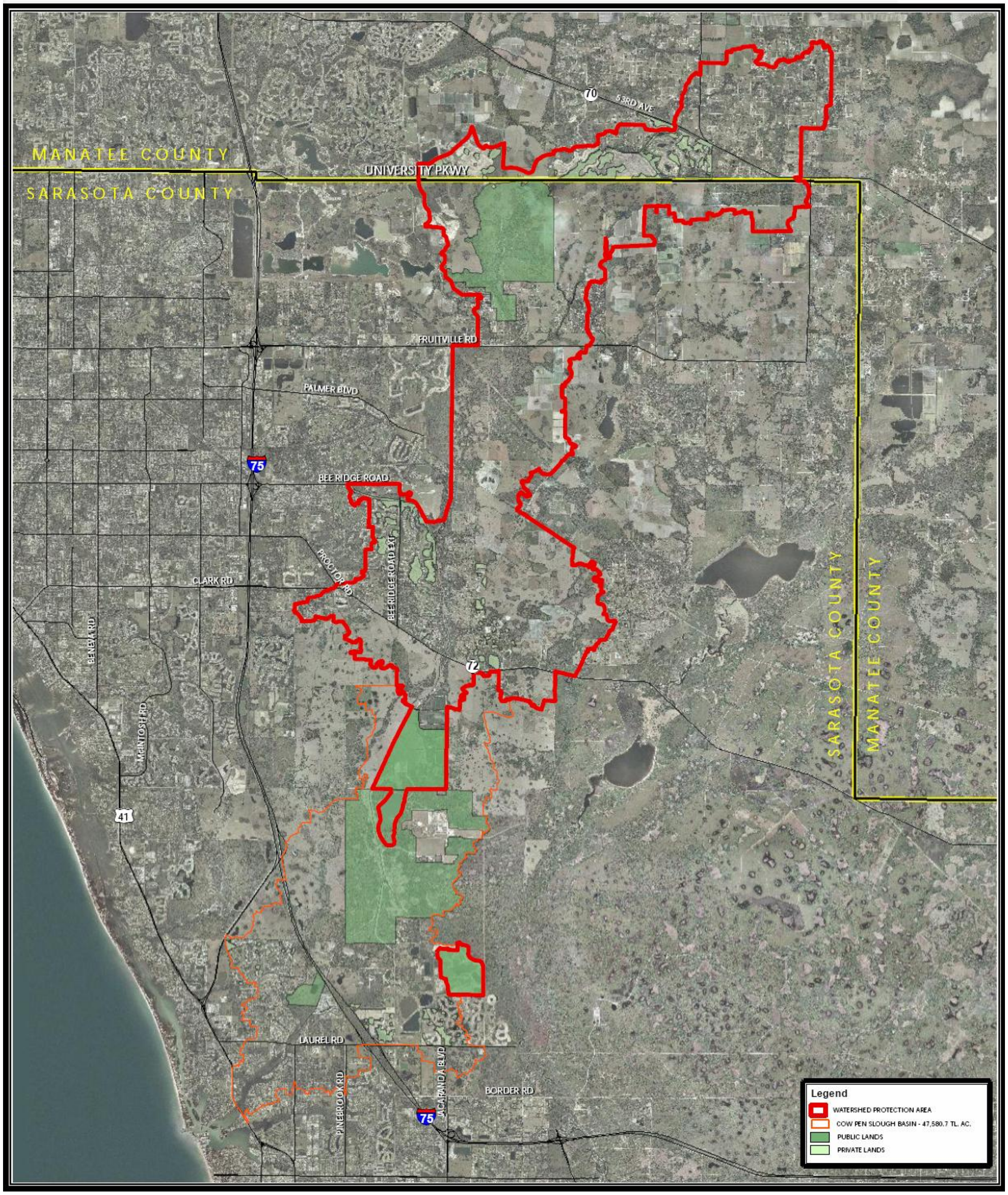

Figure 6 – Publicly Owned Lands and Private Owned Protected Lands

12.4 Aquatic Buffers

The 2050 Plan provides up to 500-foot aquatic buffer from named creeks and flow-ways. If the 2050 Plan is not implemented and in areas along the Cow Pen Canal that are already developed, it is recommended that additional incentives be provided for property owners within 100 feet of the banks of the Cow Pen Canal or contributing tributary to receive grants such as those provided by the SCG Neighborhoods Grant program, to plant and maintain native vegetation within their adjacent property.

12.5 Site Design

In its most recent Comprehensive Plan update Sarasota County has committed to develop low impact design (LID) standards by 2007. Low impact design standards are site specific measures that mitigate the effect of impervious surfaces and stormwater pollutants.

12.6 Erosion and Sediment Control

SWFWMD, Sarasota County and FDEP regulatory standards and policies for Erosion and Sediment Control during construction activities should reflect the state-of-the-art of evolving technologies. In addition, BMPs for all construction projects within the WSWPA should be inspected daily for compliance.

12.7 Watershed Stewardship

Aside from Sarasota County, there are three watershed stewardship constituencies within the WSWPA: large agricultural landowners, developers and existing residents.

Each audience has an identifiable set of concerns and interests that can shape a common strategy for ensuring water quality within the watershed.

For large land-owners
The large private landowners within the WSWPA are generally not absentee owners. They are families that have a long-history within the community and a deep love and respect for the watershed. The County currently encourages landowners to work with the Soil and Conservation District and Sarasota County Cooperative Extension to implement Best Management Practices for agricultural uses, production and range management.

For developers
For new developments, Sarasota County has a robust set of goals, objective, policies and standards with respect to watershed management,

For existing residents
Sarasota County Cooperative Extension has an outreach program – the Florida Yards and Neighborhoods Program - to encourage the reduction in the use of pesticides and fertilizers and the adoption of Florida-friendly landscaping and

native habitat. The County's commitment to the encouragement of active civic engagement in watershed stewardship is covered in the previous Stakeholder Involvement section of this report.

The County has an on-going effort to reduce the potential for excess nutrient input to watercourses through better management practices associated with the application of fertilizers.

Strategies that have been identified for this initiative include:
- Establishment of a waterway lot setback
- Establishment of non-fertilizing zones
- Establishment of native vegetation buffers
- Establishment of low-head berms along seawalls
- Use of low phosphorous fertilizers
- Use of slow release fertilizers, particularly during the wet season
- Require soil testing before fertilization
- Education (making fertilizer bags easier to understand, development of green industries best management practices, neighborhood environmental report card)

13.0 STAKEHOLDER INVOLVEMENT

A comprehensive watershed management plan needs to effectively coordinate the efforts and resources of a complex and overlapping array of agencies, organizations and institutions within and across several level of government. Each entity has a distinct role to play in understanding how to protect the WSWPA.

Aligning the efforts and resources of stakeholders towards common goals is critical to the adoption and implementation of any watershed plan. Undoubtedly Sarasota County will play the lead role in organizing the regulatory, technical and financial stakeholders and partners – the FDEP, the SWFWMD, the Authority, the Charlotte Harbor NEP, and non-profit and public agencies – to appropriately define the necessary roles and distinct and shared responsibilities for meeting the objectives of the watershed plan.

It is just as necessary to actively engage the large property owners, businesses and residents that are within the WSWPA itself since their decisions, activities and investments will have a significant impact on water quality and the health and vitality of the watershed.

Sarasota County has a well-established track record of engaging watershed stakeholders, particularly civic and business leadership. Sarasota County's strong interest and support in water quality and watershed protection is reflected in the fact that it is encompassed by two National Estuary Programs – Sarasota Bay and Charlotte Harbor.

Sarasota County Government (SCG) has continually demonstrated strong support for public involvement in watershed issues. Several years ago SCG held workshops in each watershed – the Watershed Story: Connecting every Home to the Bay.

Neighbors with the assistance of Sarasota County started a grassroots movement known as NEST (Neighborhood Environmental Stewardship Team) to restore and protect natural habitat in their neighborhood. The group enlisted school science teams, businesses and community organizations to work together to restore the native ecosystem for the neighborhood to enjoy. The County has expanded NEST into other neighborhoods and built more partnerships with homeowner associations, civic groups, environmental groups and schools to educate the residents, promote community ownership and create advocates for a healthy environment. The NEST program can provide a tool for initial and continued watershed stakeholder involvement and stewardship.

The Science and Environmental Council of Sarasota County (SEC) created a series of workshops designed to create a common understanding across a diverse group of stakeholders regarding the interrelationship of the vitality of estuaries and watersheds, water conservation strategies, and the value of regional water supply coordination. To this end, the SEC invited a broad group of local government decision-makers in land use planning and water management, local water utility operators, civic leaders, developers, builders and private land use planners to participate in a well-attended and well-received series of dialogs. This program provided a transferable template for initial stakeholder engagement.

The Lemon Bay League is a consortium of homeowners, businesses and not-for-profit groups spanning the two counties which touch Lemon Bay. Following the development of the Lemon Bay Watershed Management Plan, the group is moving forward to develop a community plan around the Lemon Bay Watershed. The plan is designed to coordinate existing neighborhood and area plans, develop an area land use plan, and develop criteria for sustainable development. This watershed-based stakeholder organization could provide a model to sustain watershed stewardship.

In January 2006, Sarasota County hosted a Dona and Roberts Bay public watershed workshop. Over 100 people attended and approximately 35 attendees then participated in small group discussions. A follow-up community update was held on August 26th. These workshops have proven effective in generating a strong sense of public ownership and civic involvement in watershed issues.

14.0 CONSULTANT RECOMMENDATIONS

The following draft recommendations and potential incentives are provided to add value to the existing Sarasota County Watershed Management Goals. A reference is also provided to the Catalog of Federal Funding Sources for Watershed Protection

Purpose of Water Supply Watershed Protection Area Plan:

- In preparing this Plan, existing Comprehensive Plan Watershed Management goals were reviewed relative to water supply. As a credit to Sarasota County government, this review indicated that current regulations address many if not most of these goals. However, additional watershed specific issues and opportunities were identified. For those watershed specific issues, the Plan proposes incentive based protection mechanisms that can be proposed to watershed stakeholders.

- This Plan is not intended to impact the continuance of agricultural activities that are consistent with local, state and federal standards.

- This Plan is not intended to, and may not be used to, inhibit or restrict future development forms that are consistent with comprehensive plan and/or zoning designations.

Incentive Based Protection Mechanisms

- New developments in the WSWPA shall provide 150% times the volume of required by the Sarasota County Land Development Regulations for the selected treatment system or the State requirements for Class III waterbodies, whichever is more strict. As an incentive to provide the additional treatment volume, Sarasota County will support the use of permanent pool volume over littoral zones in stormwater management systems.

- Watercourse greenways in a surface water supply watershed would serve a significant public purpose that should be reflected by the highest possible density bonuses under 2050, conservation subdivisions, and any other incentive-based develop forms that may be created by Sarasota County.

- It is recommended that additional incentives be provided for existing property owners within 100 feet of the banks of the Cow Pen Canal or contributing tributary through the Neighborhoods Grant program to plant and maintain native vegetation within their adjacent property.

- Sarasota County should promote Low Impact Development strategies to more effectively remove pollutants at their source, but not necessarily to reduce runoff volumes in the WSWPA. The intended outcome should be a match of pre and post pollutant loads from new development. Sarasota County should streamline reviews that incorporate LID strategies.

Strategic Watershed Management Opportunities

- Based upon their strategic, on-line locations, it is recommended that Sarasota County discuss potential partnership opportunities with either the private property interests associated with the LT Ranch site and the Hi Hat Old Grove site for regional stormwater facilities that could be incorporated into the WSWPA.

- It is recommended that Sarasota County consider providing adequate traffic barriers along each side of State Road 780 (Fruitville Road) and State Road 72 (Clark Road) where they cross the Cow Pen Canal and that the roadside stormwater drainage should be crowned away from the canal.

- It is recommended that Sarasota County engage Manatee County and property owners just south of the Manatee/Sarasota County line to see if the easterly extension of University Parkway can be aligned to minimize the extent of its crossing of the headwater floodplain.

Sarasota County should consider a surcharge on the potable water rates to fund watershed restoration and water quality enhancement activities within the WSWPA.

Federal Funding Sources for Watershed Protection

Catalog of Federal Funding Sources for Watershed Protection

The Catalog of Federal Funding Sources for Watershed Protection Web site is a searchable database of financial assistance sources (grants, loans, cost-sharing) available to fund a variety of watershed protection projects.

Searchable Catalog of Federal Funding Sources for Watershed Protection epa.gov/watershedfunding

Agricultural Management Assistance Database www.nrcs.usda.gov/programs/ama
Clean Water Act Section 319(h) funding (epa.gov/nps/ 319hfunds.html) is provided to designated state and tribal agencies to implement approved nonpoint source management programs.

Environmental Quality Incentives Program (www.nrcs.usda. gov/programs/eqip) offers financial, technical, and educational assistance to install or implement structural, vegetative, and management practices designed to conserve soil and other natural resources.

Conservation Reserve and Conservation Reserve Enhancement Programs (www.fsa.usda.gov/dafp/cepd/default. htm) implemented by the U.S. Department of Agriculture provide financial incentives to encourage farmers and ranchers.

National Management Measures to Control Nonpoint Source Pollution from Agriculture epa.gov/nps/agmm This technical guidance and reference document is for use by state, local, and tribal managers in the implementation of nonpoint source pollution management programs. It contains information on effective, readily available, and economically achievable means of reducing pollution of surface and ground water from agriculture.

National Agriculture Compliance Assistance Center epa.gov/agriculture or call toll-free: 1-888-663-2155 EPA's National Agriculture Compliance Assistance Center is the "first stop" for information about environmental requirements that affect the agricultural community.

Chapter 5 - Water Quality Appendices

Photo of Dona Bay at Venice Jetty submitted to Sarasota County

TM 4.3.1 – DATA COLLECTION AND REVIEW

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBS&J to summarize the techniques used to develop a comprehensive and relational database for the DBWMP, consistent with Task 4.3.1 of the DBWMP contract.

2.0 INTRODUCTION

This effort is part of the overall Water Quality efforts defined in Task 4.3 of the DBWMP. Specifically, this task includes related water quality evaluations and as-needed sampling and analysis. To facilitate data evaluation and analysis, data from multiple agencies and sampling programs needed to be gathered and combined in one comprehensive database. PBS&J was charged with Task 4.3.1 to "conduct a through search and review" of existing data sources including STORET/IWR databases and various agencies such as Sarasota County and the Southwest Florida Water Management District (SWFWMD). The end result of this effort is a single, relational Access database.

The multiple values of a relational database for the DBWMP include the following:

- All data collected within the geographic area of interest is located in a central location
- Each and every data point can be accessed in a logical manner
- Descriptive information (collection sites, collection method) can be queried in a similar manner as the data itself
- All parameters (including those not originally queried) collected at any given location can be graphically displayed
- The degree of independence or inter-dependence of data sets can be graphically displayed

The two basic techniques for displaying contents in a relational database are the traditional tabular display, and a graphic representation of the relationship between different data sets. For users more accustomed to a simple listing of data sets available for the DBWMP, the "Show Table" query displays the data sets available for query. For the DBWMP, there are 42 data sets. These include the following general categories:

- USGS flow and stage data for Shakett Creek and Blackburn Canal
- Rainfall data
- Continuous recording water quality data collected by Sarasota County
- Monthly water quality data collected by SWFWMD
- Monthly water quality data collected by Mote Marine Laboratory
- Oyster health and distributions
- Seagrass health and distributions
- Wetland types and water levels in the Pinelands Preserve
- Data sets available from IWR run 23.1

In a relational database, the complete listing of databases is available in a format that allows for the user to easily determine the totality of data available for various locations, and the different data sets available for a single parameter. For example, a query of the "Relationships" display would allow a user to determine that in addition to data on the health of oysters in Dona Bay, additional data sets exist at those same locations for dissolved oxygen, temperature, pH, salinity, water depth and turbidity. This would allow a data user to decide whether or not data are available to test for potential relationships between oyster health and salinity, or oyster health and turbidity values, as two examples.

3.0 DATA COLLECTION AND DATABASE CREATION

Data were collected from a variety of sources, though most of the data included in the final database were provided to PBS&J via the Sarasota County ftp site:

ftp://ftp.co.sarasota.fl.us/Pub/Stormwater/ToolsResources/DBWMP

The data on this ftp site included data from multiple agencies such as Sarasota County, Mote Marine Laboratory (Mote), the United States Geological Survey (USGS), and

SWFWMD. The other main source of data was run 23.1 of the Impaired Waters Rule (IWR) database. Some of the data from the IWR duplicated that obtained from Sarasota County. Hard copies of previous reports and studies on DARB are located at this location. At an appropriate time, it would be a simple matter of copying pdf files of these reports to a website that the public could easily access, such as the County's Water Atlas site.

A relational MS Access® database was created that compiled all collected data from all agencies. Separate tables were created in the database for station information and collected data. Links were created between station tables and all tables containing data collected at those stations. Thus, a query can be run to output all data in the database for a specific station, or set of station locations.

The database includes hydrologic data (discharge, gage height, and rainfall) collected from the Sarasota County Government's (SCG) Automated Rainfall Monitoring Stations (ARMS) from 2003-2005. Additional rainfall data include CMR data from 1998 to early 2004 and Pinelands rainfall data from 2002-2005. The database contains biological data from SCG monitoring of seagrass and oyster habitat along with associated water clarity and water quality data. Water quality data also include Mote grab samples, as contracted by SCG. Additionally, data recorded by SCG water quality data loggers are included in the database. Data from USGS gages in the Dona Bay watershed are also provided. Finally, several tables in the database contain data regarding cover and discharge in the Pinelands wetlands. All data tables in the database can be updated as more data are acquired from long term monitoring projects.

4.0 LOCATION OF THE RELATIONAL DATABASE

Due to the large amount of data collected and displayed within this relational data base, there is not a way to produce a meaningful hard copy report containing its contents. The size of the database is presently 53,832 KB. By its very nature, relational databases are meant to be accessed in an interactive manner. As an interim procedure, the relational database, titled "Dona Bay.mdb" is presently located at the following ftp site:

ftp://ftp.co.sarasota.fl.us/Pub/Stormwater/ToolsResources/DBWMP/Products/Task%204%20-%20Watershed%20Management%20Plan/Task%204.3%20-%20Water%20Quality/Task%204.3.1%20-%20Data%20Collection/

A permanent location for this database is most likely to be the County's Watershed Atlas website, which would allow the general public to access these data themselves (providing they have the software to run it, and the bandwidth to allow for transmission of such a large amount of data in a reasonable amount of time).

TM 4.3.2 – DATA ANALYSIS

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

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b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBS&J to present a summary of efforts to develop a statistically robust and scientifically valid relationship between salinity and flows in Dona and Roberts Bays. These relationships were developed using existing and potential flow regimes, based on data supplied from KHA as part of the water budget development portion of the DBWMP contract. This effort is consistent with Task 4.3.2 of the DBWMP contract.

2.0 INTRODUCTION

This effort is part of the overall Water Quality efforts defined in Task 4.3 of the DBWMP. Specifically, this task includes related evaluations and an assessment of potential restoration/enhancement sites for the study area. Since the intent of the project is to consider alternatives for watershed restoration/enhancement of the Dona Bay watershed and its hydrologic regimes, PBS&J was tasked with performing regression analyses of salinity and flow data, to determine existing and potential salinity values at various locations throughout Shakett Creek and Dona Bay.

Most estuarine organisms are classified as "euryhaline" meaning they can tolerate a broad range of salinities. Salinities are important not only in terms of the "average" salinity value, but also in terms of the minimum, maximum, and variation in salinity that is experienced. The salinity regimes considered appropriate for the long-term survival of various organisms found in Dona and Roberts Bays were summarized by Estevez (2006). The salinity requirements derived by Estevez (2006) vary by species.

Hard clams do best in areas where the mean bottom salinity is maintained above 20 ppt, while oysters do best within a range of salinities between 10 and 28 ppt.

For oysters, while adults can tolerate salinities as low as 6 ppt for up to 2 weeks, they cannot tolerate salinities below 2 ppt for much longer than a single week. Juvenile oysters are less tolerant of low salinities than adults, and the most successful spawning events occur when salinities are above 10 ppt.

For successful spawning and larval recruitment (based on data from red drum, seatrout and snook) salinities should be within the range of "seasonally appropriate levels." Red drum and seatrout larvae can tolerate salinities between 15 and 35 ppt.

In contrast, juvenile snook require freshwater for successful development. The need for freshwater habitats for juvenile snook is not due to a lethal impact of salt on the fish themselves; rather, it is related to lethal impacts of salinity on the preferred prey of juvenile snook (Estevez 2006).

3.0 DEVELOPMENT OF SALINITY VS. FLOW DATA SETS, AND COMPARISON TO "TARGET" SALINITY VALUES FOR DONA BAY

KHA developed an historical flow record for Cow Pen Slough, using techniques outlined previously outlined by SWFWMD and referenced in Technical Memorandum 4.2.2 - Water Quantity|Water Budget Approach. These data were supplied to PBS&J as a record of monthly flow values for the period between November 1966 and December 2005.

During the period of August 2003 to September 2005, the SWFMWD recorded salinities at 25 stations located throughout the DARB system (Figure 1).

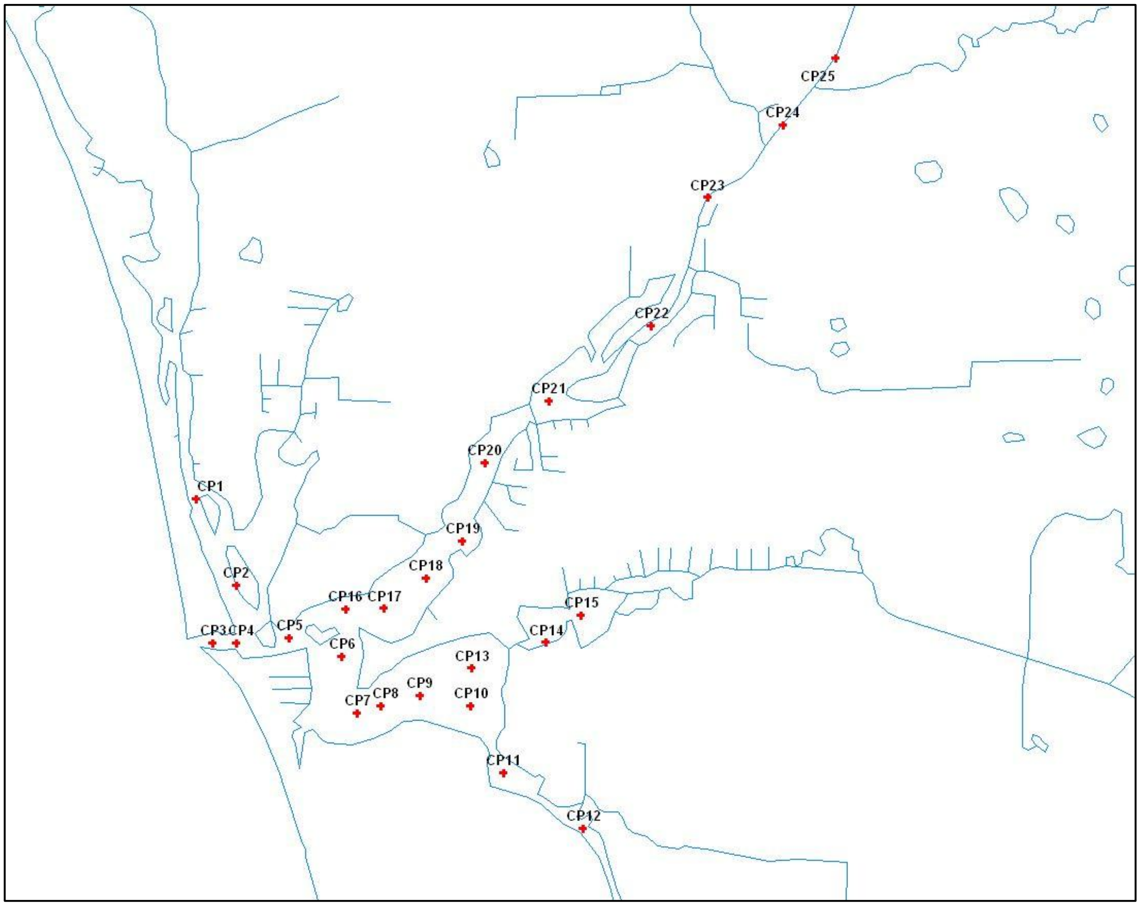


Figure 1 – Location of SWFWMD Water Quality Monitoring Stations

Salinity data from these locations and flow data down Cow Pen Canal were then compared to determine if there was a relationship between flows (monthly averages) and salinity values collected during that same month. To reduce the possibility of including confounding errors, salinity data were normalized for sampling depths (0.5 meters below the surface). Also to avoid the inclusion of confounding influences, data were restricted to that time period when salinity data were available from all locations (March 2004 to September 2005). At several locations (stations 4, 8, and 15) there was insufficient data to allow for a statistically valid comparison of flows vs. salinities (at least at depths of 0.5 m for the period of March 2004 to September 2005) – these stations were excluded from further analysis.

A comparison of various potentially significant regression types was run for all stations except 4, 8, and 15 using StatGraphics©. This software package allows for a comparison of more than 20 mathematical regression techniques. The regression equation with the highest R-squared value (the best fit) was then selected, as illustrated in Figure 2 using data from Station 25.

Station 25

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Logarithmic-X	**-0.8147**	**66.37%**
Square root-Y logarithmic-X	-0.8092	65.48%
Squared-Y logarithmic-X	-0.7643	58.41%
Logarithmic-Y square root-X	-0.7407	54.87%
Multiplicative	-0.7380	54.47%
Square root-X	-0.7174	51.46%
Reciprocal-Y	0.7022	49.31%
Reciprocal-Y square root-X	0.6932	48.06%
Exponential	-0.6640	44.09%
Squared-Y square root-X	-0.6526	42.59%
Reciprocal-Y squared-X	0.6465	41.79%
Reciprocal-Y logarithmic-X	0.5863	34.37%
Reciprocal-X	0.5849	34.21%
Linear	-0.5724	32.76%
Squared-Y reciprocal-X	0.5638	31.79%
Square root-Y reciprocal-X	0.5568	31.00%
Logarithmic-Y squared-X	-0.5407	29.24%
Squared-Y	-0.5061	25.61%
Square root-Y squared-X	-0.4658	21.69%
S-curve model	0.4620	21.34%
Squared-X	-0.4103	16.83%
Double squared	-0.3508	12.31%
Double reciprocal	-0.2917	8.51%

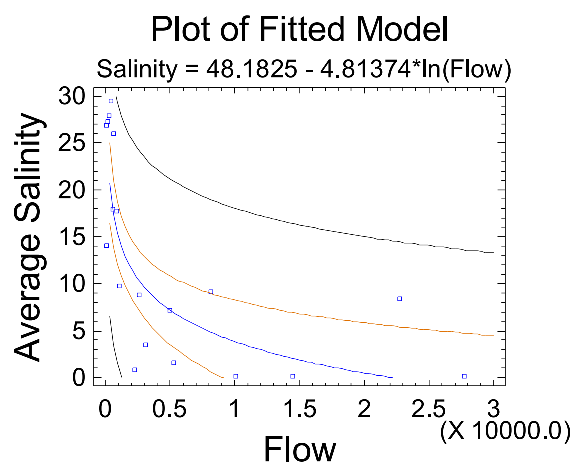


Figure 2 – Regression Output for Flow vs. Salinity for Station 25

For Station 25, the best-fit equation for the relationship between flow (as the independent variable) and salinity (as the potentially significant independent variable) was that of a logarithmic-X vs. non-transformed Y. The relationship was highly statistically significant ($p < 0.01$).

For stations located in either Roberts Bay or Curry Creek / Blackburn Canal, regressions were compared between salinity and flows at Cow Pen Slough vs. salinity and flows from Blackburn Canal. As should be expected, at all these stations (7, 9, 10, 11, 12, 13, and 14) there was a similarly strong relationship between salinity and flows in Blackburn Canal as there was between salinity and flows down Cow Pen Canal. At station 8, there was not a similar data set at the same water depth and time period (described above). As the intent of this effort was to examine the potential for reduced flows to affect salinities, and as the only flows likely to be reduced via the proposed watershed/hydrologic restoration projects, flow-salinity relationships were further developed only for those station in Shakett Creek and Dona Bay.

For each station, the regression equation developed (as in Figure 1) was then used to calculate the predicted salinity for each of the months from November 1966 to December

2005. This allowed for the production of approximately 480 monthly salinity estimates (12 months per year times 40 years). Monthly salinities were then re-calculated using estimates of Cow Pen Canal flows that either bypass, over flow or are generated by the watershed located between the upper and lower water level control structures under the conceptual Phase 3 watershed/hydrologic restoration plan. These flows represent the volume of freshwater that would be still delivered to Shakett Creek and Dona Bay from the Cow Pen Canal.

The average salinities for each month (e.g., January, February, etc.) over the period of record were then calculated for each scenario – existing vs. potential (i.e. Phase 3 configuration). The following figures represent differences in existing vs. potential salinity regimes at stations 25, 19, and 5. These stations represent potential changes in salinity regimes at the base of the weir on Cow Pen Slough, at Shakett Creek at U.S. 41, and in Dona Bay close to Venice Inlet, respectively.

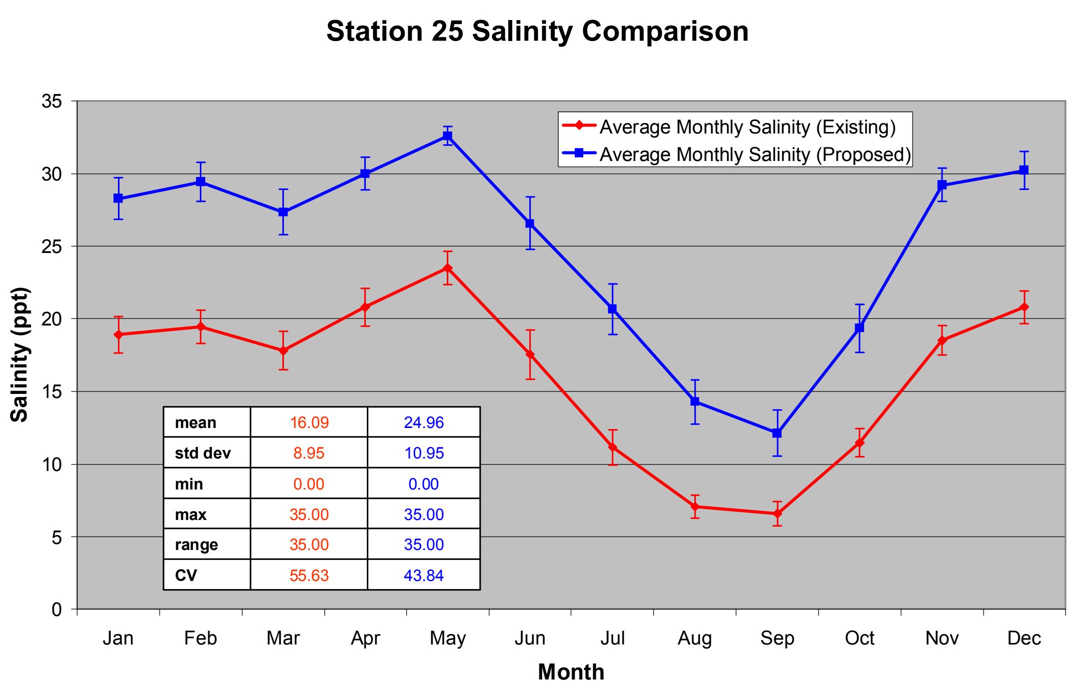


Figure 3 – Existing vs. Potential Salinity Regimes at Station 25 (means ± s.e.)

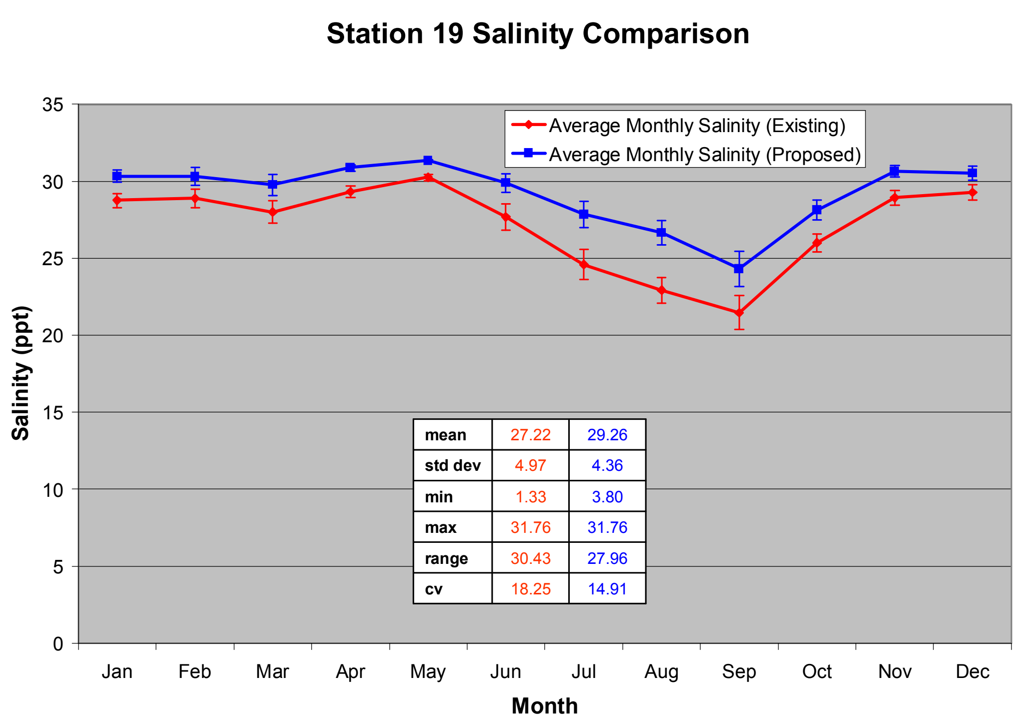
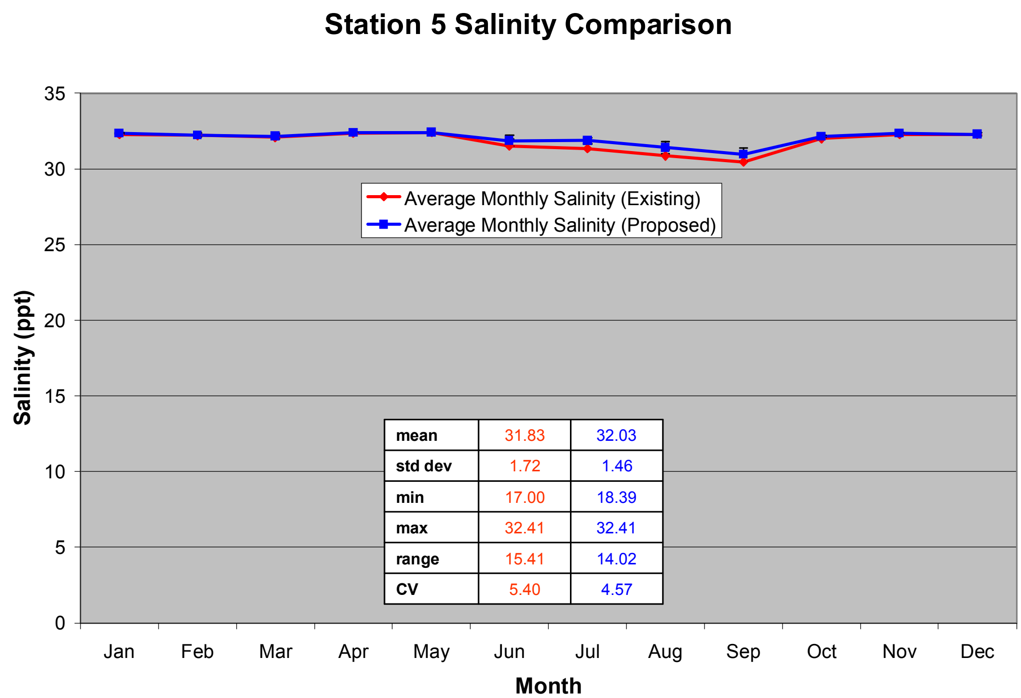


Figure 4 – Existing vs. Potential Salinity Regimes at Station 19 (means ± s.e.)



mean	31.83	32.03
std dev	1.72	1.46
min	17.00	18.39
max	32.41	32.41
range	15.41	14.02
CV	5.40	4.57

Figure 5 – Existing vs. Potential Salinity Regimes at Station 5 (means ± s.e.)

The results from these analyses suggest that while substantial changes in salinity are possible in some of the locations in the Shakett Creek, with implementation of the watershed/hydrologic restoration plans s envisioned, other locations are not likely to be strongly affected.

In the upper reaches of Shakett Creek, such as at Station 25, salinities might be expected to increase such that salinities would be less likely to drop below 10 ppt, with implementation of the Phase 3 watershed/hydrologic restoration plans. Based on data from Estevez (2006) these locations might be likely to produce salinity regimes more supportive of successful spawning events for oysters.

At locations closer to Venice Inlet, such as Station 5, results indicate changes in salinity would be minimal to the point of perhaps not being detectable. Habitats in this area dependent upon the existing salinity regimes in Dona Bay would not likely be impacted.

For those locations in the lower reaches of Shakett Creek down to the upper portions of Dona Bay, potential changes in salinity regimes are likely to be intermediate between those found for Stations 25 and 5. In these locations, benefits to biological communities might be more strongly related to a reduction in the variability of salinity values, rather than responses to changes in mean values.

In general, responses of benthic habitats to altered salinity regimes associated with the reduced freshwater volumes resulting from the watershed/hydrologic restoration plans are likely to be either positive (upper Shakett Creek), intermediate (lower Shakett Creek and upper Dona Bay) or minimal to absent (lower Dona Bay). There is no information that would suggest that the watershed/hydrologic restoration plans would have a deleterious impact to benthic communities, should potential flow reduction scenarios be implemented.

The figures below are paired for the remaining stations, with the first figure showing the results of the flow vs. salinity regression modeling, and the second figure showing the plots of existing vs. potential salinity regimes, using potential flow diversion scenarios. Station 25, discussed above is not repeated, and stations 7 through 15 which are in either Roberts Bay or Curry Creek (discussed above) are not included.

Station 24

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Logarithmic-X	**-0.8195**	**67.15%**
Square root-Y logarithmic-X	-0.8008	64.13%
Squared-Y logarithmic-X	-0.7790	60.69%
Logarithmic-Y square root-X	-0.7320	53.58%
Square root-X	-0.7288	53.11%
Multiplicative	-0.7259	52.70%
Reciprocal-Y	0.7133	50.88%
Reciprocal-Y square root-X	0.7037	49.52%
Squared-Y square root-X	-0.6694	44.81%
Exponential	-0.6581	43.31%
Reciprocal-Y squared-X	0.6577	43.26%
Square root-Y	-0.6250	39.06%
Reciprocal-Y logarithmic-X	0.5952	35.43%
Linear	-0.5881	34.59%
Reciprocal-X	0.5851	34.24%
Squared-Y reciprocal-X	0.5732	32.86%
Square root-Y reciprocal-X	0.5469	29.91%
Logarithmic-Y squared-X	-0.5369	28.82%
Squared-Y	-0.5232	27.37%
Square root-Y squared-X	-0.4751	22.57%
S-curve model	0.4517	20.40%
Squared-X	-0.4281	18.32%
Double squared -	0.3669	13.46%
Double reciprocal	-0.2964	8.78%

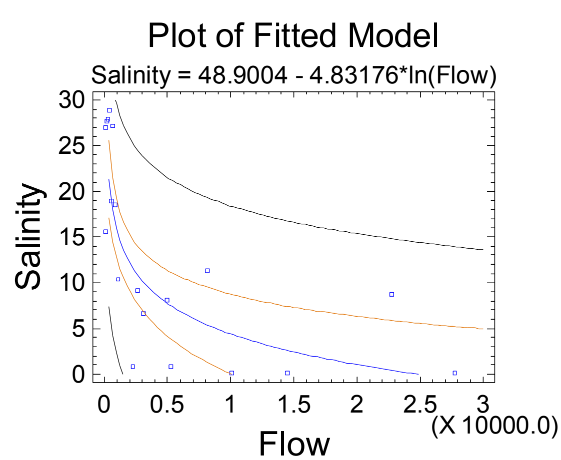


Figure 6 – Regression Output for Flow vs. Salinity for Station 24

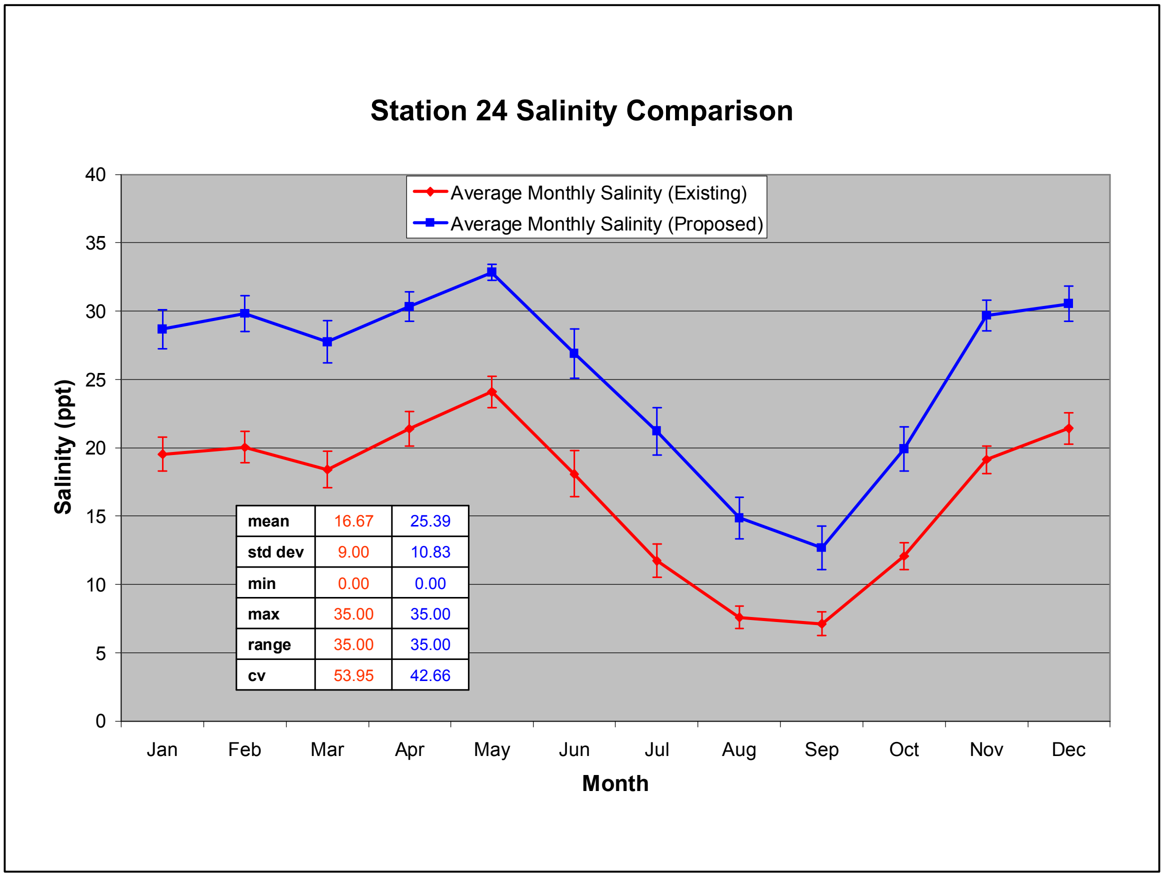


Figure 7 – Existing vs. Potential Salinity Regimes at Station 24 (means ± s.e.)

Station 23

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Logarithmic-X	**-0.8552**	**73.13%**
Square root-Y logarithmic-X	-0.8405	70.64%
Squared-Y logarithmic-X	-0.8219	67.56%
Square root-X	-0.7749	60.04%
Logarithmic-Y square root-X	-0.7707	59.40%
Multiplicative	-0.7613	57.95%
Squared-Y square root-X	-0.7255	52.63%
Reciprocal-Y	0.7186	51.63%
Reciprocal-Y square root-X	0.7037	49.51%
Exponential	-0.6965	48.51%
Reciprocal-Y squared-X	0.6709	45.01%
Linear	-0.6321	39.96%
Reciprocal-Y logarithmic-X	0.5925	35.10%
Reciprocal-X	0.5840	34.11%
Squared-Y	-0.5751	33.07%
Logarithmic-Y squared-X	-0.5724	32.77%
Squared-Y reciprocal-X	0.5624	31.63%
Square root-Y reciprocal-X	0.5587	31.22%
Square root-Y squared-X	-0.5112	26.13%
S-curve model	0.4706	22.15%
Squared-X	-0.4626	21.40%
Double squared	-0.4058	16.47%
Double reciprocal	-0.2963	8.78%

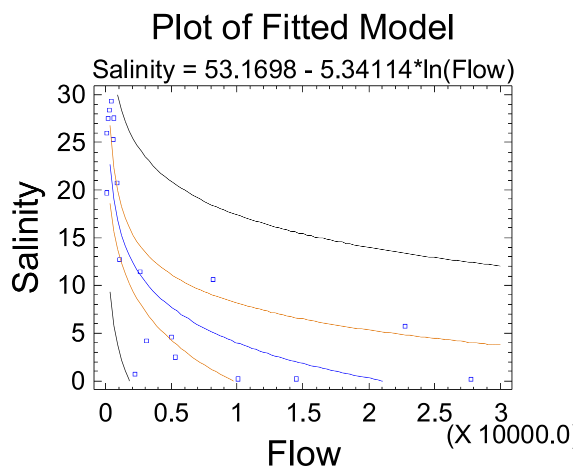


Figure 8 – Regression Output for Flow vs. Salinity for Station 23

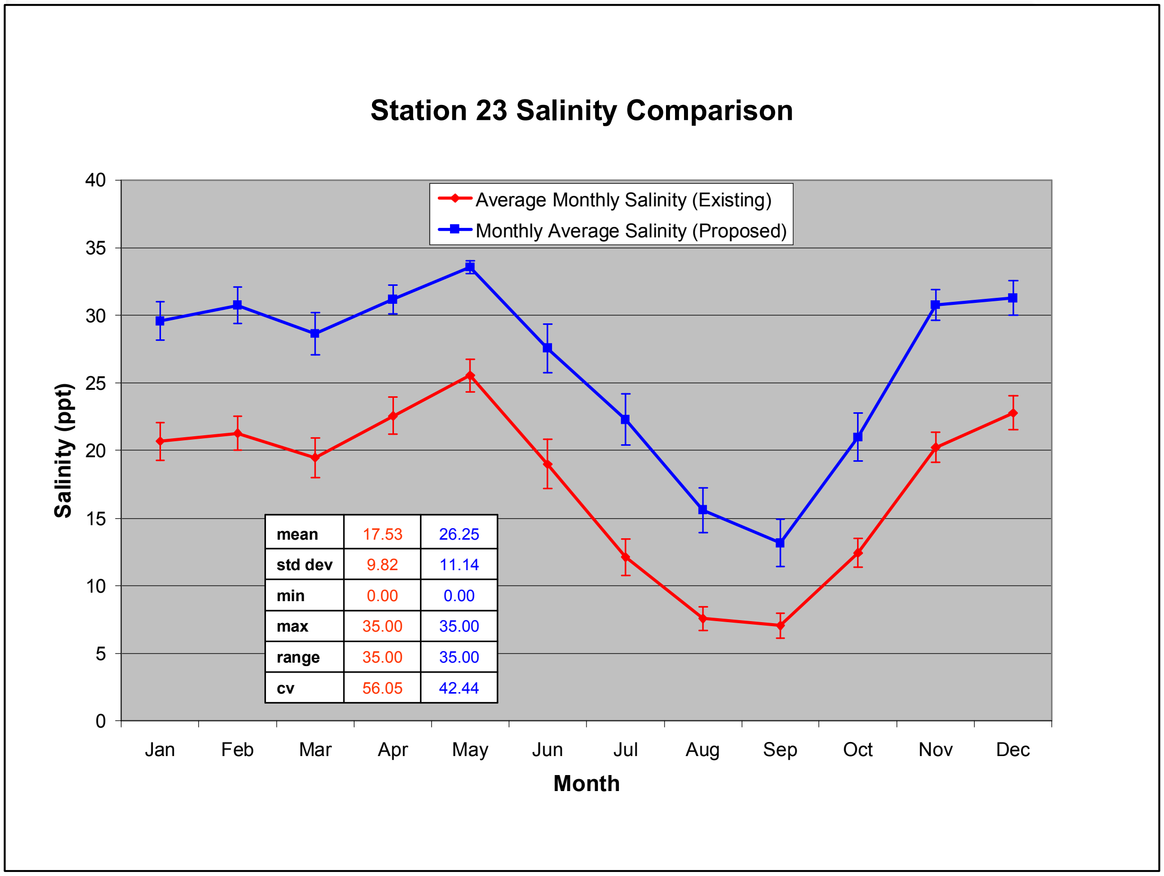


Figure 9 – Existing vs. Potential Salinity Regimes at Station 23 (means ± s.e.)

Station 22

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Logarithmic-X	**-0.8579**	**73.59%**
Squared-Y logarithmic-X	-0.8394	70.46%
Square root-Y logarithmic-X	-0.8309	69.04%
Square root-X	-0.7937	63.00%
Logarithmic-Y square root-X	-0.7863	61.83%
Reciprocal-Y squared-X	0.7690	59.14%
Squared-Y square root-X	-0.7462	55.68%
Exponential	-0.7411	54.93%
Multiplicative	-0.7333	53.77%
Square root-Y	-0.7063	49.89%
Reciprocal-Y square root-X	0.7058	49.81%
Linear	-0.6576	43.24%
Logarithmic-Y squared-X	-0.6348	40.30%
Squared-Y	-0.5948	35.38%
Squared-Y reciprocal-X	0.5766	33.25%
Reciprocal-X	0.5734	32.88%
Reciprocal-Y logarithmic-X	0.5566	30.98%
Square root-Y squared-X	-0.5531	30.60%
Square root-Y reciprocal-X	0.5269	27.77%
Squared-X	-0.4867	23.69%
Double squared	-0.4208	17.71%
S-curve model	0.4179	17.46%
Double reciprocal	-0.2541	6.46%

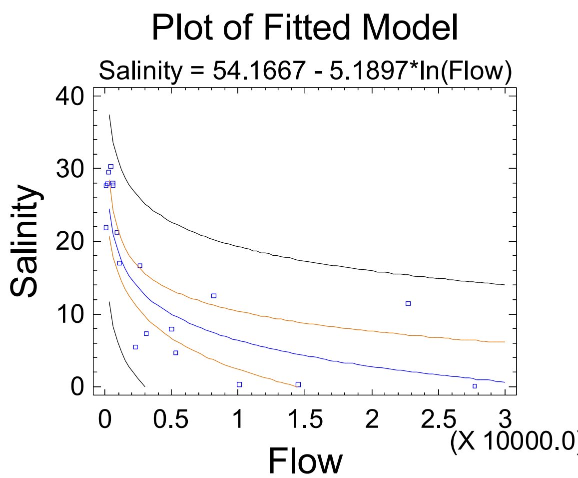


Figure 10 – Regression Output for Flow vs. Salinity for Station 22

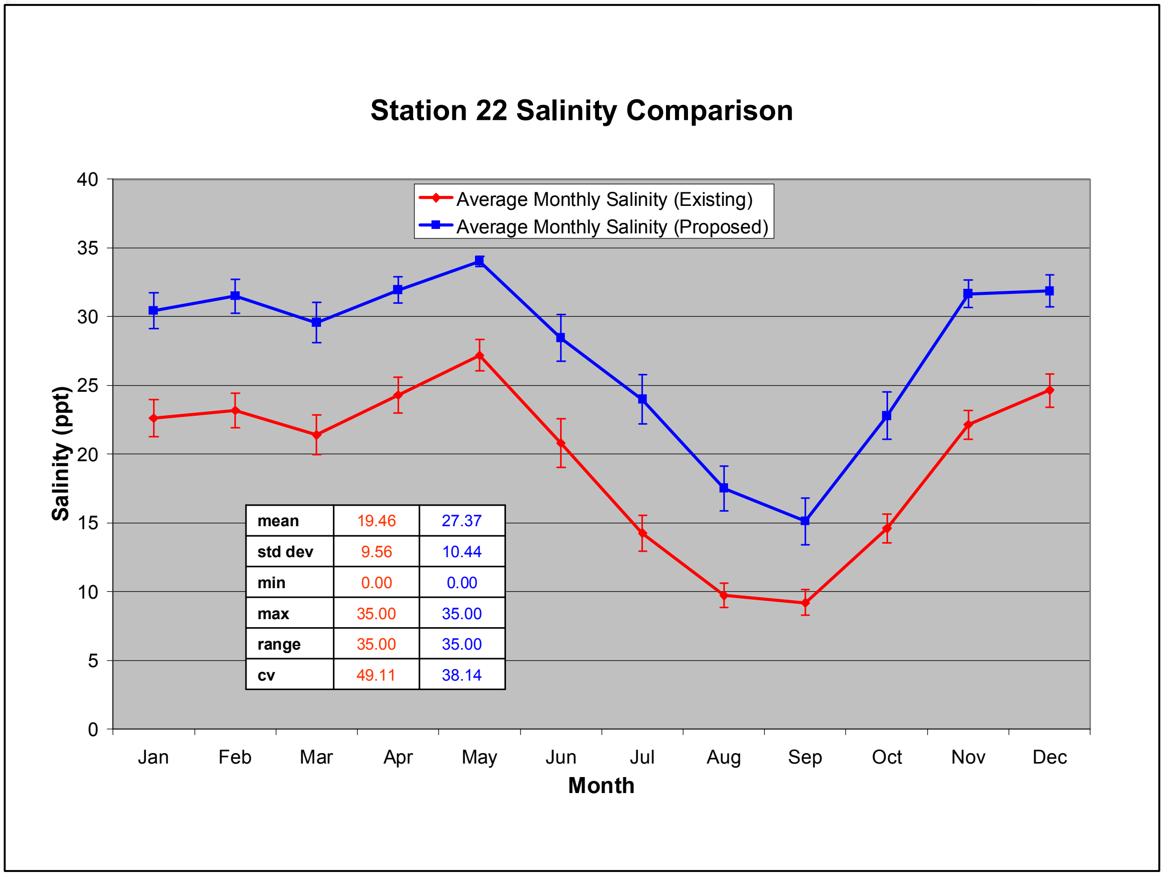


Figure 11 – Existing vs. Potential Salinity Regimes at Station 22 (means ± s.e.)

Station 21

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y logarithmic-X	**-0.8661**	**75.01%**
Logarithmic-X	-0.8576	73.56%
Square root-X	-0.8473	71.79%
Square root-Y logarithmic-X	-0.8054	64.87%
Squared-Y square root-X	-0.8042	64.68%
Logarithmic-Y square root-X	-0.7830	61.32%
Square root-Y	-0.7702	59.32%
Exponential	-0.7569	57.29%
Linear	-0.7443	55.39%
Multiplicative	-0.7048	49.68%
Squared-Y	-0.6679	44.61%
Logarithmic-Y squared-X	-0.6585	43.36%
Reciprocal-Y	0.6420	41.21%
Square root-Y squared-X	-0.6369	40.57%
Reciprocal-Y square root-X	0.6253	39.10%
Squared-X	-0.5866	34.40%
Reciprocal-Y squared-X	0.5827	33.95%
Squared-Y reciprocal-X	0.5682	32.29%
Reciprocal-X	0.5310	28.20%
Reciprocal-Y logarithmic-X	0.5133	26.35%
Double squared	-0.4942	24.42%
Square root-Y reciprocal-X	0.4715	22.23%
S-curve model	0.3812	14.53%
Double reciprocal	-0.2416	5.84%

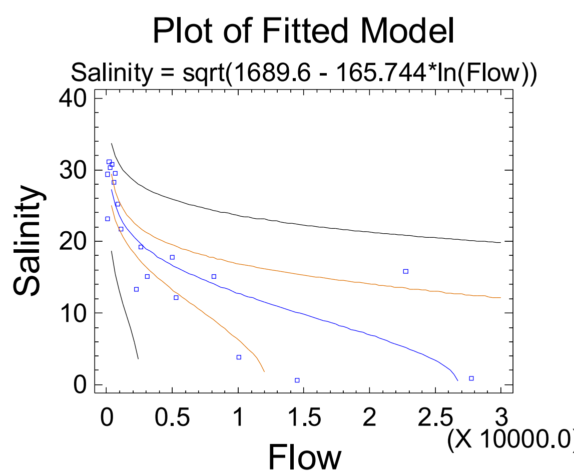


Figure 12 – Regression Output for Flow vs. Salinity for Station 21

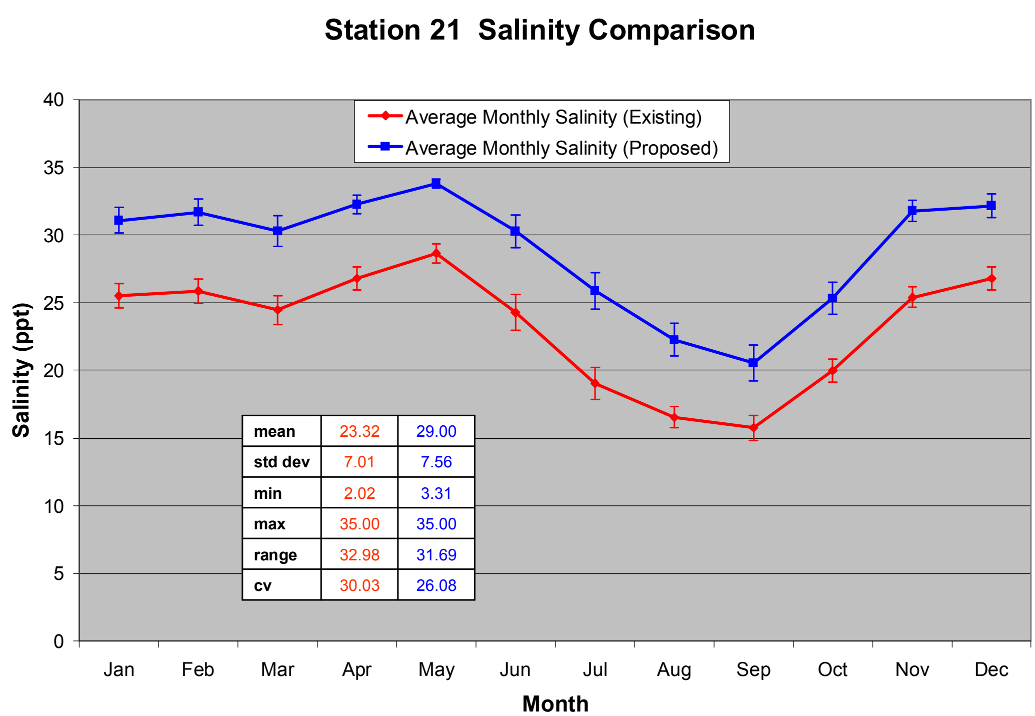


Figure 13 – Existing vs. Potential Salinity Regimes at Station 21 (means ± s.e.)

Station 20

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y logarithmic-X	**-0.8691**	**75.54%**
Square root-X	-0.8682	75.37%
Squared-Y square root-X	-0.8591	73.80%
Logarithmic-X	-0.8295	68.81%
Square root-Y	-0.8036	64.57%
Linear	-0.7958	63.33%
Logarithmic-Y square root-X	-0.7931	62.90%
Exponential	-0.7898	62.37%
Square root-Y logarithmic-X	-0.7715	59.53%
Squared-Y	-0.7477	55.91%
Reciprocal-Y	0.7395	54.68%
Reciprocal-Y squared-X	0.7291	53.16%
Logarithmic-Y squared-X	-0.7149	51.11%
Square root-Y squared-X	-0.6905	47.68%
Reciprocal-Y square root-X	0.6899	47.60%
Multiplicative	-0.6881	47.34%
Squared-X	-0.6534	42.69%
Double squared	-0.5775	33.35%
Reciprocal-Y logarithmic-X	0.5459	29.80%
Squared-Y reciprocal-X	0.5186	26.89%
Reciprocal-X	0.4695	22.04%
Square root-Y reciprocal-X	0.4176	17.44%
S-curve model	0.3512	12.33%
Double reciprocal	-0.2486	6.18%

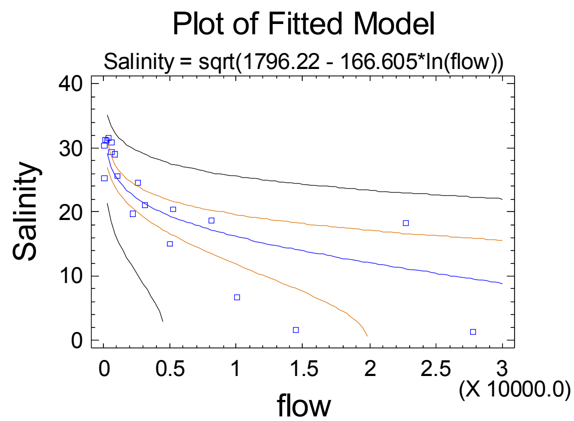


Figure 14 – Regression Output for Flow vs. Salinity for Station 20

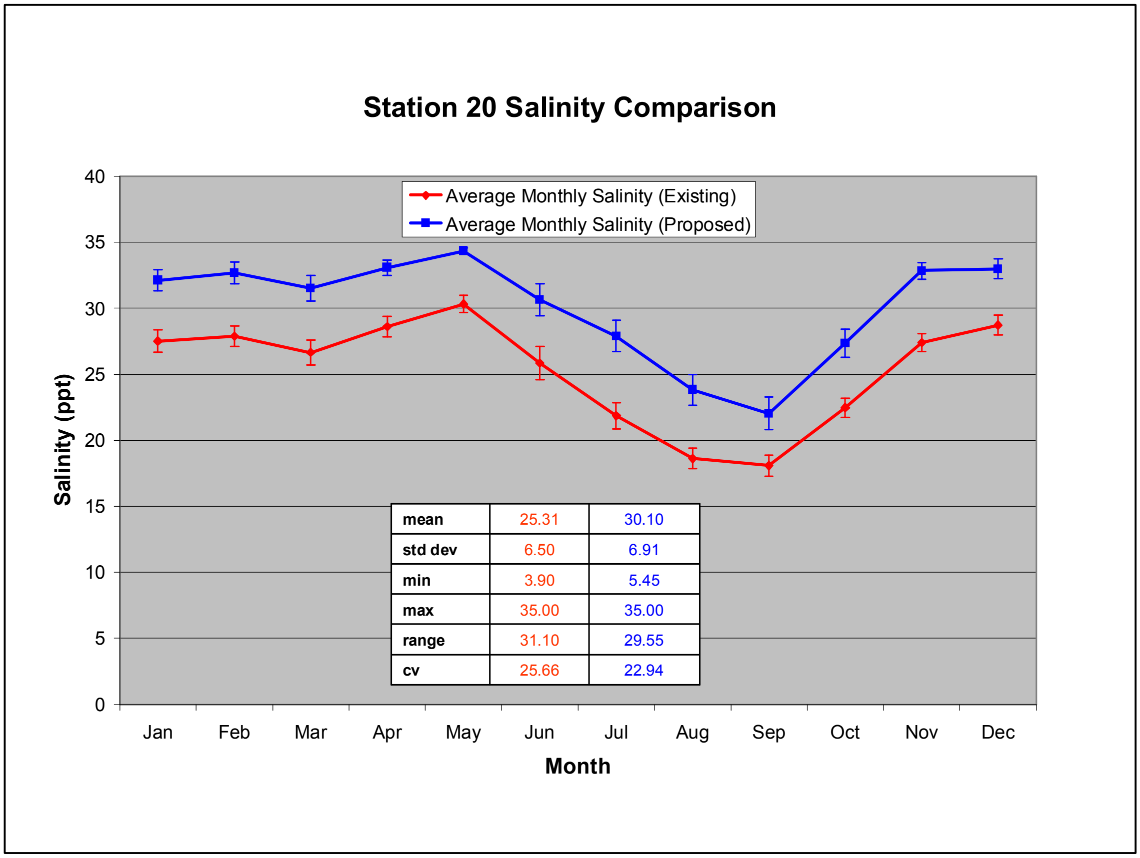


Figure 15 – Existing vs. Potential Salinity Regimes at Station 20 (means ± s.e.)

Station 19

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y square root-X	**-0.8378**	**70.19%**
Squared-Y logarithmic-X	-0.8376	70.17%
Square root-X	-0.8348	69.68%
Logarithmic-X	-0.7964	63.43%
Reciprocal-Y squared-X	0.7874	62.01%
Square root-Y	-0.7836	61.40%
Logarithmic-Y square root-X	-0.7810	60.99%
Exponential	-0.7805	60.92%
Linear	-0.7761	60.23%
Square root-Y logarithmic-X	-0.7518	56.52%
Reciprocal-Y	0.7495	56.17%
Logarithmic-Y squared-X	-0.7467	55.75%
Squared-Y	-0.7419	55.04%
Square root-Y squared-X	-0.7132	50.87%
Reciprocal-Y square root-X	0.6919	47.87%
Multiplicative	-0.6911	47.77%
Squared-X	-0.6750	45.56%
Double squared	-0.6016	36.19%
Reciprocal-Y logarithmic-X	0.5575	31.08%
Squared-Y reciprocal-X	0.4921	24.21%
Reciprocal-X	0.4510	20.34%
Square root-Y reciprocal-X	0.4135	17.09%
S-curve model	0.3658	13.38%
Double reciprocal	-0.2673	7.15%

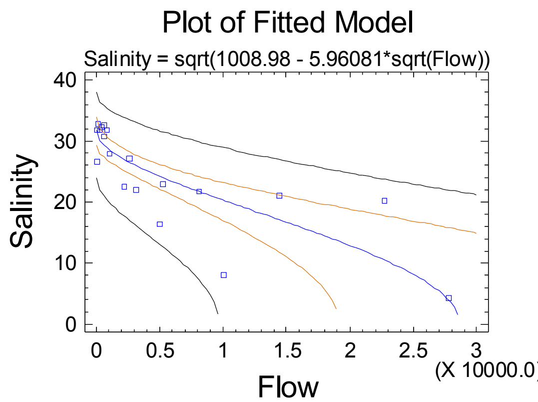


Figure 16 – Regression Output for Flow vs. Salinity for Station 19

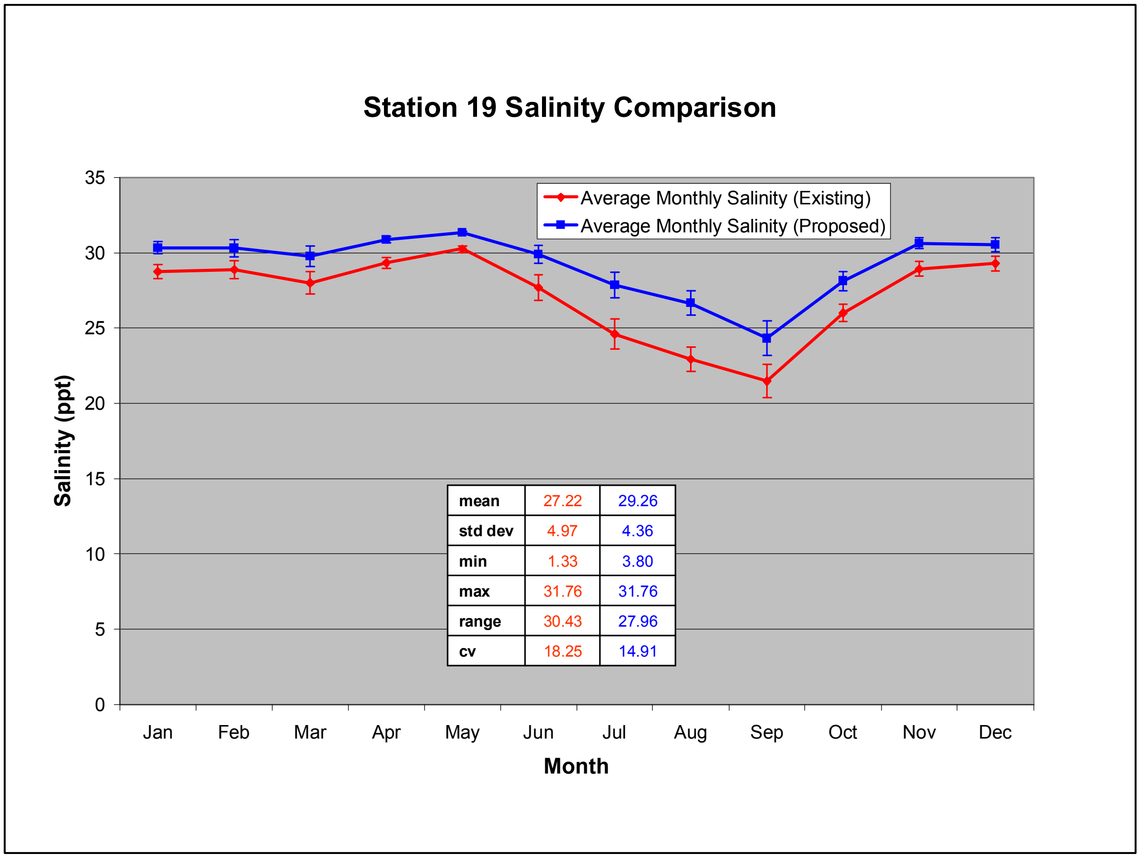


Figure 17 – Existing vs. Potential Salinity Regimes at Station 19 (means ± s.e.)

Station 18

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Reciprocal-Y squared-X	**0.7564**	**57.21%**
Reciprocal-Y	0.7132	50.86%
Exponential	-0.7009	49.13%
Logarithmic-Y squared-X	-0.6996	48.94%
Square root-X	-0.6962	48.47%
Squared-Y square root-X	-0.6935	48.09%
Square root-Y	-0.6878	47.31%
Logarithmic-Y square root-X	-0.6861	47.08%
Linear	-0.6720	45.15%
Squared-Y logarithmic-X	-0.6709	45.01%
Square root-Y squared-X	-0.6642	44.11%
Reciprocal-Y square root-X	0.6589	43.41%
Logarithmic-X	-0.6440	41.47%
Squared-Y	-0.6393	40.86%
Squared-X	-0.6279	39.43%
Square root-Y logarithmic-X	-0.6232	38.84%
Multiplicative	-0.5972	35.66%
Double squared	-0.5631	31.70%
Reciprocal-Y logarithmic-X	0.5351	28.63%
Squared-Y reciprocal-X	0.3775	14.25%
Reciprocal-X	0.3518	12.38%
Square root-Y reciprocal-X	0.3330	11.09%
S-curve model	0.3104	9.63%
Double reciprocal	-0.2598	6.75%

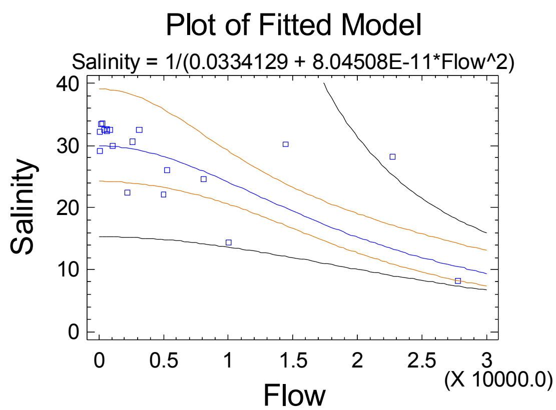
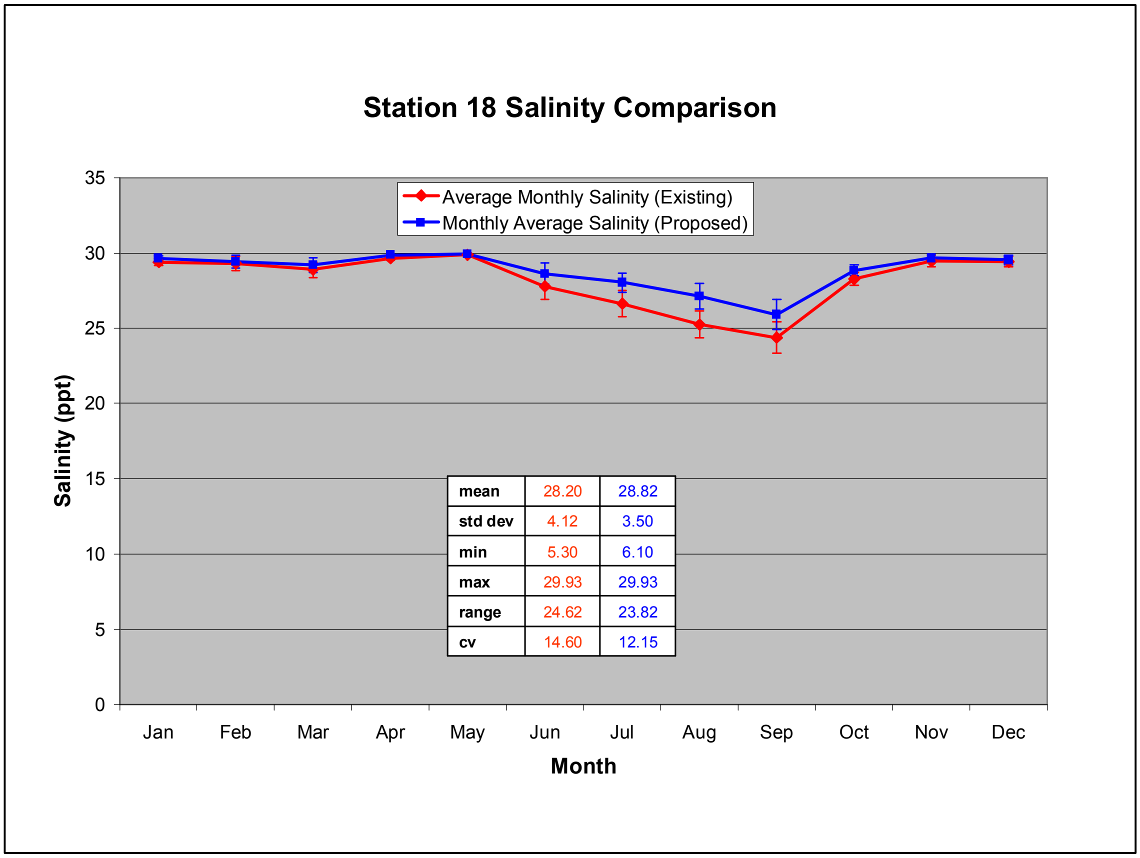


Figure 18 – Regression Output for Flow vs. Salinity for Station 18



mean	28.20	28.82
std dev	4.12	3.50
min	5.30	6.10
max	29.93	29.93
range	24.62	23.82
cv	14.60	12.15

Figure 19 – Existing vs. Potential Salinity Regimes at Station 18 (means ± s.e.)

Station 17

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y square root-X	**-0.7935**	**62.97%**
Square root-X	-0.7873	61.98%
Logarithmic-Y square root-X	-0.7779	60.51%
Reciprocal-Y square root-X	0.7648	58.50%
Squared-Y logarithmic-X	-0.7546	56.94%
Reciprocal-Y	0.7526	56.64%
Exponential	-0.7492	56.12%
Square root-Y	-0.7467	55.75%
Linear	-0.7438	55.32%
Squared-Y	-0.7372	54.35%
Logarithmic-X	-0.7362	54.20%
Square root-Y logarithmic-X	-0.7253	52.61%
Multiplicative	-0.7133	50.88%
Reciprocal-Y squared-X	0.7053	49.75%
Reciprocal-Y logarithmic-X	0.6860	47.06%
Logarithmic-Y squared-X	-0.6821	46.52%
Square root-Y squared-X	-0.6705	44.96%
Squared-X	-0.6592	43.45%
Double squared	-0.6377	40.67%
Squared-Y reciprocal-X	0.4217	17.79%
Reciprocal-X	0.4063	16.51%
Square root-Y reciprocal-X	0.3974	15.79%
S-curve model	0.3877	15.03%
Double reciprocal	-0.3659	13.39%

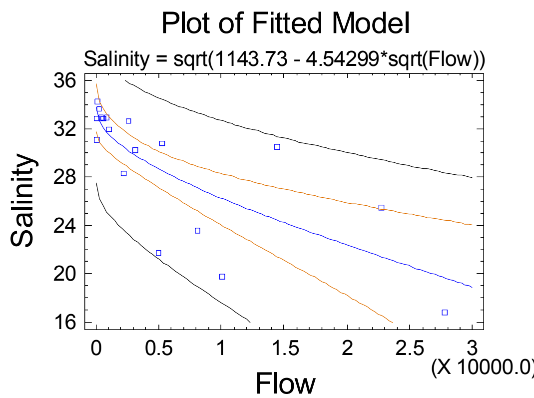


Figure 20 – Regression Output for Flow vs. Salinity for Station 17

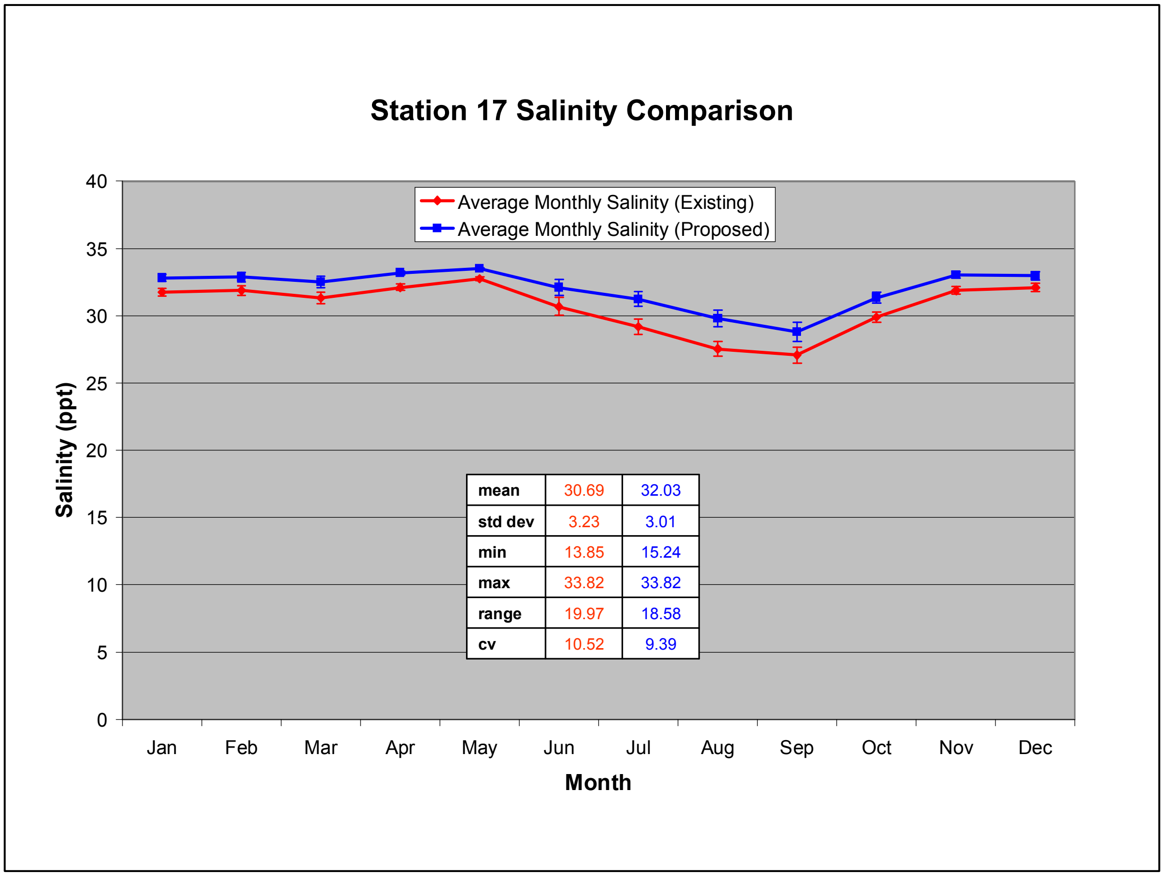


Figure 21 – Existing vs. Potential Salinity Regimes at Station 17 (means ± s.e.)

Station 16

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y logarithmic-X	**-0.7568**	**57.28%**
Logarithmic-X	-0.7259	52.69%
Squared-Y square root-X	-0.7145	51.05%
Square root-Y logarithmic-X	-0.7066	49.93%
Square root-X	-0.6879	47.32%
Multiplicative	-0.6846	46.87%
Logarithmic-Y square root-X	-0.6506	42.32%
Reciprocal-Y logarithmic-X	0.6331	40.08%
Squared-Y	-0.6073	36.89%
Reciprocal-Y square root-X	0.6024	36.29%
Linear	-0.5833	34.03%
Square root-Y	-0.5675	32.21%
Exponential	-0.5490	30.14%
Squared-Y reciprocal-X	0.5162	26.64%
Reciprocal-Y	0.5043	25.43%
Reciprocal-X	0.4889	23.91%
Square root-Y reciprocal-X	0.4728	22.36%
Double squared	-0.4599	21.15%
S-curve model	0.4550	20.70%
Squared-X	-0.4372	19.12%
Square root-Y squared-X	-0.4222	17.83%
Double reciprocal	-0.4149	17.21%
Logarithmic-Y squared-X	-0.4046	16.37%
Reciprocal-Y squared-X	0.3621	13.11%

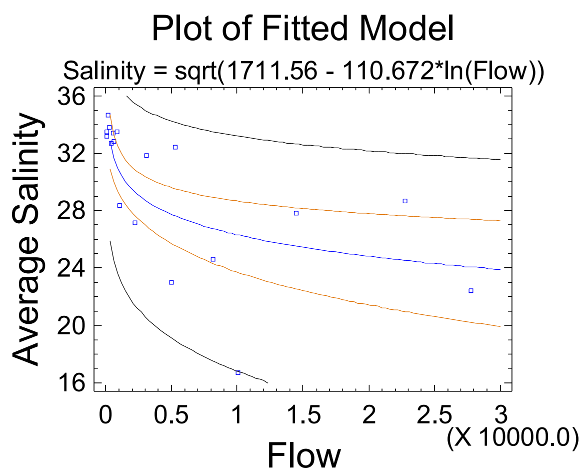
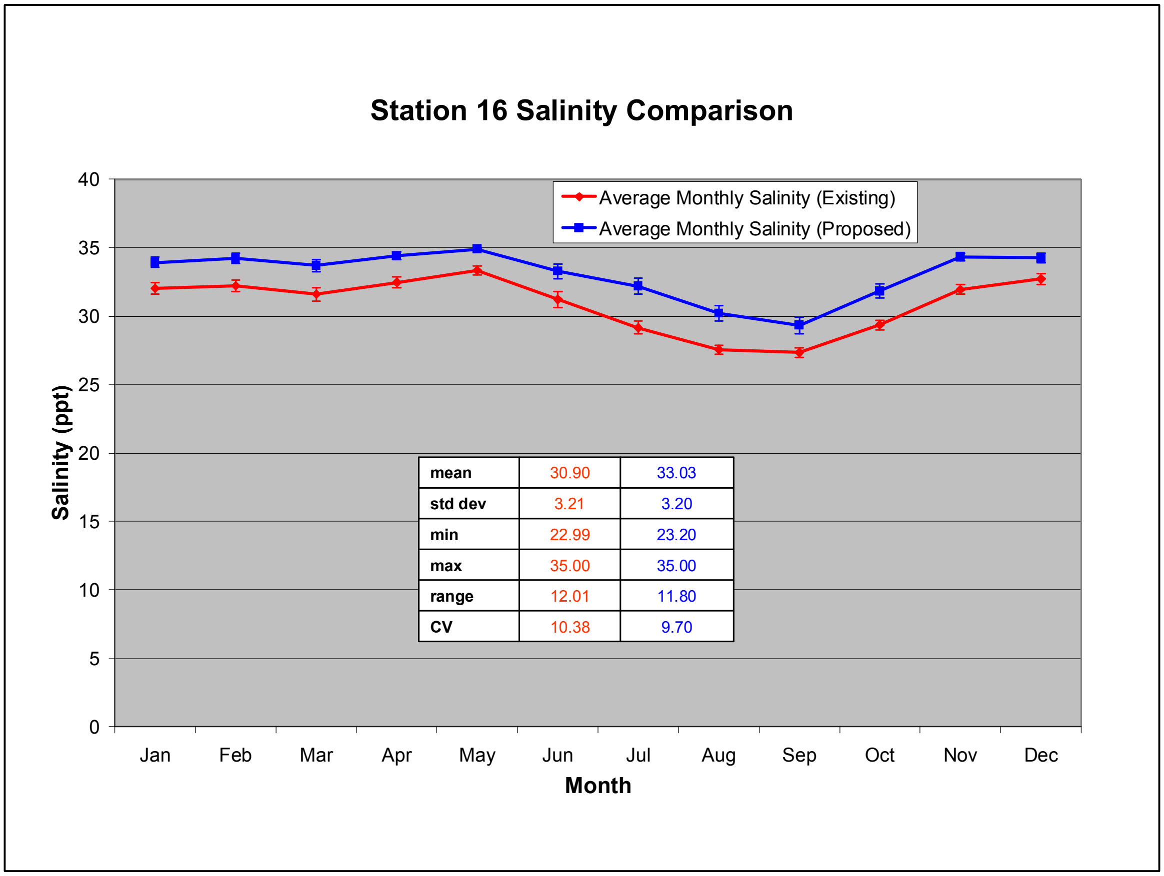


Figure 22 – Regression Output for Flow vs. Salinity for Station 16



mean	30.90	33.03
std dev	3.21	3.20
min	22.99	23.20
max	35.00	35.00
range	12.01	11.80
CV	10.38	9.70

Figure 23 – Existing vs. Potential Salinity Regimes at Station 16 (means ± s.e.)

Station 6

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y logarithmic-X	**-0.6590**	**43.43%**
Logarithmic-X	-0.6461	41.74%
Square root-Y logarithmic-X	-0.6393	40.87%
Multiplicative	-0.6322	39.97%
Reciprocal-Y logarithmic-X	0.6175	38.13%
Squared-Y square root-X	-0.6124	37.50%
Square root-X	-0.5967	35.60%
Logarithmic-Y square root-X	-0.5798	33.62%
Reciprocal-Y square root-X	0.5620	31.58%
Squared-Y	-0.5005	25.05%
Linear	-0.4836	23.39%
Square root-Y	-0.4747	22.54%
Exponential	-0.4656	21.68%
Squared-Y reciprocal-X	0.4589	21.06%
Reciprocal-X	0.4506	20.31%
Reciprocal-Y	0.4466	19.95%
Square root-Y reciprocal-X	0.4463	19.92%
S-curve model	0.4420	19.53%
Double reciprocal	-0.4329	18.74%
Double squared	-0.3437	11.81%
Squared-X	-0.3270	10.69%
Square root-Y squared-X	-0.3183	10.13%
Logarithmic-Y squared-X	-0.3095	9.58%
Reciprocal-Y squared-X	0.2911	8.48%

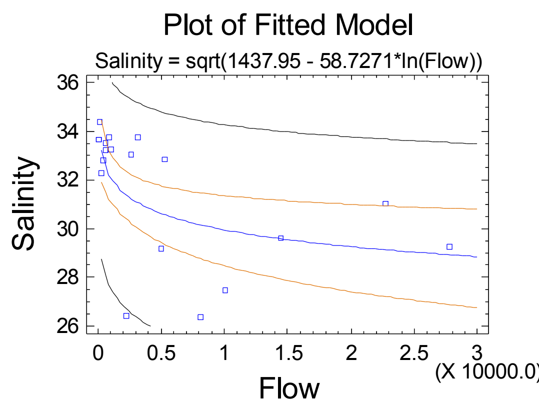
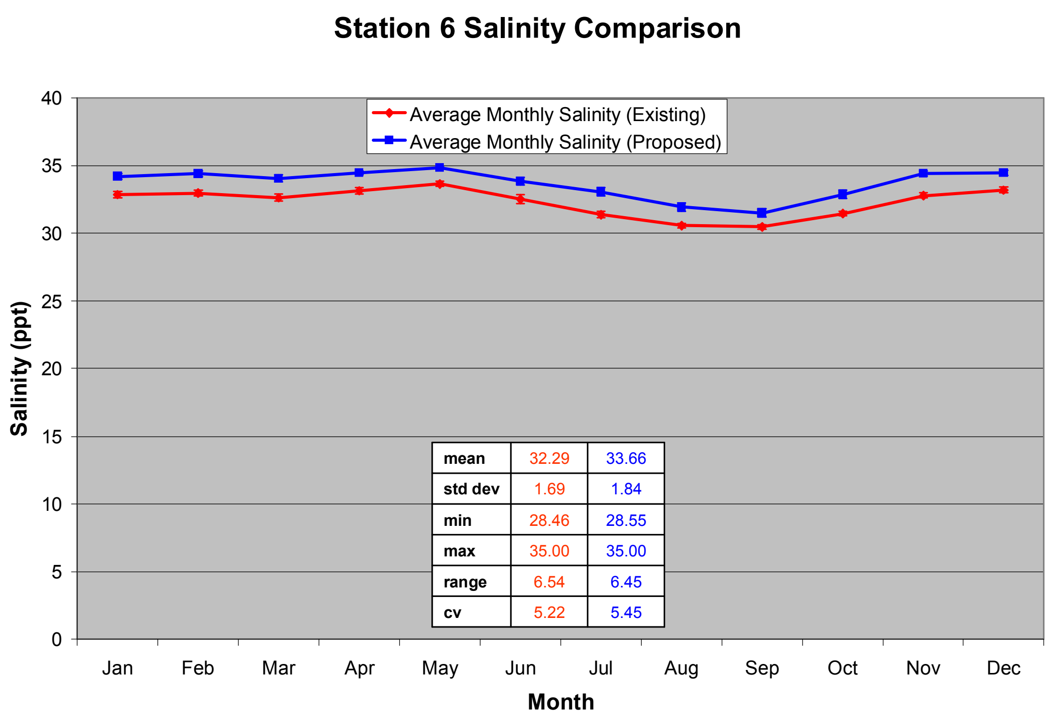


Figure 24 – Regression Output for Flow vs. Salinity for Station 6



mean	32.29	33.66
std dev	1.69	1.84
min	28.46	28.55
max	35.00	35.00
range	6.54	6.45
cv	5.22	5.45

Figure 25 – Existing vs. Potential Salinity Regimes at Station 6 (means + s.e.)

Station 5

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Reciprocal-Y squared-X	**0.8540**	**72.93%**
Reciprocal-Y	0.8497	72.19%
Exponential	-0.8470	71.75%
Square root-Y	-0.8446	71.33%
Linear	-0.8415	70.81%
Logarithmic-Y squared-X	-0.8370	70.06%
Squared-Y	-0.8336	69.48%
Squared-Y square root-X	-0.8319	69.20%
Square root-X	-0.8289	68.71%
Square root-Y squared-X	-0.8275	68.48%
Logarithmic-Y square root-X	-0.8231	67.75%
Squared-X	-0.8176	66.84%
Reciprocal-Y square root-X	0.8143	66.30%
Double squared	-0.7965	63.43%
Squared-Y logarithmic-X	-0.7440	55.35%
Logarithmic-X	-0.7309	53.42%
Square root-Y logarithmic-X	-0.7233	52.31%
Multiplicative	-0.7149	51.11%
Reciprocal-Y logarithmic-X	0.6961	48.45%
Squared-Y reciprocal-X	0.4213	17.75%
Reciprocal-X	0.4080	16.65%
Square root-Y reciprocal-X	0.4007	16.06%
S-curve model	0.3929	15.44%
Double reciprocal	-0.3760	14.14%

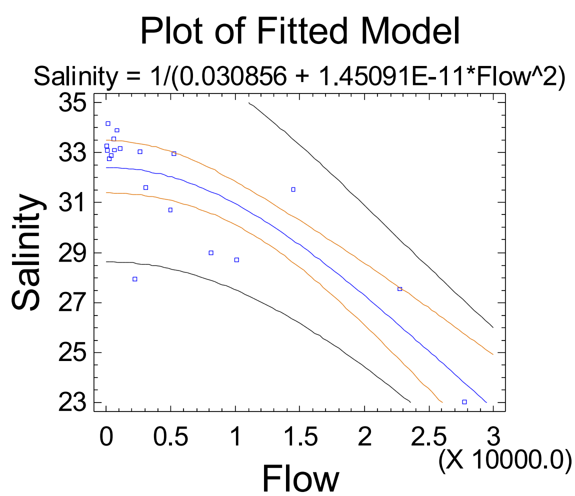


Figure 26 – Regression Output for Flow vs. Salinity for Station 5

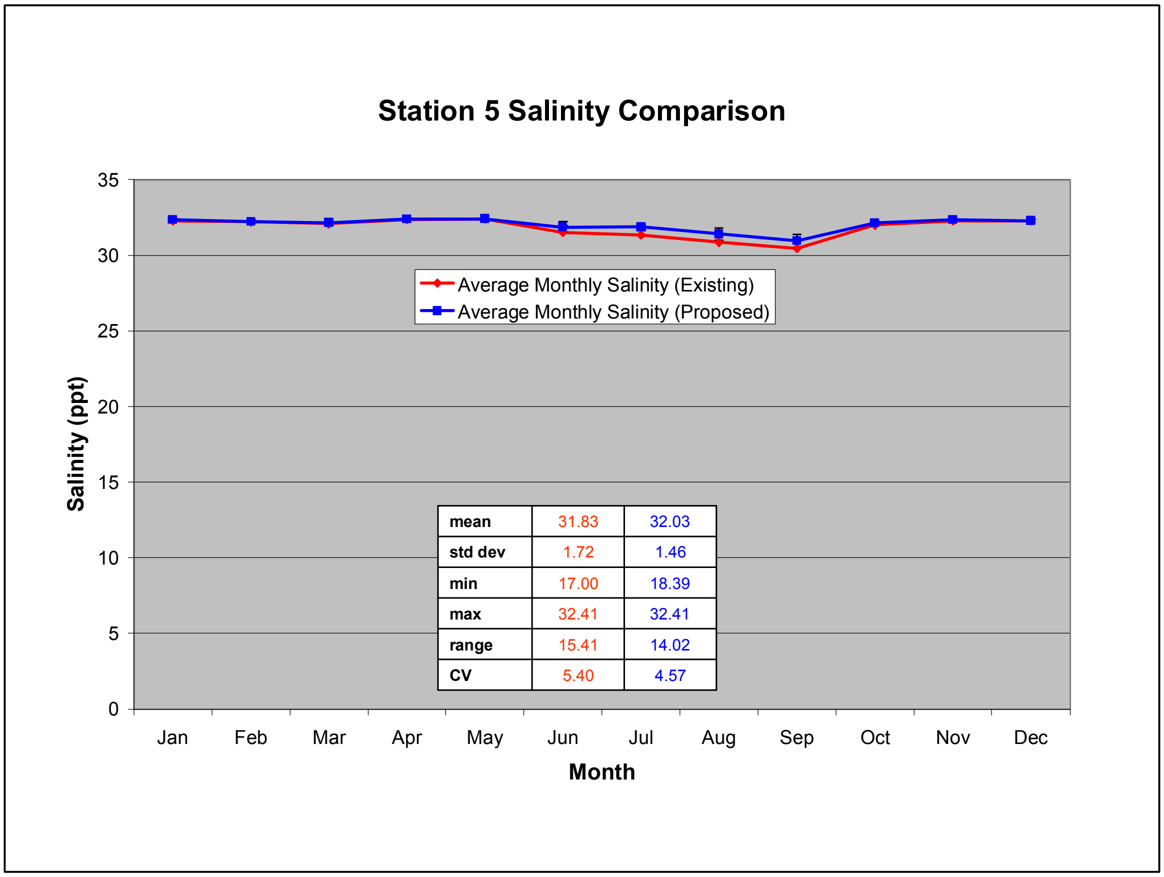


Figure 27 – Existing vs. Potential Salinity Regimes at Station 5 (means ± s.e.)

Station 3

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Reciprocal-Y squared-X	**0.6901**	**47.63%**
Logarithmic-Y squared-X	-0.6754	45.62%
Reciprocal-Y	0.6750	45.57%
Exponential	-0.6685	44.69%
Square root-Y squared-X	-0.6679	44.61%
Square root-Y	-0.6650	44.22%
Linear	-0.6613	43.73%
Squared-X	-0.6603	43.60%
Logarithmic-Y square root-X	-0.6556	42.98%
Square root-X	-0.6553	42.94%
Reciprocal-Y square root-X	0.6551	42.92%
Squared-Y square root-X	-0.6541	42.78%
Squared-Y	-0.6536	42.71%
Double squared	-0.6450	41.60%
Squared-Y logarithmic-X	-0.6051	36.62%
Logarithmic-X	-0.5993	35.92%
Multiplicative	-0.5925	35.11%
Reciprocal-Y logarithmic-X	0.5847	34.19%
Squared-Y reciprocal-X	0.3745	14.02%
Reciprocal-X	0.3662	13.41%
Square root-Y reciprocal-X	0.3618	13.09%
S-curve model	0.3572	12.76%
Double reciprocal	-0.3475	12.08%

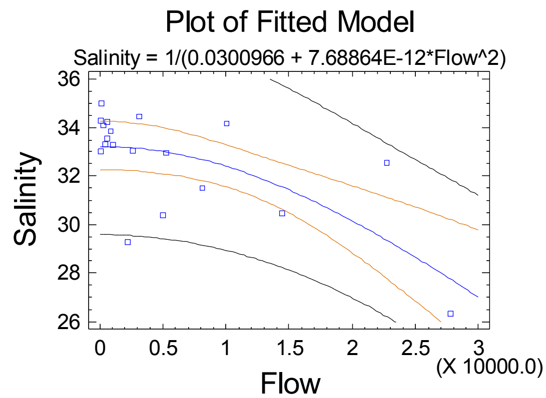
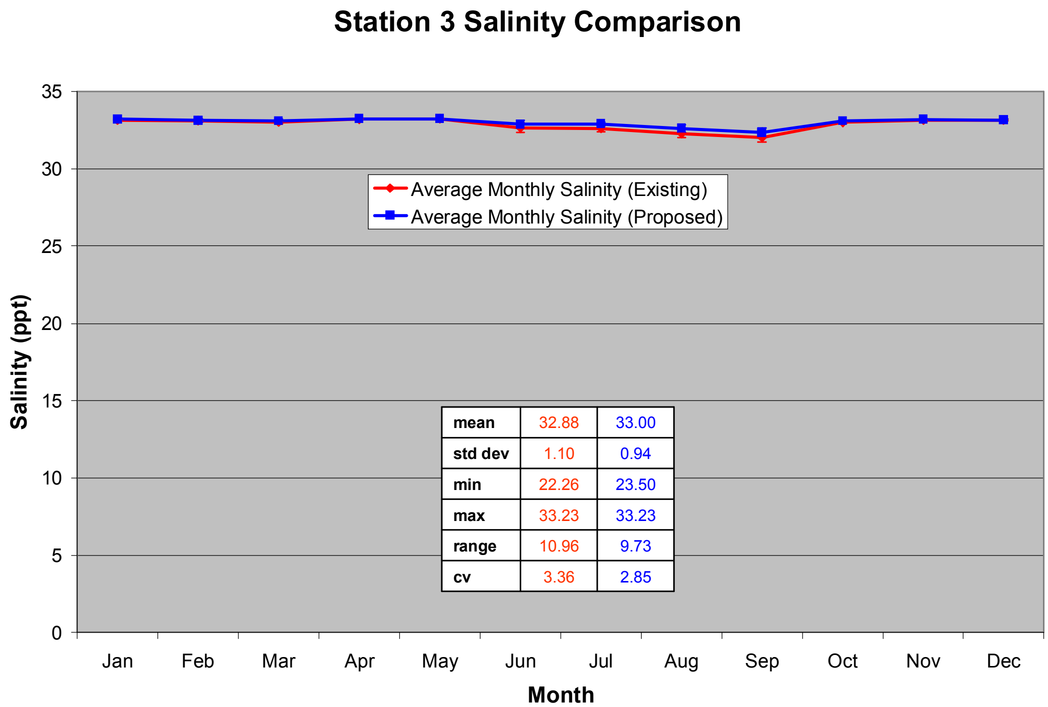


Figure 28 – Regression Output for Flow vs. Salinity for Station 3



mean	32.88	33.00
std dev	1.10	0.94
min	22.26	23.50
max	33.23	33.23
range	10.96	9.73
cv	3.36	2.85

Figure 29 – Existing vs. Potential Salinity Regimes at Station 3 (means ± s.e.)

Station 2

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Squared-Y square root-X	**-0.5770**	**33.30%**
Square root-X	-0.5735	32.89%
Logarithmic-Y square root-X	-0.5695	32.43%
Reciprocal-Y square root-X	0.5650	31.92%
Squared-Y logarithmic-X	-0.5623	31.62%
Logarithmic-X	-0.5573	31.06%
Multiplicative	-0.5520	30.47%
Reciprocal-Y logarithmic-X	0.5464	29.85%
Squared-Y	-0.5256	27.63%
Linear	-0.5231	27.37%
Square root-Y	-0.5217	27.22%
Exponential	-0.5201	27.05%
Reciprocal-Y	0.5166	26.69%
Double squared	-0.4544	20.65%
Squared-X	-0.4532	20.54%
Square root-Y squared-X	-0.4523	20.46%
Logarithmic-Y squared-X	-0.4513	20.37%
Reciprocal-Y squared-X	0.4490	20.16%
Squared-Y reciprocal-X	0.3202	10.25%
Reciprocal-X	0.3151	9.93%
Square root-Y reciprocal-X	0.3125	9.77%
S-curve model	0.3100	9.61%
Double reciprocal	-0.3049	9.29%

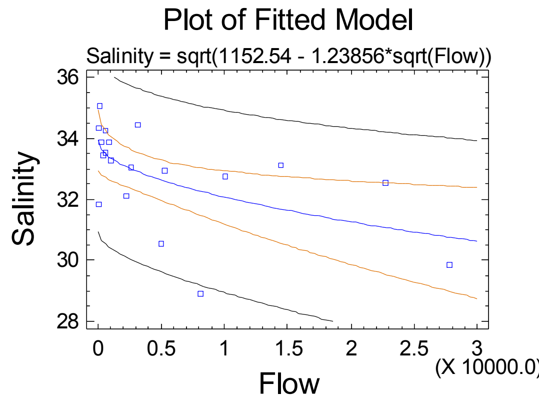


Figure 30 – Regression Output for Flow vs. Salinity for Station 2

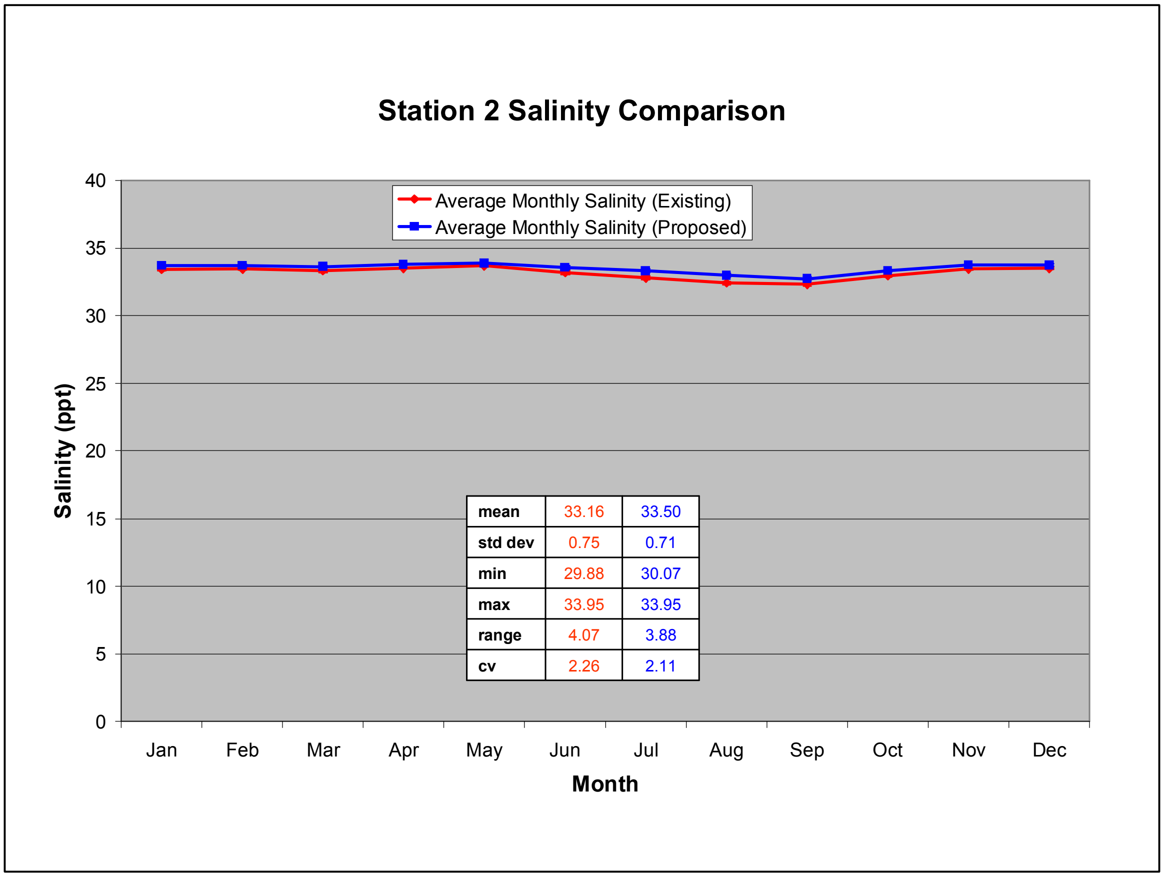


Figure 31 – Existing vs. Potential Salinity Regimes at Station 2 (means ± s.e.)

Station 1

Comparison of Alternative Models

Model	*Correlation*	*R-Squared*
Reciprocal-Y squared-X	**0.6616**	**43.77%**
Logarithmic-Y squared-X	-0.6518	42.48%
Square root-Y squared-X	-0.6468	41.83%
Squared-X	-0.6417	41.17%
Double squared	-0.6312	39.84%
Reciprocal-Y	0.6010	36.12%
Exponential	-0.5949	35.39%
Square root-Y	-0.5917	35.01%
Linear	-0.5885	34.63%
Squared-Y	-0.5818	33.84%
Reciprocal-Y square root-X	0.5248	27.54%
Logarithmic-Y square root-X	-0.5225	27.30%
Square root-X	-0.5201	27.05%
Squared-Y square root-X	-0.5174	26.77%
Squared-Y logarithmic-X	-0.3934	15.47%
Logarithmic-X	-0.3903	15.23%
Multiplicative	-0.3871	14.98%
Reciprocal-Y logarithmic-X	0.3839	14.74%
Squared-Y reciprocal-X	0.1539	2.37%
Reciprocal-X	0.1455	2.12%
Square root-Y reciprocal-X	0.1414	2.00%
S-curve model	0.1374	1.89%
Double reciprocal	-0.1295	1.68%

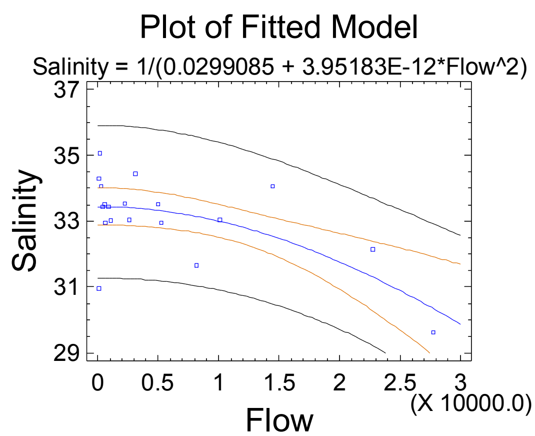


Figure 32 – Regression Output for Flow vs. Salinity for Station 1

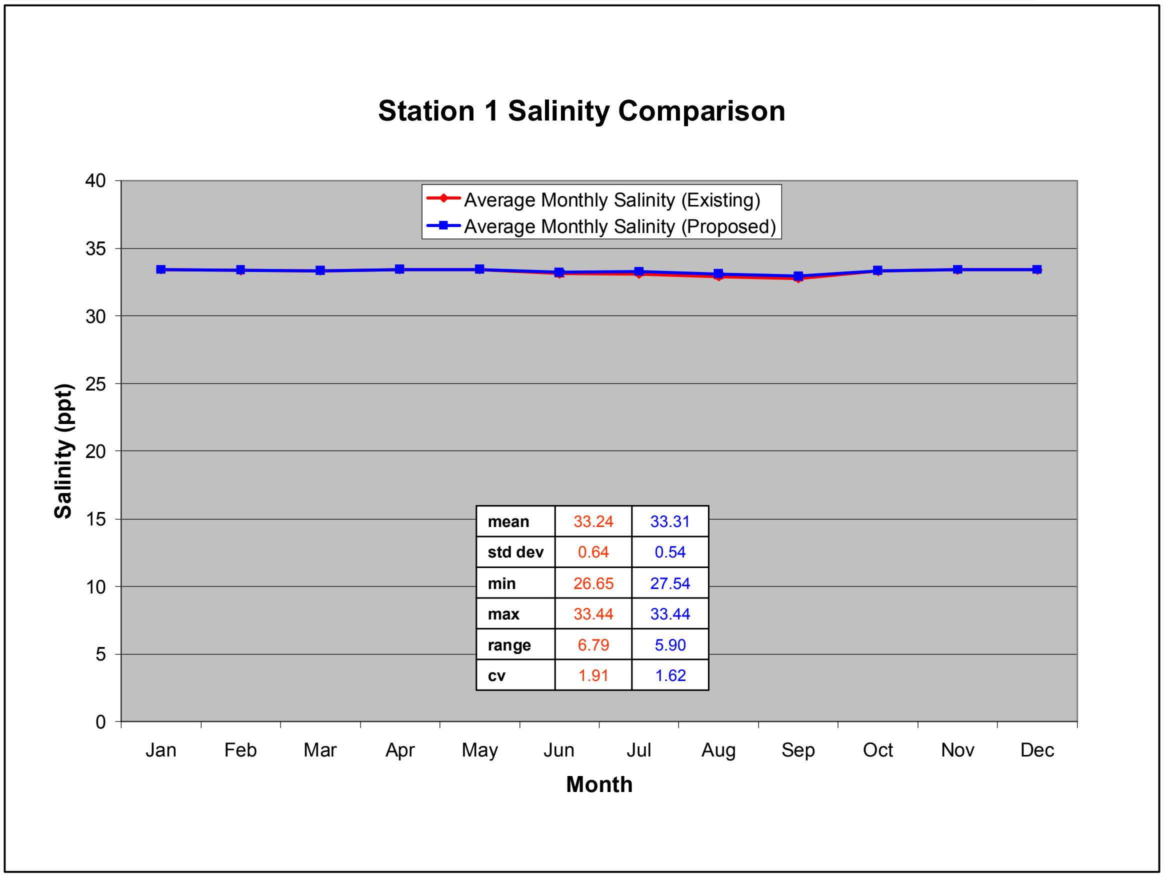


Figure 33 – Existing vs. Potential Salinity Regimes at Station 1 (means ± s.e.)

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TM 4.3.3 – ALTERNATIVE IMPACT ANALYSIS

1.0 BACKGROUND

Sarasota County in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD) are currently completing the necessary, pre-requisite data collection and analysis as well as the comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum has been prepared by PBS&J to present a summary of efforts to develop a statistically robust and scientifically valid estimate of pollutant load reduction estimates to Dona Bay associated with the implementation of potential flow diversion scenarios. These estimates were developed using existing and potential flow regimes, based on data supplied from KHA as part of Technical Memorandum 4.2.2 – Water Quantity | Water Budget Approach. This effort is consistent with Task 4.3.3 of the DBWMP contract.

2.0 INTRODUCTION

This effort is part of the overall Water Quality efforts defined in Task 4.3 of the DBWMP. Specifically, this task includes related evaluations and an assessment of potential restoration/enhancement sites for the study area. Since the intent of the project is to consider alternatives for watershed restoration/enhancement of the Dona Bay watershed and its hydrologic regimes, PBS&J was tasked with estimating potential reductions in pollutant loads that would be predicted based upon potential watershed/hydrologic restoration scenarios for Dona Bay.

In both Tampa and Sarasota Bays, recent increases in seagrass coverage have accompanied concurrent increases in water quality. In turn, these improvements in water quality have been linked to significant reductions in anthropogenic nutrient loads (e.g., Johansson 1991, Johansson and Greening 1999, Tomasko et al. 2005).

If proposed freshwater reduction scenarios as proposed under the Dona Bay watershed/hydrologic restoration plans were to be implemented, there is a potential for the concurrent reduction in pollutant loads delivered to Shakett Creek and Dona Bay.

3.0 DEVELOPMENT OF POLLUTANT LOAD REDUCTION SCENARIOS FOR DONA BAY

Based upon transferred equations originally developed by SWFWMD, KHA developed an historical flow record for the Cow Pen Canal as referenced in Technical Memorandum 4.2.2 – Water Quantity | Water budget Approach. This resulted in a data subset of monthly flow values for the period between November 1966 and December 2005 that was used for the purposes of this task. An estimate of the potential load reduction into Dona Bay from the Cow Pen Canal was constructed using the historical flow record developed for the Cow Pen Canal.

These monthly flow estimates were then re-calculated using excess Cow Pen Canal flows remaining after Phases 1, 2 and 3 of proposed watershed/hydrologic restoration projects. These hases represent the diversion of an annual average of 5, 10 and 15 mgd of excess freshwater from the Cow Pen Canal, respectively. The remaining excess flows would be delivered into Shakett Creek even after the implementation of each of the phases of the proposed watershed/hydrologic restoration plan.

A standard technique for developing pollutant loading models is to estimate nonpoint source loads based on a combination of flows and pollutant concentrations. This technique has been used for Tampa Bay (e.g., Pribble et al. 2001), Lemon Bay (Tomasko et al. 2001) and Charlotte Harbor (Squires et al. 1998). For this task, flows into Dona Bay were based on estimates for the period November 1966 to December 2005. These flows were then multiplied by “event mean concentration” values for the land use of “rangeland” used for the Charlotte Harbor watershed, and contained within the report conducted for the SWFWMD’s Charlotte Harbor SWIM program (Coastal Environmental, Inc. 1995). The land use category of rangeland was thought to be an appropriate one to use, based on the low-density agricultural activities that characterize most of the watershed. Although there is a substantial amount of urbanization located in the coastal area that immediately surrounds Dona Bay, these areas do not contribute to the flows measured at the lower water level control structure at the Cow Pen Canal gage site. Event mean concentrations, or EMC values, are the concentration required to account for a measured load; they are synonymous with the term “flow-weighted average.” Measured flows were multiplied by EMC values for total nitrogen (1.24 mg / liter), total phosphorus (0.01 mg / liter), and total suspended solids (11.0 mg / liter) as found in Coastal Environmental, Inc. (1995).

Monthly loads were calculated over the period of record, and then summed to create an annual load for each calendar year. This resulted in an average of 40 annual load estimates (1966 to 2005) for each of the four scenarios examined – current conditions vs. potential load reductions associated with implementation of Phases 1, 2, and 3 of the proposed watershed/hydrologic restoration project.

An additional effort was conducted to determine the potential for pollutant load reductions not directly associated with the volume of water redirected through the historical flow path and storage of the original and enhanced Cow Pen Slough anticipated under each of the phases.

One of the potential configurations for developing a linked habitat restoration – water supply augmentation scenario for flow diversions is the creation or enhancement of significant wetland and storage features in the Dona Bay watershed. If such a system was to involve re-routing water from the Cow Pen Canal through a series the original slough flow path that would now consist of marshes and deep ponds / reservoirs. The load reduction associated with routing water through such a system, as opposed to the channelized delivery of water that now occurs, is expected to have significant pollutant removal potential.

As a means of developing an "upper boundary" of pollutant load reductions, load reduction efficiencies associated with a typical wet detention system were applied to the quantity of water re-directed to the Cow Pen Slough flow path. The load reduction efficiencies used were 30, 50 and 80 percent for total nitrogen, total phosphorus, and total suspended solids, respectively. These load reduction efficiencies are either equal to or lower than values used by the SWFWMD to estimate reductions in pollutant loads for the Melburne Pond Stormwater Retrofit project (SWFWMD 2003).

The figures shown below contain estimates of loads for nitrogen, phosphorus and total suspended solids for each of four scenarios: 1) existing conditions, 2) loads after Phase I implementation, 3) loads after Phase II implementation, and 4) loads after Phase III implementation.

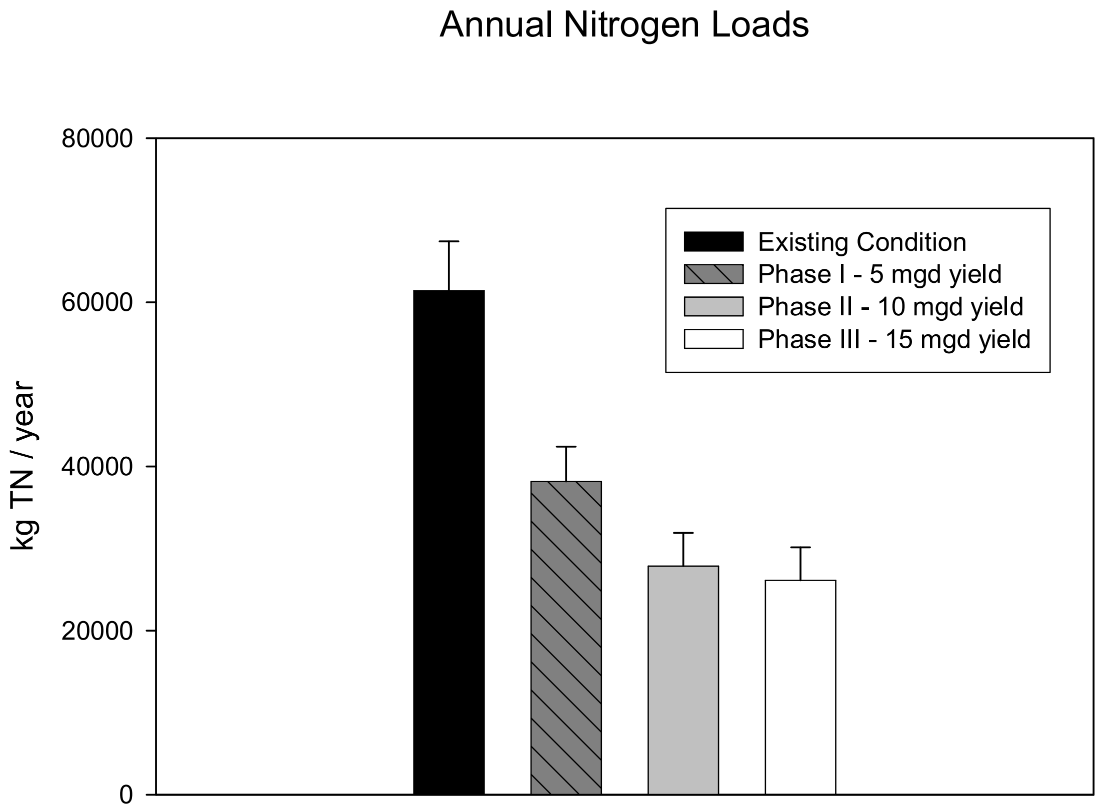

Figure 1 – Loads of Total Nitrogen from the Cow Pen Canal for Four Scenarios (means $\pm$ s.e.)

Results suggest that nitrogen loads to Shakett Creek and Dona Bay from the Cow Pen Canal could be reduced by 38 to perhaps 57 percent.

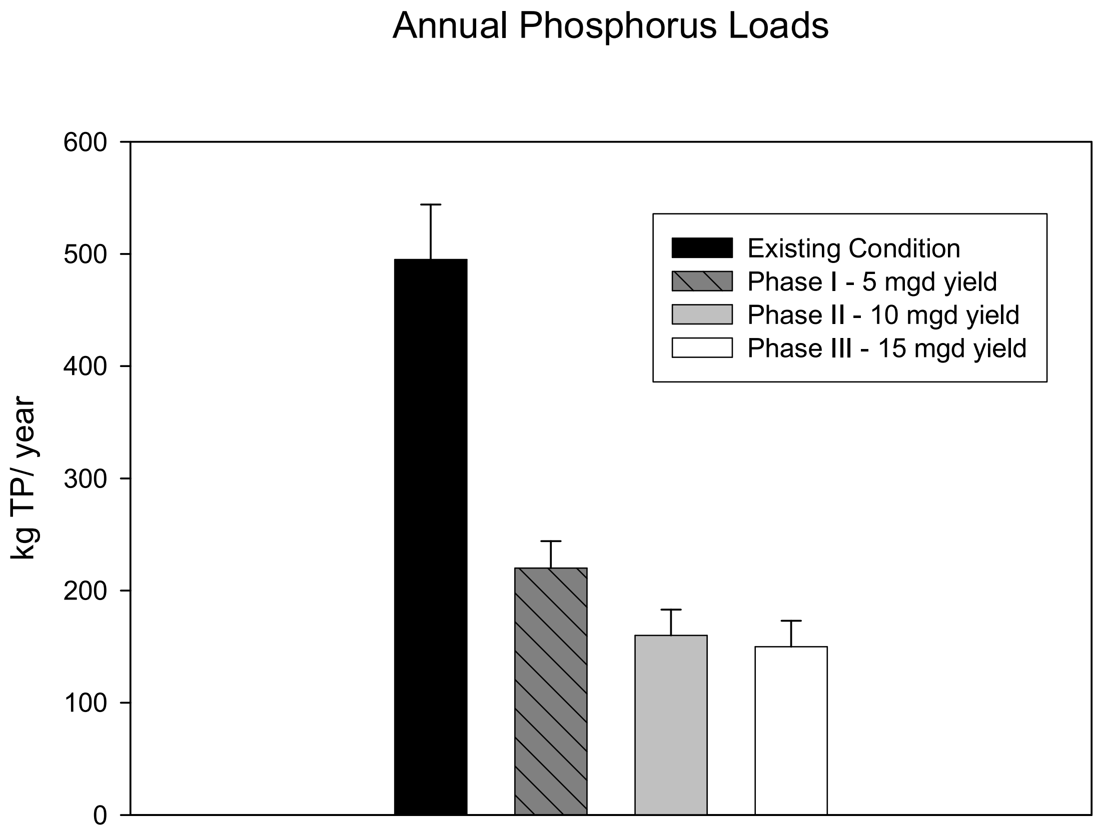

Figure 2 – Loads of Total Phosphorus from Cow Pen Canal for Four Scenarios (means ± s.e.)

For phosphorus, results suggest that loads to Shakett Creek and Dona Bay from the Cow Pen Canal could be reduced by 56 to 70 percent, reflecting the relatively higher load reduction expected for phosphorus, compared to nitrogen.

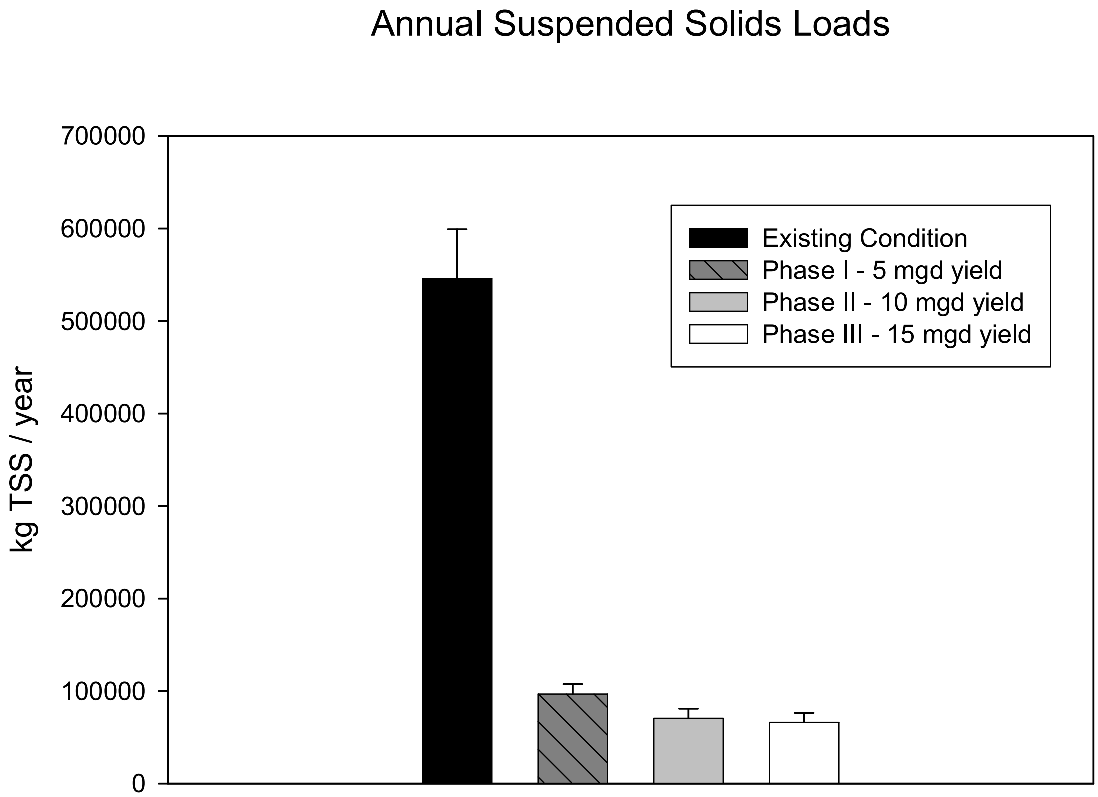

Figure 3 – Loads of Total Suspended Solids from the Cow Pen Canal for Four Scenarios (means + s.e.)

Load reduction estimates for total suspended solids range between 82 and 88 percent. The load reduction estimate for total suspended solids contains the highest percent reduction calculated, which is based on the extremely efficient reduction in suspended materials that occurs with most stormwater runoff treatment systems.

In general, responses of benthic habitats to pollutant load reductions associated with potential flow diversion scenarios are likely to be significant. This analysis suggests that the all three phases of the proposed watershed/hydrologic restoration project would have a beneficial effect to benthic communities. The percent reduction in nitrogen loads possible (38 to 57 percent) would be similar to the percent load reductions for nitrogen that were experienced by Tampa Bay and Sarasota Bay in recent years (Tomasko et al. 2005).

Therefore it is likely that a similar degree of improvement in estuarine health, such as seagrass recovery, might be possible for Dona Bay, should the watershed/hydrologic restoration project be implemented.

Chapter 6 – Flood Protection Appendices

View of Flood Waters in
Myakka River State Park

TM 4.4.1 – INCLUSION OF WATERSHED CONNECTIONS

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD), is currently completing the pre-requisite data collection and analysis and comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum (TM) has been prepared by KHA to present completed work for the inclusion of watershed connections to the Cow Pen Slough/Shakett Creek stormwater model (Dona Bay Model), consistent with Task 4.4.1 of the DBWMP contract

2.0 WATERSHED CONNECTIONS

Because relatively flat topography is a characteristic of the watershed, several hydraulic connections exist between the Dona Bay and adjacent watersheds during major flood events. These connections can allow floodwaters to potentially move between adjacent watershed areas. This work effort will focus on updating the flood prediction model to connect portions of the Lower Myakka River, Roberts Bay, Phillippi Creek and South Creek to the Dona Bay watershed in order to quantify these potential watershed interconnections. **Figure 2.0** presents the 100-year floodplains for Dona Bay and the Lower Myakka River watersheds in this vicinity where they may become connected.

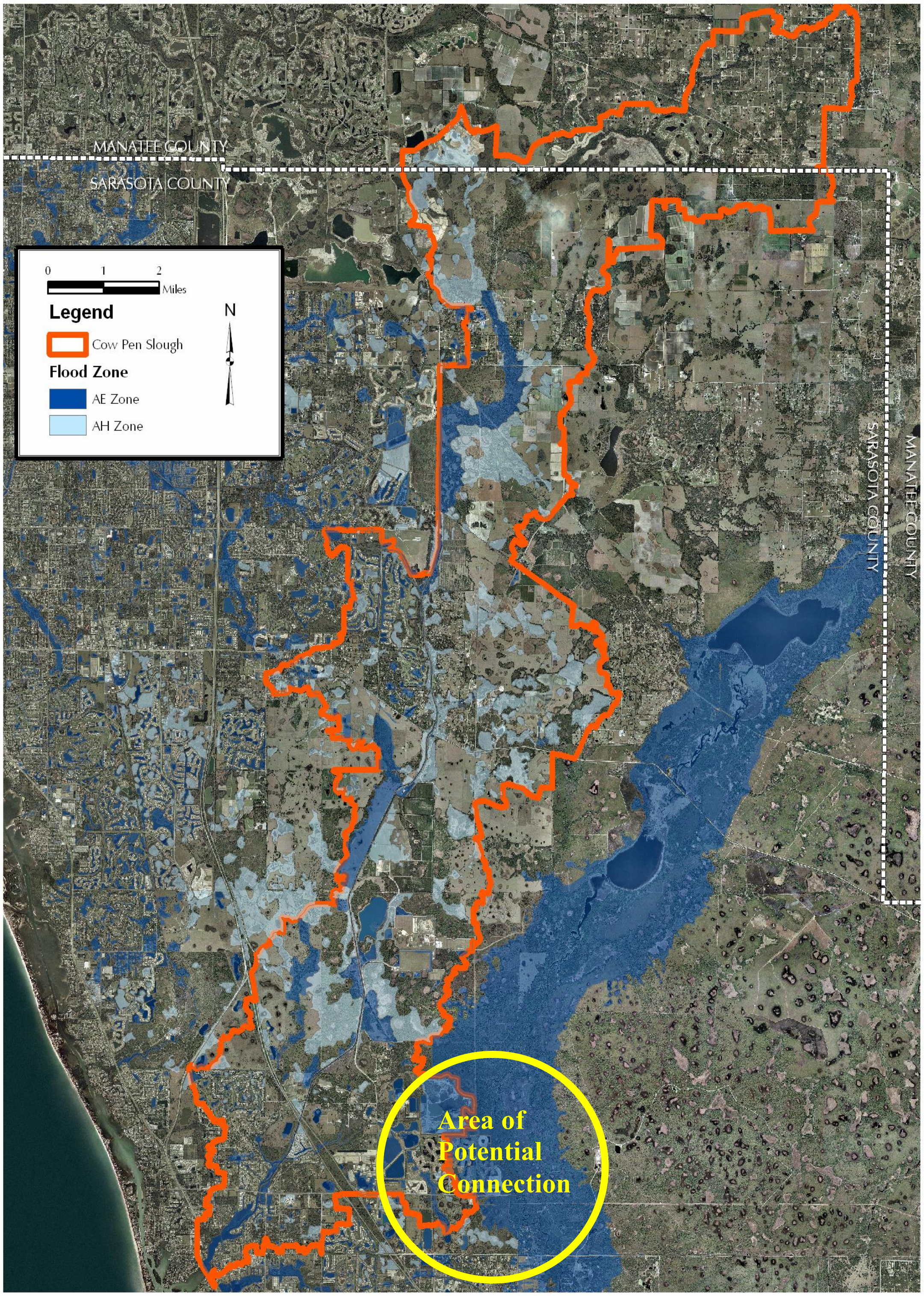

Figure 2.0 – Dona Bay and Myakka River Floodplain

Work completed to date under the initial contract authorization includes the Lower Myakka River from the northern limits of the Pinelands Reserve south to the confluence of the Blackburn canal. Subsequent work will include the additional model connections of the Dona Bay watershed to the adjacent watershed areas of Roberts Bay, Phillippi Creek and South Creek when authorized by SCG.

2.1 Approach

To consider the effects and impacts of potential hydraulic connections with the Lower Myakka River Watershed, model adjustments were made to the Dona Bay watershed model. The modifications made to the Dona Bay watershed model included connecting applicable portions of the Lower Myakka River watershed model. Hydrographs (time/discharge relationships) were developed at each Myakka River node through this vicinity based upon review of measured flood hydrographs at USGS gage site 02298830 and predicted flood flows developed in the 1978 USGS Report entitled "Magnitude and Frequency of the Myakka River, Southwest Florida". In addition, stage/discharge information was taken from the 1978 USGS report at each node along the Myakka River. Together the time-discharge (hydrographs) and stage-discharge relationships provided a boundary stage and discharge regimes at the Myakka River nodes that were added to the Dona Bay model. The completed model adjustment allow the review of both watershed's peak stages and discharge overflows between each watershed in the vicinity of interest.

2.2 Overview of Watershed Model Incorporation:

Specific tasks that were completed to incorporate applicable components on the Lower Myakka River watershed model into the Dona Bay watershed model included:

- Incorporated Lower Myakka River watershed sub-basins MR180060 through MR180094 for areas west of Myakka River.
- Reviewed and performed a quality control of the links associated with the potential watershed interconnections.
- Identified link connections to the Dona Bay watershed model.
- Identified link connections to other Lower Myakka River sub-basins.

Figure 2.2, provided at the end of this Technical Memorandum presents a map of the limits of areas incorporated from the Lower Myakka River watershed model. This Figure identifies the sub-basins, nodes, and associated hydraulic links incorporated into the Dona Bay watershed model. Hydraulic link connections to the Dona Bay watershed model are identified west of the mapped area for the Lower Myakka River watershed model.

The hydraulic connections between the watersheds in this vicinity of interest typically include natural overflow characteristics along the normal watershed ridge between the Dona Bay and Lower Myakka River watershed boundaries. For the purpose of defining the hydraulic overflow characteristics, SWFWMD's topographic aerial maps were reviewed to define an irregular transect, perpendicular to the direction of flow at the watershed ridge. Channel connections that exist between the Myakka River and the Dona Bay watersheds were represented by cross sectional data obtained from field surveys conducted during the development of the Lower Myakka River watershed model.

Finally, hydrographs and stage-discharge rating curve sets for the sub-basin and node locations were established for the areas of the Myakka River that are cross-hatched **Figure 2.2**.

2.3 Overview of Myakka River Boundary Control Nodes and Rating Curves:

The following tasks were completed to facilitate the Myakka River boundary hydrographs and stage-discharge rating curves into the updated Dona Bay watershed model:

- Established sub-basin and rating curve schematic for updated model and connectivity.
- Established sub-basin areas and hydrology input for the Myakka River node locations. (**Appendix A; Table 2.3.1**)
- Established river flow travel lag times for each River sub-basin using velocity output from the 1978 USGS study. (**Appendix A; Table 2.3.2**)
- Established stage-discharge tables based upon the 1978 USGS study and developed a rating curve operating table at the Myakka River node locations. (**Appendix A; Table 2.3.3**)
- Developed a working model for hydrology and rating curve data developments.

Figure 2.2 also presents an insert showing a representative approach for the hydrograph and stage-discharge rating curves for each of the river nodes and their respective sub-basin location on the Myakka River. This insert details the two (2) sub-basins that make up the runoff hydrographs at each location along the Myakka River. Hydrologic parameters for these basins were developed to produce peak discharges that are consistent with peak discharges generated by the 1978 USGS study for the 100-year storm event. Since the 1978 USGS study did not account for the time of peak discharge occurrence, a lag time corresponding to the velocity travel times reported in the USGS study was applied to measured peak discharges and times at USGS gage 02298830. These hydrographs provide time-discharge information for the stage-discharge rating curves for each Myakka River node considered.

The stage-discharge rating curves are based upon computed stage and discharge values for the 2yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, 200-yr and 500-yr developed in the 1978 USGS study.

2.4 MODEL SIMULATIONS

Interim model simulations were conducted for the 2-yr, 5-yr, 10-yr, 25-yr and 100-yr design storm events. **APPENDIX B** present maps for each simulation comparing the connected model results against the existing Dona Bay model results. Areas shown "red" indicate areas which reflected an increase in flood levels. Areas shown "green" indicate areas which reflected reduced flood levels and areas shown "yellow" indicate areas which reflected no change to flood levels.

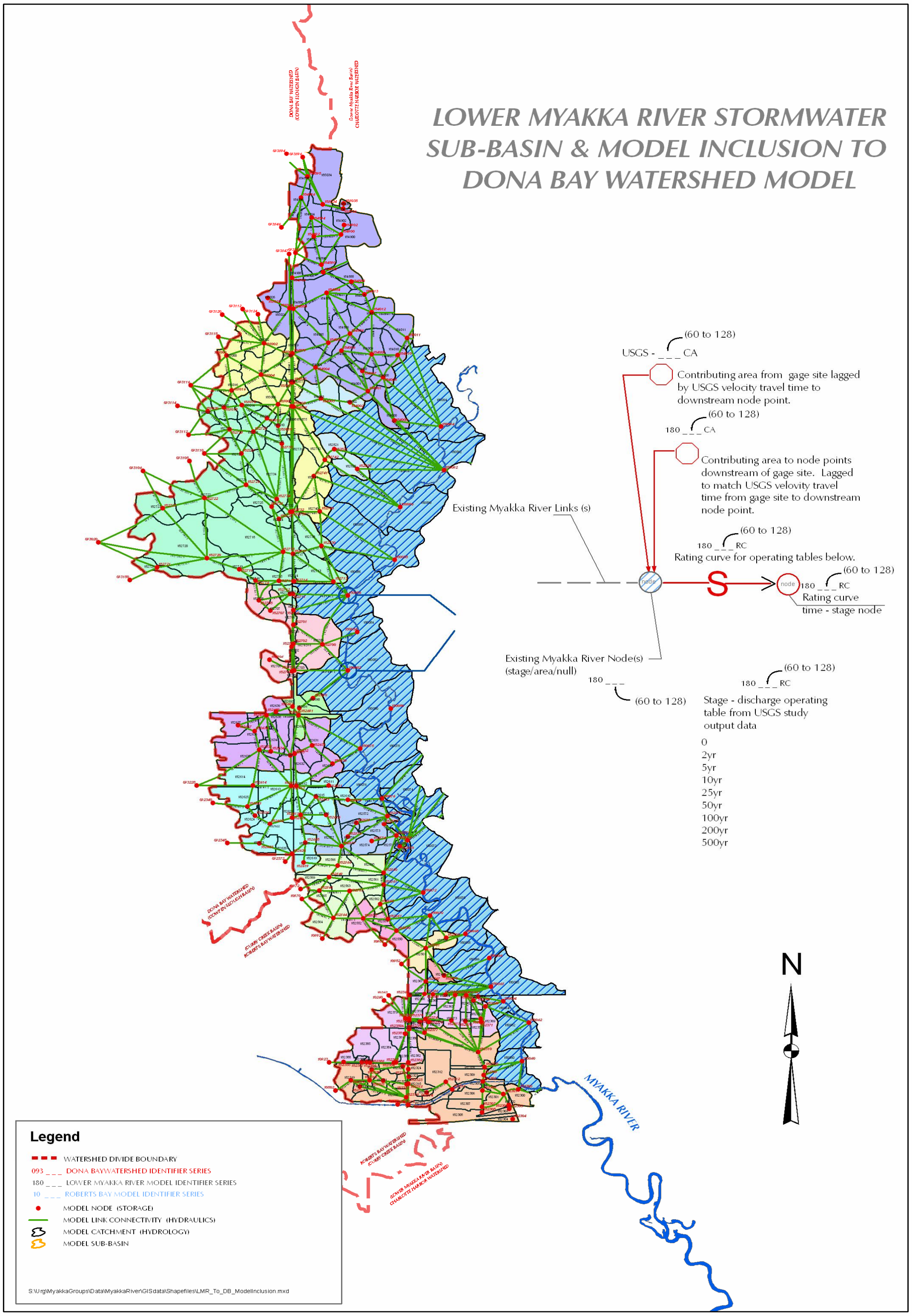

Figure 2.2 – Model Area Incorporated from Lower Myakka River watershed

APPENDIX A – INCLUSION OF WATERSHED CONNECTIONS

Myakka River Subbasins Hydrology
Sub-basin Acerage and Discharge

Subbasin ID	Westerly Sub-basins (ac)	Main Sub-basins (ac)	Easterly Sub-basins (ac)	Upper Basin Sub-basins (ac)	Increment Total (ac)	Contributing Total (ac)	Unit Discharge Q' (cfs/ac)	Increment Total Q' (cfs)	Contributing Total Q' (cfs)	Target USGS Q 100-yr (cfs)	Total Qp (cfs)	Upstream Gage Contribution Qp (cfs)	Downstream Gage Contribution Qp (cfs)	Area (ac)	PRF	CN	Tc (min)	Flow Max (cfs)	Time Max (hrs)
	SUB-BASIN ACERAGE INVENTORY						SUB-BASIN DISCHARGE DISRTIBUTION INVENTORY							SUB-BASIN PARAMETERS AND SIMULATED DISCHARGES					
MR100060	300.09	42.38	25.56		368.01	39388.67	1.113968165	409.9506884	750	10500	10500	7965	2535.000	39388.67	UH400C	78	6323.2	2535.121	82.75
MR100062		41.48	36.6		78.08	39018.68	1.113968165	86.97847817	340.0493116		10090.04931	7965	2125.049	39018.68	UH400C	78	7480	2125.216	95.25
MR100064	210.64	16.54			227.18	38940.58	1.113968165	253.0708334	253.0708334		10003.07083	7965	2038.071	38940.58	UH400C	78	7785	2038.282	96.75
MR100065		83.63	6636.99		6720.62	38713.4	0.01033234	69.43972888	400	9750	9750	7965	1785.000	38713.4	UH400C	78	6840	1785.502	110.25
MR100066	10.51	42.81			53.32	31992.78	0.01033234	0.550920353	330.5602711		9680.560271	7965	1715.560	31992.78	UH400C	78	7600	1715.166	96.75
MR100068	33.47	45.47	1397.86		1476.8	31939.46	0.01033234	15.25879928	330.0093508		9680.009351	7965	1715.009	31939.46	UH400C	78	7588	1715.006	96.50
MR100070	44.24	90.9			135.14	30462.66	0.01033234	1.396312388	314.7505515		9664.750551	7965	1699.751	30462.66	UH400C	78	7301	1699.655	93.25
MR100072	153.24	117.92	39.32		310.48	30327.52	0.01033234	3.207984832	313.3542391		9663.354239	7965	1698.354	30327.52	UH400C	78	7274	1698.366	93.00
MR100074	116.2	77.88	497.46		691.54	30017.04	0.01033234	7.145226201	310.1462543		9660.146254	7965	1695.146	30017.04	UH400C	78	7213	1695.113	92.50
MR100076	258.39	59.2			317.59	29325.5	0.01033234	3.281447787	303.0010281		9653.001028	7965	1688.001	29325.5	UH400C	78	7075	1688.177	91.00
MR100078	203.68	112.45	908.69		1224.82	29007.91	0.01033234	12.65525632	299.7195803		9649.71958	7965	1684.720	29007.91	UH400C	78	7012	1684.812	90.25
MR100080		73.83	67.13		140.96	27783.09	0.01033234	1.456446606	287.064324		9637.064324	7965	1672.064	27783.09	UH400C	78	6765	1672.226	87.50
MR100082	39.97	139.51			179.48	27642.13	0.01033234	1.854448331	285.6078774		9635.607877	7965	1670.608	27642.13	UH400C	78	6737	1670.611	87.25
MR100084	134.53	26.5	1156.39		1317.42	27462.65	0.01033234	13.61203098	283.753429		9633.753429	7965	1668.753	27462.65	UH400C	78	6701	1668.626	86.75
MR100086	738.68	118.07			856.75	26145.23	0.01033234	8.852232044	270.1413861		9620.141386	7965	1655.141	26145.23	UH400C	78	6430	1655.072	83.75
MR100088	275.08	122.46	1156.39		1553.93	25288.48	0.01033234	16.05573284	261.289186		9611.289186	7965	1646.289	25288.48	UH400C	78	6250	1646.614	82.00
MR100090		132.89	78.58		211.47	23734.55	0.01033234	2.184979878	245.2334334		9595.233433	7965	1630.233	23734.55	UH400C	78	5922	1630.357	78.50
MR100092	88.01	214.79	198.22		501.02	23523.08	0.01033234	5.17670884	243.0484535		9593.048454	7965	1628.048	23523.08	UH400C	78	5877	1628.105	78.00
MR100094	619.18	146.72			765.9	23022.06	0.01033234	7.913538981	237.8717447		9587.871745	7965	1622.872	23022.06	UH400C	78	5770	1622.735	76.75
MR100096	5.13	61.93	173.57		240.63	22256.16	0.01033234	2.486270904	229.9582057		9579.958206	7965	1614.958	22256.16	UH400C	78	5604	1614.819	75.00
MR100098	133.85	117.93			251.78	22015.53	0.01033234	2.601476491	227.4719048		9577.471905	7965	1612.472	22015.53	UH400C	78	5551	1612.471	74.25
MR1000100		248.96	162.89		411.85	21763.75	0.01033234	4.255374108	224.8704583		9574.870458	7965	1609.870	21763.75	UH400C	78	5496	1609.843	73.75
MR1000102		55.5			55.5	21351.9	0.01033234	0.573444854	220.6150642		9570.615064	7965	1605.615	21351.9	UH400C	78	5405	1605.725	72.75
MR1000104		91.96			91.96	21296.4	0.01033234	0.950161959	220.0416393		9570.041639	7965	1605.042	21296.4	UH400C	78	5393	1605.078	72.75
MR1000106	176.07	338.99	8262.76		8777.82	21204.44	0.01033234	90.69541812	219.0914774		9569.091477	7965	1604.091	21204.44	UH400C	78	5373	1604.044	72.50
MR1000108		99.25			99.25	12426.62	0.01033234	1.025484716	128.3980592		9478.398059	7965	1513.398	12426.62	UH400C	78	3313	1513.626	50.50
MR1000110	69.22	232.49			301.71	12327.37	0.01033234	3.117370213	127.3705745		9477.370575	7965	1512.371	12327.37	UH400C	78	3289	1512.248	50.25
MR1000112	1520.36	298.74			1819.1	12025.66	0.01033234	18.79555916	124.2532043		9474.253204	7965	1509.253	12025.66	UH400C	78	3212.5	1509.809	49.50
MR1000118	153.23	1262	1145.09	5936.27	8496.59	10206.56	0.01033234	87.78965423	105.4576452		9455.457645	7965	1490.458	10206.56	UH400C	78	2750	1490.382	44.50
MR1000122	46.89	143.52			190.41	1709.97	0.01033234	1.967380804	17.66799093		9367.667991	7965	1402.668	1709.97	UH400C	78	356	1402.127	18.25
MR1000124	221.86	169.74			391.6	1519.56	0.01033234	4.046144229	15.70081012		9365.70081	7965	1400.701	1519.56	UH400C	78	306.1	1400.823	15.50
MR1000126	71.37				71.37	1127.98	0.01033234	0.737419085	11.6544859		9361.654486	7965	1396.654	1127.98	UH400C	78	207.3	1396.956	14.25
MR1000128	3.83	82.59		990.17	1056.59	1056.59	0.01033234	10.91704681	10.91704681	9350	9360.917047	7965	1395.917	1056.59	UH400C	78	190	1395.829	14.00
USGS-Gage				140500								7965			UH400C	78	7200	7965.537	92.25

Table 2.3.1 - Sub-basin Areas and Hydrology

USGS Myakka River Study Data - Peak Flow Time (100-Year Event)
Reach Inventory of Modeled Sections, Distance and Peak Flow Velocity

Location	Reach (id)	Xsec (id)	Station (ft)	Length (ft)	Vel(100) (ft/s)	Increment (sec)	Increment (min)	Increment (hrs)	Cumulative Total (hrs)	Lower Myakka River Model Node (id)	Upstream Gage Basin Peak Time (hrs)	Upstream Gage Basin Lag Time To Node (hrs)	Combined Basin Peak Time At Node (hrs)	Downstream Contributing Basin Peak Time (hrs)	Downstream Contributing Basin Peak Lag Time To Node (hrs)
	STUDY SECTION, DISTANCES & VELOCITIES					STUDY PEAK FLOW TRAVEL TIMES				MODELED SUB-BASIN PEAK TIME AND SUB-BASIN LAG TIME					
USGS Stream Gage	3	132	132120							USGS Gage	92.25		92.25		
				2300	0.24	9583.333	159.722	2.662							
Bridge Approach	3	AP130	129820						2.662						
	3	128													
				870	0.46	1456.522	24.275	0.405	3.067	1000128	92.25	3.07	95.32	14.00	81.32
S.R. 72 Bridge	3	BO128	129150												
Bridge Exit	3	TW128	129150												
				1530	0.22	6954.545	115.909	1.932							
	3	126	127620						4.998	1000126	92.25	5.00	97.25	14.25	83.00
				1960	0.22	8909.091	148.485	2.475							
	3	124	125660						7.473	1000124	92.25	7.47	99.72	15.50	84.22
				3370	0.23	14652.174	244.203	4.070							
	3	122	122290						11.543	1000122	92.25	11.54	103.79	16.25	87.54
				3540	0.21	16857.143	280.952	4.683							
	3	120	118750						16.226		92.25	16.23	108.48		
Lower Myakka Lake	3	118		6250	0.34	18382.353	306.373	5.106	21.332	1000118	92.25	21.33	113.58	44.50	69.08
	3	114	112500												
				2930	0.30	9766.667	162.778	2.713							
	3	112	109570						24.045	1000112	92.25	24.04	116.29	49.50	66.79
				2090	0.18	11611.111	193.519	3.225							
	3	110	107480						27.270	1000110	92.25	27.27	119.52	50.25	69.27
				1350	0.18	7500.000	125.000	2.083							
	3	108	106130						29.354	1000108	92.25	29.35	121.60	50.50	71.10
				2670	0.17	15705.882	261.765	4.363							
	3	106	103460						33.716	1000106	92.25	33.72	125.97	72.50	53.47
				2960	0.19	15578.947	259.649	4.327							
	3	104	100500						38.044	1000104	92.25	38.04	130.29	72.75	57.54
				2110	0.25	8440.000	140.667	2.344							
	3	102	98390						40.388	1000102	92.25	40.39	132.64	72.75	59.89
				2120	0.30	7066.667	117.778	1.963							
	3	100	96270						42.351	1000100	92.25	42.35	134.60	73.75	60.85
				3710	0.27	13740.741	229.012	3.817							
	3	98	92560						46.168	100098	92.25	46.17	138.42	74.25	64.17
				3200	0.27	11851.852	197.531	3.292							
Down's Dam	3	96	89360						49.460	100096	92.25	49.46	141.71	75.00	66.71
				2040	0.29	7034.483	117.241	1.954							
	3	94	87320						51.414	100094	92.25	51.41	143.66	76.75	66.91
				2150	0.28	7678.571	127.976	2.133							
	3	92	85170						53.547	100092	92.25	53.55	145.80	78.00	67.80
				2700	0.31	8709.677	145.161	2.419							
	3	90	82470						55.967	100090	92.25	55.97	148.22	78.50	69.72
				3170	0.22	14409.091	240.152	4.003							
	3	88	79300						59.969	100088	92.25	59.97	152.22	82.00	70.22
				2420	0.26	9307.692	155.128	2.585							
	3	86	76880						62.555	100086	92.25	62.55	154.80	83.75	71.05
				1920	0.28	6857.143	114.286	1.905							
	3	84	74960						64.459	100084	92.25	64.46	156.71	86.75	69.96
				3440	0.22	15636.364	260.606	4.343							
	3	82	71520						68.803	100082	92.25	68.80	161.05	87.25	73.80
				3600	0.28	12857.143	214.286	3.571							
	3	80	67920						72.374	100080	92.25	72.37	164.62	87.50	77.12
				2320	0.25	9280.000	154.667	2.578							
	3	78	65600						74.952	100078	92.25	74.95	167.20	90.25	76.95
				2870	0.24	11958.333	199.306	3.322							
	3	76	62730						78.274	100076	92.25	78.27	170.52	91.00	79.52
				2770	0.34	8147.059	135.784	2.263							
	3	74	59960						80.537	100074	92.25	80.54	172.79	92.50	80.29
				2760	0.26	10615.385	176.923	2.949							
	3	72	57200						83.486	100072	92.25	83.49	175.74	93.00	82.74
				2100	0.21	10000.000	166.667	2.778							
	3	70	55100						86.263	100070	92.25	86.26	178.51	93.25	85.26
				2720	0.31	8774.194	146.237	2.437							
	3	68	52380						88.701	100068	92.25	88.70	180.95	96.50	84.45
				1930	0.46	4195.652	69.928	1.165							
	3	66	50450						89.866	100066	92.25	89.87	182.12	96.75	85.37
	3	65		1300	0.81	1604.938	26.749	0.446	90.312	100065	92.25	90.31	182.56	110.25	72.31
Bridge Approach	3	AP64	49150												
				150	6.40	23.438	0.391	0.007							
Border Road Bridge	3	64BO	49000												
Bridge Exit	3	TW-64	49000						90.318						
				240	0.83	289.157	4.819	0.080							
	2	64	48760						90.398	100064	92.25	90.40	182.65	98.75	83.90
				1210	0.49	2469.388	41.156	0.686							
	2	62	47550						91.085	100062	92.25	91.08	183.33	95.25	88.08
				1560	0.66	2363.636	39.394	0.657							
Curry Creek	2	60	45990						91.741	100060	92.25	91.74	183.99	82.75	101.24

Table 2.3.2 - River Flow Travel Lag Times

Myakka River Nodes
Stage-Discharge Operating Tables
Values From USGS Study Results

	Node	Stage (elev)	Discharge (cfs)		Node	Stage (elev)	Discharge (cfs)		Node	Stage (elev)	Discharge (cfs)		Node	Stage (elev)	Discharge (cfs)
(002-Yr)	180060	5.05	2180	(002-Yr)	180068	8.57	2110	(002-Yr)	180078	10.81	2110	(002-Yr)	180088	13.19	2110
(005-Yr)		7.47	3880	(005-Yr)		11.49	3830	(005-Yr)		12.96	3830	(005-Yr)		14.48	3830
(010-Yr)		8.76	5180	(010-Yr)		12.51	4820	(010-Yr)		13.76	4820	(010-Yr)		15.28	4820
(025-Yr)		10.35	7050	(025-Yr)		13.55	6800	(025-Yr)		14.67	6800	(025-Yr)		16.05	6800
(050-Yr)		11.18	8700	(050-Yr)		13.81	8100	(050-Yr)		14.81	8100	(050-Yr)		16.08	8100
(100-Yr)		11.85	10500	(100-Yr)		14.22	9750	(100-Yr)		15.10	9750	(100-Yr)		16.35	9750
(200-Yr)		12.48	12800	(200-Yr)		14.47	11700	(200-Yr)		15.48	11700	(200-Yr)		16.71	11700
(500-Yr)		13.02	15500	(500-Yr)		14.81	14300	(500-Yr)		15.80	14300	(500-Yr)		17.05	14300
(002-Yr)	180062	5.30	2180	(002-Yr)	180070	9.07	2110	(002-Yr)	180080	11.31	2110	(002-Yr)	180090	13.89	2110
(005-Yr)		7.72	3880	(005-Yr)		11.85	3830	(005-Yr)		13.21	3830	(005-Yr)		14.98	3830
(010-Yr)		9.01	5180	(010-Yr)		12.78	4820	(010-Yr)		14.01	4820	(010-Yr)		15.51	4820
(025-Yr)		10.71	7050	(025-Yr)		13.80	6800	(025-Yr)		14.92	6800	(025-Yr)		16.34	6800
(050-Yr)		11.43	8700	(050-Yr)		14.08	8100	(050-Yr)		15.08	8100	(050-Yr)		16.40	8100
(100-Yr)		12.10	10500	(100-Yr)		14.35	9750	(100-Yr)		15.35	9750	(100-Yr)		16.68	9750
(200-Yr)		12.73	12800	(200-Yr)		14.61	11700	(200-Yr)		15.71	11700	(200-Yr)		17.08	11700
(500-Yr)		13.27	15500	(500-Yr)		14.95	14300	(500-Yr)		16.05	14300	(500-Yr)		17.43	14300
(002-Yr)	180064	5.30	2180	(002-Yr)	180072	9.32	2110	(002-Yr)	180082	12.08	2110	(002-Yr)	180092	13.94	2110
(005-Yr)		7.72	3880	(005-Yr)		12.10	3830	(005-Yr)		13.71	3830	(005-Yr)		15.31	3830
(010-Yr)		9.01	5180	(010-Yr)		12.90	4820	(010-Yr)		14.51	4820	(010-Yr)		15.85	4820
(025-Yr)		10.71	7050	(025-Yr)		13.87	6800	(025-Yr)		15.30	6800	(025-Yr)		16.70	6800
(050-Yr)		11.43	8700	(050-Yr)		14.08	8100	(050-Yr)		15.31	8100	(050-Yr)		16.78	8100
(100-Yr)		12.10	10500	(100-Yr)		14.35	9750	(100-Yr)		15.60	9750	(100-Yr)		17.09	9750
(200-Yr)		12.73	12800	(200-Yr)		14.61	11700	(200-Yr)		15.98	11700	(200-Yr)		17.58	11700
(500-Yr)		13.40	15500	(500-Yr)		14.95	14300	(500-Yr)		16.30	14300	(500-Yr)		17.93	14300
														14.19	2110
(002-Yr)	180065	5.65	2110	(002-Yr)	180074	9.94	2110	(002-Yr)	180084	12.58	2110	(002-Yr)	180094		
(005-Yr)		8.22	3830	(005-Yr)		12.48	3830	(005-Yr)		13.98	3830	(005-Yr)		15.58	3830
(010-Yr)		9.51	4820	(010-Yr)		13.28	4820	(010-Yr)		14.78	4820	(010-Yr)		16.10	4820
(025-Yr)		10.98	6800	(025-Yr)		14.17	6800	(025-Yr)		15.55	6800	(025-Yr)		16.95	6800
(050-Yr)		11.68	8100	(050-Yr)		14.31	8100	(050-Yr)		15.58	8100	(050-Yr)		17.03	8100
(100-Yr)		12.35	9750	(100-Yr)		14.60	9750	(100-Yr)		15.85	9750	(100-Yr)		17.34	9750
(200-Yr)		12.98	11700	(200-Yr)		14.98	11700	(200-Yr)		16.21	11700	(200-Yr)		17.81	11700
(500-Yr)		13.50	14300	(500-Yr)		15.30	14300	(500-Yr)		16.55	14300	(500-Yr)		18.18	14300
(002-Yr)	180066	7.57	2110	(002-Yr)	180076	10.44	2110	(002-Yr)	180086	12.81	2110				
(005-Yr)		10.49	3830	(005-Yr)		12.71	3830	(005-Yr)		14.21	3830				
(010-Yr)		11.76	4820	(010-Yr)		13.51	4820	(010-Yr)		15.01	4820				
(025-Yr)		12.92	6800	(025-Yr)		14.42	6800	(025-Yr)		15.80	6800				
(050-Yr)		13.31	8100	(050-Yr)		14.58	8100	(050-Yr)		15.81	8100				
(100-Yr)		13.72	9750	(100-Yr)		14.85	9750	(100-Yr)		16.10	9750				
(200-Yr)		13.97	11700	(200-Yr)		15.21	11700	(200-Yr)		16.46	11700				
(500-Yr)		14.31	14300	(500-Yr)		15.55	14300	(500-Yr)		16.80	14300				

Table 2.3.3 – Stage-Discharge Operating Tables

APPENDIX B – SIMULATION MAP COMPARISONS

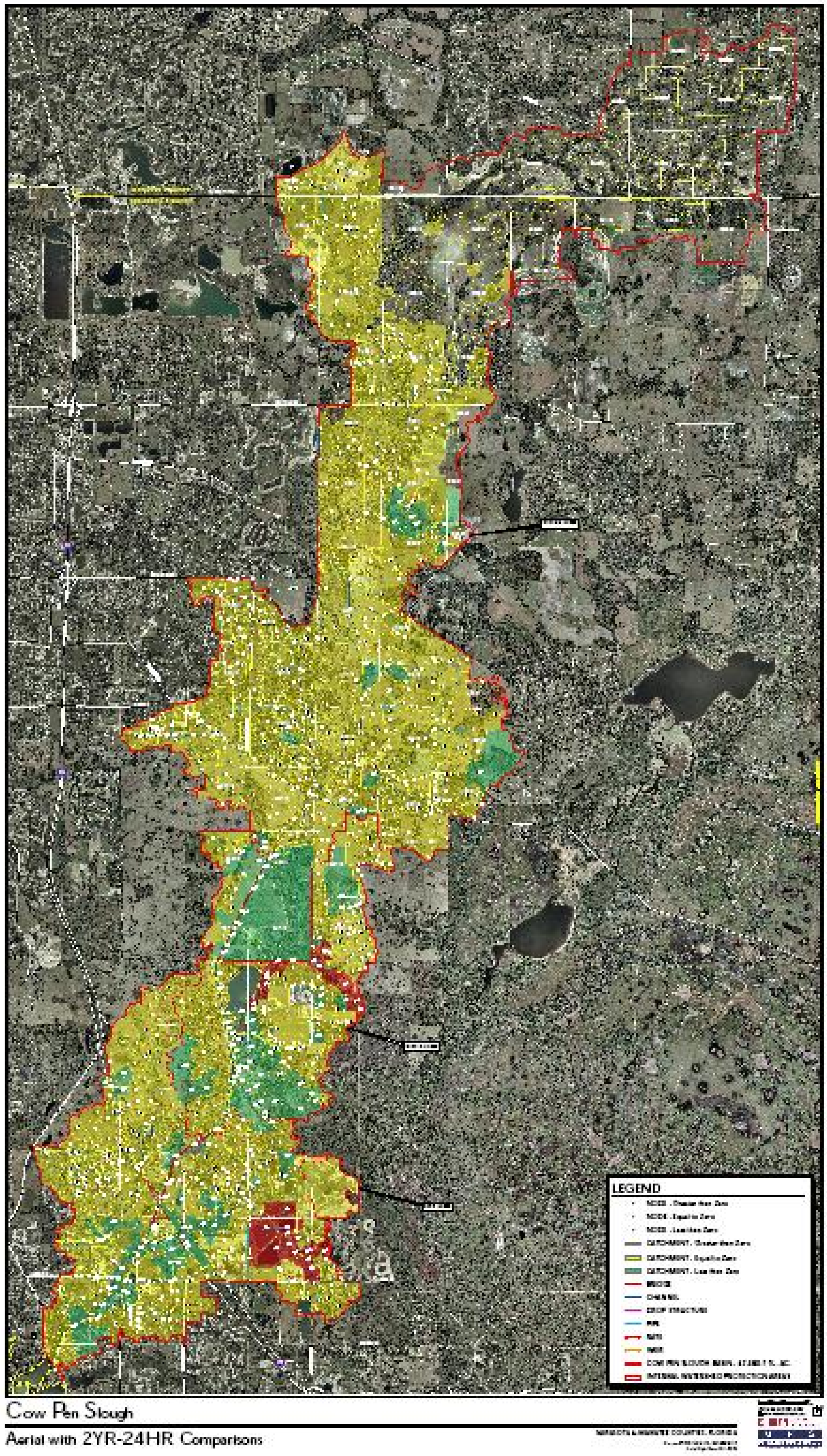

Figure B1 – 2-Year Storm Event Comparison

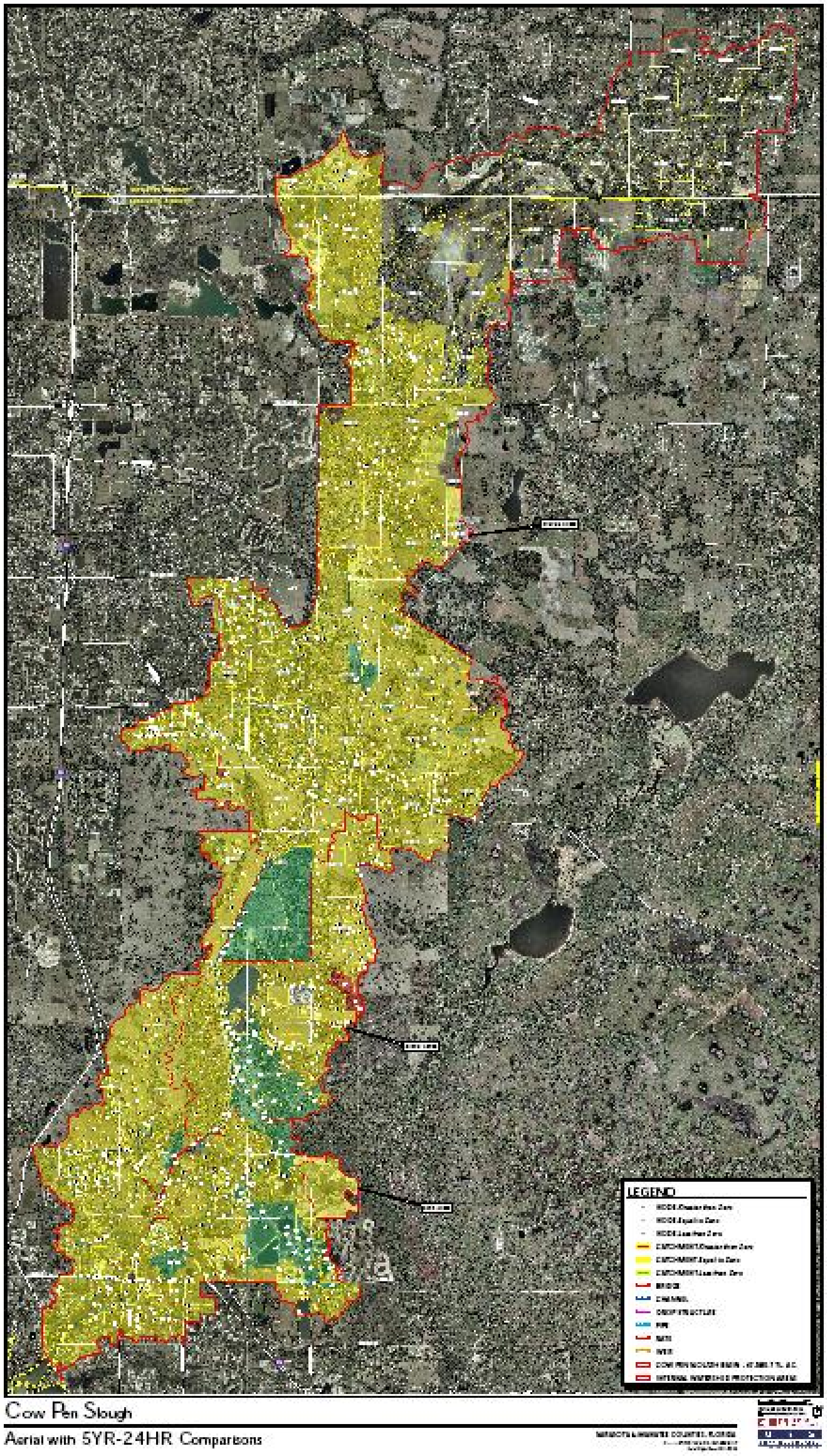

Figure B2 – 5-Year Storm Event Comparison

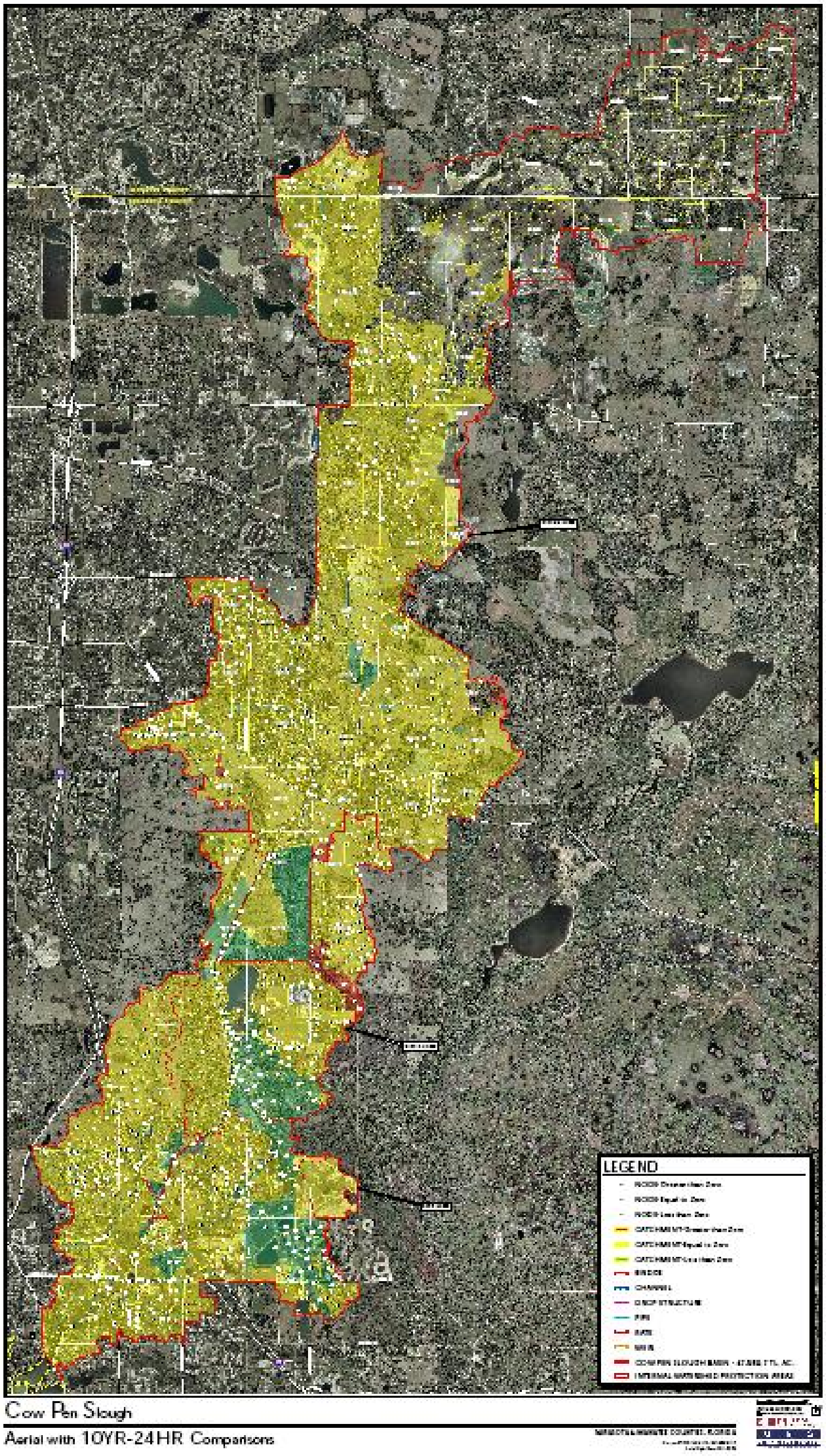

Figure B3 – 10-Year Storm Event Comparison

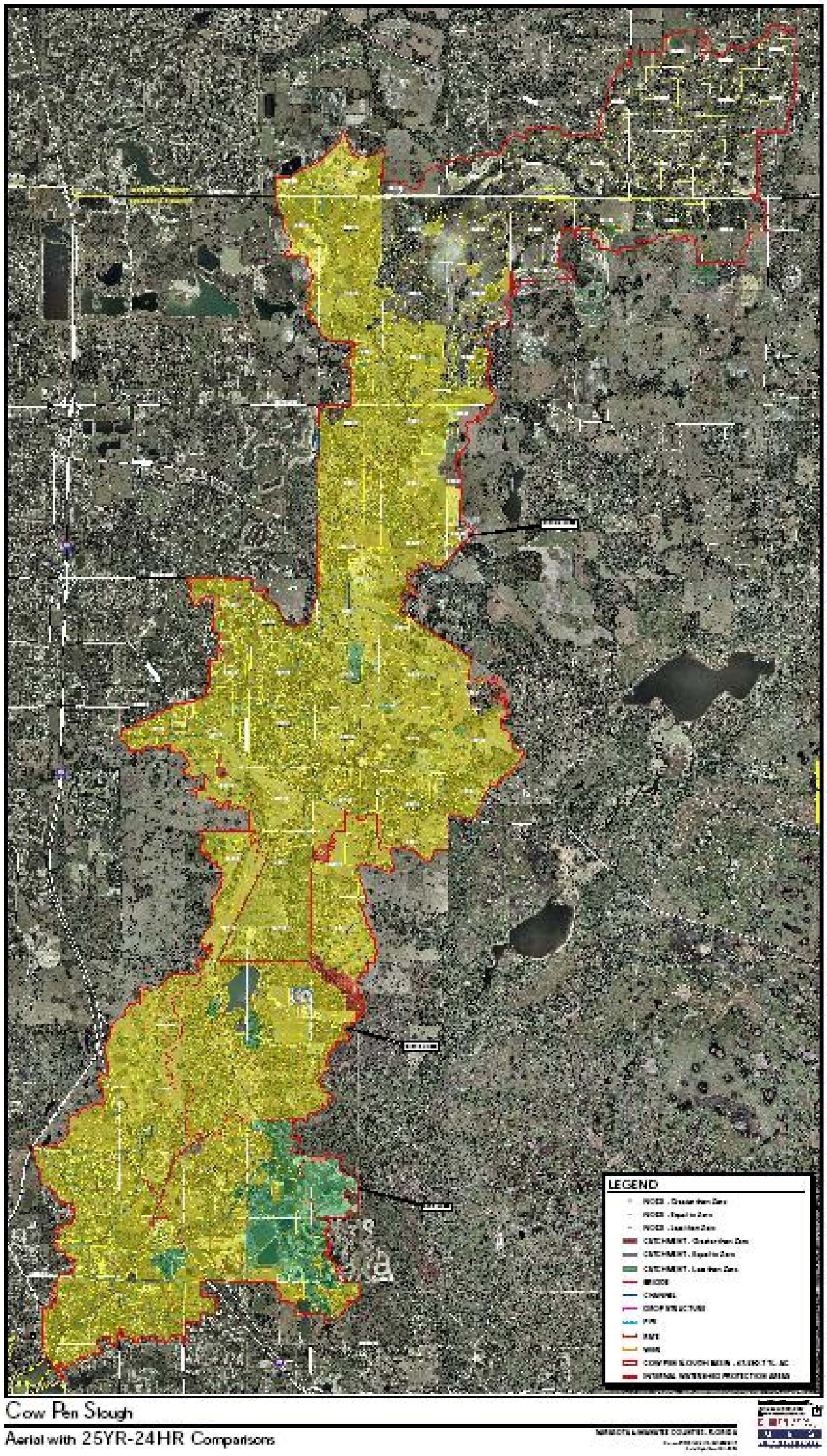

Figure B4 – 25-Year Storm Event Comparison

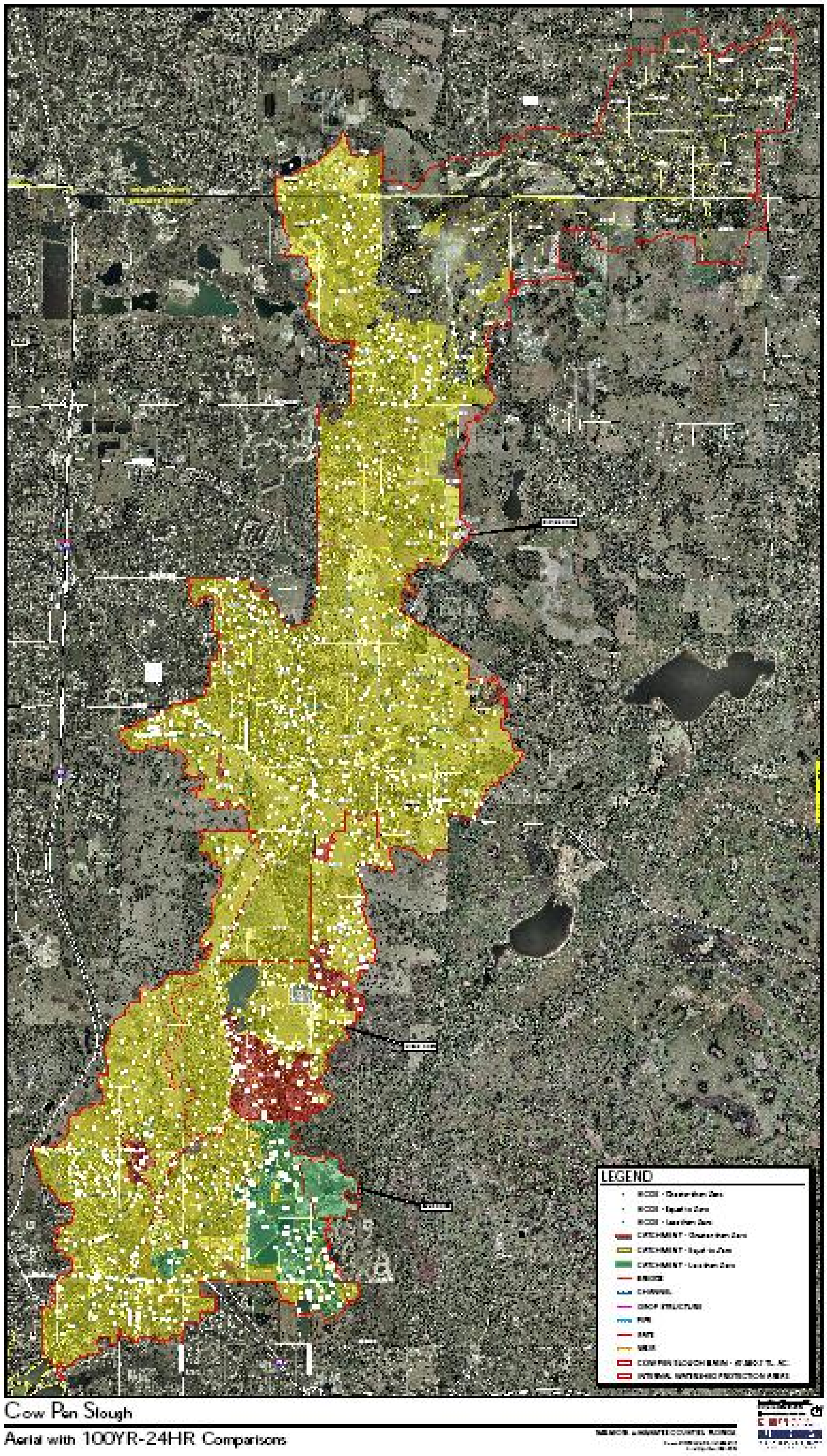

Figure B5 – 100-Year Storm Event Comparison

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TM 4.4.2 - CONTINUE MODEL VALIDATION

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and SWFWMD, is currently completing the pre-requisite data collection and analysis and comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marin Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the Southwest Florida Water Management District (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum (TM) has been prepared by KHA to present the analyses of the continued model validation, consistent with Task 4.4.2 of the DWMP contract. The purpose of the analysis is to perform further verification of the Dona Bay watershed model relative to the prediction of runoff hydrographs and volumes.

2.0 COW PEN SLOUGH MONITORING STATIONS

SCG maintains two automated rainfall monitoring stations (ARMS) located at water control structures 1 and 2 within the Dona Bay watershed. The stations concurrently measure water levels and rainfall at two (2) locations in the Cow Pen canal. With cooperative funding assistance from SWFWMD, periodic measurements of stages and discharges have been made since 2003 to establish rating curves. The rating curves allow for conversion of the continuous measured stage data to continuous discharges.

From the rating curves runoff discharges and volumes can be computed at these stations. Therefore, the relationship between measured rainfall and runoff can be evaluated annually, monthly, seasonally or on an event basis. This TM is interested in evaluation of the measured data relative to single rainfall events. The measured rainfall for an event can also be used to predict resulting discharges and runoff by coding it into a computer model such as Inter Connected Pond Routing (ICPR). Simulated runoff can then be compared to measured runoff to aid in the validation of the computer model.

For the purpose of this TM, two (2) rainfall events were simulated using the Dona Bay watershed computer model. Simulated hydrographs were then compared to measured hydrographs at the 2 water level control structures.

In addition, this TM compared the individual stage and discharge measurements with the stage and discharge relationships simulation by the Dona Bay watershed model for the two (2) water level control structures. Since both structures have operable gates, comparisons were made at both structures for the gates open and the gates.

3.0 STORM EVENT SIMULATION VERIFICATION

3.1 Selection of Rainfall Events

Flow measurements from the Cow Pen canal between 2004 and 2005 were reviewed to select discrete runoff producing rainfall events. Events were selected in the wet season during 2004 and the other during the dry season during 2005. **Figure 1** and **Figure 2** present the annual hydrographs for 2004 and 2005, respectively.

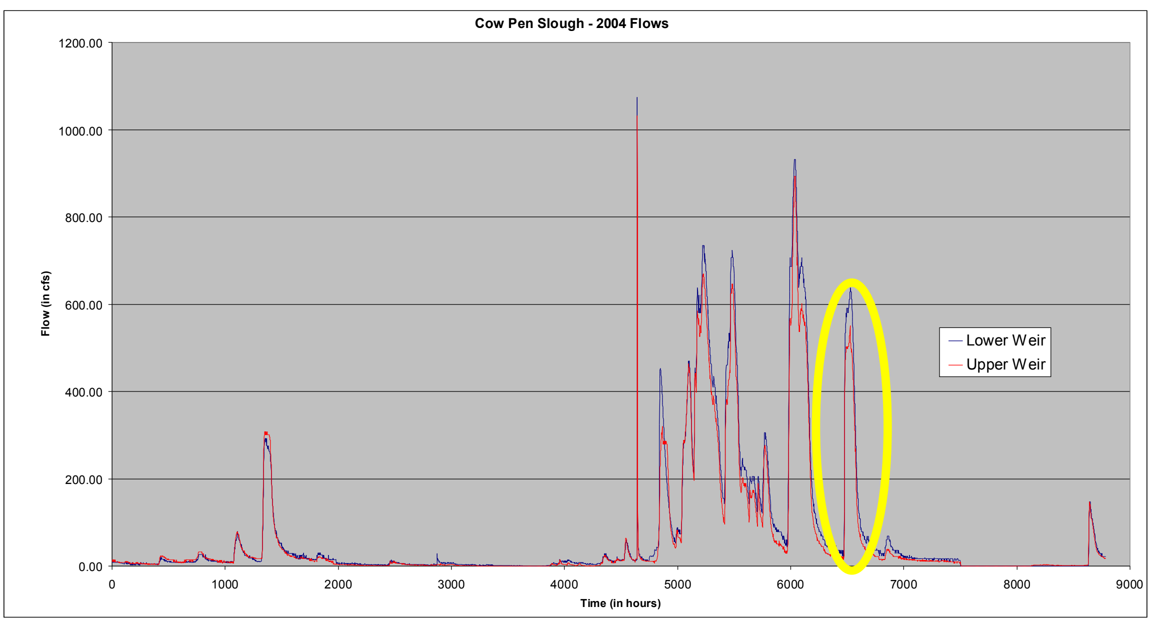


Figure 1 – 2004 Flows in Cow Pen Slough
(September 2004 Event Highlighted)

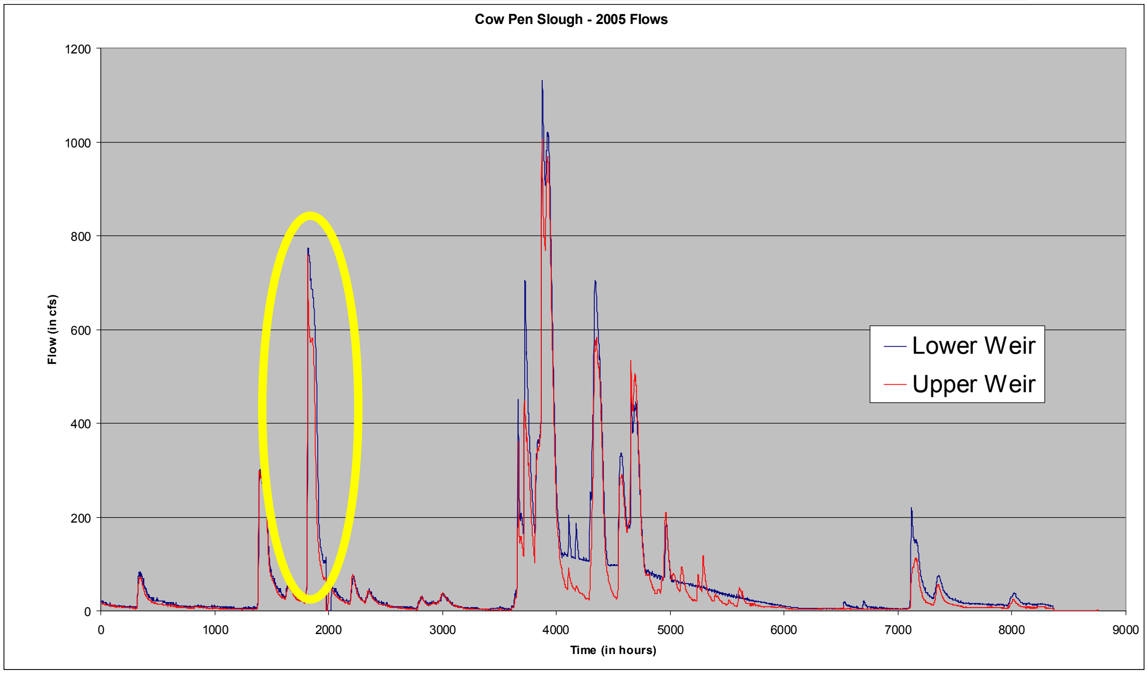


Figure 2 – 2005 Flows in Cow Pen Slough
(March 2005 Event Highlighted)

The selected events for this study occurred in both the normal dry and wet seasons, when the water level control structure gates would typically be closed and open, respectively. For each of the events considered, the volumes of actual rainfall and runoff were determined such that an event specific runoff curve number (CN) could be computed as prescribed in TR-55, Urban Hydrology for Small Watersheds. The hydrologic input parameters determined for each of the simulated rainfall events are:

Parameters	***September 2004***	***March 2005***
Rainfall date; time	9/25; 5:00PM	3/17; 4:00PM
	9/27; 6:00PM	3/18; 5:00PM
Rainfall, (P)	2.71 inches	3.43 inches
Duration, (t)	36 hours	25 hours
Runoff, (R)	1.74 inches (UWLCS)	1.71 inches (UWLCS)
	1.79 inches (LWLCS)	1.88 inches (LWLCS)
Soil Storage, (S)	1.08 inches (UWLCS)	2.33 inches (UWLCS)
	1.00 inches (LWLCS)	1.90 inches (LWLCS)
Curve Number (CN)	90.3 (UWLCS)	81.8 (UWLCS)
	90.9 (LWLCS)	84.0 (LWLCS)

3.2 Rainfall Data and Distribution

The ICPR hydrology module requires that each rainfall event be converted to a dimensionless time versus rainfall distribution. This is accomplished by dividing the cumulative rainfall and time increments by the total rainfall volume and duration, respectively. Incremental values, cumulative totals and developed dimensionless rainfall distributions for each event are contained at the end of this TM.

3.3 Storm Event Simulations

Each of the selected rainfall events were simulated using the ICPR computer model developed for the Dona Bay watershed model. As a result, hydrographs were developed at both gage sites/structures. Additionally, the curve number (CN) parameter calculated for each rainfall event was applied to all sub-basins to assure that the simulated runoff volumes match measured runoff volumes. The simulated hydrographs were then compared to the measured hydrographs.

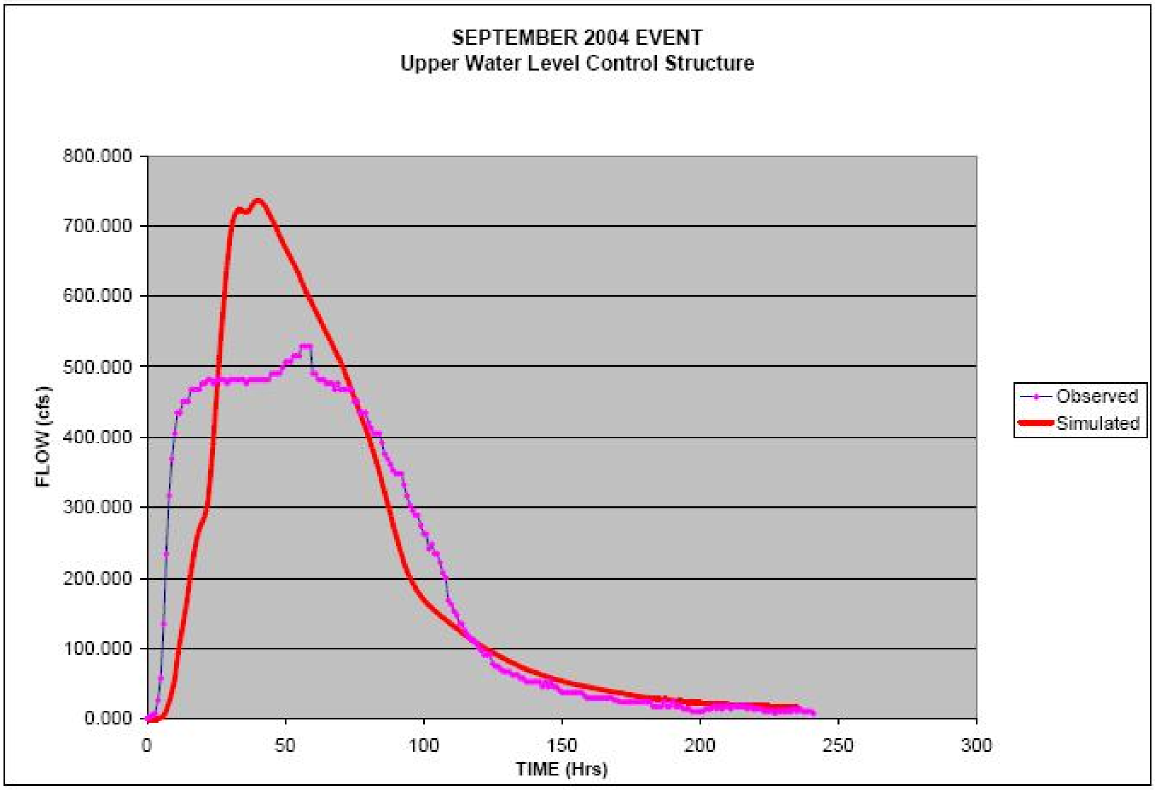
3.4 Results of Storm Event Simulations

It should be noted that initial CN parameters and simulation results indicated that the model under predicted total runoff volumes for each of the events studied. The September 2004 simulation produced runoff volumes 20% to 25% less than observed data for the Upper and Lower water level control structures respectively. The March 2005 simulation produced runoff volumes 30% to 33% less than observed data for the Upper and Lower water level control structures respectively. As the simulated runoff volumes did not match the measured runoff volumes, single hydrographs simulations were developed at each of the water level control structures applying the rainfall distribution and Curve Number (CN) methodology presented in Section 3.1. The single hydrograph simulations produced runoff volumes consistent with the measured runoff volumes. This confirmed that the rainfall distribution, CN and soils storage calculations were accurate but did not explain why they deviated for the entire watershed model simulation.

Next, the mass balance reports for the initial model simulations were reviewed. These mass balance reports indicated that outflow volumes were less than generated inflow volumes in similar percentages as previously reported. The differences in inflow and outflow volumes are accounted for in the amount of retention or "dead" storage that exists in the watershed. To compensate for this retention storage, the runoff volumes were increased accordingly and the CN parameters were recalculated. The adjusted model parameters are provided below:

Adjusted Parameter	***September 2004***	***March 2005***
Runoff, (R)	2.11 inches (UWLCS)	2.05 inches (UWLCS)
	2.16 inches (LWLCS)	2.18 inches (LWLCS)
Soil Storage, (S)	0.59 inches (UWLCS)	1.61 inches (UWLCS)
	0.53 inches (LWLCS)	1.41 inches (LWLCS)
Curve Number (CN)	94.4 (UWLCS)	86.1 (UWLCS)
	94.9 (LWLCS)	87.7 (LWLCS)

Adjusted parameter simulations and measured storm hydrographs are compared below for each storm event evaluated in addition to single hydrograph simulations using the initial parameters.



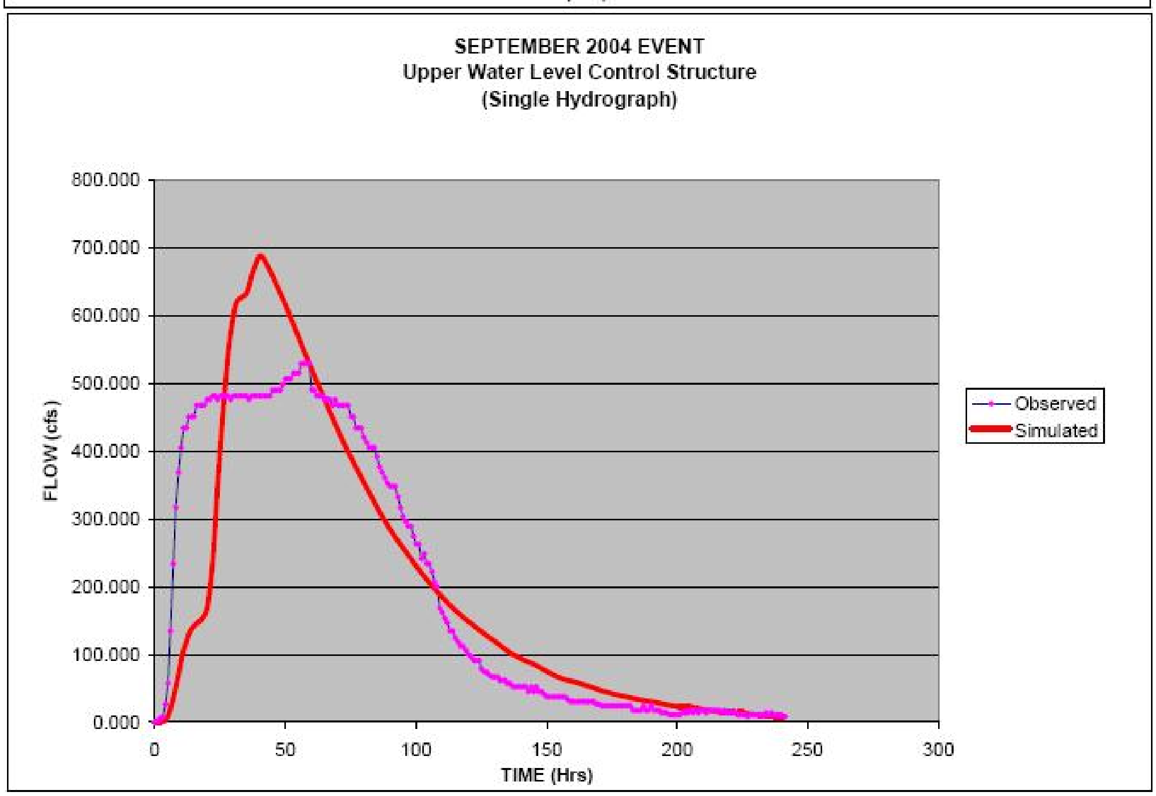
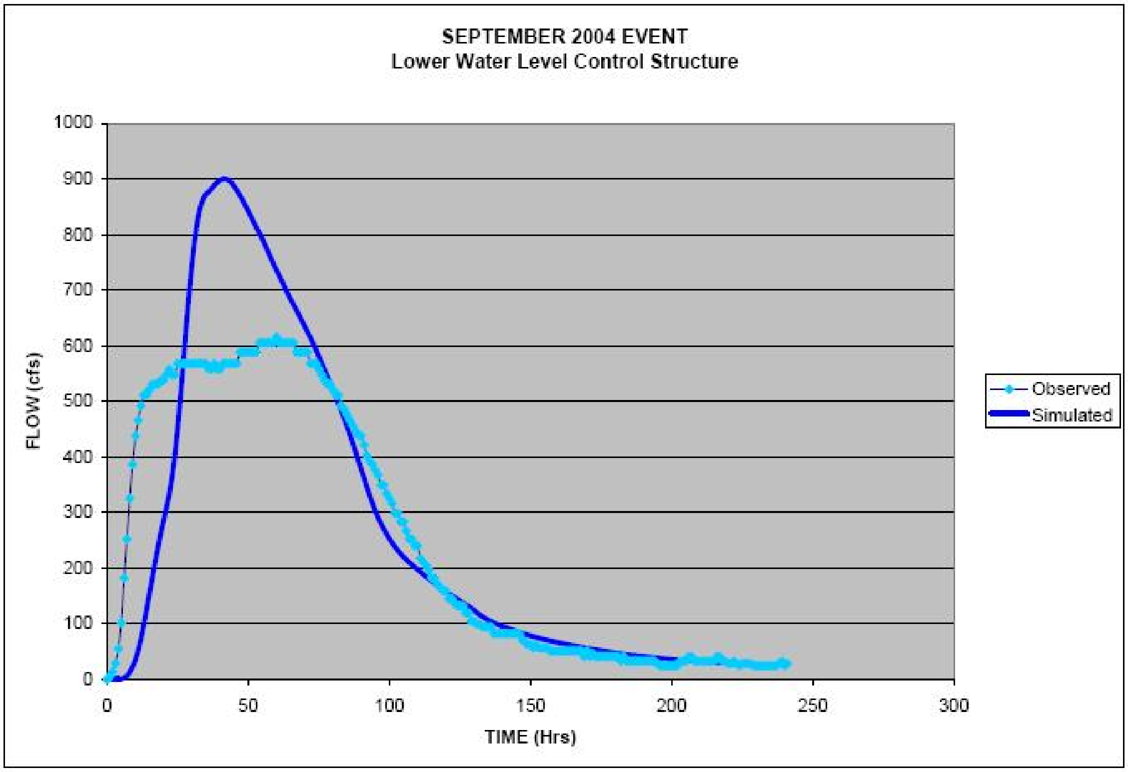


Figure 3 – September 2004 Event Comparison (Upper WLCS)



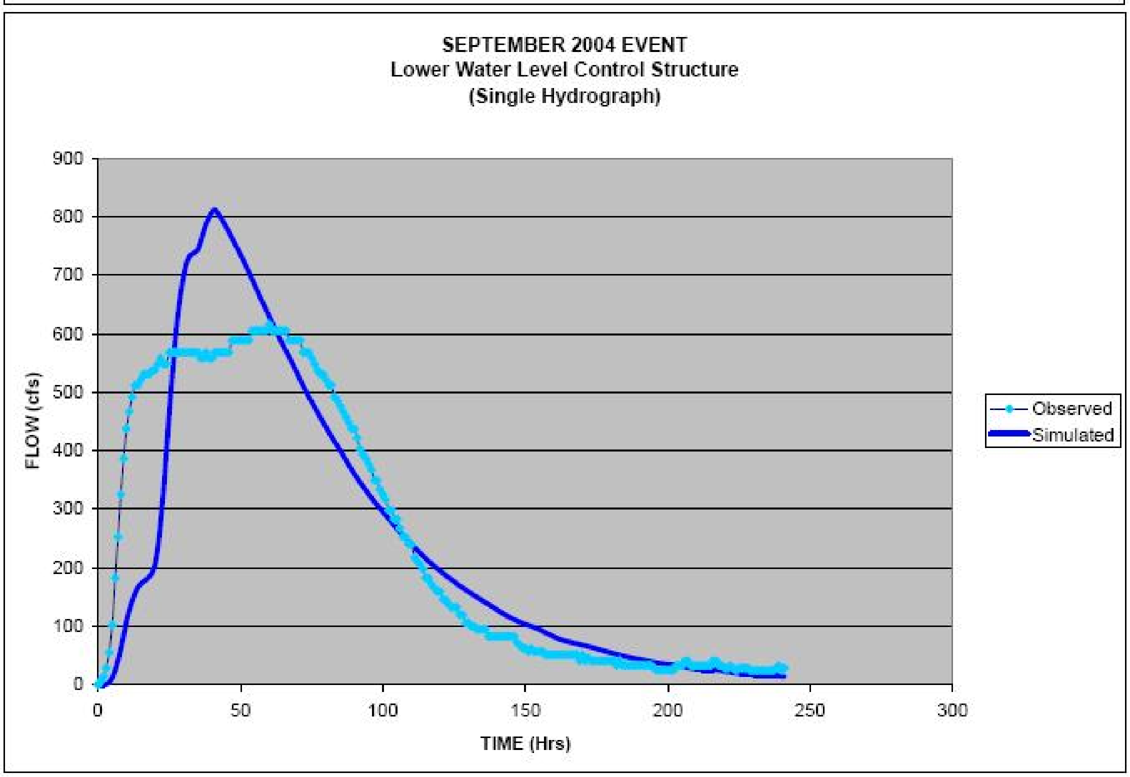
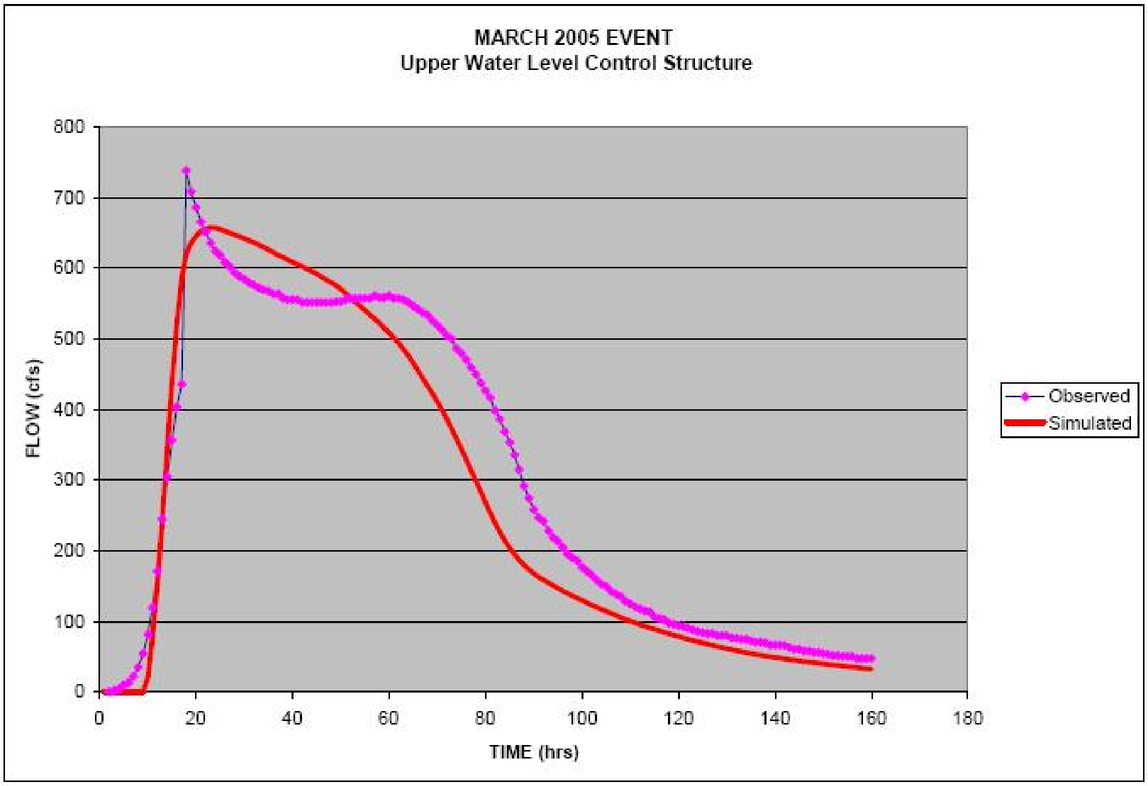


Figure 4 – September 2004 Event Comparison (Lower WLCS)



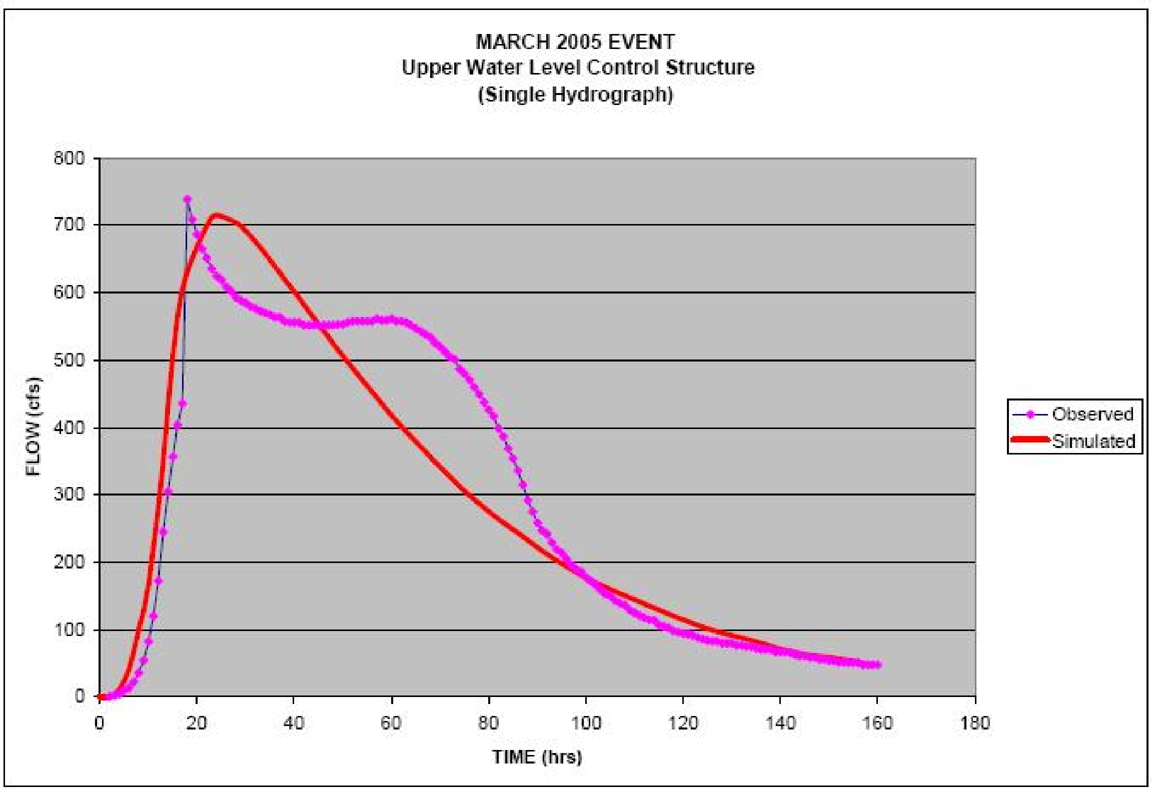
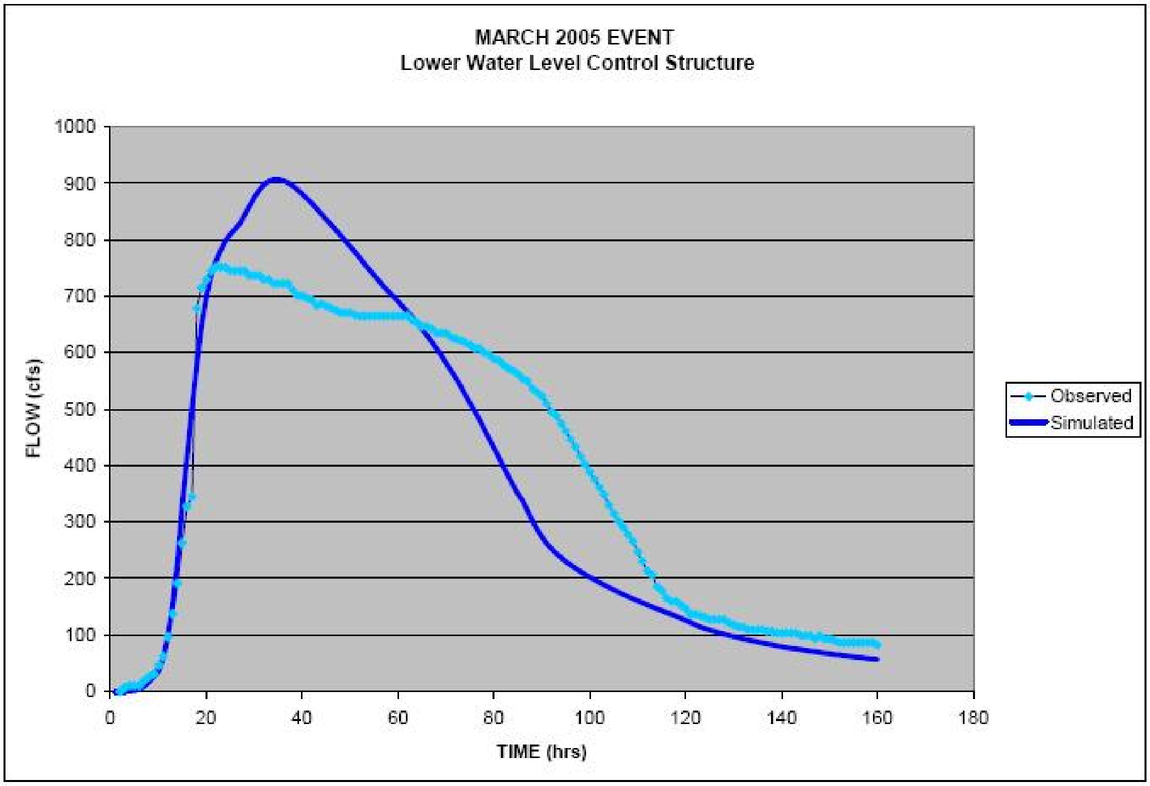


Figure 5 – March 2005 Event Comparison (Upper WLCS)



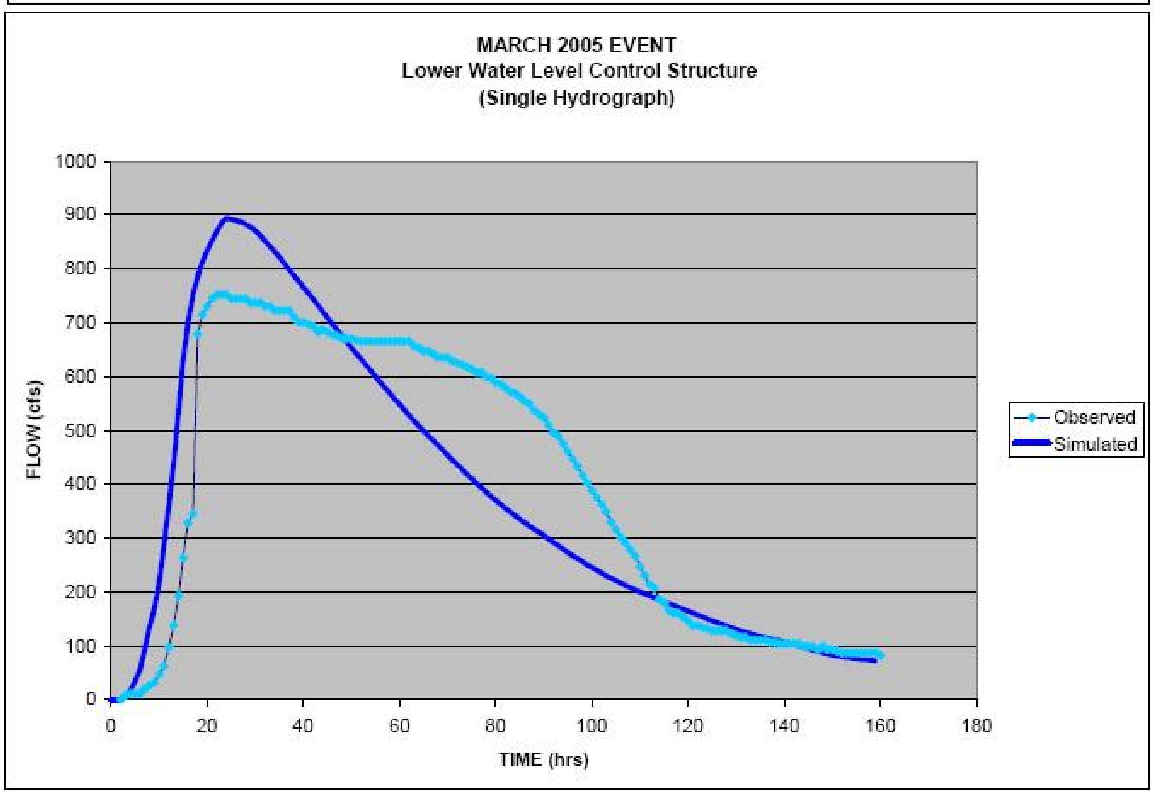


Figure 6 – March 2005 Event Comparison (Lower WLCS)

3.5 Conclusions

Figures 3 through 6 indicate that the model results reasonably predict total runoff volumes as well as the general shape and timing of the measured hydrographs. However, the simulated results tend to over-predict the measured peak flows, particularly for the September, 2004 storm event. Measured flows at both gate structures also appear to have flattened and extended peak flow regimes when compared to simulated time flow relationships. This suggests that peak flow and stages may be truncated due to possible over-bank relief upstream of each gate structure. The original SCS Work Plan for the Cow Pen Canal included berm breaches at various locations along each side of the canal. Although these berm breaches are reflected per the original plans within the model, it is entirely feasible that adjacent property owners have lowered them over the years for various reasons. It is recommended that these areas be field surveyed to validate and identify any model adjustments needed (i.e. breach lengths, inverts).

4.0 CONTROL STRUCTURE – RATING CURVE VERIFICATION

For each of the two (2) water level control structures in the Cow Pen canal, comparisons of individual stage and discharge measurements with the stage and discharge relationships used by the Dona Bay watershed model were reviewed. Since both structures have operable gates, comparisons were made at both structures for the gates open and the gates closed. Simulated and measured stage and flow values are compared in Figure 7 through Figure 10.

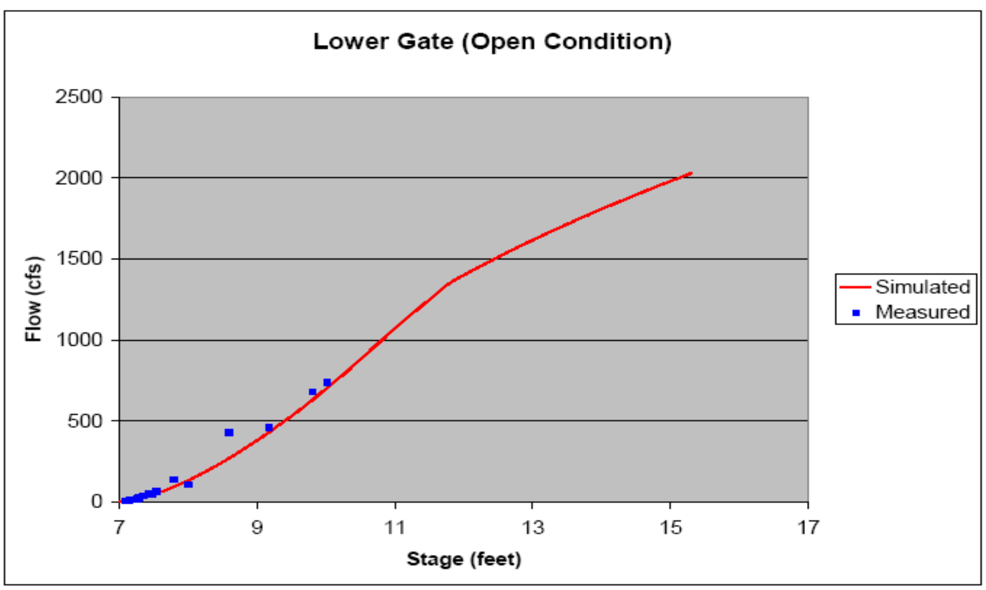


Figure 7 – Stage-Flow Comparison on Lower Gate (opened gates condition)

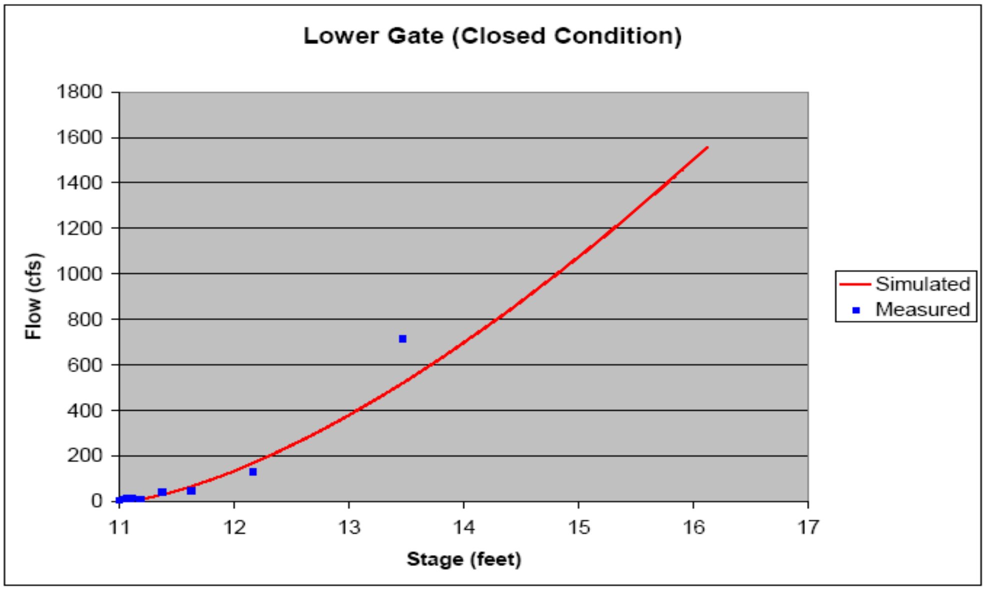


Figure 8 – Stage-Flow Comparison on Lower Gate (closed gates condition)

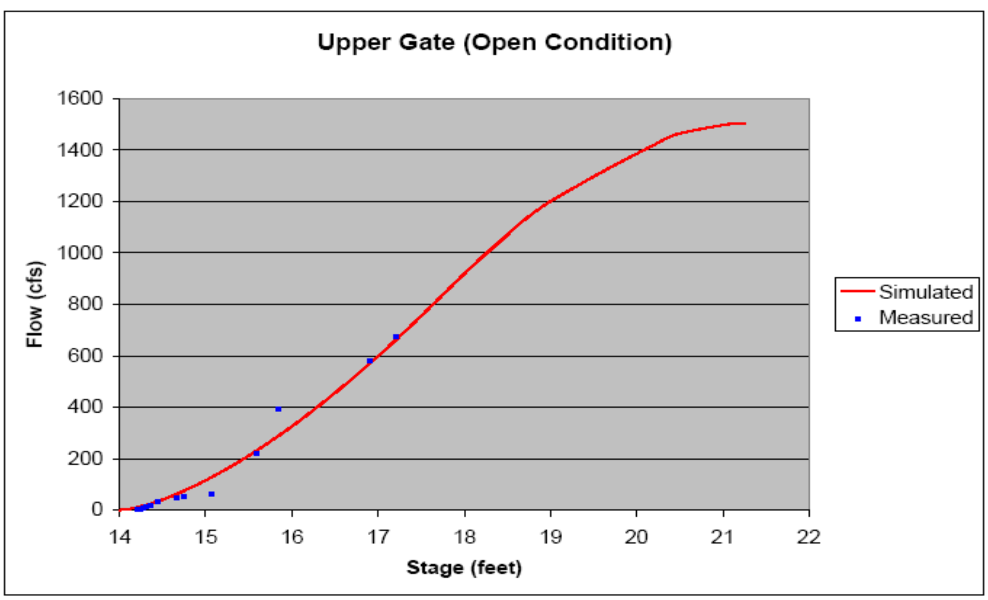


Figure 9 – Stage-Flow Comparison on Upper Gate (opened gates condition)

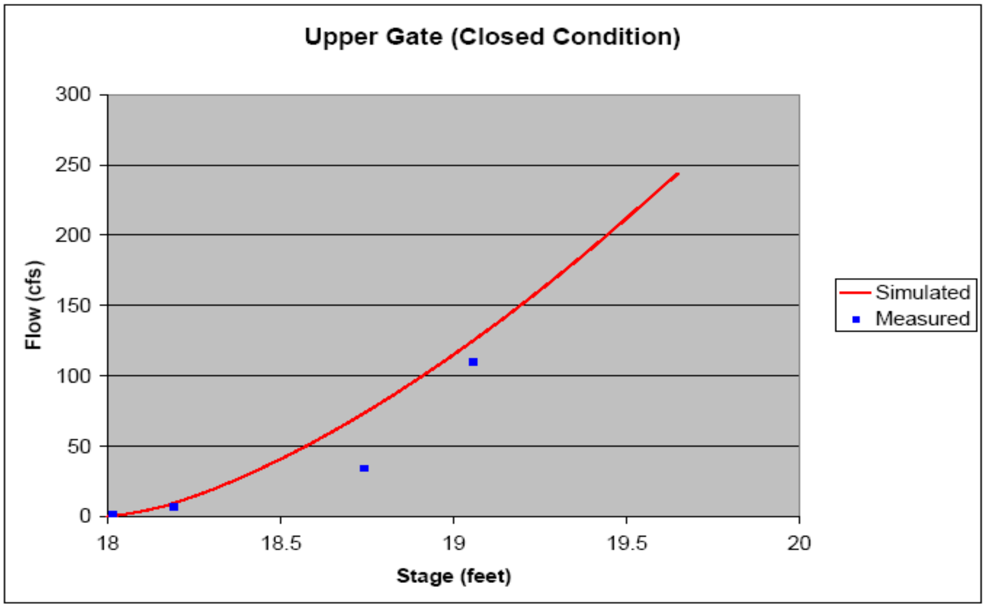


Figure 10 – Stage-Flow Comparison on Upper Gate (closed gates condition)

5.0 CONCLUSION

The Dona Bay watershed model appears to reasonably predict key components (i.e. volume, shape, time to peak) of single storm hydrographs, given a defined rainfall event and antecedent moisture conditions. However, the simulations indicate that simulated peak discharges exceed simulated peak discharges, particularly for the September 2004 storm event. This could be an anomaly for this storm in particular or a result of changes in the design height of the berm breaches along the Cow Pen canal. 2006 rainfall and discharge data for the Cow Pen canal should be reviewed to determine if other discrete storm events could be chosen for additional verification simulations. In addition, field surveying of the Cow Pen Slough canal berm breach should be obtained to determine if indeed they have been lowered,

DEVELOPED DIMENSIONLESS RAINFALL DISTRIBUTIONS

SEPTEMBER 2004 RAINFALL EVENT					SEP04-2.IHL DIMENSIONLESS RAINFALL DISTRIBUTION	
Date	Tinc	Pinc	Tcum	Pcum	T	P
9/26/2004 6:00	0	0.00	0	0	0	0
9/26/2004 7:00	1	0.03	1	0.03	0.027778	0.01107
9/26/2004 8:00	1	0.06	2	0.09	0.055556	0.03321
9/26/2004 9:00	1	0.27	3	0.36	0.083333	0.132841
9/26/2004 10:00	1	0.06	4	0.42	0.111111	0.154982
9/26/2004 11:00	1	0.19	5	0.61	0.138889	0.225092
9/26/2004 12:00	1	0.09	6	0.7	0.166667	0.258303
9/26/2004 13:00	1	0.08	7	0.78	0.194444	0.287823
9/26/2004 14:00	1	0.01	8	0.79	0.222222	0.291513
9/26/2004 15:00	1	0.16	9	0.95	0.25	0.350554
9/26/2004 16:00	1	0.03	10	0.98	0.277778	0.361624
9/26/2004 17:00	1	0.00	11	0.98	0.305556	0.361624
9/26/2004 18:00	1	0.01	12	0.99	0.333333	0.365314
9/26/2004 19:00	1	0.00	13	0.99	0.361111	0.365314
9/26/2004 20:00	1	0.04	14	1.03	0.388889	0.380074
9/26/2004 21:00	1	0.00	15	1.03	0.416667	0.380074
9/26/2004 22:00	1	0.00	16	1.03	0.444444	0.380074
9/26/2004 23:00	1	0.01	17	1.04	0.472222	0.383764
9/27/2004 0:00	1	0.03	18	1.07	0.5	0.394834
9/27/2004 1:00	1	0.04	19	1.11	0.527778	0.409594
9/27/2004 2:00	1	0.19	20	1.3	0.555556	0.479705
9/27/2004 3:00	1	0.24	21	1.54	0.583333	0.568266
9/27/2004 4:00	1	0.22	22	1.76	0.611111	0.649446
9/27/2004 5:00	1	0.22	23	1.98	0.638889	0.730627
9/27/2004 6:00	1	0.08	24	2.06	0.666667	0.760148
9/27/2004 7:00	1	0.06	25	2.12	0.694444	0.782288
9/27/2004 8:00	1	0.10	26	2.22	0.722222	0.819188
9/27/2004 9:00	1	0.21	27	2.43	0.75	0.896679
9/27/2004 10:00	1	0.01	28	2.44	0.777778	0.900369
9/27/2004 11:00	1	0.00	29	2.44	0.805556	0.900369
9/27/2004 12:00	1	0.00	30	2.44	0.833333	0.900369
9/27/2004 13:00	1	0.00	31	2.44	0.861111	0.900369
9/27/2004 14:00	1	0.00	32	2.44	0.888889	0.900369
9/27/2004 15:00	1	0.06	33	2.5	0.916667	0.922509
9/27/2004 16:00	1	0.00	34	2.5	0.944444	0.922509
9/27/2004 17:00	1	0.02	35	2.52	0.972222	0.929889
9/27/2004 18:00	1	0.19	36	2.71	1	1
	36	2.71				

DEVELOPED DIMENSIONLESS RAINFALL DISTRIBUTIONS

MARCH 2005 RAINFALL EVENT					MAR5U.IHL DIMENSIONLESS RAINFALL DISTRIBUTION	
Date	**Tinc**	**Pinc**	**Tcum**	**Pcum**	**T**	**P**
3/17/2005 17:00	0	0.00	0	0.00	0	0
3/17/2005 18:00	1	0.20	1	0.20	0.04	0.058309
3/17/2005 19:00	1	0.00	2	0.20	0.08	0.058309
3/17/2005 20:00	1	0.75	3	0.95	0.12	0.276968
3/17/2005 21:00	1	0.00	4	0.95	0.16	0.276968
3/17/2005 22:00	1	0.25	5	1.20	0.2	0.349854
3/17/2005 23:00	1	0.00	6	1.20	0.24	0.349854
3/18/2005 0:00	1	0.45	7	1.65	0.28	0.48105
3/18/2005 1:00	1	0.00	8	1.65	0.32	0.48105
3/18/2005 2:00	1	0.00	9	1.65	0.36	0.48105
3/18/2005 3:00	1	0.50	10	2.15	0.4	0.626822
3/18/2005 4:00	1	0.25	11	2.40	0.44	0.699708
3/18/2005 5:00	1	0.25	12	2.65	0.48	0.772595
3/18/2005 6:00	1	0.27	13	2.92	0.52	0.851312
3/18/2005 7:00	1	0.25	14	3.17	0.56	0.924198
3/18/2005 8:00	1	0.00	15	3.17	0.6	0.924198
3/18/2005 9:00	1	0.00	16	3.17	0.64	0.924198
3/18/2005 10:00	1	0.00	17	3.17	0.68	0.924198
3/18/2005 11:00	1	0.00	18	3.17	0.72	0.924198
3/18/2005 12:00	1	0.23	19	3.40	0.76	0.991254
3/18/2005 13:00	1	0.00	20	3.40	0.8	0.991254
3/18/2005 14:00	1	0.00	21	3.40	0.84	0.991254
3/18/2005 15:00	1	0.00	22	3.40	0.88	0.991254
3/18/2005 16:00	1	0.00	23	3.40	0.92	0.991254
3/18/2005 17:00	1	0.00	24	3.40	0.96	0.991254
	1	0.03	25	3.43	1	1
	25	3.43				

TM 4.4.3 – REGIONAL STORMWATER FEASIBILITY STUDY

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD), is currently completing the necessary, pre-requisite data collection and analysis as well as comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

1. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
2. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
3. Protect existing and future property owners from flood damage.
4. Protect existing water quality.
5. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum (TM) has been prepared by KHA to address Task 4.4.3 of the DBWMP contract. Specifically, the Albritton Site, Venice Minerals Site, LT-Ranch Site and Hi-Hat Old Grove Site were evaluated for their potential to provide regional stormwater management.

2.0 DESCRIPTION OF POTENTIAL REGIONAL STORMWATER SITES

2.1 Albritton Site

As proposed under the Phase configuration 2 presented in Technical Memorandum 4.2.7, and Alternative 3 of Technical Memorandum 4.2.4.2, the operating range for water supply of the Albritton site will allow for it to also be used to accept flood waters. In addition, since the Albritton site would function as a "flow through" system, it will also provide regional water quality treatment by providing significantly increased residence time. The value of the Albritton site for stormwater treatment has been considered relative to pollutant removal efficiency in Technical Memorandum 4.3.3. Therefore, this analysis was focused on evaluating the potential benefits of the Albritton site as a flood storage facility.

2.1.1 Model Set-Up

The model set-up for the Albritton site has previously been described in Technical Memorandum 4.4.5 under the Phase configuration 2.

2.1.2 Model Results

The simulation results for the Albriton site are provided in Technical Memorandum 4.2.5 under the Phase configuration 2. Based upon this simulation, the subbasin areas that will experience reductions in flood stages are extensive and are shaded in green on **Figure 1**. This potential "benefit" area encompasses approximately 10,500 acres and represents a total floodwater volume reduction equivalent to approximately 1,179 acre-feet of floodplain storage.

Figure 2 presents an overlay of the potential benefit area (cross-hatched) and the future land use map. Based upon this overlay, approximately 5,800 acres of designated rural lands, located entirely north of I-75 would be included in the potential benefit area. However, much of this rural designated land is currently already developed as low density residential subdivisions or situated in areas susceptible to flooding (including the LT Ranch and Hi-Hat Old Grove sites). This rural designation would allow residential densities of either 1 unit per 5 acres or 1 unit per 10 acres. At these low densities, adequate open space should be available on each lot to minimize floodplain encroachment. And in the event that the low densities are clustered under the conservation subdivision option, it is likely that adequate open space, corresponding to existing floodplain areas would be set aside to minimize floodplain encroachment. Therefore, the market for floodplain compensation for rural designated land uses is expected to be limited.

It is also noted that approximately 970 acres of designated moderate density residential lands, located south of I-75 would be included in the potential benefit area. However since most of the moderate density residential area included in the potential benefit area is already developed or included in the recent Fox Creek public acquisition site, the market for floodplain compensation may be limited for this area.

Figure 3 presents an overlay of the potential benefit area (cross-hatched) and the 2050 overlay. Based upon this overlay, much of the potential benefit area occurs in proposed greenway and existing, rural heritage resource management areas. Only 1,614 acres of designated village and open space resource management areas are encompassed in the potential benefit area. Since 50% of the village and open space resource management areas are required to be in open space, it is anticipated that much of the potential benefit areas will be included within the open space. Additionally, much of this potential benefit area is situated in areas susceptible to flooding (including the LT Ranch and Hi-Hat Old Grove sites).

Because this site is located in an area that historically provided floodplain in the watershed prior to the dikes and pumps constructed in association with the citrus operation and since this “regained” floodplain storage may be “lost” with phase configuration 3, it is not recommended that the Albritton site be pursued as a regional stormwater facility. If the phase configuration 3 is not pursued, this could be reconsidered. However, the watershed may be built out by the time a final decision is made elative to the phase configuration 3.

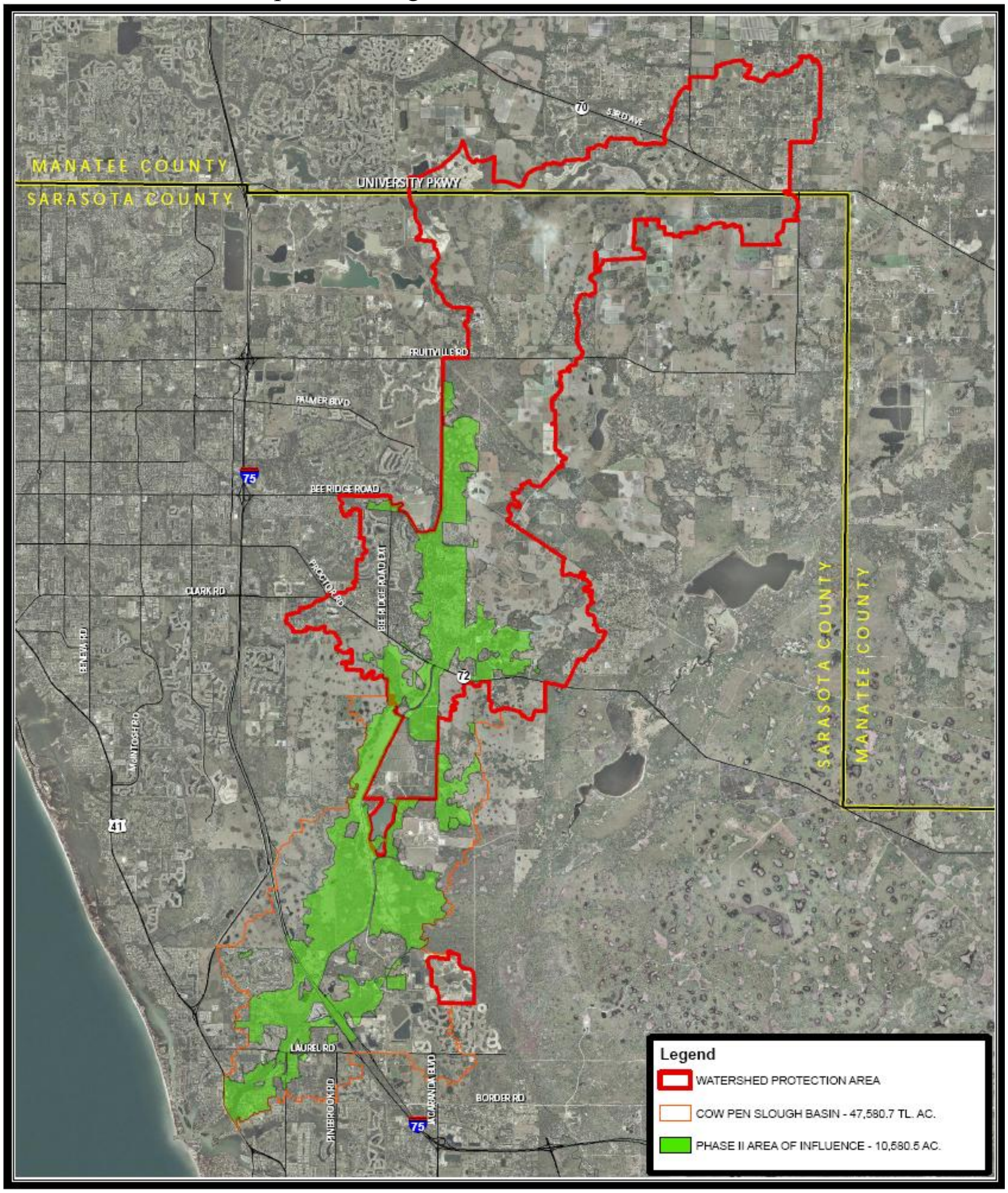


Figure 1 - Albritton Site, Potential Benefit Area

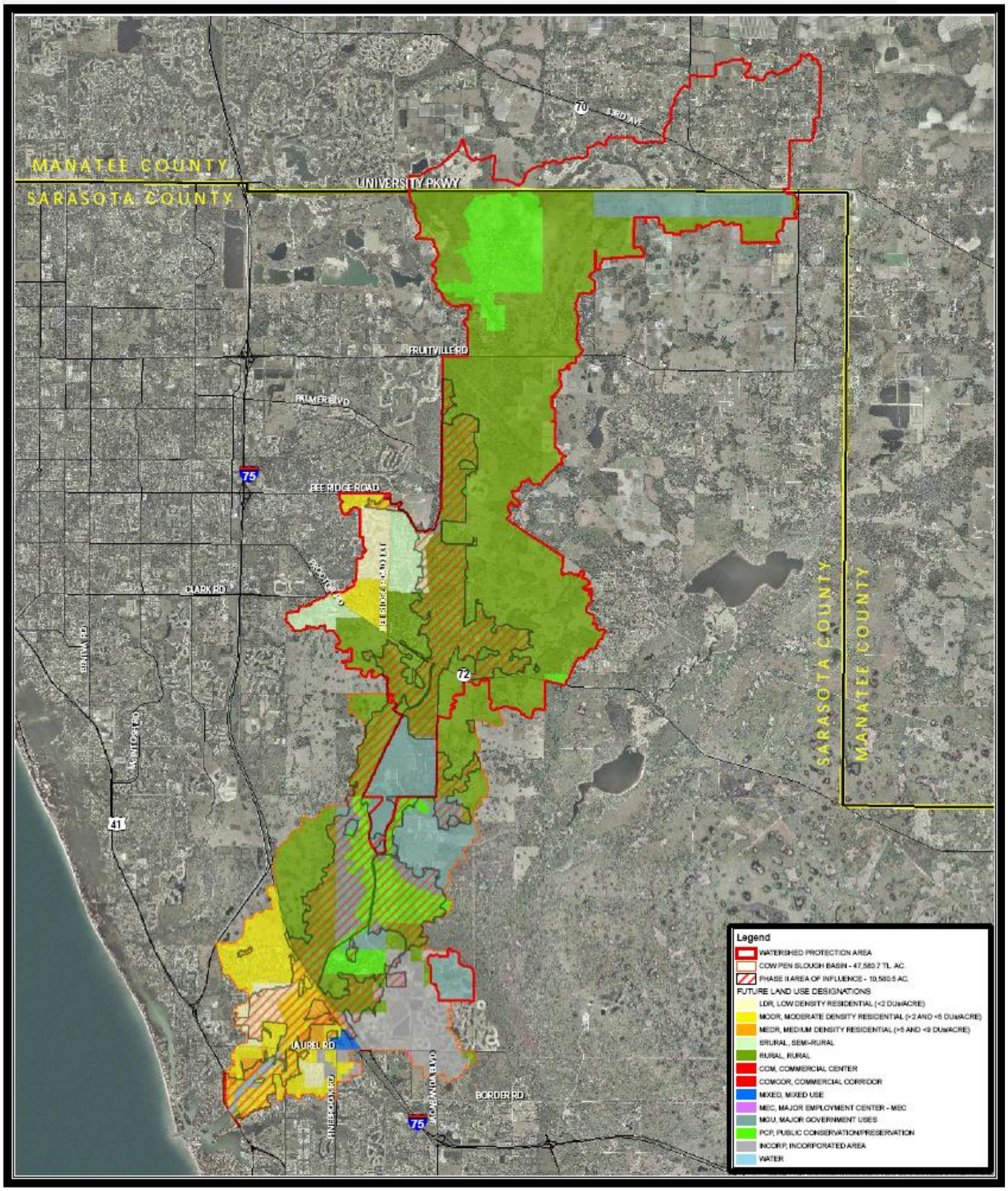


Figure 2 - Albritton Site, Potential Benefit Area with Future Land Use Map

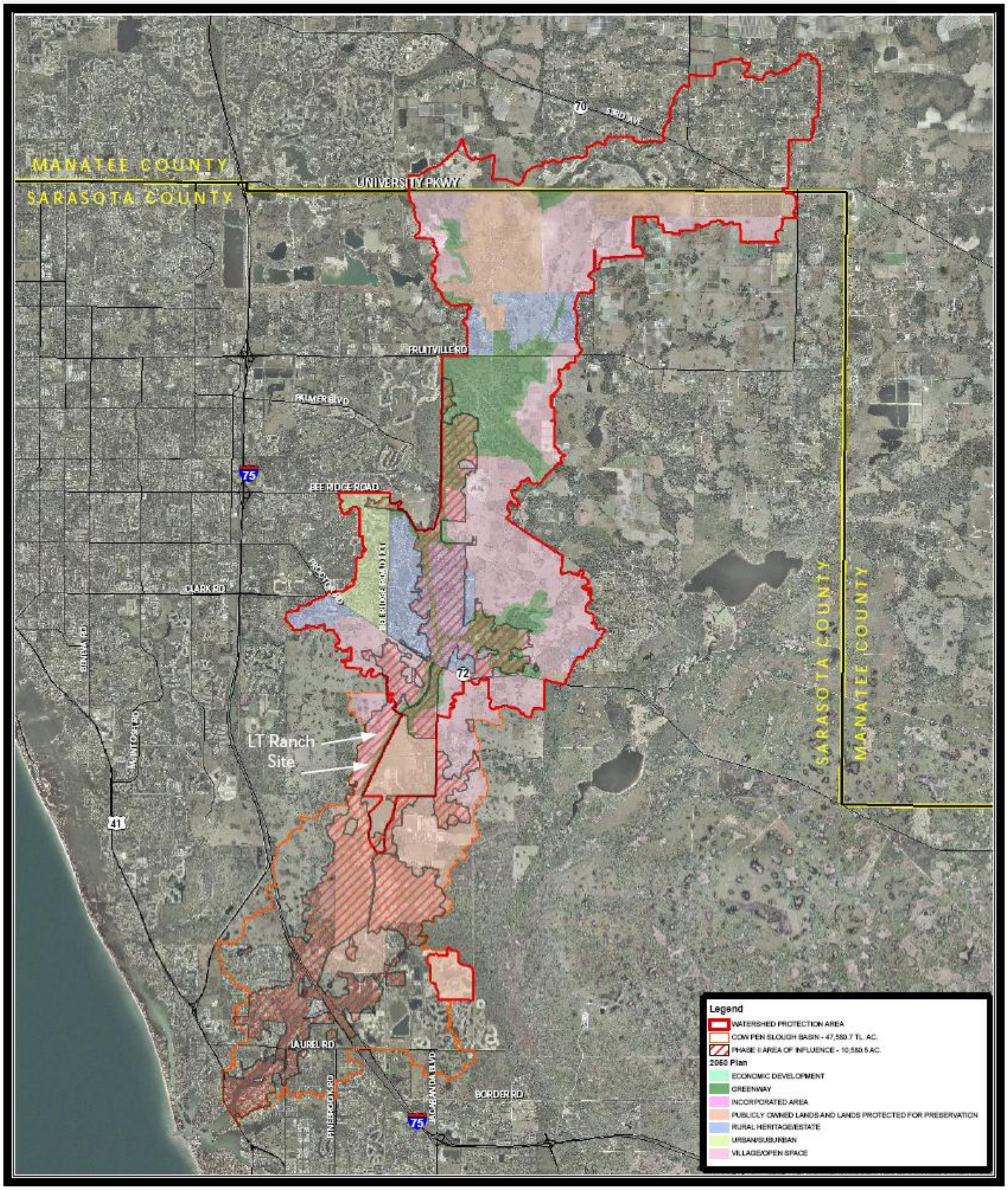


Figure 3 - Albritton Site, Potential Benefit Area with 2050 Overlay

2.2 Venice Minerals Site

The Dona Bay Watershed Management Plan anticipates that the Venice Minerals site would be used exclusively as a surface water supply reservoir. Since the proposed operating range for this reservoir would preclude it from being used as a regional stormwater facility, it was not further considered in this evaluation.

2.3 LT Ranch Site

The LT Ranch site is currently part of the LT Ranch and is under private ownership. However, it is part of the original Cow Pen Slough and current 100-year floodplain. It is strategically located from a water storage perspective and provides a regional stormwater opportunity. Since it is located entirely on private property, it use as a regional stormwater facility would need to be coordinated with, and advocated by the LT Ranch. It is noted that conversion of this site to a wetland marsh type of regional stormwater facility could be eligible for funding assistance through the Natural Resources Conservation Service's (NRCS) Wetland Reserve Program. As a marsh area, this site could also potentially provide pre-treatment of surface waters prior to diversion into the Albritton reservoir. It could also be incorporated into the Phase 2 configuration for the Dona Bay watershed as an expansion of the Albriton reservoir and flood storage facility. This would likely require public acquisition of the LT Ranch site. For the purpose of this evaluation, the potential benefit area of LT Ranch site was considered independently, under the Phase configuration 3 of the Dona Bay watershed plan as presented in Technical Memorandum 4.2.7.

2.3.1 Model Set-Up

The model set-up for the LT Ranch site essentially aggregated all subbasins and nodes in the historical Cow Pen Slough into a single subbasin and storage node, respectively. It was assumed that the entire area was excavated to elevation ±12.0 ft. NGVD. Further, it was assumed that the upper water level control structure for the Cow Pen Canal was configured with side gates on the west side to divert water into the LT Ranch site and that the main overflow gates to the downstream canal were set at elevation 14.0 ft. NGVD. Therefore, elevation 14.0 ft. would be the control water level of the LT Ranch site. A complete set of worksheet templates for model additions, deletions and modifications as needed to reflect this evaluation were provided to the Sarasota County Stormwater Division under a separate cover.

2.3.2 Model Results

The simulation results for the LT Ranch site are summarized in Appendix A. Based upon this simulation, the subbasin areas that will experience reductions in flood stages are extensive and are shaded in green on **Figure 4**. This potential "benefit" area encompasses approximately 9,500 acres and represents a total volume floodwater reduction equivalent to approximately 819 acre-feet of floodplain storage.

Figure 5 presents an overlay of the potential benefit area (cross-hatched) and the future land use map. Based upon this overlay, approximately 5,100 acres of designated rural lands, located entirely north of I-75 would be included in the potential benefit area, including the LT Ranch site itself. However, much of this rural designated land is currently already developed as low density residential subdivisions or situated in areas susceptible flooding (including the subject LT Ranch site and Hi-Hat Old Grove site). This rural designation would allow residential densities of either 1 unit per 5 acres or 1 unit per 10 acres. At these low densities, adequate open space should be available on each lot to minimize floodplain encroachment. And in the event that the low densities are clustered under the conservation subdivision option, it is likely that adequate open space, corresponding to existing floodplain areas would be set aside to minimize floodplain encroachment. Therefore, the market for floodplain compensation for rural designated land uses is expected to be limited.

It is also noted that approximately 950 acres of designated moderate density residential lands, located south of I-75 would be included in the potential benefit area. However since most of the moderate density residential area included in the potential benefit area is already developed or included in the recent Fox Creek public acquisition site, the market for floodplain compensation may be limited for this area.

Figure 6 presents an overlay of the potential benefit area (cross-hatched) and the 2050 overlay. Based upon this overlay, much of the potential benefit area occurs in proposed greenway and existing, rural heritage resource management areas. Only 1,540 acres of designated village and open space resource management areas are encompassed in the potential benefit area. Since 50% of the village and open space resource management area is required to be in open space, it is anticipated that much of the potentially benefit areas will be included within the open space. Additionally, much of this potential benefit area is situated in the areas susceptible to flooding (including the subject LT Ranch site and Hi-Hat Old Grove site).

Although there may not be a significant market for floodplain storage, the LT Ranch site might still serve as a regional stormwater facility as part of a future upstream village. Under this scenario, it would be developed as a regional stormwater facility which could also provide for wetland restoration, in association with a privately initiated development proposal. Since this is a desirable form for managing stormwater and can provide incidental benefits in the watershed, this should be supported by Sarasota County through possible federal and/or state grant programs or through stormwater utility assessment credits.

Finally since the key to both hydrologic/watershed restoration and water supply yields is storage, it might be worthwhile to consider public acquisition of this site and incorporating it into the Albritton reservoir.

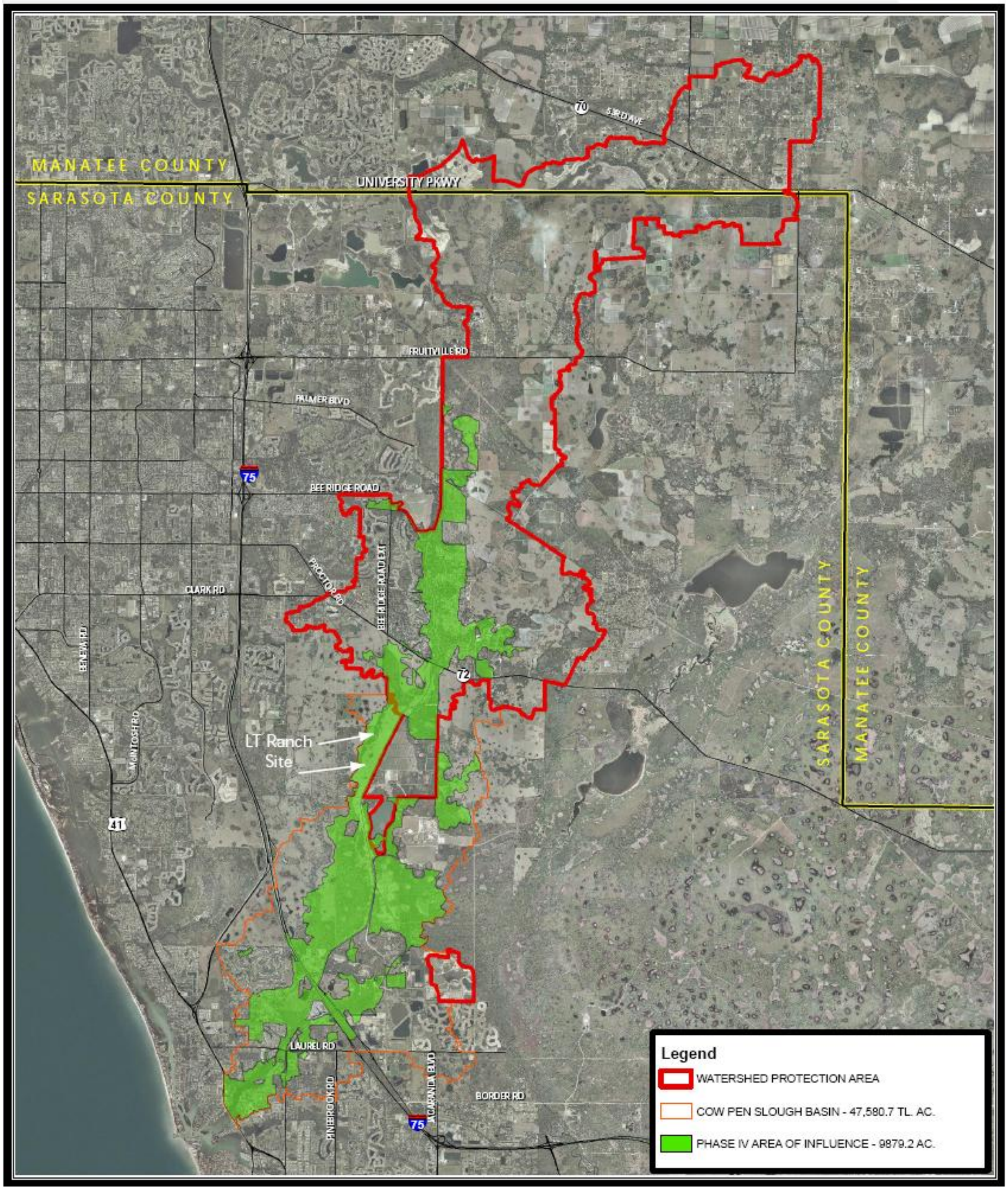


Figure 4 – LT Ranch Site, Potential Benefit Area

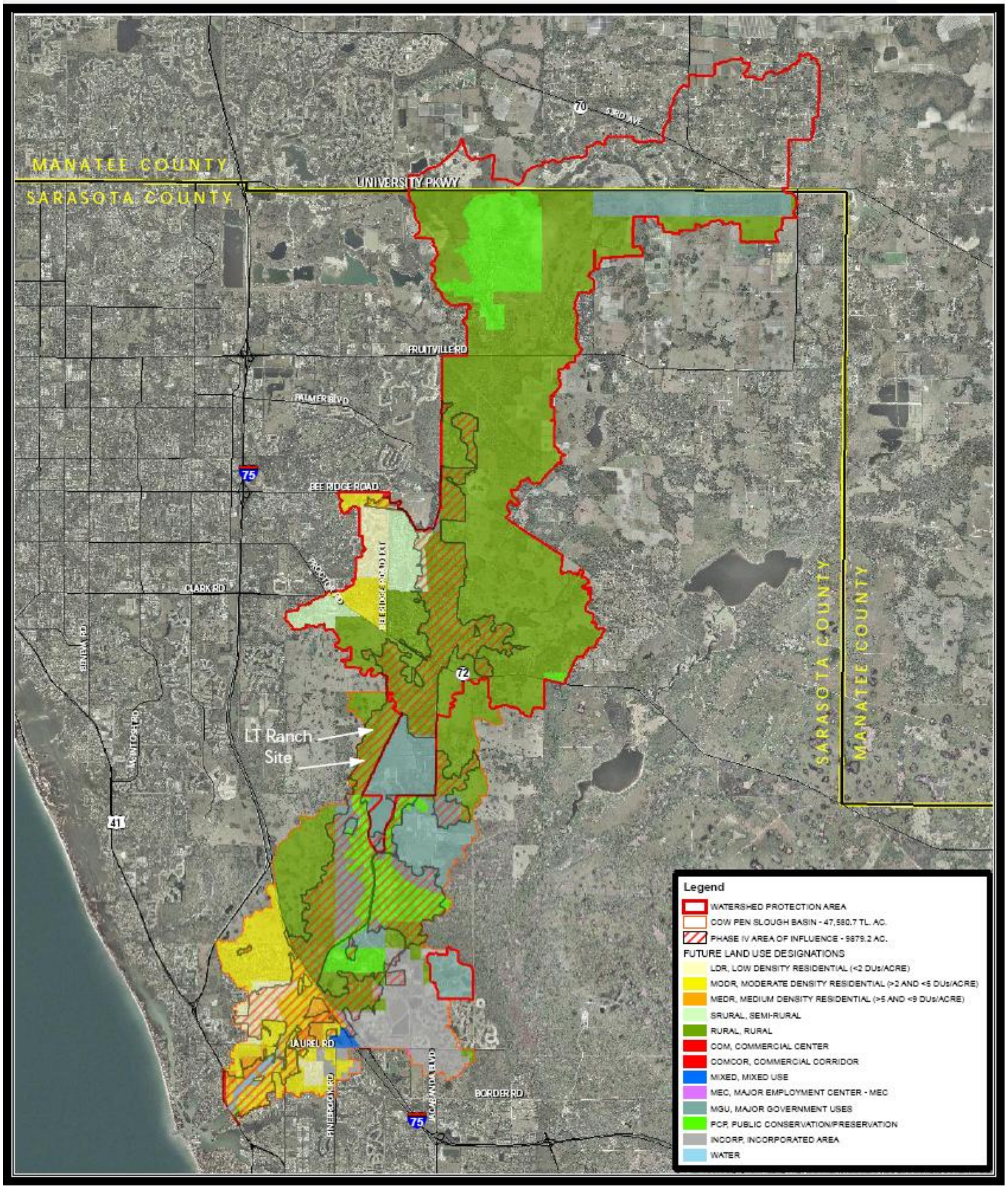


Figure 5 – LT Ranch Site, Potential Benefit Area with Future Land Use Map

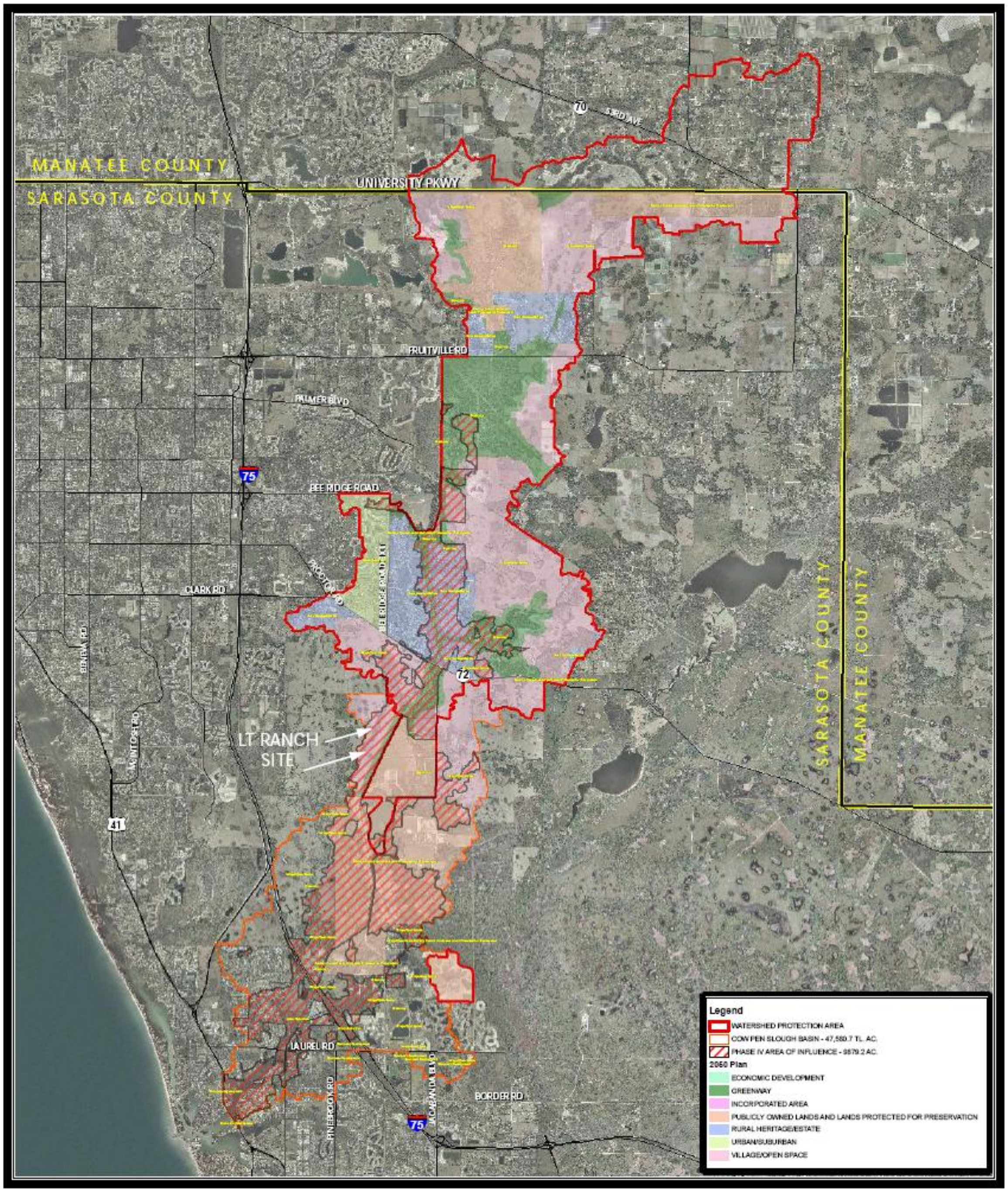


Figure 6 – LT Ranch Site, Potential Benefit Area with 2050 Overlay

2.4 Hi-Hat Old Grove Site

The Hi-Hat Old Grove site is currently part of the Hit-Hat Ranch and is under private ownership as an existing citrus operation. It is located in a historical flow way area and the current 100-year floodplain. It is strategically located from a water storage perspective and provides an opportunity for a regional stormwater facility. Since it is located entirely on private property, its use as a regional stormwater facility would need to be coordinated with, and advocated by the Hi-Hat Ranch. It could function to provide both regional stormwater treatment and flood attenuation for future upstream development. It is noted that conversion of this site to a wetland marsh type of regional stormwater facility could be eligible for funding assistance through the Natural Resources Conservation Service's (NRCS) Wetland Reserve Program. As a marsh area, this site could also potentially provide pre-treatment of surface waters prior to diversion into the downstream Cow Pen canal and the Albritton reservoir. For the purpose of this evaluation, the potential benefit area of Old Grove site was considered independently, assuming the Phase configuration 3 of the Dona Bay watershed plan as presented in Technical Memorandum 4.2.7.

2.4.1 Model Set-Up

The model set-up for the Old Grove site essentially aggregated several subbasins and nodes located in the vicinity of the current citrus operation into a single subbasin and storage node, respectively. It was assumed that the entire area was excavated to be a permanent pool stormwater lake. Further, it was assumed that the inoperable water level control structure located downstream of the Old Grove site was restored/reconstructed to serve as the control structure for the subject Old Grove site and that the main overflow gates to the downstream canal were set at elevation 23.0 ft. NGVD. Therefore, 23.0 ft. would be the control water level of the Old Grove site. A complete set of templates worksheets for model additions, deletions and modifications as needed to reflect this evaluation were provided to the Sarasota County Stormwater Division under a separate cover.

2.4.2 Model Results

The simulation results for the Old Grove are summarized in Appendix B. Based upon this simulation, the subbasin areas that will experience reductions in flood stages are extensive and are shaded in green on **Figure 7**. This potential "benefit" area encompasses approximately 11,000 acres and represents a total floodwater volume reduction equivalent to approximately 4,345 acre-feet of floodplain storage.

Figure 8 presents an overlay of the potential benefit area (cross-hatched) and the future land use map. Based upon this overlay, approximately 6,580 acres of designated rural lands, located entirely north of I-75 would be included in the potential benefit area. However, much of this rural designated land is currently already developed as low density residential subdivisions or situated in areas which are susceptible to flooding (including the LT Ranch site and subject Hi-Hat Old Grove site). This rural designation would allow residential densities of either 1 unit per 5 acres or 1 unit per 10 acres. At these low densities, adequate open space should be available on each lot to minimize floodplain encroachment. And in the event that the low densities are clustered under the conservation subdivision option, it is likely that adequate open space, corresponding to existing floodplain areas would be set aside to minimize floodplain encroachment. Therefore, the market for floodplain compensation for rural designated land uses is expected to be limited.

It is also noted that approximately 950 acres of designated moderate density residential lands, located south of I-75 would be included in the potential benefit area. However since most of the moderate density residential area included in the potential benefit area is already developed or included in the recent Fox Creek public acquisition site, the market for floodplain compensation may be limited for this area

Figure 9 presents an overlay of the potential benefit area (cross-hatched) and the 2050 overlay. Based upon this overlay, much of the potential benefit area occurs in proposed greenway and existing, rural heritage resource management areas. Only 1,731 acres of designated village and open space resource management areas are encompassed in the potential benefit area. Since 50% of the village and open space resource management area is required to be in open space, it is anticipated that much of the potential benefit areas will be included within the open space. Additionally, much of this potential benefit area is situated in the areas susceptible to flooding (including the LT Ranch site and subject Hi-Hat Old Grove site).

Although there may not be a significant market for floodplain storage, the Hi-Hat Old Grove site could still serve as a regional stormwater facility as part of a future upstream village. Under this scenario, it would be developed as a regional stormwater facility in association with a privately initiated development proposal. Since this is a desirable form for managing stormwater and can provide incidental benefits in the watershed, this should be supported by Sarasota County through possible federal and/or state grant programs or through stormwater utility assessment credits.

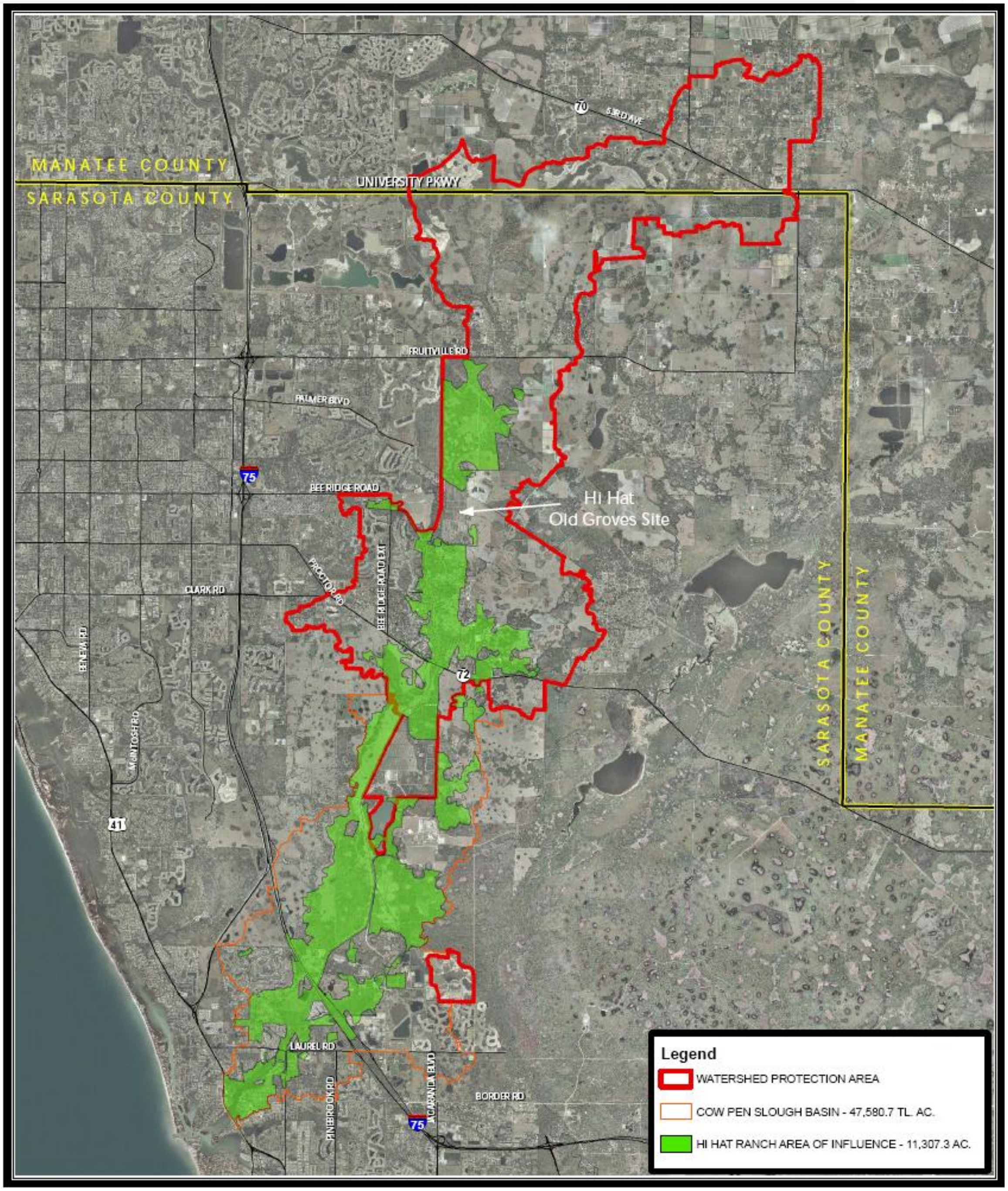


Figure 7 – Hi-Hat Old Grove Site, Potential Benefit Area

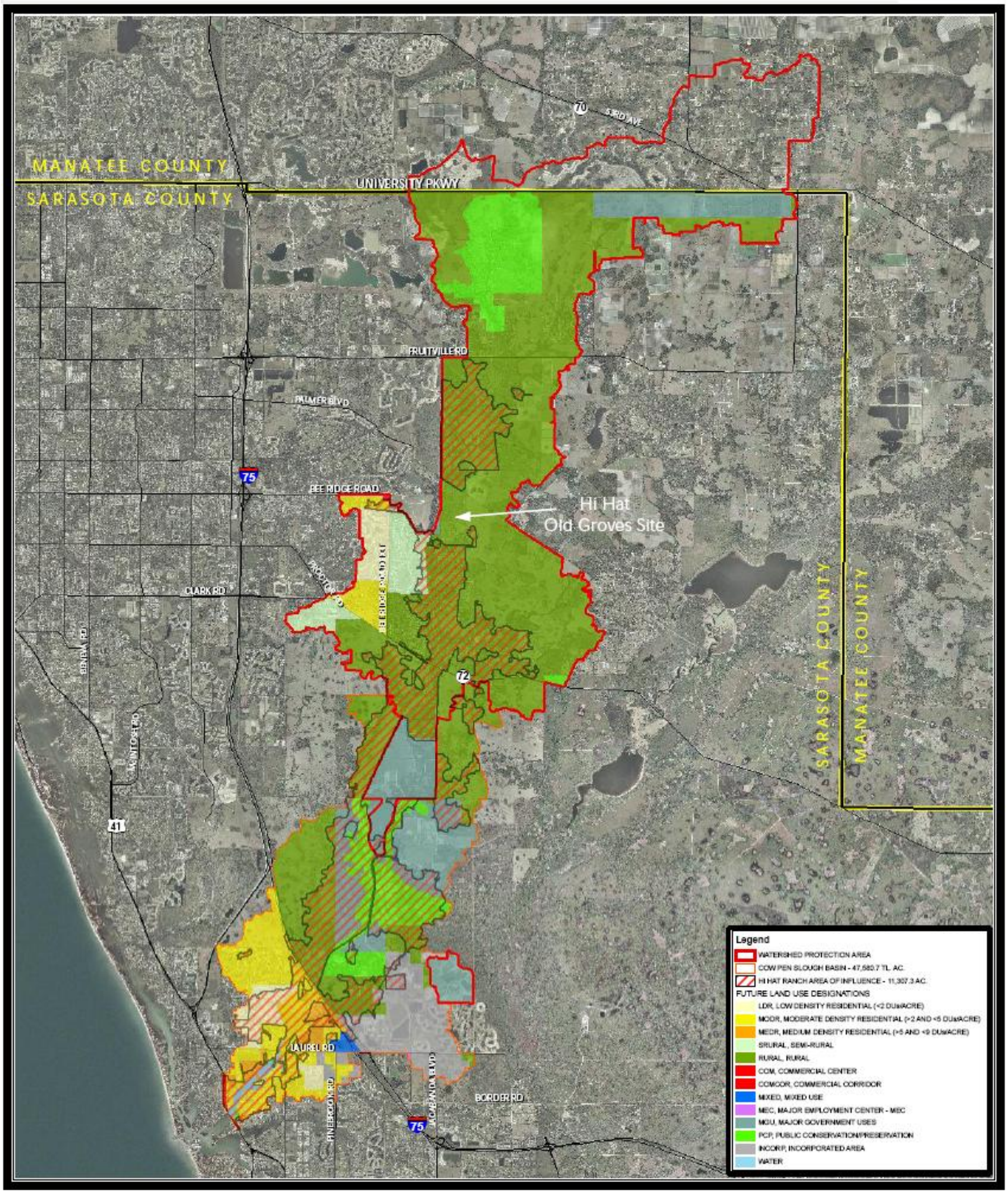


Figure 8 – Hi-Hat Old Grove Site, Potential Benefit Area with Future Land Use Map

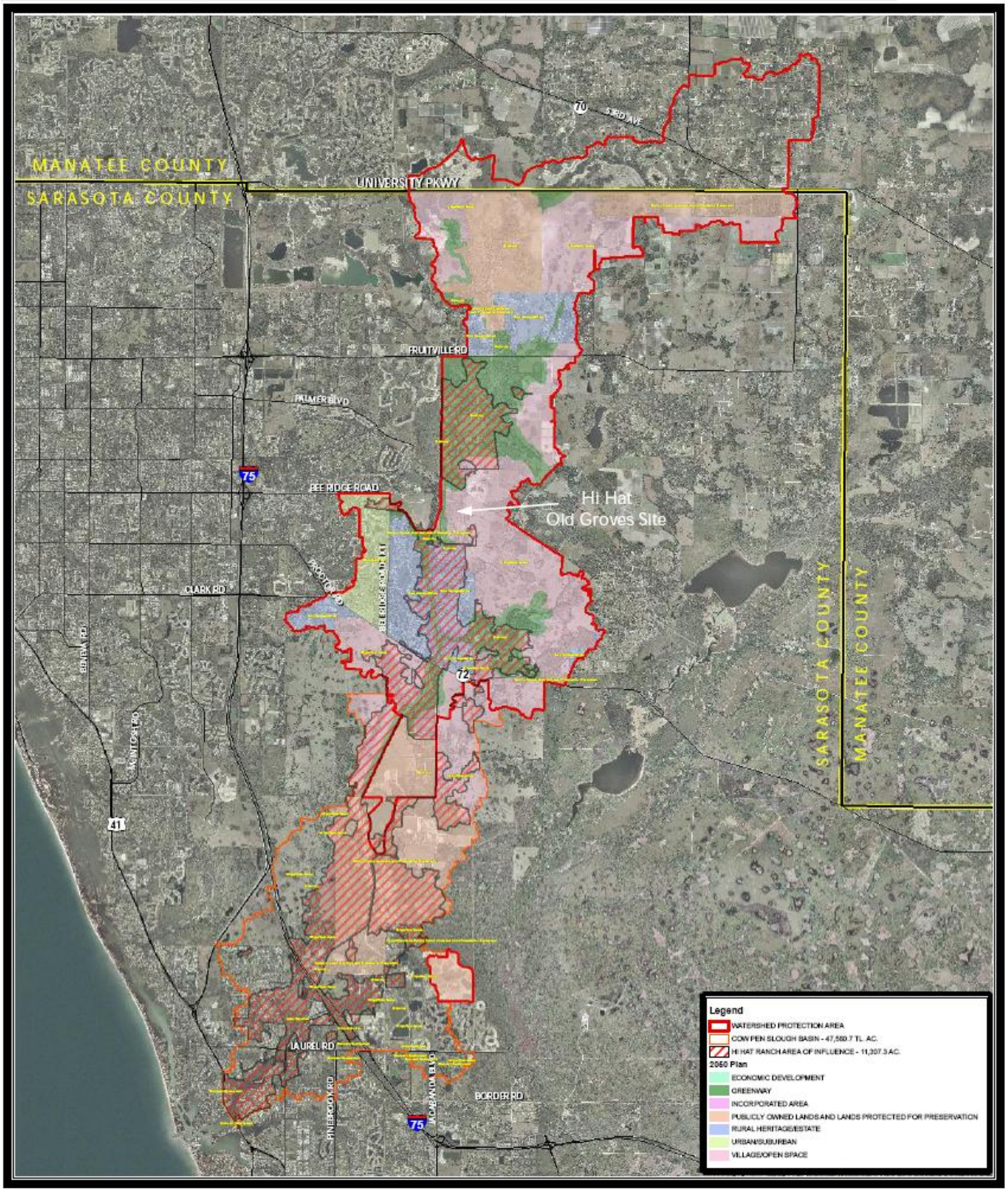


Figure 9 – Hi-Hat Old Grove Site, Potential Benefit Area with 2050 Overlay

3.0 CONCLUSIONS

Of the four sites considered as regional stormwater facilities, including the Albritton site, the Venice Minerals site, the LT Ranch site, and the Hi-Hat Old Grove site, the Venice Minerals site was not evaluated since its proposes an operating range for water supply that would preclude it from additional storage uses. All three of the remaining sites evaluated would independently be effective in reducing flood stages throughout the Dona Bay watershed. **Table 1** provides a summary of the 3 potential regional stormwater facilities evaluated.

Regional Stormwater Site	Area (acres)	Volume Reduction (acre-feet)	Benefit Area (acres)	Rural (acres)	Moderate Density (acres)	2050 Village (acres)
Albritton	±580	1,179	10,500	5,800	970	1,614
LT Ranch	±350	819	9,500	5,100	950	1,540
Old Grove	±415	4,345	11,000	6,580	950	1,731

Table 1 – Summary of Regional Stormwater Facilities in the Dona Bay Watershed

The Hi-Hat Old Grove site appears to have the greatest potential in terms of floodplain reduction (and the increase in the volume of floodplain storage). However, under both the existing future land use map and the 2050 overlay, the market for such regional stormwater appears limited. In addition, the flood reduction benefits "gained" by the Albritton site in large part reflects the removal of the levee and pumps constructed in association with the previous citrus operation. This "gained" benefit will also be "lost" under the phase 3 configuration proposed for watershed restoration and alternative water supply development.

The LT Ranch and Hi-Hat Old Grove sites may still effectively serve as regional stormwater facilities in association with privately initiated village development proposals. Since this is a desirable form for managing stormwater and can provide incidental benefits in the watershed, this should be supported by Sarasota County through possible federal and/or state grant programs or through stormwater utility assessment credits. In the case of the LT Ranch site, it may also be advantageous to consider public acquisition and incorporation into the Albritton reservoir for addition hydrologic/watershed restoration and alternative water supply.

It is recommended that private property owners for the LT Ranch site and the Hi-Hat Old Grove site be contacted and made aware of the potential benefits of these two sites. Sarasota County should advocate the development of these facilities as regional stormwater facilities.

TM 4.4.4 – DEVELOPMENT OF SCS SOIL CONSERVATION PLAN OVERLAY FOR PINELANDS AREA

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and SWFWMD is currently completing the pre-requisite data collection and analysis and comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marine Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the Southwest Florida Water Management District (SWFWMD), to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor National Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and SCG's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

a. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
b. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
c. Protect existing and future property owners from flood damage.
d. Protect existing water quality.
e. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum (TM) has been prepared by KHA to present completed work for the mapping of the historical SCS drainage plan for portions of the Pinelands Reserve area east of the Cow Pen Slough canal, consistent with Task 4.4.4 of the DBWMP contract.

2.0 OVERVIEW AND PURPOSE

In 1959, the United States Department of Agriculture, Soil Conservation Service (SCS), prepared a soil conservation plan including a drainage plan for cooperator, C. H. Downs. This property has since been purchased by Sarasota County in part for the Central County Solid Waste Facility and is currently referred to as the Pinelands Reserve. In recent years, adjacent land owners have expressed concerns about potential impacts to drainage patterns. To better evaluate these concerns, the 1959 SCS drainage plan was digitized and superimposed over a current aerial map.

3.0 PROCEDURE

For this effort, a scanned copy of the 1959 aerial SCS drainage plan was provided by SCG. **Figure 3.1** presents the scanned image. The image was used to identify original drainage that had occurred upon and in the vicinity of the Pinelands site. The ditching identified was mostly between otherwise isolated wetlands that were ultimately connected to either the historical Cow Pen Slough system or the"Old Cow Pen Slough" canal. The ditch segments were digitized or traced using current computer technology referencing flow direction. Horizontal locations were coordinated with the current mapping coordinate system. Once completed, the mapping effort was converted into a GIS layer which enables it to be superimposed over current aerial images.

Figure 3.1 – 1959 SCS Aerial and Soil Conservation Plan
(Old Cowpen Slough Highlighted)

4.0 GIS OVERLAY COMPARISON

Once created, the GIS layer was superposed over a recent, 2006 aerial image. The recent image identifies the existing footprint of facilities constructed with the Central County Solid Waste Facility. The overlay was reviewed to identify locations were flow patterns based upon the SCS plan may be impacted from installation of subsequent facilities. **Figure 4.1** presents the overlay of the SCS flow patterns (in blue) and identifies areas that should be investigated where subsequent activities may have impeded these flow patterns (in orange). A digital GIS map has also been provided to SCG.

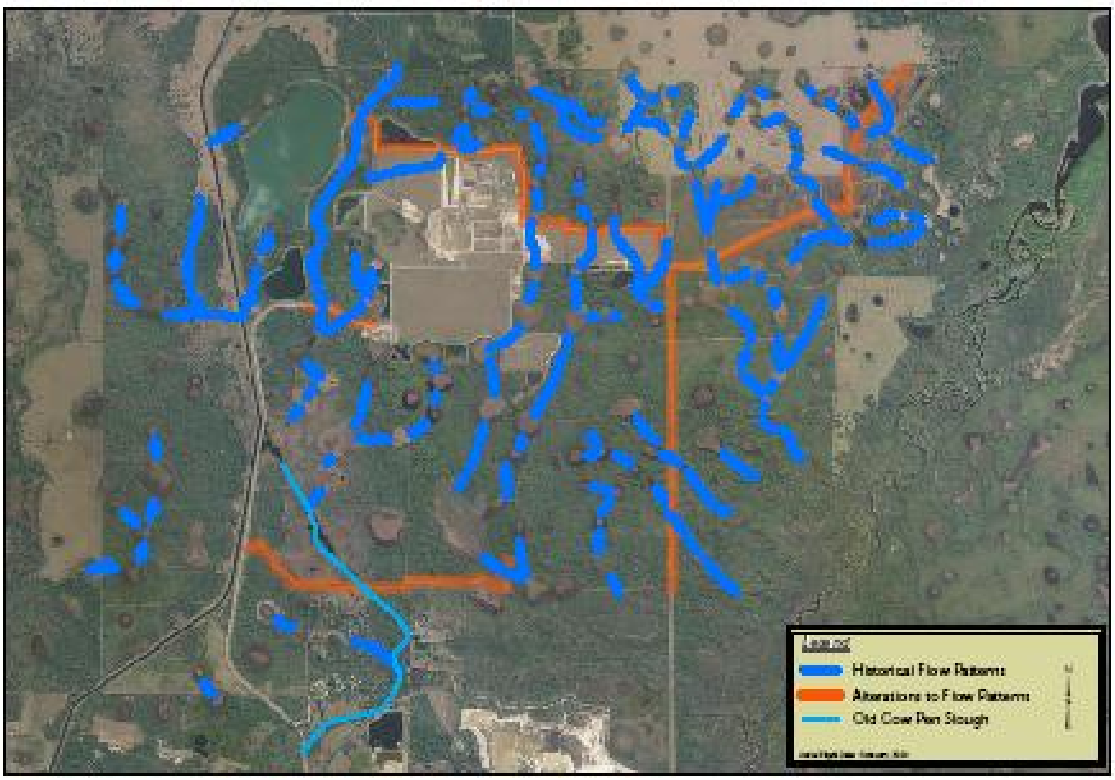


Figure 4.1- Historical SCS Drainage Plan and Identified Alterations

TM 4.4.5 – ALTERNATIVE IMPACT ANALYSIS

1.0 BACKGROUND

Sarasota County, in cooperation with the Peace River Manasota Regional Water Supply Authority and the Southwest Florida Water Management District (SWFWMD), is currently completing the necessary, pre-requisite data collection and analysis as well as comprehensive watershed management plan for the Dona Bay Watershed. Kimley-Horn and Associates, Inc. (KHA), PBS&J, Biological Research Associates (BRA), Earth Balance, and Mote Marin Laboratory have been contracted by Sarasota County Government (SCG), with funding assistance from the SWFWMD, to prepare the Dona Bay Watershed Management Plan (DBWMP).

This regional initiative promotes and furthers the implementation of the Charlotte Harbor national Estuary Program (NEP) Comprehensive Conservation Management Plan, SWFWMD's Southern Coastal Watershed Comprehensive Watershed Management Plan; and Sarasota County's Comprehensive Plan. Specifically, this initiative is to plan, design, and implement a comprehensive watershed management plan for the Dona Bay watershed that will address the following general objectives:

1. Provide a more natural freshwater/saltwater regime in the tidal portions of Dona Bay.
2. Provide a more natural freshwater flow regime pattern for the Dona Bay watershed.
3. Protect existing and future property owners from flood damage.
4. Protect existing water quality.
5. Develop potential alternative surface water supply options that are consistent with, and support other plan objectives.

This Technical Memorandum (TM) has been prepared by KHA to address Task 4.4.5 of the DBWMP contract. Specifically, the various program phase configurations presented in Technical Memorandum 4.2.7 were evaluated using the Sarasota County watershed model for Dona Bay to determine their impact on flood stages throughout the watershed. Tables comparing the proposed flood stages to existing flood stages at each node and for each phase configuration are provided in the Appendices at the end of this Technical Memorandum. Based upon the impact analyses, no additional level of service deficiencies will be created by any of the proposed phase configurations when compared to current conditions. In fact, the model simulations indicate that phase configurations will have an overall benefit on off-site flood stages throughout the watershed.

2.0 DESCRIPTION OF DONA BAY MODEL INPUT MODIFICATIONS

Model simulations corresponding to each of the phase configurations were performed to evaluate their potential impact on existing 100-year flood stages in the Dona Bay watershed. This section briefly describes each phase configuration and inventories the specific adjustments made to the input for the watershed model. In addition to the three phase configurations, it was also necessary to first update the existing conditions model to more accurately reflect the Albritton site and surrounding area. A hydraulic evaluation was also performed to assess the installation of a low head weir in the Blackburn Canal, in the vicinity of Jackson Road.

2.1 Revised Existing Conditions

- Created two baseline models. The first to simulate the system flowing with the gates for both water level control structures (095000 and 091198) open. The second with the upper water level control structure (095000) gates closed and the lower water level control structure (091198) gate open.
- In addition to the gates being closed in the "gates closed model", initial stages were also raised for the purpose of balancing adjacent sub-basin nodes to correct for the new initial stage.
- The area to the north of the project was redefined to match existing conditions on the SWFWMD 1.0 foot topographic maps.
- Modified both the subbasins and nodes for both 093204 and 095005
- All further modification will be preformed with the second "gates closed model" as the base.
- A complete set of templates worksheets for model additions, deletions and modifications as needed to reflect this evaluation were provided to the Sarasota County Stormwater Division under a separate cover.

2.2 Phase Configuration 1

Phase configuration 1 includes the diversion of the water in the Cow Pen Canal at the upper water level control structure into and through the Albritton site. At the south end of the Albritton site, water would flow through the existing Pinelands borrow pits and through a proposed underground pipe to the Venice Minerals site. However, when stages in the Pinelands borrow pits and the Venice Minerals reservoir reach elevation 18 ft., the connection from the Albritton site would be "closed". Therefore, this analysis considers the impact to flood stages for the 100-year design storm assuming that initial water levels in the Albritton site are at elevation 18 ft. and that water cannot overflow to the Pinelands pits or the Venice Minerals. A complete set of templates worksheets for model additions, deletions and modifications as needed to reflect this evaluation were provided to the Sarasota County Stormwater Division under a separate cover.

- Install a side gate system to the Albriton site similar to those for the main "on-line" gates.
- Modified subbasins areas and parameters as well as storage for node 095005.
- Assumed a berm at elevation 23 ft. as necessary to assure flood levels within the Albritton property are contained within the area owned by the County.
- The southeast corner of the property was assumed to be a marsh as assumed in Alternative 3 of Technical Memorandum 4.2.4.2. This was done to address potential increases to off-site flood stages to the east on the Hawkins Ranch.

- Added the created marsh area in the southeast portion of the Albritton site to node 093513 with weir 093202W1.
- Modified the node storage and subbasin areas for 093200 (Albritton site) and 093202 (southeast Marsh).
- Deleted Node and Subbasin 093204.
- Created two smaller subbasins just to the south of the property referred to as 093200W and 093200E.
- Added a weir to connect both of the subbasins to the south.
- Installed 4 weirs [093200W (3)] and [093200OT (1)] from the canal into the reservoir allowing for floodwaters from the canal to be diverted into Albrittons (node 093200). Three weirs were set with their inverts at elevation 12.5, with gate heights and spans of 4.0 feet and 12.0 feet, respectively. The overtopping weir, 093200OT was set at 16.50 feet with a span of 36.0 feet and an infinite rise.

2.3 Phase Configuration 2

Phase configuration 2 is the same as that for phase configuration 1 but assumes that the Albritton site is excavated as a surface water lake/reservoir consistent with Alternative 3 of Technical Memorandum 4.2.4.2. As in the phase 1 configuration analysis, this analysis considers the impact to flood stages for the 100-year design storm assuming that initial water levels in the Albritton site are at elevation 18 ft. and that water cannot overflow to the Pinelands pits or the Venice Minerals. A complete set of templates worksheets for model additions, deletions and modifications as needed to reflect this evaluation were provided to the Sarasota County Stormwater Division under a separate cover.

- Increased the storage for node 093200 to reflect the excavation of the Albriton site.
- Raised perimeter berm around Albritton (node 093200) to elevation 38 ft..

2.4 Phase Configuration 3

Phase configuration 3 is the same as that for phase configuration 2 but assumes that the Albritton site is not available to provide flood storage since under this phase configuration it would be used exclusively for water supply. Therefore, the side gates to the Cow Pen Canal would be closed and flood waters could not enter the Albritton site. Hydraulically, this phase configuration is very similar to current conditions with respect to the Albritton site. A complete set of templates worksheets for model additions, deletions and modifications as needed to reflect this evaluation were provided to the Sarasota County Stormwater Division under a separate cover.

- The side gate weirs from the Cow Pen Canal to the Albritton site added in the phase 1 configuration were turned off.

- The initial stage in the Albritton site was initiated at elevation 28.0 ft. but considered as a closed basin.
- Both side gates added in the phase 1 configuration at upper water level control structure to node 093200 were shut "off", not allowing flood waters from the Cow Pen Canal to enter the Albritton site.
- The initial stage in the Albritton site was modified to elevation of 28ft.
- Please see Appendix E for addition/deletion/modification templates.

The DBF Comparator was utilized to compare each sequential phase to the previous phase (or the revised existing conditions) to verify that the modifications to the model had been made accurately.

3.0 RESULTS OF DONA BAY MODEL SIMULATIONS

3.1 Phase 1 Configuration

The model simulation results for the phase 1 configuration are provided in Appendix B and indicate substantial reductions in flood stages throughout the watershed. **Figure 1** provides a graphical representation of the results with areas of flood stages increases in pink (under 0.10 ft.) or red (over 0.10 ft.) and areas of flood decreases in dark green. Areas in light green represent areas with no change in 100-year flood stages.

Based upon the model simulation for the phase 1 configuration, 100-year flood stages in the Albritton site (represented by node 093200) increase 3.60 feet. Based upon model simulation for the phase 1 configuration, allowing flood waters to re-enter the Albritton site resulted in significant reductions in flood stages throughout the watershed. In addition, the created marsh in the southeast portion of the Albritton site will be effective in accommodating off-site drainage from the Hawkins Ranch property.

However, due to the closure of the upper water level control structure gates, the model simulation for the phase 1 configuration indicates some limited, minor rises directly upstream of the structure at node 095001 (0.017 ft. increase), node 095004 (0.006 ft. increase), 095002 (0.018 ft. increase), and node 091380 (0.015 ft. increase). It is anticipated that these increases could be mitigated by slightly opening the gates on the upper water level control structure. The model simulation for the phase 1 configuration also indicates an increase at node 091556 (0.006 ft. increase). This is not considered an adverse increase and can be addressed during final design. The only other increase worth noting is node 094160 (0.073 ft. increase). This increase seems to be an anomaly since all other nodes in this area either decrease or do not change. The 0.073 foot rise is not considered to be an adverse increase and if need be can likely be addressed during final design.

3.2 Phase 2 Configuration

The model simulation results for the phase 2 configuration are provided in Appendix C and indicate substantial reductions in flood stages throughout the watershed. **Figure 2** provides a graphical representation of the results with areas of flood stages increases in pink (under 0.10 ft.) or red (over 0.10 ft.) and areas of flood decreases in dark green. Areas in light green represent areas with no change in 100-year flood stages.

The model simulation for the phase 2 configuration does indicate a few minor increases in flood stages consistent with those from the phase 1 configuration simulation. Two additional nodes increases occur upstream of the upper water level control structure. Based upon the model simulation for the phase 2 configuration, nodes 095006 and 095008 indicate rises of 0.012 feet and 0.007 feet, respectively.

3.3 Phase 3 Configuration

As previously indicated, the gates on the upper water level control structure were opened to elevation 14.0 ft. for the phase 3 configuration model configuration. This is consistent with the existing conditions model.

The model simulation results for the phase 3 configuration are provided in Appendix D and indicate substantial reductions in flood stages throughout the watershed. **Figure 3** provides a graphical representation of the results with areas of flood stages increases in pink (under 0.10 ft.) or red (over 0.10 ft.) and areas of flood decreases in dark green. Areas in light green represent areas with no change in 100-year flood stages.

The only basin that showed a rise different from the other two phases was basin 091553 south of the project area. This basin had a rise of 0.007 feet and therefore showed up in the comparison table as a potential problem. Any potential negative effect found in this exercise can be reduced upon final design.

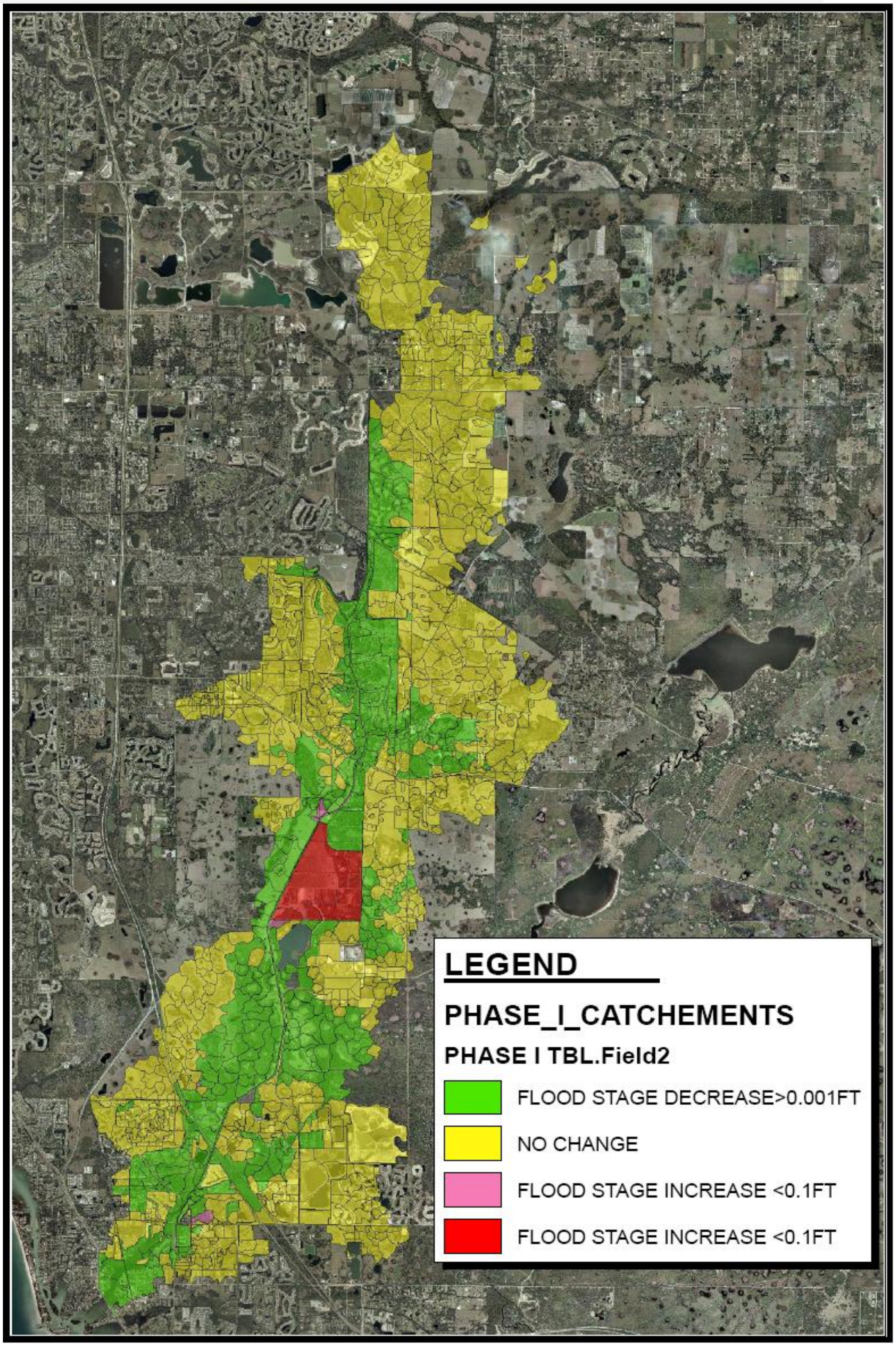


Figure 1 – Phase Configuration 1 Model Simulation Results

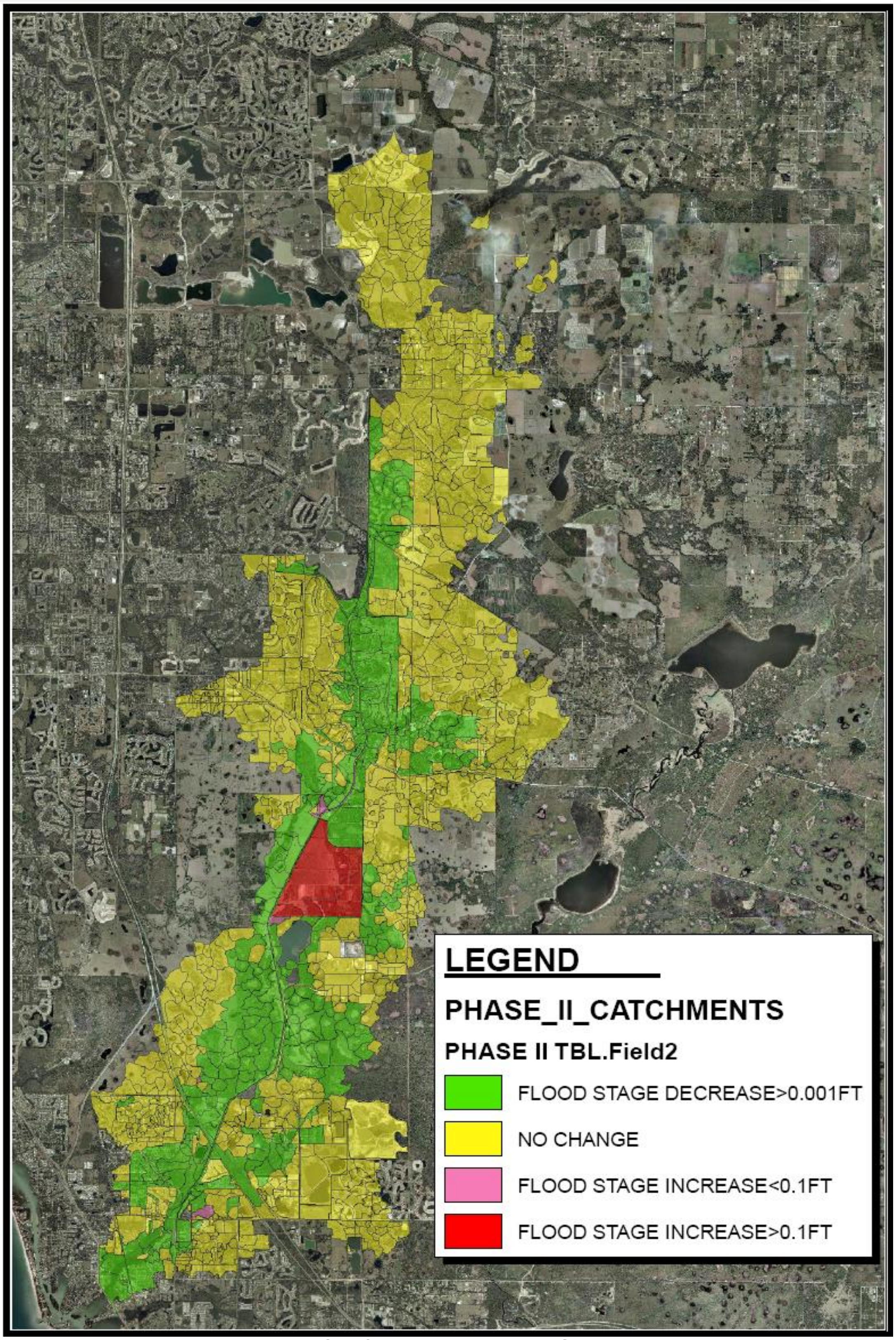


Figure 2 – Phase Configuration 2 Model Simulation Results

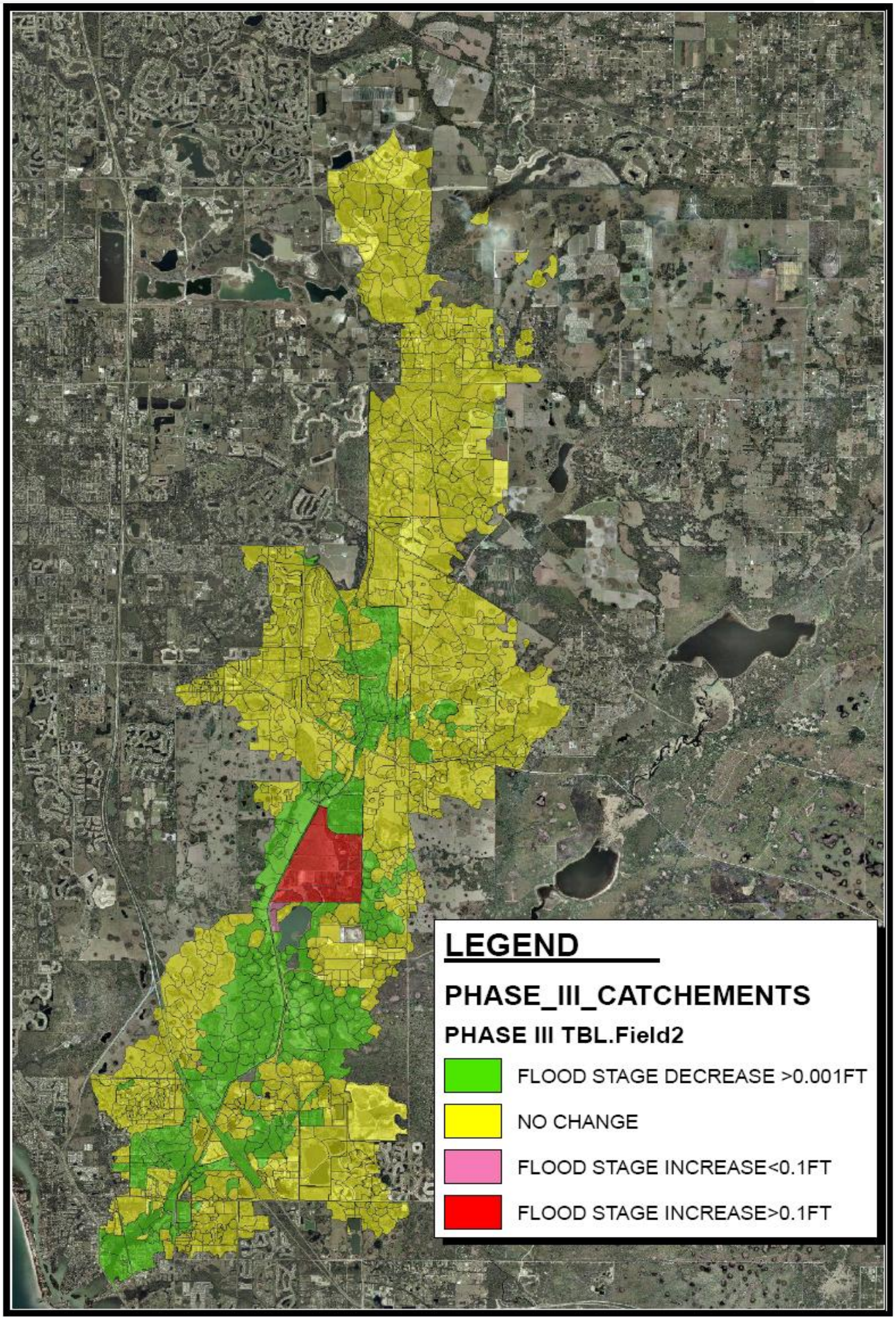


Figure 3 – Phase Configuration 3 Model Simulation Results

4.0 BLACKBURN CANAL WEIR EVALUATION

Technical Memorandum 4.4.2 included an evaluation of the potential reductions on excess freshwater flows diverted from the Myakka River to Roberts Bay by the Blackburn Canal. This previous evaluation considered freshwater reductions associated with a low-head weir placed in the Blackburn Canal, just east of Jackson Road. Weir elevations evaluated were 2.0 ft., 2.5 ft., and 3.0 ft. NGVD. Based upon recent stage-discharge information collected by the USGS between March 6, 2004 and August 29, 2005, these three trial weir elevations correspond to discharge rates of 38 cfs, 68.5 cfs, and 96 cfs, respectively.

The purpose of this evaluation is to determine the impact on flood levels in the Myakka River, if a low-head weir is constructed in Blackburn Canal. To perform this evaluation the flood parameters determined by the USGS in their 1977 report entitled *Magnitude and Frequency of Flooding on the Myakka River, Southwest Florida* were utilized. These key parameters are provided in **Table 1** below:

Flood Frequency	Flow at Jackson Road in Blackburn Canal	Stage at Jackson Road in Blackburn Canal	Stage Downstream of Myakka Confluence in Blackburn Canal
2-year	86 cfs	4.1	4.5
5-year	270 cfs	7.2	7.7
10-year	361 cfs	8.2	8.7
25-year	494 cfs	9.2	9.7
50-year	609 cfs	9.7	10.2
100-year	735 cfs	10.7	11.2

Table 1 – Flood Parameters in the Vicinity of Jackson Road and Blackburn Canal

To evaluate the impact of a low-head weir on upstream flood stages, a worst case scenario was initially considered. This worst case scenario considered a low-head weir elevation of 3.0 ft., with varying weir widths of 50 ft., 100 ft., 150 ft., and 200 ft. Since the 2-year flood elevation in the vicinity of the proposed weir is elevation 4.1 ft., the weir would be submerged for all flood events. Therefore to determine the flow capacity of the low-head weir, the following equation would apply:

Q(submerged) = Q (free flow) x ((1-((h-downstream)/(h-upstream))^(3/2))^0.385

Table 2 presents the results of the analyses and indicates that for all flood events and weir lengths, adequate capacity exists in the Blackburn Canal to accommodate the existing discharge rates without impacting flood levels in the Myakka River. In addition, because the weir would be submerged during flood conditions, velocities across the weir are estimated to be less than 2 feet per second. If a low-head weir is pursued to restore freshwater flows in the Myakka River, more detailed modeling/analyses can be performed.

Freq	Q – exist	TW	L	HW	H/Y	C1	Q – free	Q - sub
2	86	4.1	50	4.5	0.50	0.646575	318	217
5	270	7.2	50	7.7	1.57	0.731811	1995	974
10	361	8.2	50	8.7	1.90	0.758789	2762	1254
25	494	9.2	50	9.7	2.23	0.785803	3645	1557
50	609	9.7	50	10.2	2.40	0.799319	4131	1718
100	735	10.7	50	11.2	2.73	0.826364	5191	2054
Freq	Q – exist	TW	L	HW	H/Y	C1	Q – free	Q - sub
2	86	4.1	100	4.5	0.50	0.646575	635	434
5	270	7.2	100	7.7	1.57	0.731811	3989	1947
10	361	8.2	100	8.7	1.90	0.758789	5524	2508
25	494	9.2	100	9.7	2.23	0.785803	7291	3115
50	609	9.7	100	10.2	2.40	0.799319	8262	3435
100	735	10.7	100	11.2	2.73	0.826364	10381	4109
Freq	Q – exist	TW	L	HW	H/Y	C1	Q - free	Q - sub
2	86	4.1	150	4.5	0.50	0.646575	953	651
5	270	7.2	150	7.7	1.57	0.731811	5984	2921
10	361	8.2	150	8.7	1.90	0.758789	8287	3763
25	494	9.2	150	9.7	2.23	0.785803	10936	4672
50	609	9.7	150	10.2	2.40	0.799319	12393	5153
100	735	10.7	150	11.2	2.73	0.826364	15572	6163
Freq	Q – exist	TW	L	HW	H/Y	C1	Q - free	Q - sub
2	86	4.1	200	4.5	0.50	0.646575	1271	869
5	270	7.2	200	7.7	1.57	0.731811	7979	3895
10	361	8.2	200	8.7	1.90	0.758789	11049	5017
25	494	9.2	200	9.7	2.23	0.785803	14582	6230
50	609	9.7	200	10.2	2.40	0.799319	16523	6870
100	735	10.7	200	11.2	2.73	0.826364	20762	8218

Table 2 – Summary of Low-Head Weir Evaluation

Where: Freq. = flood frequency
Qexst = existing flood discharge
TW = existing flood stage in Blackburn Canal downstream of proposed weir
L = assumed weir length
HW = existing flood stage in Blackburn Canal upstream of proposed weir and downstream of confluence with the Myakka River
H/Y = HW – Weir Invert (= 3.0) / Weir Height (assumed at 3 feet)

C1 = ((0.6035+(0.0813*(H/Y))+(0.000295/3))*((1+(0.00361/(HW-3)))^1.5))

Qfree = ((2/3)*C1*L)*((2*g)^0.5)*((HW-3)^1.5)

Qsub = (Qfree*(1-(((TW-3)/(HW7-3))^1.5))^0.385)

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