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# ST. LUCIE AND INDIAN RIVER COUNTIES WATER RESOURCES STUDY

## FINAL SUMMARY REPORT

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

# St. Lucie and Indian River Counties Water Resources Study

**Final Summary Report**

**November 2009**


**Prepared for:**

**South Florida Water Management District**

**St. Johns River Water Management District**

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# St Lucie and Indian River Counties Water Resources Study

# Executive Summary

## Study Purpose

The purpose of this study was to evaluate the potential for capturing excess water that is currently being discharged to the Indian River Lagoon in northern St. Lucie County and southern Indian River County and making it available for beneficial uses. The study also evaluated the reconnection of the C-25 Basin in the South Florida Water Management District (SFWMD) and C-52 in the St. Johns River Water Management District (SJRWMD) so that available water supplies could be conveyed to meet demands across jurisdictional boundaries. The study objectives were to:

- Identify the quantity and timing of water available for diversion and storage;
- Identify water quality information needed to size water quality improvement facilities;
- Identify and provide cost estimates for the improvements and modifications to the existing conveyance systems necessary for excess runoff diversion and storage;
- Identify, develop cost estimates, and evaluate conceptual alternatives for storing excess runoff, and
- Provide conceptual designs and cost estimates for the highest ranked alternative in support of feasibility analysis and a future Basis of Design Report.

## Study Process

The study process consisted of the following activities:

- Data compilation and analysis,
- Identification of alternative plans,
- Evaluation of alternative plans,
- Identification of the preferred plan, and
- Development of an implementation strategy.

Formal stakeholder meetings were conducted throughout the study. Stakeholder input was also obtained through smaller informal meetings, site visits, phone calls.

**Data Compilation and Analysis**

Through a literature review, thirteen projects and studies that are related to the issues addressed in this study were identified and evaluated. Three of the projects were found to have substantial impacts on the assumptions used for this study. Key findings are summarized below:

- *The Indian River Lagoon – South (IRL-S) Project* is a component of the Comprehensive Everglades Restoration Plan (CERP). The plan includes storage reservoirs and stormwater treatment areas (STAs) in the C-23, C-24, and C-25 Basins designed to attenuate stormwater discharges that disrupt natural salinity regimes in the St. Lucie Estuary and Indian River Lagoon. Land acquisition has been completed and design is underway for the IRL-S Project features in the C-23 and C-24 Basins. For analysis of certain alternatives in this study, it was assumed that the C-23/24 North and South Reservoirs and STA included in the IRL-S Project will be in place. There has been no land acquisition or detailed design work initiated for the C-25 reservoir and STA component of the IRL-S Project.

- *The North Fork of the St. Lucie River Water Reservation* was required by the federal Water Resources Development Act (WRDA) of 2000 as a condition for signing an agreement to receive federal CERP funding for the Indian River Lagoon – South Project. The water reservation is a legal mechanism to set aside water for the protection of fish and wildlife or public health and safety. When a water reservation is in place, volumes and timing of water at specific locations are protected for the natural system ahead of consumptive uses such as new development. Water withdrawals evaluated for this study were limited to avoid violation of the water reservation.

- *The Upper St. Johns River Basin (USJRB) Project* is located in the northern portion of the study area. With the development of an inter-district hydraulic connection, flows from the SFWMD to the SJRWMD would have to pass through C-52 and Blue Cypress Water Management Area (BCWMA), components of the USJRB Project. A number of constraints on flows to and from the BCWMA are necessary to maintain flood control and protect natural resources, including listed species.

Drainage basins were delineated and the physical and operational characteristics of the water management systems in the study area were identified. The schematic shown in Figure 8 represents the four independent water management systems in the study area: Upper St. Johns River Basin Project, Indian River Farms Water Control District, Ft. Pierce Farms Water Control District, and the C-23, C-24, and

C-25 Basins. Except for the USJRB Project, all other water management systems discharge excess stormwater runoff to Indian River Lagoon.

Large volumes of water are discharged to the Indian River Lagoon from the study area. The median annual discharges to IRL from the C-23, C-24, and C-25 Basin are each about 130,000 acre-ft. The Indian River Farms Water Control District's Main, South, and North Canals collectively discharge a median annual volume of just over 100,000 acre-ft. These flows are relatively flashy – there are extended periods with little or no flow with short periods of very high flows.

The Florida Department of Environmental Protection has listed numerous water bodies in the study area as impaired under Section 303(d) of the Clean Water Act. This indicates that the water quality does not meet applicable standards. Impairments are based on the following parameters: dissolved oxygen, fecal coliforms, nutrients, and mercury.

The study guideline with respect to water quality was to avoid inter-basin transfers of water that would degrade the quality of the receiving water or cause a violation of a water quality standard. Total phosphorus was used to assess the need for water quality treatment to meet this guidline. The following table shows the median total phosphorus concentrations for the main water bodies in the study area:

| | **Median Total Phosphorus concentration (mg/l)** |
|---|---|
| Basin 1 (Ft. Pierce Farms Water Control District | 0.178 |
| C-23 | 0.338 |
| C-24 | 0.261 |
| C-25 | 0.158 |

Total phosphorus data for the Indian River Farms Water Control District was only available for 2006. For that period, total phosphorus concentrations ranged between 0.064 and 0.120 mg/l. The SJRWMD standard for total phosphorus concentrations in the Upper St. Johns River Basin Project is 0.080 mg/l. As a result, any discharges from the SFWMD northward into the Upper St. Johns River Basin Project would require treatment to avoid degradation.

**Identification of Alternative Plans**

Preliminary alternatives were identified through a series of meetings with stakeholders and individuals that are knowledgeable of the water resources issues in the study and input from the project team. The goal was to identify a large number of alternatives that represent a variety of concepts in terms of their scale and types of approaches. No attempt was made to evaluate the alternatives at this point – all alternatives were retained.

Preliminary alternatives fell into two categories: Inter-District transfer alternatives and other alternatives. The Inter-District transfer alternatives enable the exchange of water between SFWMD and SJRWMD. This concept could be applied at a number of scales with and without storage being included. The other alternatives are generally intended to impact more localized areas.

A total of 16 preliminary alternatives were identified and subjected to a screening process. Three of the preliminary alternatives were eliminated during the initial screening because they were being undertaken by others or did not directly address the objectives of this study. The remaining preliminary alternatives were then evaluated based on qualitative measures of cost, potential availability of water, and water quality. Cost was assessed in terms of the extent of new infrastructure that would be required for each alternative. Availability of water was based on the average annual discharge of water to IRL from the drainage area that would be included in each alternative. Water quality was assessed in terms of whether treatment would be required to prevent increases in total phosphorus concentrations of the receiving water body. It was assumed that since the IRL-S Project features in the C-23 and C-24 Basins include an STA, no additional treatment would be required to discharge water to the C-25 Basin.

Screening of the preliminary alternatives resulted in identification of the following four alternatives to be carried forward for more detailed evaluation.

- **C-25 Central Reservoir (ICS-01)** - This alternative would enable the capture and storage of excess flows from the western C-25 Basin and C-25 Extension Basin in a central above-ground storage reservoir with a pumped inflow. An inter-district connection would be established to enable discharges between SJRWMD and SFWMD. This connection would involve removal of an existing plug in the Turnpike Canal, construction of a water control structure, and construction of a pump station adjacent to S-253 to discharge water northward into the Upper St. Johns River Basin Project. A stormwater treatment area would be required to reduce total phosphorus concentrations to 0.080 mg/l for discharges from the C-25 Basin to the Upper St. Johns River Basin Project.

- **C-23, 24, and 25 Central Reservoir (ICS-02) -** This alternative would contain all of the components of the C-25 Central Reservoir Alternative in addition to canal improvements to the north/south section of C-25 from its junction with the east/west section of C-25 to G-81. The canal improvements would provide conveyance capacity to move water from the C-23/24 Basins up C-25 to the storage reservoir. It was assumed that the C-23 and C-24 reservoirs and STA components of the IRL-S Project will be in place. Only excess water that would be available when the IRL-S reservoirs and STA in the C-23 and C-24 Basins are in place would be available for storage in the reservoir. The water reservation for the North Fork of the St. Lucie River was maintained in this study.

- **C-25/Basin 1 Central Reservoir (ICSB-01)** - This alternative includes all the components of the C-25 Central Reservoir Alternative plus a connection with Basin 1 (Ft. Pierce Farms Water Control District). An existing canal would be improved from C-25 to the main Ft. Pierce Farms Water Control District canal. A water control structure would be constructed in the canal to control flows. This would allow excess water from Basin 1 to be discharged into the lower section of C-25 between S-99 and S-50. A pump station would be constructed to lift water from downstream to upstream of S-99. This would expand the available drainage area from which excess flows could be captured beyond what is included in the C-25 Central Reservoir Alternative.

- **Indian River Farms Water Control District Reservoir (IRFWCD-R)** - This alternative includes the addition of an above ground reservoir (***Figure 38***) with pumped inflow immediately west of the western IRFWCD boundary. Excess water from IRFWCD could be captured and stored in the reservoir. The borrow canal for the perimeter levee of the IRFWCD would be improved to convey excess water from a main lateral canal to the reservoir. A pump station would be required to pump water from the middle to the upper pool within the IRFWCD. Water stored in the reservoir could be discharged back to IRFWCD to provide supplemental water supply. Additionally, the reservoir could be connected to the west with the Upper St. Johns River Basin Project or to the St. Johns Improvement District main canal although this connection was not included in the alternative evaluated in this report.

In addition to the four alternatives described above, it was concluded that **Dispersed Storage/Water Farming** represents a potentially viable interim means of addressing the study objectives. In general, dispersed storage/water farming would consist of the provision of water management services by landowners for compensation by a public agency, presumably a water management district. The concept consists of shallow storage of water on private property using existing water management infrastructure with minimal or no additional capital improvements being required. Typically, existing agricultural pumps, drainage ditches, and levees/berms would be utilized by the land owner to store excess water during wet periods and release it to supplement regional water supply during dry periods.

**Alternative Plan Evaluation**

Three evaluation criteria were used to compare the final alternative plans.

- Discharge Delivery Rate: This is the water supply delivery discharge that an alternative plan can maintain with 90% reliability. In other words, an alternative will be capable of maintaining a constant discharge for water supply at the discharge delivery rate for 90% of the days in the period of analysis. The goal is to maximize this discharge rate.

- Reduction in flow to Indian River Lagoon (IRL): By capturing and storing canal flows for water supply, reductions in discharges to IRL will result. The goal is to maximize the reductions in flow to IRL.

- Present Value Life Cycle Cost: The present value of the total capital cost (including design, land acquisition, construction, and construction management) and operations and maintenance cost over a 60 year period of analysis with a 5.125% discount rate. While cost was not used as a constraint in this study, the goal was to provide the most cost effective alternative relative to the other alternatives.

In order to apply these evaluation criteria, it was necessary to develop additional conceptual designs for the final four alternatives. Algorithms were developed to estimate costs for reservoirs and STAs based acre-feet of storage and footprint area, respectively. The algorithms were developed utilizing Corps of Engineers' cost estimates of reservoirs and STAs for nearby projects included in the Comprehensive Everglades Restoration Plan.

An existing WaSh Model of the C-25 Basin was updated and calibrated to simulate flows for the 41-year period of record from 1965 through 2005. The WaSh Model was also used to estimate flows from Basin 1. Results from OPTI-6 simulations of the C-23 and C-24 Basins were used to estimate excess flows available for storage. These OPTI-6 results were developed by SFWMD as a part of the process for establishing a water reservation for the North Fork of the St. Lucie River. The results accounted for operations of the C-23/24 reservoirs and STA and the water reservation. Measured flows for the Indian River Farms Water Control District Canals were compiled.

Using the applicable daily flow time series for each alternative, the RESOPT Model and the cost estimating algorithm were utilized to optimize reservoir and inflow pump capacities for each alternative with the objective of maximizing the discharge delivery rate in a cost effective manner. Multiple RESOPT simulations were performed to estimate discharge delivery rates that could be achieved with various configurations of reservoir and pump capacities for each alternative. The cost estimating algorithms were applied to each configuration. The cost estimates were plotted against the discharge delivery rates for each configuration. This enabled identification of cost effective configurations and selection of optimum configurations for reservoirs and pump capacities. STAs were sized to reduce total phosphorus concentrations for the discharge delivery rate from 0.176 mg/l (the concentration in the C-25 Basin) to 0.080 mg/l (the target concentration for inflows to the Upper St. Johns River Basin Project).

The following table describes the reservoir, pump station, and STA configurations that were selected for the final four alternatives. For three alternatives, two configurations were selected.

| | Reservoir Area (acres) | Depth (ft) | Pump Capacity (cfs) | STA Area (acres) |
|---|---|---|---|---|
| ICS-01 (A) | 3,000 | 10 | 500 | 2,250 |
| ICS-01(B) | 2,000 | 10 | 300 | 1,675 |
| ICS-02(A) | 5,000 | 10 | 700 | 4,625 |
| ICS-02(B) | 3,000 | 10 | 500 | 3,500 |
| ICSB-01 | 3,000 | 10 | 400 | 2,700 |
| IRFWCD-R(A) | 2,000 | 10 | 500 | N/A |
| IRFWCD-R(B) | 1,000 | 10 | 500 | N/A |

Cost estimates were prepared for each of the alternatives. For reservoirs, pump stations, and STAs, the cost estimates were based on the algorithms derived from comparisons with nearby CERP Projects. The cost of other features such as canal improvements and water control structures were developed independently. The results of the alternative plan evaluation are summarized in the following table.

| Alternative Plan | Discharge Delivery Rate – 90% Reliability (cfs/mgd) | Flow Reductions to IRL (acre-ft/yr) | Present Value Life Cycle Costs |
|---|---|---|---|
| ICS-01(A) | 90/59 | 78,897 | $177,875,000 |
| ICS-01(B) | 67/44 | 58,563 | $127,342,000 |
| ICS-02(A) | 185/120 | 142,236 | $307,641,000 |
| ICS-02(B) | 140/91 | 113,139 | $210,919,000 |
| ICSB-01 | 108/70 | 84,462 | $192,359,000 |
| IRFWCD-R(A) | 63/41 | 44,295 | $98,239,000 |
| IRFWCD-R(B) | 53/34 | 40,214 | $61,656,000 |

### Selection of the Preferred Plan

In comparing the results of the alternative plan evaluation, it was necessary to apply weights to each of the evaluation criteria. Because providing a reliable source of water supply was the primary objective of the study, reductions in flows to the IRL was weighted half as important as discharge delivery rate and present value life cycle costs.

| Objective | Weighting Factor |
|---|---|
| Discharge delivery rate (90% reliability) | 40 |
| Reduction in IRL flows | 20 |
| Present Value life cycle costs | 40 |

These weighting factors were applied to the evaluation results and a score was computed for each alternative. The scores ranged from 0 (worst) to 1 (best). The following table shows the alternative scores.

| | **Score** |
|---|---|
| ICS-01 (A) | .485 |
| ICS-01(B) | .464 |
| ICS-02(A) | .617 |
| ICS-02(B) | .588 |
| ICSB-01 | .511 |
| IRFWCD-R(A) | .465 |
| IRFWCD-R(B) | .475 |

ICS-02(A), the C-23, 24, and 25 Central Reservoir Alternative, is the top ranked alternative and was therefore, selected as the preferred plan.

**Preferred Plan Design and Cost Estimate**

Once the preferred alternative was identified, conceptual level designs and cost estimates were developed. Designs were based on available data. Due to the conceptual nature of the study, no specific sites were identified for the project features. General descriptions of the designs are provided below.

- **Improvements to existing C-25 Canal –** Improvements would be required to a 3,500-foot long section of the C-25 canal in order to provide adequate capacity to convey water to and from the proposed reservoir. A pump station would be constructed at the G-81 structure to discharge water from the C-23 and 24 Basins northward to C-25. The pump would have a capacity of 260 cfs with a SCADA system consistent with SFWMD's existing system. The north/south 8,140-foot long segment of C-25 north of G-81 would also require a slight enlargement.

- **Inter-district Connection –** This component of the plan would enable the discharge of water between the SJRWMD and SFWMD. An existing plug in the Turnpike Canal where the private pump station was located would be removed. This would connect C-25 with Turnpike Canal, which flows under the Turnpike and terminates on the north side of the Turnpike. New right-of-way will be required to accommodate a new channel connection to C-52E. An existing private pump located on the south side of the Florida Turnpike will have to be removed and replaced immediately south of its current location. A vertical lift gate with telemetry would be constructed in the Turnpike Canal to control flows.

- **5,000 acre Reservoir –** A ten foot maximum storage depth was assumed based on the designs of nearby CERP reservoirs. In order to support a phased implementation, the reservoir would be constructed with two cells, a 3,000 acre (Cell 1) and a 2,000 acre (Cell 2). A preliminary wave run-up analysis indicated that Cell 1 perimeter levee should be a minimum of 24.8 ft above natural ground and the Cell 2 levee should be 24.0 ft above natural ground. Reservoir construction would include a single vertical lift gate (10 feet X 10 feet) with telemetry between the cells, and two-lift gates for each cell to serve as discharge structures. The reservoir would be filled using a 700 cfs pump station.
- **5,000 acre Stormwater Treatment Area -** The STA was sized to provide an outflow phosphorous concentration of 0.080 mg/l. The STA would require a 185 cfs inflow pump, between the supply canal and the upper distribution canal. The STA would be composed of 2 parallel cells, each approximately 2,500 acres in size. Each cell would have a vertical lift gate (10 feet X 10 feet) with telemetry compliant with SFWMD systems for remote access and control.

**Implementation Strategy**

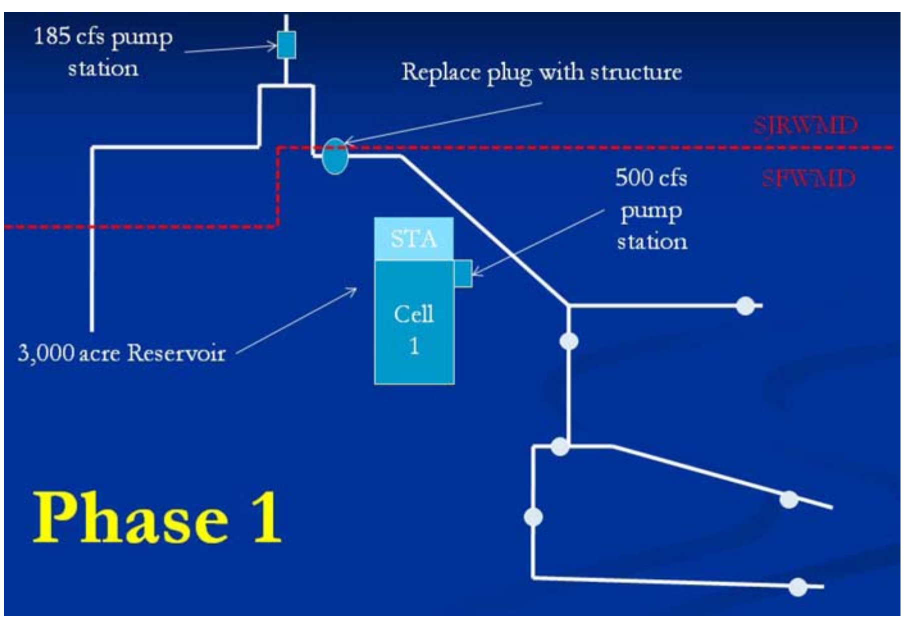
The C-23, 24, and 25 Central Storage Reservoir (ICS-02(A)) Alternative is the preferred plan. However, in order for this plan to achieve its full level of output – in terms of discharge delivery rate – it is dependent upon the operation of the C-23/24 North and South Reservoirs and STA. Without these IRL-S Project features, there would be inadequate canal conveyance capacity to discharge water from the C-23 and C-24 Basins to the ICS-02(A) reservoir. Additionally, without the IRL-S project STA, the quality of the C-23 and C-24 flows would degrade the water quality of C-25 and the ICS-02(A) STA would not be adequately sized.

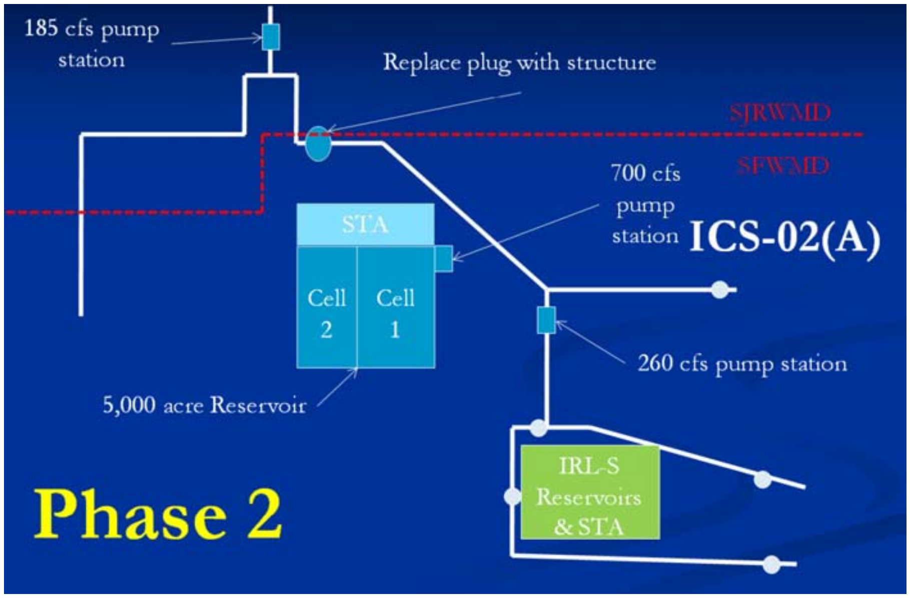
Since implementation of the IRL-S project features is dependent upon Federal appropriations and is subject to potential delays, a plan for phased implementation of ICS-02(A) has been developed. The goal would be to phase the implementation to provide early benefits, but minimize or avoid the risk that constructed features could not be fully utilized.

The preferred plan can be implemented in phases. Because dispersed storage/water farming would take advantage of existing infrastructure, it was assumed minimal construction (and cost) would be required to achieve water supply benefits. With large areas of citrus that have been decimated by canker and greening, it is likely that land owners would be willing to participate. This could provide growers with an alternative source of revenue in the interim while new disease resistant varieties of citrus are being developed. However, without a more definite estimate of the number of land owners with suitable conditions that would be willing to participate, it is not possible to estimate potential storage volumes. Additionally, there is uncertainty regarding potential costs since they are dependent upon what infrastructure might be available. A process for identifying and evaluating potential proposals and methods for compensating land owners is being developed by SFWMD. This process must be completed before the potential costs and benefits of dispersed storage/water farming can be estimated.

The first implementation phase of the preferred plan would be functionally equivalent to the C-25 Central Reservoir Alternative (ICS-01(A)). All land acquisition would be performed in Phase 1. This phase would also include construction of a 3,000 acre reservoir with a 500 cfs pump station as shown in the following figure. The structure for the pump station would be constructed to accommodate machinery for the final 700 cfs capacity. However, machinery for only 500 cfs capacity would be installed during Phase 1. The Inter-district connection (plug removal, construction of a control structure, and addition of a 185 cfs pump station) would also be constructed in Phase 1.

Phase 2 would be initiated when the C-23/24 reservoirs and STA are constructed as a part of the IRL-S Project. In the second phase, a second cell (2,000 acres) would be added to the reservoir, additional pump units would be installed to add 200 cfs capacity to the reservoir inflow pump station, and a 260 cfs pump station would be constructed at G-81. The STA would also be expanded to add a second 2,500 acre cell.






The costs and benefits (in terms of discharge delivery rate and reductions in flow to IRL) for each implementation phase are shown in the following table.

| | **Discharge Delivery @ 90% Reliability (cfs)** | **Reductions in Flow to IRL (acre-ft/yr)** | **Cost** |
|---|---|---|---|
| Phase I | 90 | 78,900 | $155,000,000 |
| Phase 2 | 95 | 63,300 | $60,000,000 |
| Total | 185 | 142,200 | $215,000,000 |

The high cost of Phase 1 relative to Phase 2 is the result of the following factors:

- All land costs are included in Phase 1.
- The Phase 2 reservoir and STA cells would use one side of the Phase 1 reservoir and STA cells.
- The Inter-district connection (plug removal, control structure, and pump station) would be constructed in Phase 1.
- The reservoir inflow pump station structure would be constructed in Phase 1 – only the addition of pump units for an additional 200 cfs capacity would be added in Phase 2.

**Findings**

- Large volumes of stormwater from the C-23, 24, and 25 Basins are currently being discharged to tide in the IRL. These discharges disrupt natural salinity regimes and degrade water quality. Excess flows in these basins represent a significant source of water that could be captured, stored, and made available for beneficial uses.

- The Indian River Farms Water Control District also provides a potential source of water that could be captured and stored for beneficial use. While there is less flow available (because of a smaller drainage area), the flows are more consistent and reliable. This would provide for very efficient utilization of the available water supply. However, the service area benefited by the additional water would be limited to the WCD.

- The top ranking alternative identified in this study was the C-23, 24, and 25 Central Storage Reservoir. It would consist of an Inter-District connection, a 5,000 acre reservoir, a 5,000 acre STA, two pump stations to move water in the canal system, and canal conveyance improvements. The planning level estimate of construction cost is $215 million. This plan would provide the following benefits:

    - 120 MGD discharge delivery rate maintained 90% of the time to meet water supply demands

    - Reductions in flows to IRL of 142,200 acre-ft/yr

- By creating an Inter-District connection between SFWMD and SJRWMD, improved water management flexibility would provide flood control and water supply benefits. Water supply deliveries could be conveyed to much larger service areas. Stormwater discharges from the C-25 Extension Basin currently flow northward to the Upper St. Johns River where they exacerbate flooding during extreme conditions. An inter-District connection would allow these flows to be conveyed to C-25 for storage in the reservoir.

- Because the full benefits of the preferred alternative are dependent on the operation of the C-23/24 Reservoirs and STA components of the IRL-S Project, implementation could be phased. Initially, dispersed storage/water farming options could be considered for implementation prior to initiation of construction. Then, construction could be completed in two phases; Phase I to be implemented first and Phase II to be implemented when the IRL-S Project features are constructed.

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## Acknowledgements

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# Study Purpose and Process

The purpose of this study was to evaluate the potential for capturing excess water that is currently being discharged to the Indian River Lagoon and making it available for beneficial uses in St. Lucie and Indian River Counties. The study also evaluated the reconnection of the South Florida Water Management District and the St. Johns River Water Management District so that available water supplies could be conveyed to meet demands across jurisdictional boundaries.

This report was prepared for the South Florida Water Management District (SFWMD) and the St. Johns River Water Management District (SJRWMD). The objectives of the study were to:

- Identify the quantity and timing of water available for diversion and storage;
- Identify water quality information needed to size water quality improvement facilities;
- Identify and provide cost estimates for the improvements and modifications to the existing conveyance systems necessary for excess runoff diversion and storage;
- Identify, develop cost estimates, and evaluate conceptual alternatives for storing excess runoff, and
- Provide conceptual designs and cost estimates for the highest ranked alternative in support of feasibility analysis and a future Basis of Design Report.

The following steps were taken during the study and are described in this report.

- A kickoff meeting was conducted with the study team followed by a stakeholder meeting. The objectives of the meetings were to:
    - Describe the study objectives and process,
    - Obtain input on important water resources issues in the study area, and
    - Identify potential information sources.
- A literature review and data compilation effort were performed to:

- Collect and evaluate relevant information from other related studies and projects.

- Compile information describing the primary and secondary canal systems and related drainage basin delineations.

- Compile information on the existing water management system, including structure and canal designs and operating rules.

- Review and evaluate flow characteristics in the study area, including statistical analyses of daily, seasonal, and annual flows in the primary canals.

- Evaluate water supply demands and conditions in the study area.

- Perform a characterization of existing water quality conditions in the primary canals in the study area.

- Alternative Plan formulation identified five final alternatives for more detailed evaluation. The plan formulation process consisted of the following:

    - Development of a set of evaluation criteria and design factors to be used in the subsequent evaluation step, but were also used to guide the identification of preliminary alternatives.

    - Identification of a broad set of preliminary alternatives through a brainstorming process and coordination with knowledgeable individuals.

    - Qualitative evaluation of the alternatives based on potential flow volumes that could be stored, infrastructure requirements, and water quality conditions.

    - A stakeholder meeting was conducted to present and discuss the plan formulation results and qualitative evaluation of the alternatives.

    - Based on the results of the qualitative alternative evaluation and input from the stakeholders, alternatives were selected for more detailed evaluation.

- Alternative plan evaluations were performed using the results of hydrologic modeling, preliminary designs, and conceptual cost estimates. The following steps were taken:

- Hydrologic model simulations of the alternatives were performed. This included model set-up, calibration, and verification.

- Storage volumes and pump capacities of the alternatives were optimized to cost effectively maximize water supply yield.

- Conceptual cost estimates were developed.

- An evaluation matrix was prepared showing the results applying the evaluation criteria to the alternatives and costs.

- A stakeholder meeting was conducted to present the results of the alternative evaluation and obtain comments.

- Based on the alternative evaluation results and input at the stakeholder meeting, the preferred alternative was identified.

* More detailed designs and cost estimates were prepared for the components of the preferred alternative.

* An implementation strategy was developed for the preferred alternative.

* The results of the study are documented in this report.

# Related Projects and Studies

This section provides brief summaries of the projects and studies that are related to the issues being addressed in this study. In cases where the scope or geographic range of related projects is beyond this study, only the relevant aspects of the projects or studies are summarized. The following projects and studies are summarized:

Indian River Lagoon – South Project (USACE 2004)

Indian River Lagoon – North Feasibility Study (USACE 2003)

Summary and Methodology, C-25 Basin and Upper St. Johns River Basin Reconnection St. Lucie and Indian River Counties (PBS&J 2006)

Upper St. Johns River Basin Project

St. Lucie River Watershed Protection Plan (SFWMD 2009a)

East Indian River County Master Stormwater Management Plan (Indian River County 2003)

Indian River Lagoon Comprehensive Conservation and Management Plan Update 2008 (NEP 2008)

IRL SWIM Plan (SFWMD 2002)

North Fork of the St. Lucie River MFL (SFWMD 2002)

North Fork of the St. Lucie River Water Reservation (SFWMD 2009b)

Upper East Coast Water Supply Plan (SFWMD 2006)

Alternative Water Supply Master Plan, Indian River County (CDM 2007)

Draft Water Supply Assessment 2008, St. Johns River Water Management District (SJRWMD 2009)

## INDIAN RIVER LAGOON – SOUTH PROJECT

The Final Integrated Project Implementation Report (PIR) and Environmental Impact Statement for the Indian River Lagoon Project documents the planning process for selection of the recommended plan for restoration of the southern Indian River Lagoon (IRL) (USACE and SFWMD 2004). The southern Indian River Lagoon estuary system has been degraded by large and frequently occurring discharges of freshwater, and by an excessive accumulation of muck in estuary and lagoon bottoms. Together these stressors have reduced water clarity and exceeded the salinity tolerances of submerged vegetation and benthic animals.

The recommended plan includes building and operating approximately 12,600 acres of new reservoirs, approximately 8,700 acres of new stormwater treatment areas, restoring natural hydrology on approximately 92,000 acres in the watershed, restoring approximately 3,100 acres of floodplain wetlands in the North Fork of the St. Lucie River, and muck removal and habitat restoration actions inside the estuaries. The plan includes building pumps, levees, canals and other water control structures to operate and interconnect project features and provide a mechanism for re-directing freshwater discharges.

The recommended plan will significantly reduce harmful discharges to the estuaries, provide water quality treatment, restore native wetland and upland habitat in the watershed, and provide an additional source of agricultural water supply, while maintaining current Central and Southern Florida Project purposes. The recommended plan will also improve habitat for natural populations of flora and fauna, including threatened and endangered species.

***Figure 1*** was provided by Alan Bruns, USACE Project Manager and shows a map of the current configuration of the IRL-S Project. It has been modified slightly relative to the plan described in the PIR due to land acquisition considerations. Descriptions of the current plan components included in the study area are provided below.

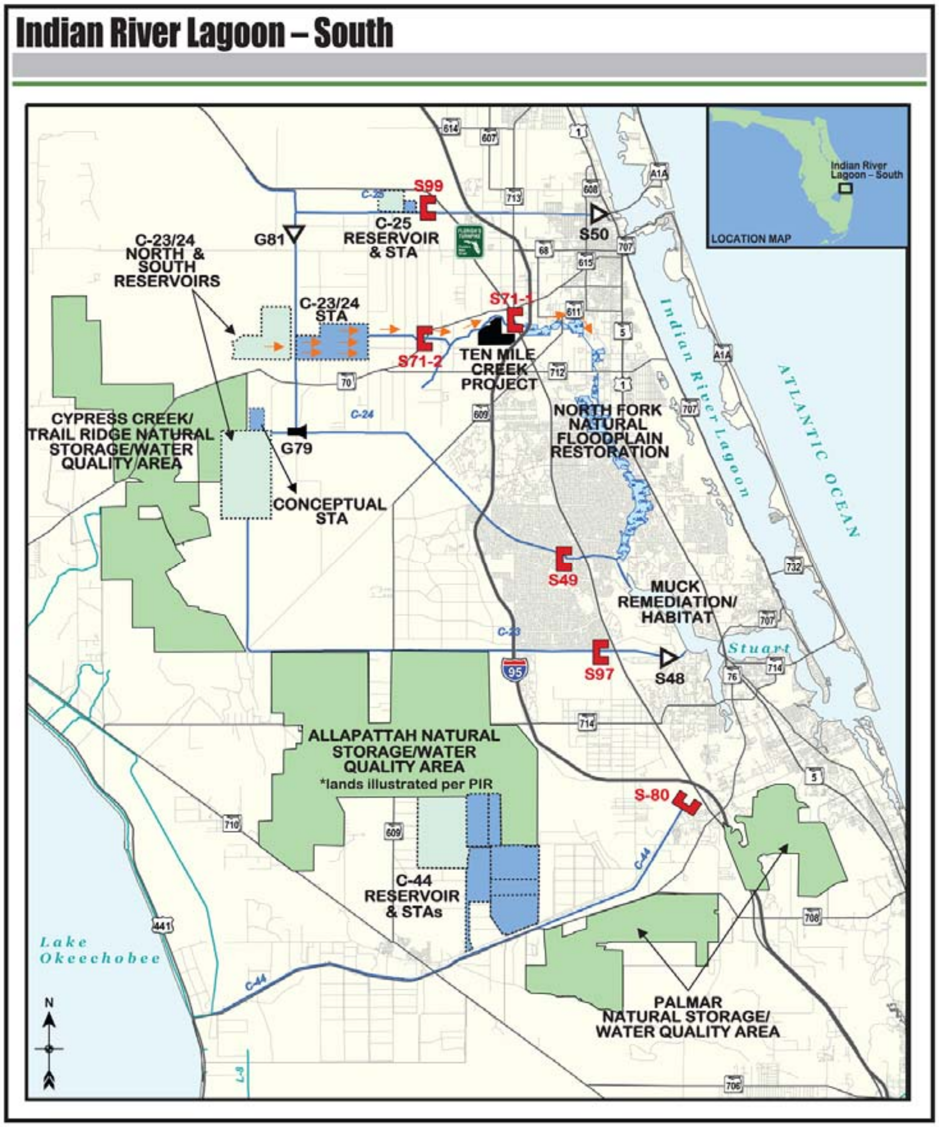



**Figure 1. Indian River Lagoon -South Project Plan.**

## C-23/24 North Reservoir

The C-23/24 North Reservoir will be located in St. Lucie County on the west side of C-24. The size and configuration of the reservoir described in the PIR has changed due to land acquisition considerations. The PIR calls for a total storage capacity of 48,500 acre-feet. Due to the need to reconfigure the North and South Reservoirs, this capacity may be changed. However, the goal is to maintain the same total storage capacity for both reservoirs. An inflow pump station will withdraw water from C-24. Water will then be discharged to the C-23/24 stormwater treatment area (STA) or released to meet water supply demands. The purpose of the reservoir is to attenuate stormwater discharges to the estuary and to provide a source of agricultural water supply.

## C-23/24 South Reservoir

The C-23/24 South Reservoir will be located in St. Lucie County north and west of C-23. Its location has been shifted southward from the footprint described in the PIR. The PIR calls for a total storage capacity of 43,400 acre-feet. Due to the need to reconfigure the North and South Reservoirs, this capacity may be changed. However, the goal is to maintain the same total storage capacity for both reservoirs.

This component will function very much like the C-23/24 North reservoir. The PIR plan includes an inverted siphon crossing under State Highway 70 to connect the C-23/24 South and North Reservoirs. However, due the reconfigured footprint, alternative means of connecting the C-23/24 South Reservoir with the C-23/24 STA are being evaluated. Discharges from the reservoir will be treated in the STA and released to the North Fork of the St. Lucie River or will be released to meet water supply demands.

## C-23/24 STA

The PIR calls for the STA to be 2,568-acres in size adjacent to the eastern boundary of the C-23/24 North Reservoir. It is anticipated that the STA will primarily discharge to Ten Mile Creek which flows to the North Fork of the St. Lucie River. Other discharge options include the C-25 and C-24 canals.

## Allapattah Complex – Natural Storage and Treatment Area

This land has been identified for use as alternative storage, rehydration, habitat restoration, and to provide incidental water quality treatment. The feature includes 42,348 acres of land in the C-23 Basin. The plan calls for filling all existing drainage features on the property to restore wetland hydroperiods. It is estimated that about 1/3 acre-foot of water per acre will be stored on the property. Structures will be provided to discharge excess water to C-23.

## Cypress Creek Complex – Natural Storage and Treatment Area

This feature includes 32,639 acres in St. Lucie and Okeechobee Counties. All drainage features on the property will be filled to facilitate rehydration of onsite wetlands and other natural areas. Only a portion of the required lands have been acquired.

## C-25 Reservoir and STA

This feature consists of a 741-acre aboveground reservoir with a maximum depth of 8-feet and a 163-acre STA. The reservoir will capture the first 0.4 inches of runoff from both the C-25 Basin and Basin 1 (Ft. Pierce Farms Water Control District

(FPFWCD)) - approximately 147,225 acres. The proposed STA is sized to treat 80% of the phosphorus load entering the STA from the reservoir. The total storage capacity of the reservoir and STA is approximately 5,392 acre-feet and is located north of and adjacent to C-25 at the S-99 structure.

Stormwater will be pumped into the reservoir from the C-25 Basin and from a new canal connection to the FPFWCD. The pump station will be designed to remove up to 250 cfs from the C-25 Canal. Water will be released from the reservoir and will flow through the STA where sediment, nutrient and other pollutant loads will be reduced. Water from the STA will be released into C-25, and from C-25 into the IRL. Water stored in the reservoir will also be available to augment water supply following the end of the summer rainy season. This project feature is designed for peak flow attenuation to the IRL; water supply benefits to legal users; and water quality benefits to reduce loading of nutrients, pesticides, and other contaminants contained in runoff presently discharged to the IRL.

### Northern Diversion

C-23 and C-24 stormwater flows will be pumped into the C-23/24 North and South Reservoirs. From storage, the water will be released to meet water supply demands or to the C-23/24 STA. Water will be discharged from the STA to the North Fork of the St. Lucie River – similar to pre-drainage conditions. However, not all C-23 and C-24 stormwater runoff can be discharged from the STA to the North Fork without causing flooding.

### Southern Diversion

Approximately 53,000 acre-feet per year of excess flow in C-23 would be directed through this southern diversion component. Under current operational rules, 31,000 acre-feet per year may go to Lake Okeechobee via S-308, and 22,000 acre-feet per year would go to the St. Lucie Estuary (SLE) via S-80. In order to achieve Natural System Targets at C-23 (Bessey Creek), this excess flow will be diverted southward through an improved existing canal located about two miles east of the western end of the C-23 Canal. This canal will connect to the C-44 Reservoir/STA to improve the quality of the stormwater prior to delivering it to a different basin (C-44). After treatment, the stormwater would be discharged to the C-44 Canal. This diversion is known as the southern diversion.

## INDIAN RIVER LAGOON – NORTH FEASIBILITY STUDY

The IRL-North Feasibility Study (USACE & SJRWMD 2003) was initiated to comprehensively examine priority areas of the Indian River Lagoon North estuarine environments, and the actions and land uses upstream, to determine the modifications that are needed to successfully restore ecological conditions and water quality of the Lagoon. The study was also intended to include analyses of alternatives for restoration of the estuarine environment surrounding the Indian River.

The study was to be cost-shared on a 50/50 basis by the Corps of Engineers and the SJRWMD. A Project Management Plan was prepared in 2003 for a major feasibility study. However, due to funding considerations, the study is currently on hold.

## SUMMARY AND METHODOLOGY, C-25 BASIN AND UPPER ST. JOHNS RIVER BASIN RECONNECTION, ST. LUCIE AND INDIAN RIVER COUNTIES

The study (PBS&J 2006) consisted of a preliminary assessment of the C-25 Basin and Upper St. Johns River Reconnection, St. Lucie and Indian River Counties, and a corresponding compilation of data available to support a more detailed feasibility analysis of the project. The study was co-sponsored by SJRWMD and SFWMD. The study initiated a process to evaluate the benefits and constraints of restoring a hydraulic connection between basins along the C-25 Canal bordering the SJRWMD and SFWMD. The report summarizes available data, identifies stakeholders, estimates freshwater available for storage, and presents a methodology for further analysis.

The following goals were considered in the evaluation of the hydraulic reconnection of the basins:

Reduction of anthropogenic freshwater flows and restoration of water quality in the IRL

Restoration, augmentation, mitigation, and/or creation of wetland areas

Augmentation of water supply and reduction of the volume of groundwater and surface water losses

Mitigation of saltwater intrusion and degrading groundwater quality

Improvement in groundwater and surface water quality

Restoration of flows necessary to maintain minimum levels, maintain recession dynamics, and maintain variability within naturally occurring ranges (i.e., avoidance of rapid reduction in flow, rapid discharge of peak flows, and frequent variations 'shocking' the system outside of recoverable ranges)

Maintenance of current levels of flood protection

Utilization of the lowest quality water to fulfill the needs of different water uses

Compatibility with local and regional water and land use plans

The study compiled flow data at the outlets of the C-25, Main, and South Canals at the structures that discharge to IRL as shown below in ***Table 1***.

### Table 1. Discharges to IRL from the C-25, Main, and South Canal Basins (Table 7, PBS&J 2006)

| Estimation of Available Freshwater per Spillway<br>3 of 5 Primary Discharge Points in the C-25 and Upper St. Johns Study Area<br>Based on Daily Mean Flow Data at Each Spillway for 40 to 50 Years of Record | | | |
|---|---|---|---|
| | C-25 Canal | Indian River Farms | |
| | S-50 | Main | South |
| Years of Record | 1965-2005 | 1949-2004 | 1950-2004 |
| Grand Total (acre-ft) | 5,540,675 | 3,008,205 | 1,573,950 |
| Median (acre-ft per year) | 131,513 | 50,729 | 29,028 |
| Minimum* (acre-ft per year) | 33,524 | 19,141 | 10,256 |
| Maximum (acre-ft per year) | 243,780 | 96,637 | 47,139 |
| Standard Deviation (acre-ft per year) | 55,081 | 14,942 | 9,070 |
| Minimum volumes for S-50 and Main are conservative in that there were days of record missing in these years. | | | |

From analysis of this data, PBS&J concluded that redirecting flows from multiple discharge points to a single or series of reservoirs may maximize capture volumes and flexibility in determining optimum pump and delivery schedules. A total of about 200,000 acre-ft per year (median value) may be available from the three canals. This volume may range from about 80,000 acre-ft in dry years to more than 350,000 acre-ft in wet years.

For each of the three canals evaluated in the study, the total volume of water that could be stored was estimated based on a range of pump capacities. In the evaluation, it was assumed that pumping rates would be constant at each of the specified pump capacities. It should be noted that the potential volumes of water that could be stored shown in the following figures do not account for withdrawals that would violate MFLs or water reservations or infringe upon other existing legal users. ***Figures 2 through 4*** show the total volumes of water discharged versus the volumes that could be captured based on ranges of pump capacities for C-25, Main, and South Canals, respectively.

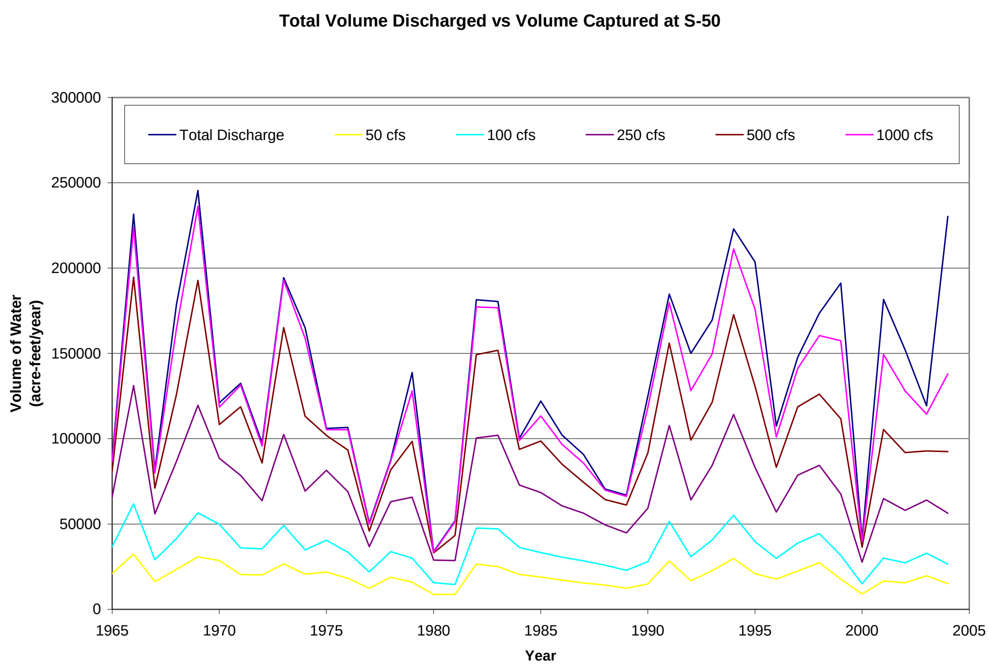



**Figure 2. Potential C-25 flow volumes that could be captured and stored based on pump capacities from 50 to 1,000 cfs (Figure 8, PBS&J 2006).**

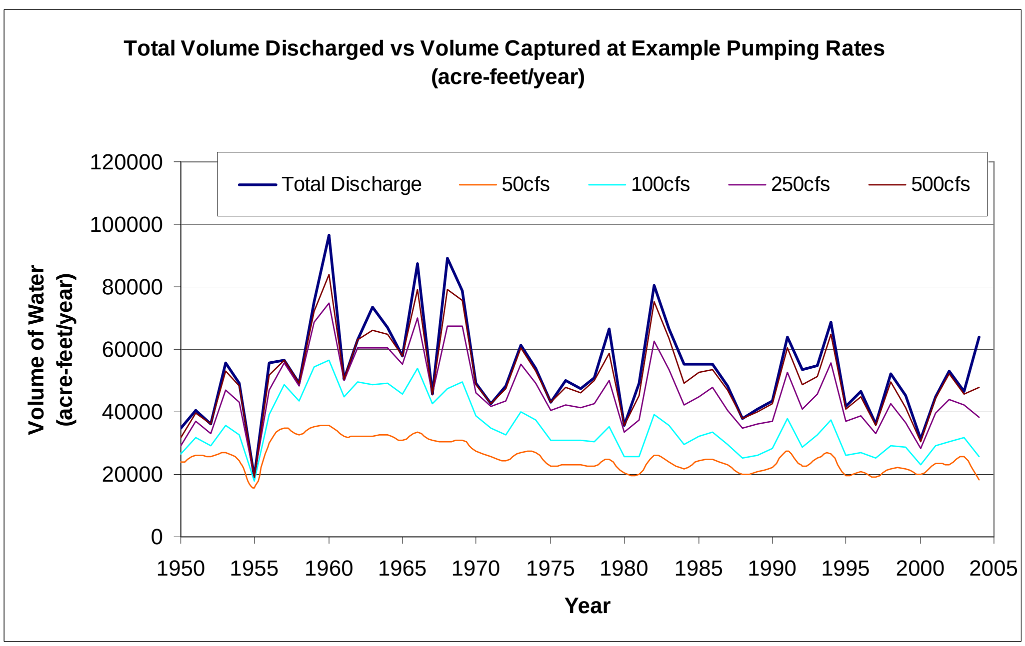



**Figure 3. Potential Main Canal flow volumes that could be captured and stored based on pump capacities from 50 to 500 cfs (Figure 12, PBS&J 2006).**

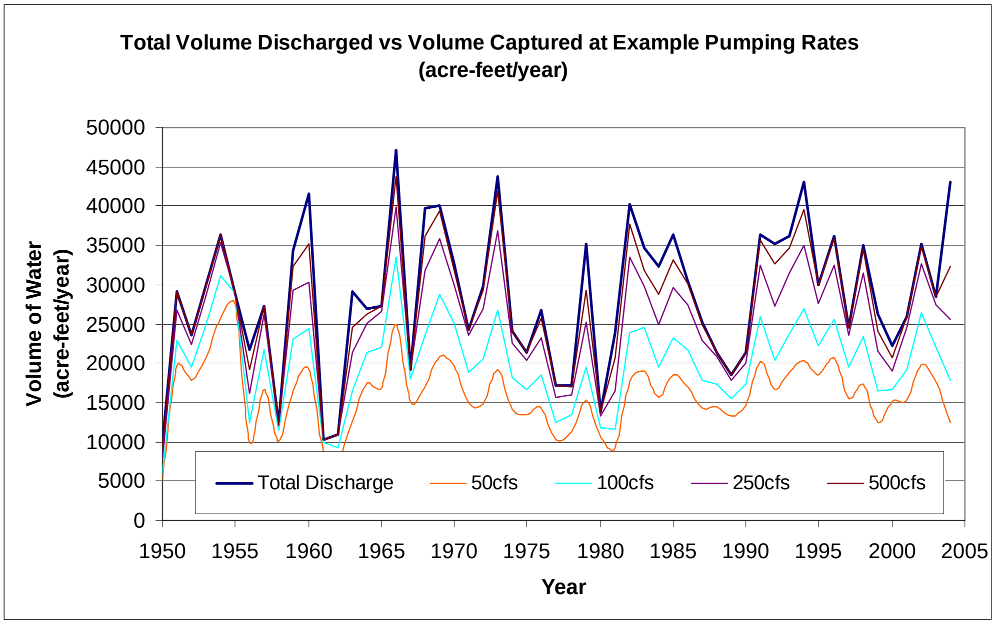



**Figure 4. Potential South Canal flow volumes that could be captured and stored based on pump capacities from 50 to 500 cfs (Figure 15, PBS&J 2006).**

Statistical analysis of rainfall stations on either side of the boundary between SFWMD and SJRWMD indicates that there is significant variability in rainfall delivery between locations over a time scale that warrants consideration of local storage and transfers for attenuating water allocation constraints. Joint contributions to storage and flexible distribution are a natural solution to this variability. Given the projected future growth of this region, the current impacts of the discharged water to the IRL, the local variability in rainfall, and the volume of water under consideration, the study concluded that there is potential to capture large volumes of water for beneficial use. It recommended additional analysis and scenario testing.

## UPPER ST. JOHNS RIVER BASIN PROJECT

The Upper St. Johns River Basin (USJRB) Project was authorized as a component of the Central and Southern Florida Project for Flood Control and Other Purposes in 1948. Originally, the Corps of Engineers worked with the Central and Southern Florida Flood Control District (now the SFWMD) to design and construct a portion of the project. Construction was initiated in the 1960's but was discontinued due to environmental concerns. Shortly after the St. Johns River Water Management District was created in 1972, a new plan for the project was developed by the Corps and SJRWMD. Construction of the project is now almost complete.

The project is designed to provide flood protection to urban and agricultural lands in the basin, provide agricultural water supply, prevent water quality degradation of the St. Johns River from agricultural runoff, restore natural hydrologic conditions in the historic floodplain, reduce unnatural freshwater discharges to tide via C-54, and minimize adverse effects to fish and wildlife habitat. The project consists of the following 6 major areas:

Ft. Drum Marsh Conservation Area: The Ft. Drum Marsh Conservation Area (MCA) is about 20,635 acres in size. Stormwater runoff from the area flows northward to the Blue Cypress MCA.

Blue Cypress Marsh Conservation Area: This area consists of the Blue Cypress Lake and surrounding wetlands – an area of about 28,796 acres. Water is released from the area to the St. Johns Marsh Conservation Area (SJMCA).

Blue Cypress Water Management Area: The Blue Cypress Water Management Area (BCWMA) is 10,750 acres in size located north of SR60 and bisected by SR 512. It is operated to prevent over-drainage and to provide flood protection and agricultural water supply. Excess water is discharged to the St. Johns Water Management Area (SJWMA).

St. Johns Water Management Area: This area is operated to provide flood protection and enhance water supply and prevent over-drainage. Water can be discharged to the historic St. Johns River floodplain or, under extreme wet conditions, to tide via C-54.

***Figure 5*** provides a map of the portion of the project located within Indian River County.

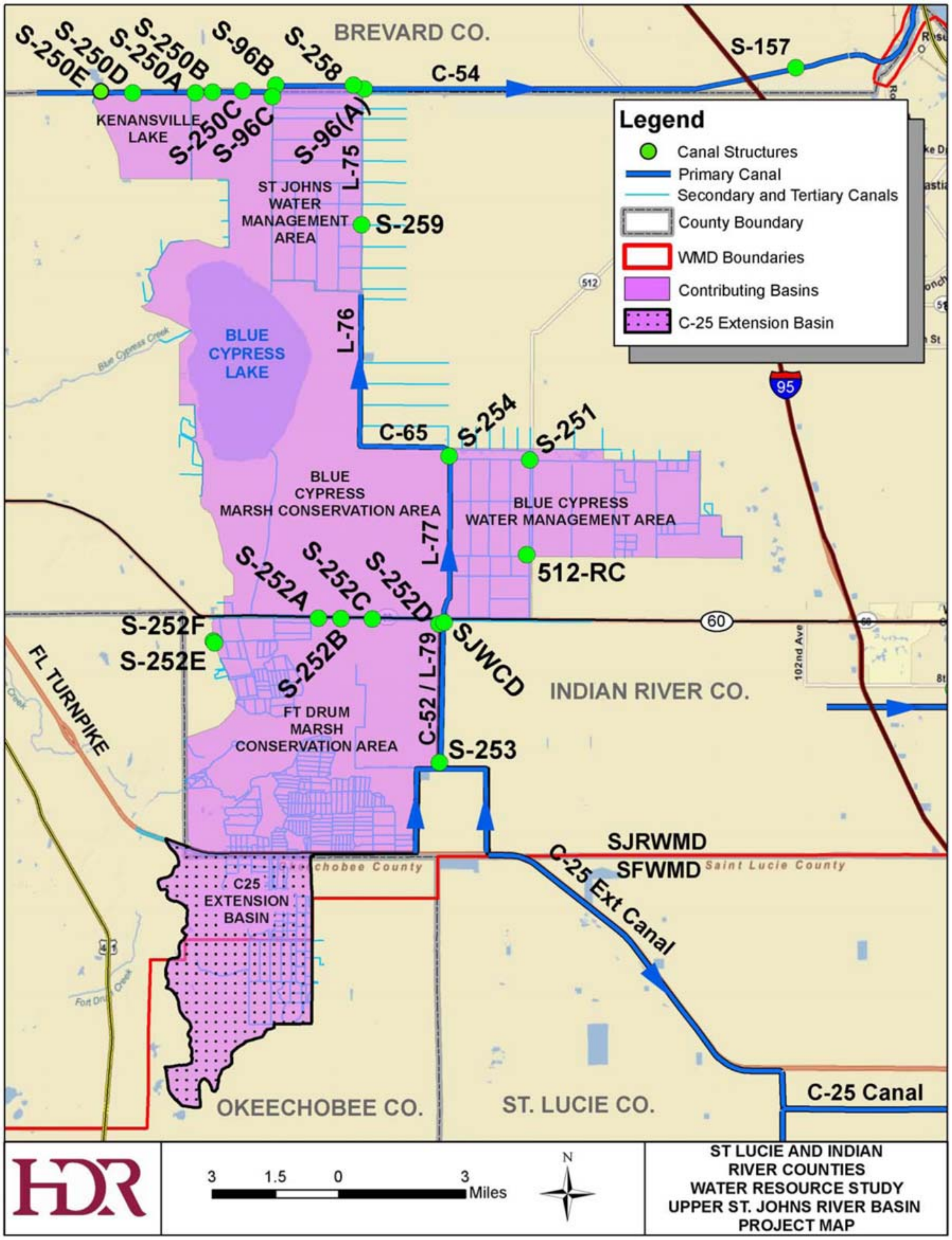



**Figure 5. Upper St. Johns River Basin Project features within Indian River County.**

# ST. LUCIE RIVER WATERSHED PROTECTION PLAN

The St. Lucie River Watershed Protection Plan (SLRWPP) was developed as a component of the Northern Everglades and Estuaries Protection Program (NEEPP) as authorized by Section 373.4595, Florida Statutes (F.S.). The primary intent of the authorizing legislation is:

> … to protect and restore surface water resources and achieve and maintain compliance with water quality standards in the Lake Okeechobee Watershed, the Caloosahatchee River Watershed, and the St. Lucie River Watershed, and downstream receiving water through the phased, comprehensive, and innovative protection program which includes long-term solutions based upon the total maximum daily loads.

Development of watershed protection plans for the Caloosahatchee and the St. Lucie Estuary Watersheds were required to be submitted to the Florida legislature by January 2009. The legislation requires the SLRWPP to include a watershed Construction Project, Pollutant Control Program, and Research and Water Quality Monitoring Program (RWQMP). The SLRWPP was developed by the SFWMD in cooperation with the Florida Department of Environmental Protection (FDEP), the Florida Department of Agriculture and Consumer Services (FDACS), Martin and St. Lucie Counties, and affected municipalities – along with a diversity of other stakeholder and public input.

One of the first steps in the plan development process was to inventory existing and planned programs and projects (e.g., Comprehensive Everglades Restoration Plan Indian River Lagoon-South project) and to determine the cumulative benefit provided by those initiatives. The cumulative benefit was then compared to the identified objectives of the watershed protection plans to determine if gaps still existed and whether additional projects or programs would be necessary. Key objectives include:

Reducing nutrient loading to the St. Lucie Estuary

Reducing the frequency and duration of undesirable salinity ranges in estuary while meeting other water related needs such as water supply and flood protection.

A set of alternatives was formulated and evaluated to fully meet the study objectives. The preferred plan consists of the best combination of watershed storage projects and water quality projects needed to help improve the quality, timing and distribution of water in the natural ecosystem. More specifically, the preferred Plan includes the Indian River Lagoon - South Final Integrated Project Implementation Report projects, best management practices (BMPs) and regulatory programs, additional regional phosphorus treatment in the C-23/24 Basin, and local water quality/quantity projects.

Main features of the preferred plan are described below:

## Reservoirs

Reservoir storage sites in the Construction Project include the reservoirs associated with the C-44 Reservoir/Stormwater Treatment Area (STA), which includes the Southern Diversion C-23 to C-44 interconnect (SLE 40) and the C-23/24 Reservoir/STA.

## Alternative Water Storage/Disposal Projects

Alternative Water Storage/Disposal construction projects essentially prevent runoff from reaching the regional drainage system or improve the timing of its delivery, and can be developed on available private, public, and tribal lands. They are used to store and/or dispose of excess water by capturing it prior to runoff or pumping it from areas or canals with excess water, and holding it on-site. Alternative Water Storage/Disposal projects typically require minimal design, engineering, and construction efforts, as compared to constructed reservoirs, because of the use of low technology approaches. Approaches include the use of existing infrastructure such as pumps to move water to the desired area and the weirs, berms, and small impoundments needed to detain the water in the facility. If they are established on existing wetlands they are designed and operated to improve the existing wetland functions. None of these features will be located inside the study area for this project.

## STAs

The C-44 STA, which includes the Southern Diversion C-23 to C-44 interconnect, and the C-23/24 STAs are two of the regional scale STAs in the Construction Project. They are components of the IRL-S Project and include associated reservoir components. In addition, the C-23/24 Water Quality Treatment Project was developed in recognition that additional phosphorus treatment may be needed for the C-23/C-24 sub-watersheds. This project is in the conceptual design phase and the exact nature of this feature will be determined in the future and included with future SLRWPP updates/refinements.

## Stormwater Management

The Construction Project includes a total of 18 local scale stormwater projects, most of which are either wet detention or baffle box projects associated with older residential developments that lack stormwater treatment systems.

## Other Plan Features

The preferred plan also includes a wide range of features as listed below:

Hybrid wetland and chemical treatment

Waste/wastewater management

Estuary water quality and habitat restoration

Muck sediment removal

Oyster habitat creation

Land management and restoration

Wetland restoration

Land conservation

Integrated growth management and restoration

Watershed pollutant control

Pollutant source control programs

Watershed research and monitoring

Specific locations for some features in the preferred Plan have already been identified. However, some project feature locations have only been identified on a sub-watershed level. Land acquisition needs will be developed over time through the Process Development and Engineering (PD&E) process. During the PD&E, conceptual planning and feasibility studies will be conducted to further evaluate project siting and real estate acquisition requirements. The results of feasibility studies will help define the real estate requirements that will be reflected in future preferred Plan updates.

## EAST INDIAN RIVER COUNTY MASTER STORMWATER MANAGEMENT PLAN

This plan was prepared by Indian River County, with the cooperation of the Indian River Farms Water Control District (IRFWCD) and the City of Vero Beach. The IRFWCD includes the entire drainage areas for the North, Main, and South Canals (aka North Relief, Main Relief, and South Relief Canals and the Vero North, Vero Main, and Vero South Canals). There are over 200 miles of manmade lateral and sub-lateral canals within IRFWCD. Accordingly, there is significant potential for erosion and transport of sediment out of the system and into IRL. High levels of TSS in the discharges have the potential to cause a significant water quality impact on aquatic resources in the region. Eroded soil particles contribute to a portion of the TSS load to IRL.

The master plan targeted a 50% reduction of the existing pollutant loads as a goal. This would produce nutrient loads to those that existed historically in the 1943 time-frame. A 60% reduction in TSS loading was also used as a goal with the objective of helping reestablish seagrass coverage to 1943 levels. Alternatives were developed and evaluated. ***Table 2*** shows the results of the alternative evaluation. ***Table 3*** shows how the alternatives were prioritized. The highest priority is given to projects for which the land is currently available.

**Table 2. East Indian River County Master Stormwater Management Plan Alternative Evaluation Results.**

| Alternative | TN Removed (lbs/year) | TN Cost ($/lb) | TP Removed (lbs/year) | TP Cost ($/lb) | TSS Removed (lbs/year) | TSS Cost ($/lb) | High Level of Treatment | Water Supply | Trash Removal | Habitat Improvement |
|---|---|---|---|---|---|---|---|---|---|---|
| No. 2 | 1188 | 59 | 168 | 418 | 56,878 | 1.24 | √ | √ | √ | |
| No. 3 | 3,393 | 42 | 500 | 285 | 84,344 | 1.68 | √ | | √ | √ |
| No. 4A | 0 | ---- | 0 | ---- | 137,900 | 0.46 | | | | |
| No. 4B | 0 | ---- | 0 | ---- | 153,221 | 0.71 | | | √ | |
| No. 6 | 10,314 | 32 | 1,462 | 225 | 184,529 | 1.79 | √ | √ | | √ |
| No. 7A | 1,458 | 48 | 207 | 337 | 51,074 | 1.36 | | | √ | |
| No. 7B | 270 | 395 | 38 | 2807 | 7975 | 13 | | | | |
| No. 8 | 3,375 | 35 | 478 | 248 | 74,621 | 1.59 | √ | | | √ |

**Table 3. Alternative Priority Ranking from the East Indian River County Master Stormwater Management Plan.**

| Table I-3. CAPITAL PROJECT PRIORITIZATION | | | |
|---|---|---|---|
| Priority Level | Alternative or Project Description | Capital Cost | Reason for Priority Level |
| High | Replacement of the Middle Radial Gate at each of the four radial gate structures, constructing a sedimentation basin immediately upstream of each structure, and installation of a floating boom immediately upstream of each structure | $1,188,000 | Immediate reduction in TSS transport, removal of floating debris, ability to store more water upstream of each structure and to control the release of the water without scouring the canal bottom |
| High | Alternative No. 6 Phase 1 (75 acres) – Southwest County Industrial Stormwater Node - Creation of a storage reservoir and artificial wetland system | $3,340,000 | High level of nutrient removal, part of the land is currently owned by the County and the remainder available to be purchased by the County, potential water supply income source. |
| High | Alternative No. 4A – Main Relief Canal Near the Vero Beach Municipal Airport – construction of a cast-in-place vortex-type stormwater treatment system and installation of a floating boom immediately upstream of the facility. | $830,000 | High level of suspended solids removal, removal of floating debris easy access for system maintenance, some nutrient removal associated with suspended solids removal. |
| High | Alternative No. 3 – South Relief Canal between 27th Avenue and Kings Highway (58th Avenue) – construction of a wetland shelf along the south canal bank and construction of a cast-in-place vortex-type stormwater treatment system adjacent to the existing radial gate structure. | $1,528,000 | High level of nutrient and suspended solids removal, all work within existing ROW, easy access for system maintenance. |
| High | Alternative No. 2 – South Relief Canal between 27th Avenue and U.S. Highway No. 1 – canal widening, construction of overflow weirs and sedimentation sumps, create in-canal storage. | $1,453,000 | Some nutrient removal, all work within existing ROW, provides irrigation water supply, additional suspended solids removal. |
| Medium | Alt. No. 4B | $1,500,000 | Cost affective TSS removal |
| Medium | Alt. No. 7A | $710,000 | Work in existing Right-of-Way Limited water supply benefit |
| Low | Alt. No. 7B | $518,000 | Expensive in $/pound |
| Low | Alt. No. 8 | $1,424,000 | Land not owned by county |

In addition to the structural alternatives described above, a series of best management practices were also evaluated. The final recommendations of the master plan called for the following:

Retrofit the existing radial gate structures with tilting weir gates to reduce sediment transport.

- Design and construct improvements in the South Relief Canal between US Highway No.1 and 27th Avenue (Alternative No.2) - This project involves the construction of weirs (control structures) in the South Relief Canal to store water that can then be used for irrigation by some of the surrounding development, and achieve some water quality improvement due to settling of suspended solids.
- Design and construct improvements in the South Relief Canal between 27th Avenue and Kings Highway (Alternative No.3) - This project consists of a wetland shelf planted in a widened canal and a solids separation unit just downstream of the South Relief Canal control structure.
- Design and construct improvements in the Main Relief Canal at Vero Beach Airport (Alternative No. 4)-This project includes widening the canal, construction of sediment sumps, and installation of a solids separation unit.
- Design and construct improvements at the Southwest Industrial Stormwater Node (Alternative No.6)-This project includes the use of the existing 35-acre parcel with a borrow pit lake, and the purchase of the adjoining parcels to create a 75-acre to 115-acre site to treat IRFWCD canal water using a combination lake and wetland treatment system, with some land retained or restored for upland ecosystem conservation. The treated water can be reused for a number of applications, including as a source of cooling water for the Calpine Blue Heron Energy Center.
- Design and construct off-line treatment facilities on Bud Jenkins Parcel (Alternative No.8)-This project includes the use of existing ponds for settling of suspended solids and the construction of wetland treatment areas on other parts of the site. Significant treatment levels can be achieved with this alternative. However, the land must be purchased which limits the priority until the parcel is purchased by the County.
- Construct an Algal Turf Scrubber as a pilot project at the Southwest Industrial Stormwater Node.
- Use alternative erosion control measures on the canal banks.
- Inventory, locate, and remove muck from specific locations where it is known to be present using a hydraulic dredge.
- Install catch basin and curb inlet inserts, and develop an operation and maintenance program for them.
- Begin a program to pave the unpaved roads that are adjacent to the canal and contributing to the sediment load.

In addition to these structural improvements, non-structural activities that are recommended are as follows:

- Pursue the use of the CREP program to purchase parcels for buffer strips or treatment sites.

- Develop a fertilization control ordinance for landscaping professionals and a long-term public information program to reduce the pollutants being contributed by the urban land use areas.
- Develop a construction site stormwater and erosion control ordinance and implement the program vigorously.

Of these recommendations, two have been implemented to date: one radial gate at each of the structures in the Main, South, and North Canals has been replaced with a tilt gate and a power screen has been installed in the Main Canal. Another of the recommended measures is currently under construction: an algal turf scrubber to reduce nutrients in the Lateral D Canal.

## INDIAN RIVER LAGOON COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN UPDATE 2008

The Indian River Lagoon National Estuary Program (NEP) is one of 28 nationwide NEPs. It was established in 1990 through EPA's designation of the IRL as an "estuary of national significance". The IRL Comprehensive Conservation and Management Plan (CCMP) was initially developed in 1996. The CCMP includes 68 recommendations in 4 topic areas and has been used to guide NEP programs.

Eleven years of implementation activities under the original IRL CCMP resulted in a remarkable amount of progress toward restoration and protection of the lagoon. However, new issues and threats such as climate change, toxic algae, and exotic invasive fauna and flora have emerged since the original IRL CCMP's development. Additionally, new science research, technologies, programs, and organizations now exist. IRL NEP's activities and annual work plans have continually evolved to adapt to these new challenges and opportunities. However, the action items in the IRL CCMP have not been updated to reflect this evolution.

In the spring and summer of 2007, the IRL NEP embarked on a process to review and update the core of the 1996 IRL CCMP and the set of 68 recommended action items. The NEP model is a non-regulatory, stakeholder-driven collaborative approach to coastal restoration and protection and is based on four cornerstones:

- A watershed focus,
- Decision-making based on sound science,
- Collaborative problem solving, and
- Public involvement.

The goals and objectives of the IRL CCMP were closely coordinated with the IRL Surface Water Management and Improvement (SWIM) Plan to maximize efficiencies in communication and program delivery. The IRL NEP adopted three of the IRL SWIM Plan goals:

Goal 1: To attain and maintain water and sediment of sufficient quality to support a healthy estuarine ecosystem.

Goal 2: To attain and maintain a functioning, healthy ecosystem which supports endangered and threatened species, fisheries, commerce, and recreation.

Goal 3: To achieve heightened public awareness and coordinated interagency management of the IRL ecosystem.

The IRL NEP added one additional goal to the CCMP relating to the identification of long-term funding resources for implementation of the CCMP's recommendations:

- Goal 4: To identify and develop long-term funding sources for prioritizing projects and programs to preserve, protect, restore, and enhance the IRL system.

The CCMP includes recommendations for improved water quality and sediment management, living resources, public and governmental support and involvement, and financing implementation. Recommendations for water quality and sediment management relative to this study call for developing and implementing strategies to address the impacts of freshwater and stormwater discharges on the resources of the Indian River Lagoon. Specific recommendations that are relevant to this study are as follows:

Develop, implement and update pollutant load reduction goals (PLRGs) for all areas of the Indian River Lagoon.

Develop and implement best management practices (BMPs) for the management of stormwater, agricultural and fresh water discharges.

Update and enhance comprehensive drainage maps of the Indian River Lagoon basin.

Reduce the impacts of muck on the Indian River Lagoon.

Strengthen existing stormwater or freshwater discharge management programs.

Educate residents and property owners about the impacts of freshwater and stormwater discharges on the Indian River Lagoon and what they can do to reduce these impacts.

Continue reviews of plans of reclamation for water control districts and the standard operating procedures and project works of each large drainage system and agricultural drainage system. Develop and implement strategies to reduce discharges and pollutant loadings to the Indian River Lagoon from these sources.

Upgrade existing urban and agricultural stormwater systems to reduce pollutant loadings to the Indian River Lagoon.

## IRL SWIM PLAN

The Florida Legislature enacted the Surface Water Improvement and Management (SWIM) Act (Chapter 373.451-373.4595, F.S.) in 1987 and revised it in 1991. This Act declares that many natural surface water systems in Florida, including the Indian River Lagoon (IRL), have been or are becoming degraded. Factors contributing to this degradation include point and non-point sources of pollution and the destruction of natural habitats. The SWIM Act directed the St. Johns River and South Florida Water Management Districts, with the cooperation of state agencies and local governments, to design and implement a plan for the improvement of surface waters and habitats in the IRL.

The first IRL SWIM Plan was published in 1989 and has been updated in 1994 and most recently in 2002. It includes a status report on the state of the Lagoon, a summary of progress on projects undertaken since the last update in 1994, and recommendations for future projects and other actions over the next 5 years.

The three major goals of the IRL SWIM Plan, first stated in the 1989 IRL SWIM Plan and re-stated in the 1994 IRL SWIM Plan (Chapter III, p. 19), have remained intact and relevant. The goals are as follows:

Goal I. To attain and maintain water and sediment of sufficient quality (". . . to Class III or better . . .", Chapter 373.453, F.S.) in order to support a healthy, macrophyte-based, estuarine lagoon ecosystem.

Goal II. To attain and maintain a functioning macrophyte-based ecosystem which supports endangered and threatened species, fisheries and wildlife.

Goal III. To achieve heightened public awareness and coordinated interagency management of the Indian River Lagoon ecosystem that results in the accomplishment of the two aforementioned goals.

The 2002 SWIM Plan updated the objectives that were designed to support each of the goals described above. The water quality objectives that support Goal 1 are relevant to this study. They are:

Restore lost seagrass beds and preserve existing seagrass beds,

Manage excessive freshwater inflows to minimize their impacts on salinity,

Decrease inputs of suspended materials from point and non-point sources,

Decrease inputs of excessive loadings of nutrients from point and non-point sources, and

Eliminate or reduce the releases of toxic substances from point and non-point sources.

## NORTH FORK OF THE ST. LUCIE RIVER MFL

Florida law requires the water management districts to develop a priority list and schedule for the establishment of minimum flows and levels (MFLs) for surface waters and aquifers within their jurisdiction (Section 373.042(1), Florida Statutes). The minimum flow is defined as the "...limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." For purposes of establishing minimum flows, significant harm is defined by SFWMD as a loss of water resource functions that takes more than two years to recover. Water resource functions protected under Chapter 373 include flood control, water quality, water supply and storage, fish and wildlife, navigation, and recreation.

A technical documentation report was prepared by the SFWMD in 2002 addressing the North and South Forks of the St. Lucie River, several major drainage and irrigation canals, the surrounding watershed, and the estuary. This system is of particular importance because it lies at the confluence of two major transportation waterways. It is located adjacent to the Indian River Lagoon (part of the National Estuary Program), and provides an outlet for discharge of excess water from Lake Okeechobee.

Minimum flow criteria established for the St. Lucie River and Estuary are linked to the concept of protecting valued ecosystem components from significant harm. The specific valued ecosystem components identified for the St. Lucie River and Estuary are the assemblage of organisms inhabiting the low salinity, oligohaline zone. The MFL for the St. Lucie River and Estuary is stated as follows:

> Mean monthly flows to the St. Lucie Estuary of more than 28 cubic feet per second from the North Fork of the St. Lucie River represent the amount of water necessary to maintain sufficient salinities in the St. Lucie Estuary in order to protect the oligohaline organisms that are valued ecosystem components of this system. If flows fall below this minimum for two consecutive months, the minimum flow criteria will be exceeded and harm occurs to estuarine resources. If harm, as defined above, occurs during two consecutive years, significant harm and a violation of the minimum flows and levels criteria occur.

The MFL document observed that the minimum 28 cfs flows to the St. Lucie Estuary should ideally be spatially distributed to no less than 21 cfs to the North Fork and no less than 7 cfs to the South Fork. However, flows in the South Fork are not monitored and there are no conveyance options to supplement South Fork flows. Therefore, the final MFL was based on North Fork flows.

The Gordy Road Structure within the North Fork of the St. Lucie River basin is currently monitored in conjunction with the Upper East Coast Water Quality Sampling Network and was recommended as the location to monitor North Fork flows.

## NORTH FORK OF THE ST LUCIE RIVER WATER RESERVATION

The federal Water Resources Development Act (WRDA) of 2000 requires the SFWMD to complete a water reservation prior to signing an agreement to receive federal CERP funding for the Indian River Lagoon – South Project. Construction of the project was authorized by WRDA 2007. A water reservation is a legal mechanism to set aside water for the protection of fish and wildlife or public health and safety. When a water reservation is in place, volumes and timing of water at specific locations are protected for the natural system ahead of consumptive uses such as new development.

Rule making was initiated by SFWMD in April 2008. A multi-step process is being utilized to ensure that the proposed water reservation is thoroughly studied and considered by scientific experts, officials, stakeholders, and the public. A panel of nationally recognized independent scientific experts reviewed research supporting the proposed reservation and published their findings in June 2009. The panel's analysis showed that the proposed reservation is supported by sound science. Public workshops to develop draft rule language began in April 2009 and will continue through October 2009.

## UPPER EAST COAST WATER SUPPLY PLAN

The Upper East Coast (UEC) Planning Area consists of St. Lucie and Martin counties and eastern Okeechobee County. Its boundaries encompass over 1,230 square miles and generally reflect the watersheds of the C-23, C-24, C-25 and C-44 canals. An update to the original 1998 Plan (1998 UEC Plan) was completed in 2004. The primary reason for the 2006 Upper East Coast Water Supply Plan Amendment was to provide important information to local governments concerning revisions to state law requirements relevant to water supply planning and the potable water provisions contained within each local government's comprehensive plan.

The UEC Planning Area's projected population growth over a 20 year period will significantly impact the region's public water demands, particularly in the urban sector. In 2006, the UEC Region's total population was expected to increase from 320,664 in 2000 to about 584,927 residents by 2025. However, the March 2009 Bureau of Economic and Business Research (BEBR) projections for this planning area have declined since 2006 by approximately 4% to a total of 560,899 residents by 2025. SFWMD uses the medium-range of BEBR population projections whereas SJRWMD uses a mix of high and medium range BEBR population projections.

While public water supply water withdrawal needs are projected to increase by 65 million gallons per day (MGD) with the region's projected rapid growth, and agricultural water demand is forecasted to decrease 7 percent, agriculture will remain the Upper East Coast Planning Area's largest water user. The largest percentage of change in urban water demand over the next 20 years will be in the thermoelectric power generation self-supply sector as three new power generation facilities are projected to be located in this region.

The utilities have identified sufficient projects to meet the projected water needs for the Year 2025, and projects specific to each major public water supplier are included in this plan amendment. Forty-seven alternative water supply projects and one traditional water supply project were submitted by local utilities for this UEC Plan Amendment.

## ALTERNATIVE WATER SUPPLY MASTER PLAN, INDIAN RIVER COUNTY

Indian River County has been experiencing rapid growth with concomitant increases in demands for water. The County currently uses brackish water from the Upper Floridan Aquifer (UFA) as the source for the production of public water supply through the reverse osmosis treatment process. This source is also used by agricultural interests for citrus cultivation and by local golf courses for supplemental irrigation (primary source for irrigation in most cases is reclaimed wastewater). Concerns have been expressed that continued development of the UFA would have adverse impacts on the existing use of artesian wells for both irrigation and freeze protection.

The County anticipates that by 2011, additional raw water capacity would need to be on line (beyond the current expansion that is underway), or have an alternative water supply identified and in place. The County has obtained a Temporary Consumptive Use Permit which allowed construction of six new wells. The final consumptive use permitting process is nearing completion for an expansion of permitted pump capacity from the UFA of up to 22.5 MGD to meet project demands through 2030. The County will continue to seek a surface water source as a preferred alternative water source to meet future demands. Build-out of the County is not expected to occur by 2025, and for that reason additional water supply will be needed for future County development beyond that point. Three alternative sources of water supply were evaluated:

Surficial Aquifer;

Seawater Desalination; and

Fresh Surface Water/Reservoirs.

The alternative water supply master plan concludes that fresh surface water, located in western Indian River County, would represent a good first choice for a future long-range alternative water supply. Treatment is not as energy intensive as other technologies. Deep well injection would not be required. After the initial construction of approximately 20 miles of pipeline that may cost from $10 million to $20 million, the operating cost would be low.

The SJRWMD is evaluating the availability of water from the St. Johns River in view of minimum flows and levels and will determine water availability in the existing and proposed water management areas. The plan notes that PBS&J (2007) concluded that a significant amount of water could potentially be captured and stored in the C-25 canal basin for water supply. This water is currently discharged to tide. In addition, it is noted that the proposed 10,000-acre Fellsmere WMA might also be a potential additional source of fresh surface water.

## DRAFT WATER SUPPLY ASSESSMENT 2008, ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

In compliance with state law, the SJRWMD has prepared water supply assessments and water supply plans at five year intervals since 1998. The draft 2008 Water Supply Assessment (WSA) will be the foundation for development of the 2010 Water Supply Plan. The Water Supply Assessment identifies future water supply needs for a 20-year planning horizon and identifies priority water resource caution areas - where projected uses cannot be sustained by proposed water sources without unacceptable impacts to water resources and related natural systems.

In the draft 2008 WSA, the extreme southern portion of Brevard County, all of Indian River County and a portion of southeast Osceola County are identified as potential PWRCAs, which means the areas may not be able to meet all future water demands without unacceptable impacts to water resources and related natural systems. Collectively, the areas identified within these three counties constitute the Southern Water Supply Planning Area.

The District has projected water use needs to the 2030 planning horizon based on population projections provided by the Bureau of Economic and Business Research (BEBR) at the University of Florida. Based on BEBR projections, the Indian River County population and water needs will increase 246% and 201%, respectively by 2025 relative to 1995 conditions.

Based on the draft assessment's findings, water level declines of up to five feet are projected in eastern Indian River County and north eastern St. Lucie County with smaller declines up to 0.5 feet projected for surrounding portions of southern Brevard County to the north and central St. Lucie County to the south. These declines are largely the result of projected increases in groundwater withdrawals to support projected increases in public supply water use through 2030.

The 2010 Water Supply Plan process has been initiated. It will allow review and further evaluation of projected water resource impacts, finalize identification of PWRCAs, complete the WSA 2008, and include it as an appendix in the 2010 plan, and identify strategies to prevent unacceptable impacts.

# Drainage Areas

The purpose of this section is to describe drainage areas and flow characteristics within the basins that have been designated as potential water source areas for this study. Potential water source areas could consist of one or more of the following basins: C-23, C-24, and C-25 Basins, Indian River Farms Water Control District (South, Main, and North Canal Basins), Basin 1 (Ft. Pierce Farms Water Control District), and the St. Johns Improvement District.

## STUDY AREA CATEGORIES

The study area can be described in three categories: water source areas, water storage areas, and water use areas (***Figure 6***). The potential for capturing excess water in the "water source areas" will be evaluated. Water will be stored in the "water storage areas" which could be within the water source areas or in nearby adjacent areas. Beneficial uses of the stored water will occur in the "water use areas" which could be within the water source areas or other areas based on available infrastructure for water conveyance.

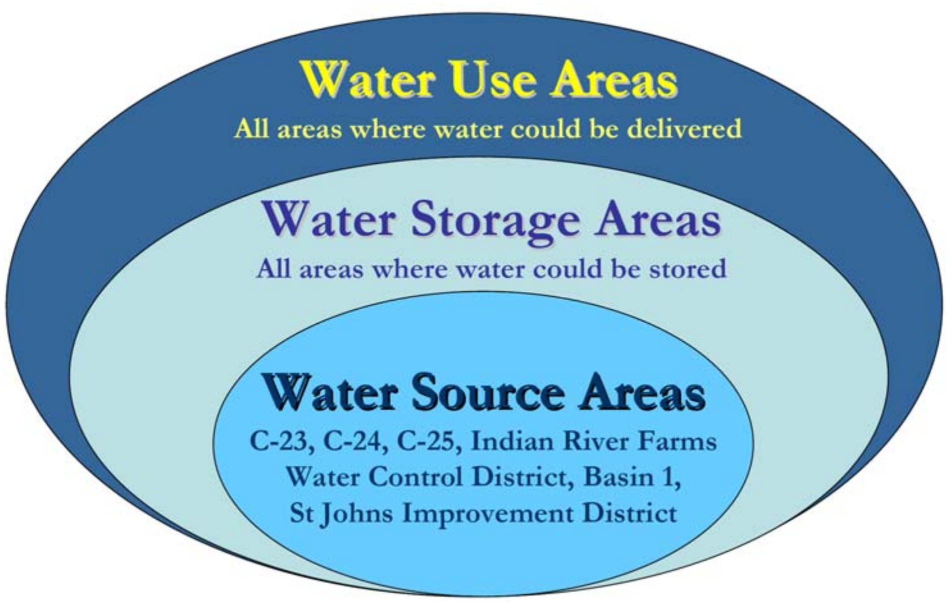



**Figure 6. Study area categories.**

A map that delineates the study area and primary water management systems is provided in ***Figure 7***.

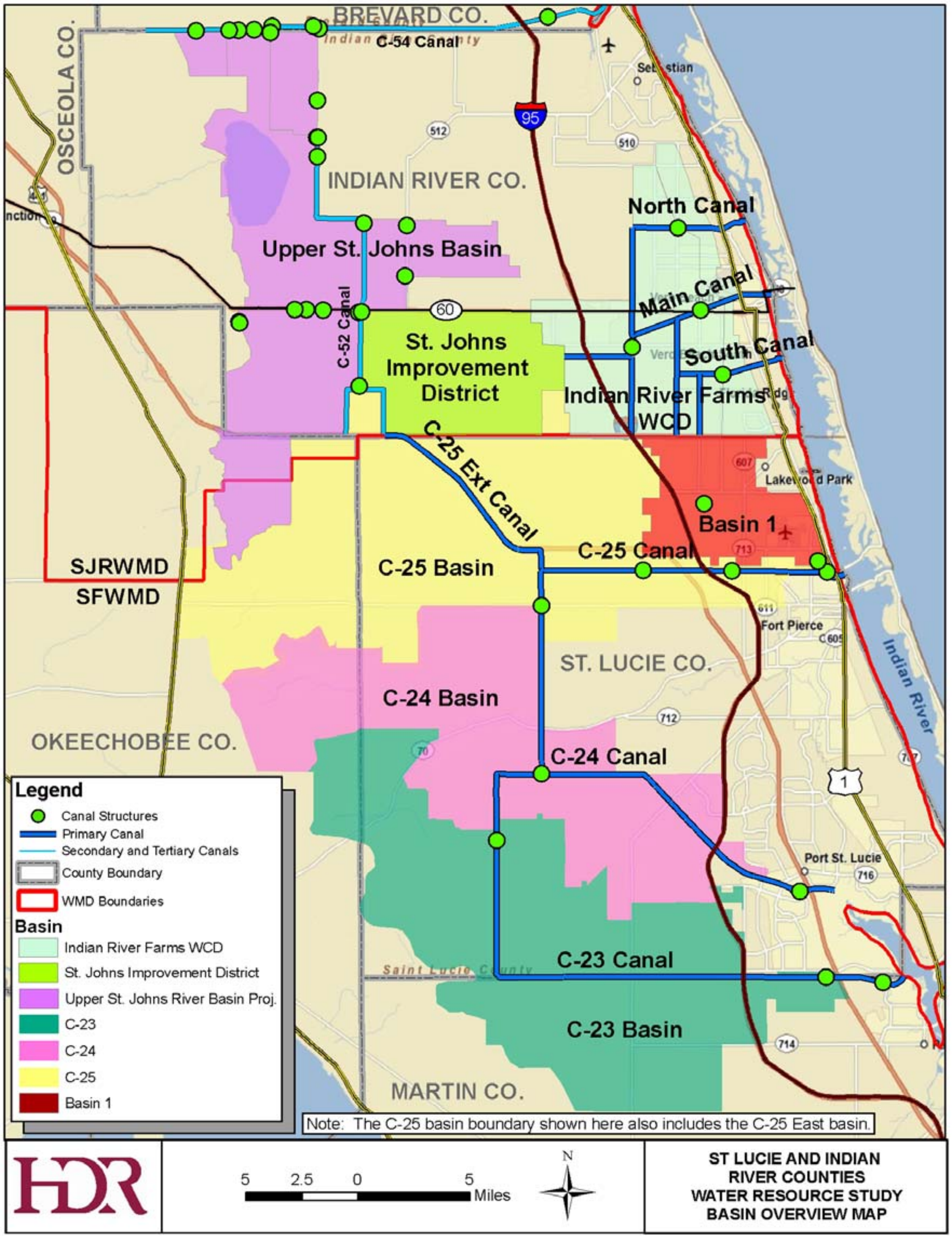



**Figure 7. Study area map.**

## DRAINAGE AREAS

***Table 4*** provides the drainage areas for the major basins and water control districts within the study area.

**Table 4. Drainage areas of basins and water control districts in the study area.**

| Basin | Area (acres) |
|---|---|
| C-23 | 112,300 |
| C-24 | 87,600 |
| C-25 | 112,100 |
| Basin 1 | 32,200 |
| St. Johns Improvement District | 28,600 |
| C-25 Extension | 10,500 |
| Indian River Farms Water Control District | 47,900 |
| Delta Farms Water Control District | 2,900 |
| Fellsmere Water Control District | 46,100 |

## FLOW PATTERNS

Water levels and flow patterns in the main canals and basins in the study area are shown below in ***Figure 8***.

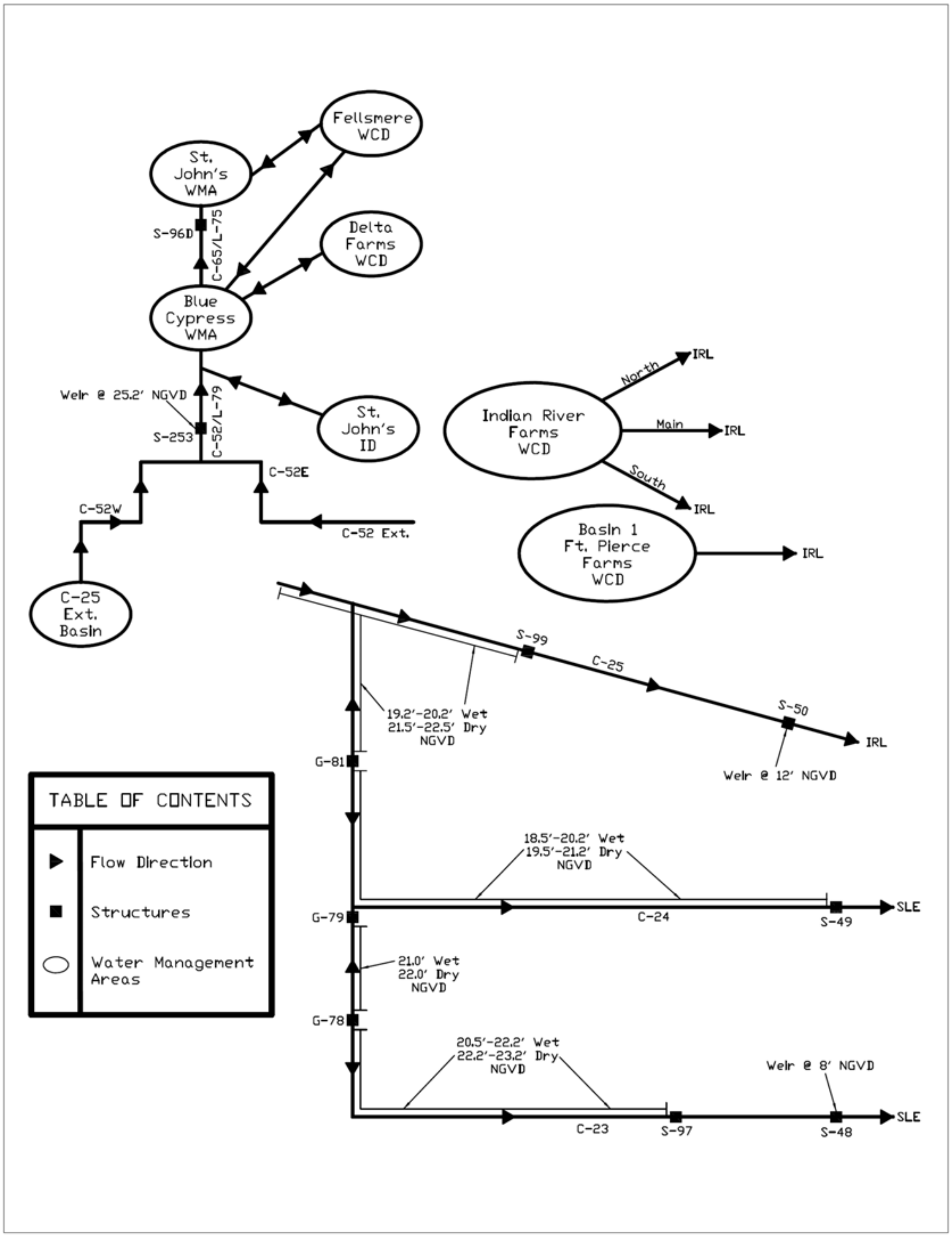



**Figure 8. Flow patterns and water levels in the study area's main canals and basins.**

# HYDROGEOLOGY

Aquifers in the study area are either the Floridan, intermediate, or surficial aquifer systems. The Floridan Aquifer is artesian and underlies the entire study area. It is divided into three hydrogeologic units: the Upper Floridan aquifer, a middle confining unit, and the Lower Floridan aquifer. The top of the Upper Floridan Aquifer is approximately -250 ft, NGVD in northern Indian River County and falls to about -700 ft, NGVD in southern St. Lucie County. The Upper Floridan Aquifer provides a source of urban and agricultural water supply in the study area. Increased withdrawals, however, could increase salinity and threaten the quality of the withdrawn water. An upward trend in salinity was observed in 16 monitoring wells in the inland area of St. Lucie and Martin Counties, and agricultural withdrawals are probably causing these increases (Reese 2004).

For the design of water storage areas, the characteristics of the upper 100 to 150 feet of sediment is most relevant. In the study area, these sediments range in age from Holocene-Pleistocene to Pliocene, or from present to about 4.2 million years. Holocene soils and undifferentiated Pleistocene sand, clay, coquinas and organic material occur at the top of the section, and are underlain by quartz sand, coquina, shell, and a few minor limestones within the Pleistocene Anastasia, Fort Thompson and Caloosahatchee Formations, and the Tamiami Formation of Pliocene age.

The Anastasia, Fort Thompson and Caloosahatchee Formations generally consist of sand, coquina, limestone, marl, and sandstone (Schiner et al, 1998). The Tamiami consists of clay, sandy clay, and shells with some cemented zones. These sediments form the surficial aquifer system, which is bounded beneath by the Hawthorn Group of Miocene age. The SAS is approximately 100 to 120 feet thick in the study area (Reese, 2004). Clayey sediments of the Hawthorne Group form the intermediate confining unit of the Floridan aquifer system. ***Table 5*** depicts a typical geologic section for the vicinity of the study area.

The surficial aquifer is the primary drinking-water source for Martin and St. Lucie Counties and furnishes about 33 percent of the drinking-water for Indian River County. It consists of the upper 100 to 150 feet of sediment. The SAS is generally unconfined or semi-confined where beds of low permeability are present. The water table is typically within five feet of land surface. The aquifer is recharged primarily by rainfall, but also by seepage from the canal system and infiltration of irrigation. Crandal (2000) found that the water quality of the surficial aquifer deteriorated in areas adjacent to agricultural operations, particularly dissolved solids and chlorides.

The ability of sediments or rock to transmit water horizontally through the aquifer (transmissivity, hydraulic conductivity), together with its ability to hold water (storage), constitute the most significant hydraulic properties of that soil or rock unit. The average transmissivity of the surfical aquifer near wellfields for Indian

River County and Vero Beach was determined to be approximately 30,000 $ft^2$/day (Toth, 2001). At an assumed thickness of 100 feet, the hydraulic conductivity would be approximately 300 ft/day.

A study by Toth (1998) showed some evidence for potentially lower surfical aquifer transmissivities in the western part of Indian River County. The results of a single-well aquifer test performed in southwestern Indian River County showed a transmissivity of approximately 180 $ft^2$/day (Toth, 1998). Single well tests, however, are influenced by well losses and well-bore storage and may not always provide reliable estimates of aquifer parameters.

The apparent thickness and transmissivity of the SAS in the study area may be substantial and could potentially affect the design and function of a water storage feature. If an above ground water storage impoundment is to fulfill its design function, vertical seepage of the stored water should be within some reasonable and acceptable rate. Part of the preliminary design evaluation would include an estimate of the volume of seepage lost based on a range of potential aquifer parameters. When site specific data can be obtained, the impact of seepage can be more accurately estimated. If the seepage is considered too excessive for the required function of the facility, then the addition of engineering controls, such as soil-bentonite cutoff walls, would require evaluation. The cost-benefit would also require evaluation since these controls can add substantial costs to the construction of the facility.

**Table 5. Generalized geology and hydrogeology of the study area.**

<table>
<tr><th>System</th><th>Series</th><th>Stratigraphic Unit</th><th></th><th>Hydrogeologic Unit</th></tr>
<tr><td rowspan="4">Quaternary</td><td>Holocene</td><td colspan="2">Undifferentiated sediments</td><td rowspan="5">Surficial Aquifer System</td></tr>
<tr><td rowspan="3">Pleistocene</td><td colspan="2">Anastasia Formation</td></tr>
<tr><td colspan="2">Fort Thompson Formation</td></tr>
<tr><td colspan="2">Caloosahatchee Formation</td></tr>
<tr><td rowspan="9">Tertiary</td><td>Pliocene</td><td colspan="2">Tamiami Formation</td></tr>
<tr><td rowspan="2">Miocene and Late Oligocene</td><td rowspan="2">Hawthorn Group</td><td>Peace River Formation</td><td rowspan="2">Intermediate Confining Unit</td></tr>
<tr><td>Arcadia Formation</td></tr>
<tr><td>Early Oligocene</td><td>Basal Hawthorn/SuwanneeUnit</td><td>Suwanee Limestone</td><td rowspan="5">Floridan Aquifer System</td></tr>
<tr><td rowspan="3">Eocene</td><td colspan="2">Ocala Limestone</td></tr>
<tr><td colspan="2">Avon Park Limestone</td></tr>
<tr><td colspan="2">Oldsmar Formation</td></tr>
<tr><td rowspan="2">Paleocene</td><td colspan="2" rowspan="2">Cedar Keys</td></tr>
<tr><td>Sub-Floridan Confining Unit</td></tr>
</table>

# Water Management

The purpose of this section is to describe the water management system design and operating rules in the study area.

## C-25 BASIN

***Figure 9*** shows a map of the C-25 Basin. The predominant land use in the C-25 Basin is agriculture. The C-25 Basin may be divided into two sub-basins based on where water may be discharged; western C-25, and eastern C-25. Together these areas cover a total of approximately 112,300 acres.

Discharges from western C-25 to the eastern portion of C-25 are controlled at S-99. According to USACE (1957), the optimum water level upstream of S-99 is 20 ft, NGVD. The discharge from C-25 into IRL is uncontrolled flow over the S-50 weir. The optimum water surface elevation in C-25 upstream of S-50 is 12 ft, NGVD (USACE 1957).

The water management infrastructure in the C-25 Basin was designed by USACE to provide protection up to 30% of the Standard Project Flood (SPF) – estimated to be approximately a 10-year storm (USACE 1957, 1958). The SPF is defined as the largest storm event that could reasonably be expected to occur in the study area.

Privately owned and operated agricultural reservoirs account for a significant volume of stormwater storage capacity in the area. It is estimated by knowledgeable water managers that approximately 12% of the C-25 basin area is utilized for privately owned agricultural reservoirs. This local storage would be expected to improve the quality of the water discharged from the basin.

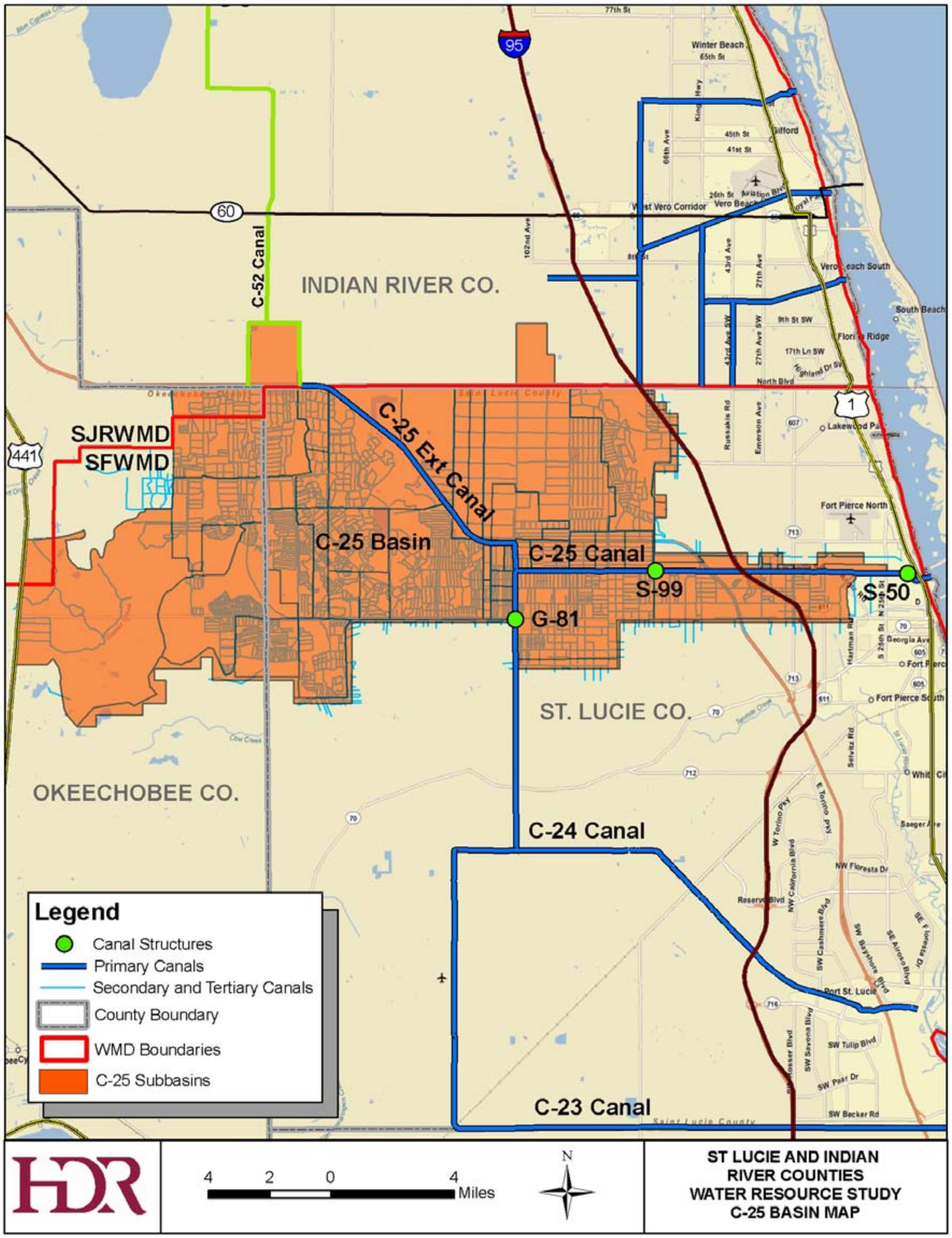



**Figure 9. C-25 Basin.**

## BASIN 1 (FT PIERCE FARMS WATER CONTROL DISTRICT)

Surface water in Basin 1 is managed for flood protection and water supply by the Fort Pierce Farms Water Control District (FPFWCD). Basin 1 (***Figure 10***) covers approximately 32,200 acres. Even though Basin 1 includes lands that are outside of FPWCD, the water management system of the FPFWCD controls the surface water in all of Basin 1. The major discharge from the FPFWCD is through the Phillip C. Gates Structure – a.k.a. Structure 1. Structure 1 is located in the primary canal of the FPFWCD/Basin 1 water control system called Canal 1. Downstream of Structure 1, Canal 1 discharges into the un-controlled segment of C-25 between S-50 and the Indian River Lagoon. The structure is estimated to be capable of discharging in excess of 500 cfs (Personal communication Boyd Gunsalus).

## C-24

The C-24 Basin is managed for water supply and flood protection (***Figure 11***). The major water control structures in C-24 Basin are G-81, G-79, and S-49. G-79 serves as a basin divide and enables the discharge of water from C-23 into C-24 when conditions allow. G-81 is at the drainage divide between C-24 and C-25 Basins. Water may be discharged from C-24 to the St. Lucie Estuary, to the south, and/or to the C-25 basin to the north, through G-81, respectively.

S-49 discharges from C-24 into the C-23A. C-23A is uncontrolled and discharges into the St. Lucie Estuary. The C-24 system was designed to provide protection up to 30% of the SPF (USACE 1957, 1958) – approximately a 10-year storm event. It is estimated that approximately 6% of the basin area is utilized as privately owned agricultural reservoirs. This local storage capacity would be expected to improve the quality of the water discharged from the basin (Personal communication Boyd Gonsalus).

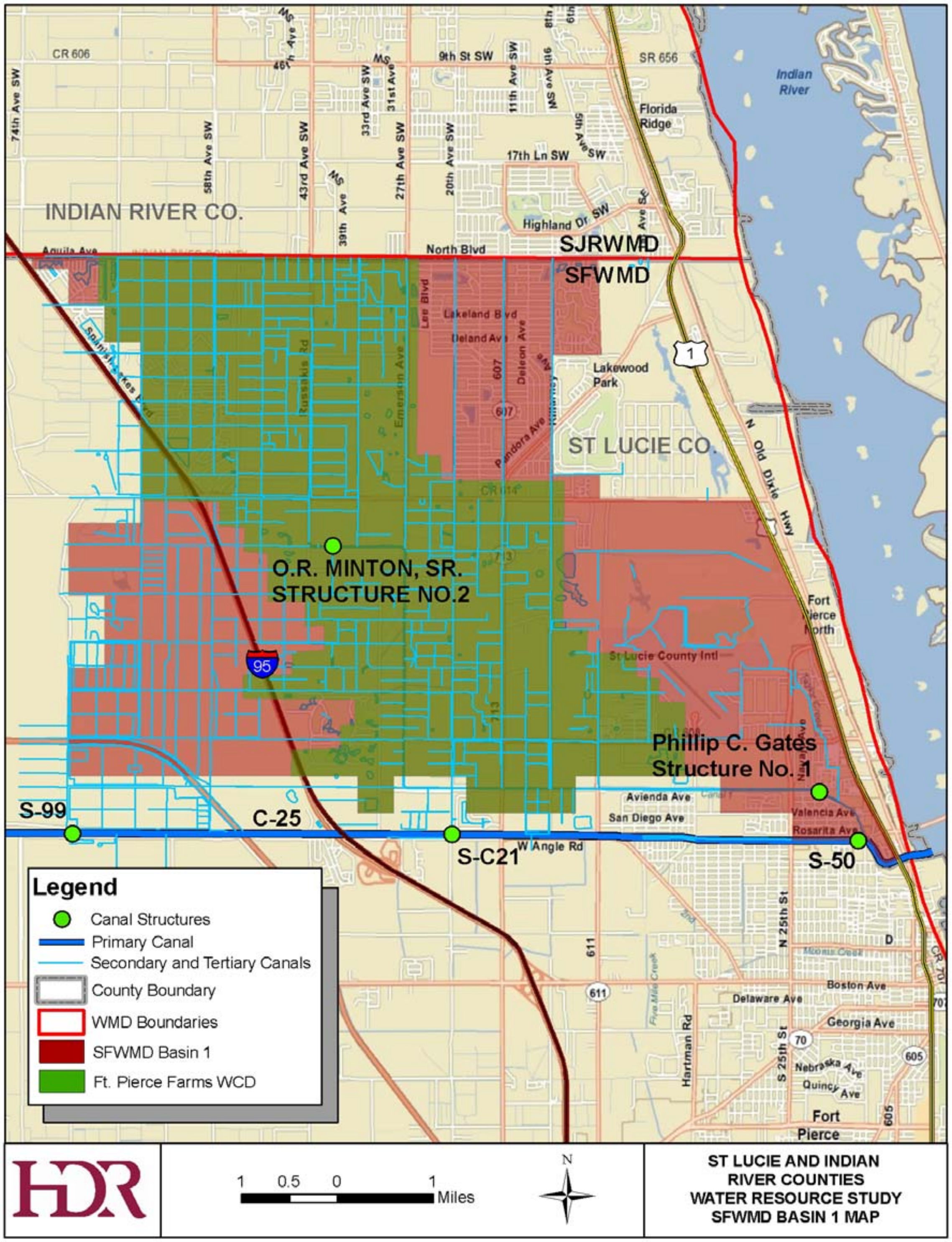



**Figure 10. Basin 1 (Ft Pierce Farms Water Control District).**

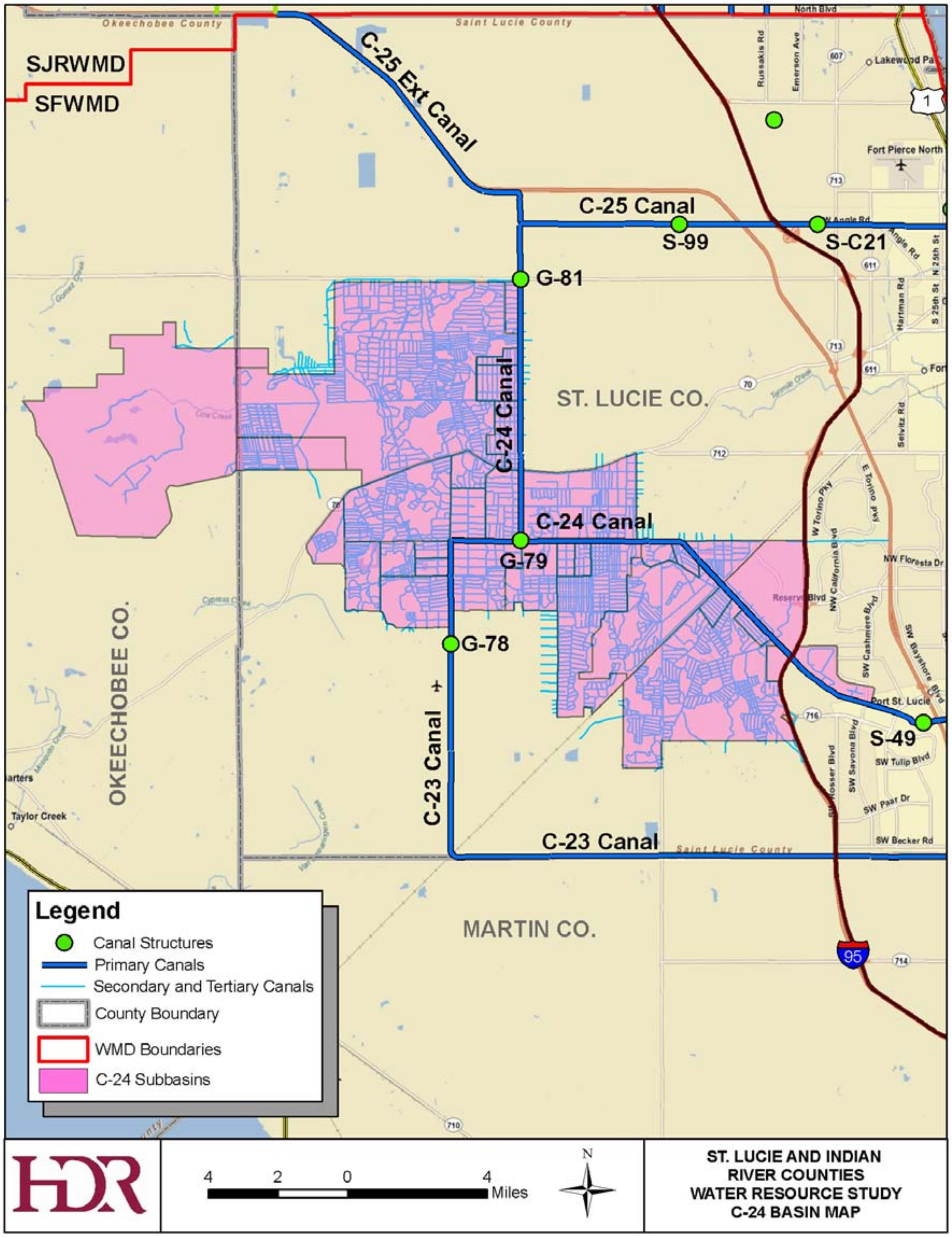



**Figure 11. C-24 Basin.**

## C-23

The C-23 Basin (***Figure 12***) is managed for water supply and flood protection. The C-23 system was designed to provide protection up to 30% of the SPF – approximately a 10-year storm event. Approximately 6% of the basin area is being utilized as privately owned agricultural reservoirs. This local storage capacity would be expected to improve the quality of the water discharged from the basin. Water may be discharged from the C-23 canal to either C-24 or the St. Lucie Estuary (USACE 1957, 1958).

## INDIAN RIVER FARMS WATER CONTROL DISTRICT

Indian River Farms Water Control District (IRFWCD) is a surface water management system which discharges directly to the IRLS. Stormwater facilities in the IRFWCD are designed for a 10-yr 24-hr storm event (***Figure 13***) (Carter 2003). There are currently three primary canals that discharge to the IRL; the North, Main and South Canals. A system of lateral and sub-lateral canals convey water to the three primary canals (IRC 2003). Four major water control structures create three sub-basins.

The Upper Sub-basin is upstream of a structure in the Lateral C canal. The water in the canals upstream of the Lateral C Structure (S-LC) is maintained at about 19 ft, NGVD in the dry season and about 17 ft, NGVD in the wet season. Downstream of S-LC in the Middle Sub-basin surface water is maintained in the system at about 16 ft, NGVD in the dry season and about 13 ft, NGVD in the wet season. The Middle Sub-basin is maintained by a structure in each of the three primary canals. Water discharged from the Middle Sub-basin enters the Lower Sub-basin. Fixed weirs or spillways, natural or man-made allow water to discharge into IRL above a fixed elevation of approximately 1.5 ft, NGVD.

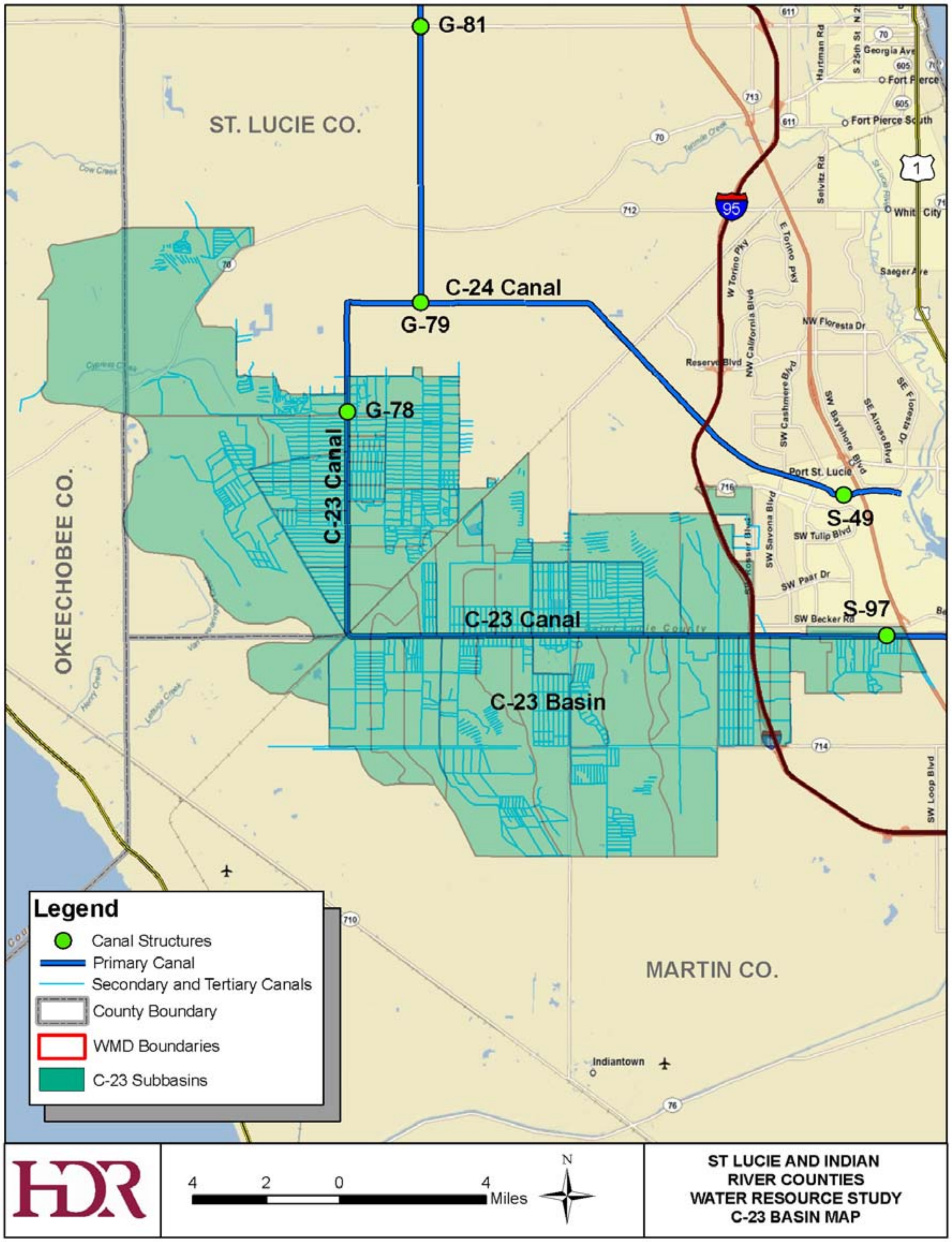



**Figure 12. C-23 Basin Map.**

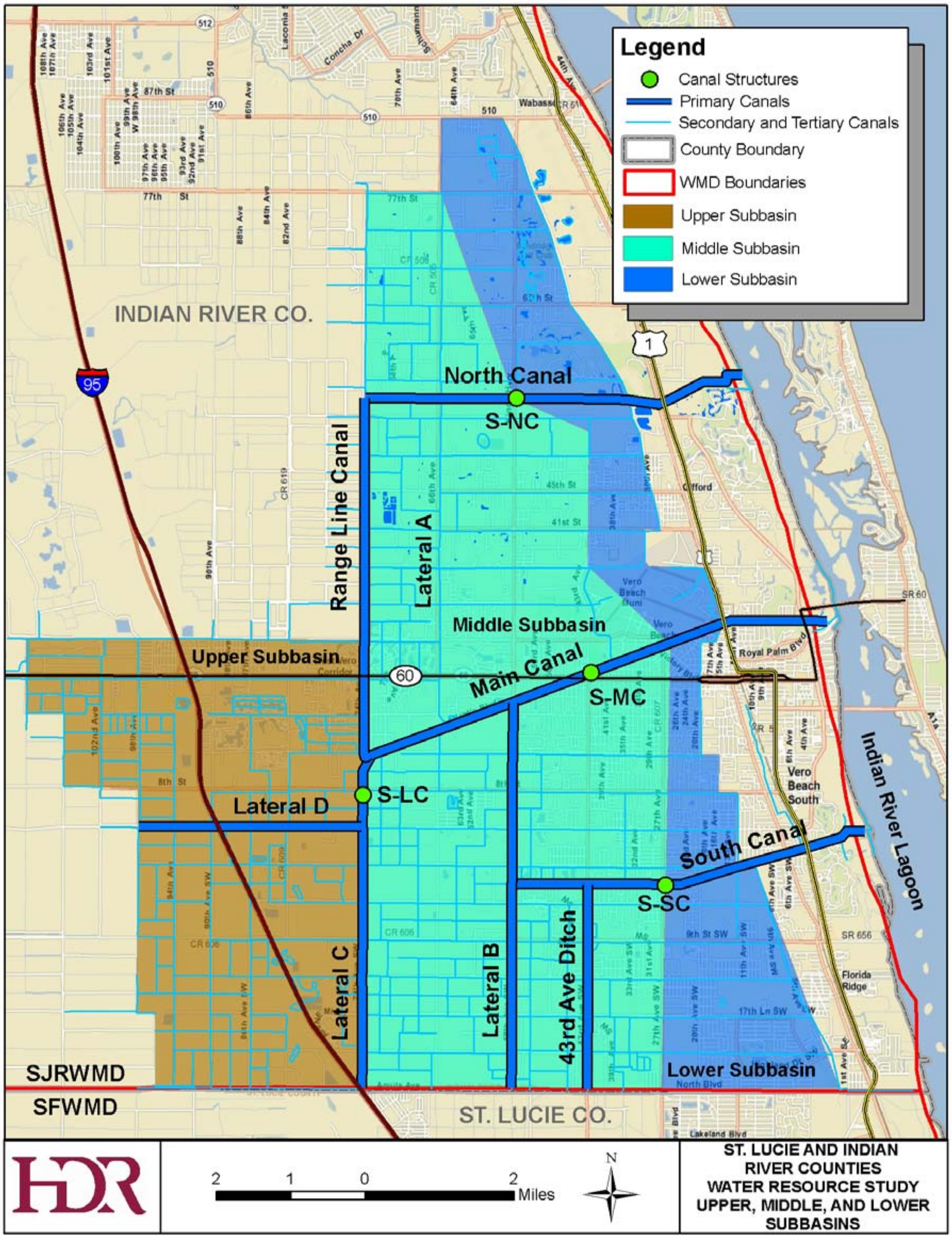



**Figure 13. Indian River Farms Water Control District (South, Main, and North Canals).**

## ST. JOHNS IMPROVEMENT DISTRICT

The St. Johns Improvement District (SJID) provides stormwater management and agricultural water supply to its 28,600 acre area. The water management system (***Figure 14***) is generally operated as a closed system, with storm water stored temporarily and then circulated for irrigation. Citrus is the largest land use in the area, currently about 22,000 acres (Personal communication with SJID Administrator).

Irrigation/runoff water within the SJID is delivered to a reservoir/wetland in the western part of the basin next to the L-79 levee and north of where the L-79 forks. This reservoir/wetland provides irrigation supply for the dry months. Water is delivered to, or from the reservoir/wetland via the Main Flow-way, a seven-mile long canal that runs east/west from the southeast corner of the reservoir/wetland. The levees that create the Main Flow-way are higher at the east end, 34 ft, MSL and lower at the west end, 31 ft, MSL (Carter 1990). The land owners may have permits to pump groundwater but the SJID does not regulate the pumping.

Discharge from the system through the SJID structure is limited by the water surface elevation in the SJID reservoir. In the dry season (winter) the gates of the SJID discharge structure are generally kept closed. Discharge during the dry season is allowed when the elevation in the reservoir is above 27.5 ft, NGVD. Since the top of the gates of the SJID structure are at 27.44 ft, NGVD, water is allowed to flow over the top of the gates. In the wet season (summer), the elevation in the reservoir must rise above 26.5 ft, NGVD before the gates can be opened (Personal communication with Bob Ulevich).

## DELTA FARMS WATER CONTROL DISTRICT

The Delta Farms WCD (DFWCD) is approximately 2,900 acres, between the SJID and the Blue Cypress Water Management Area. ***Figure 15*** provides a map showing all five water control districts in Indian River County, including DFWCD. There is an approximately 560 acre reservoir on the western edge of the DFWCD. The reservoir can discharge into a canal which runs along the east side of County Road 512 through three spillways. The rules governing the discharge of the DFWCD into the canal along the east side of CR 512 are the same as those governing the SJID discharge (Carter 2000a).

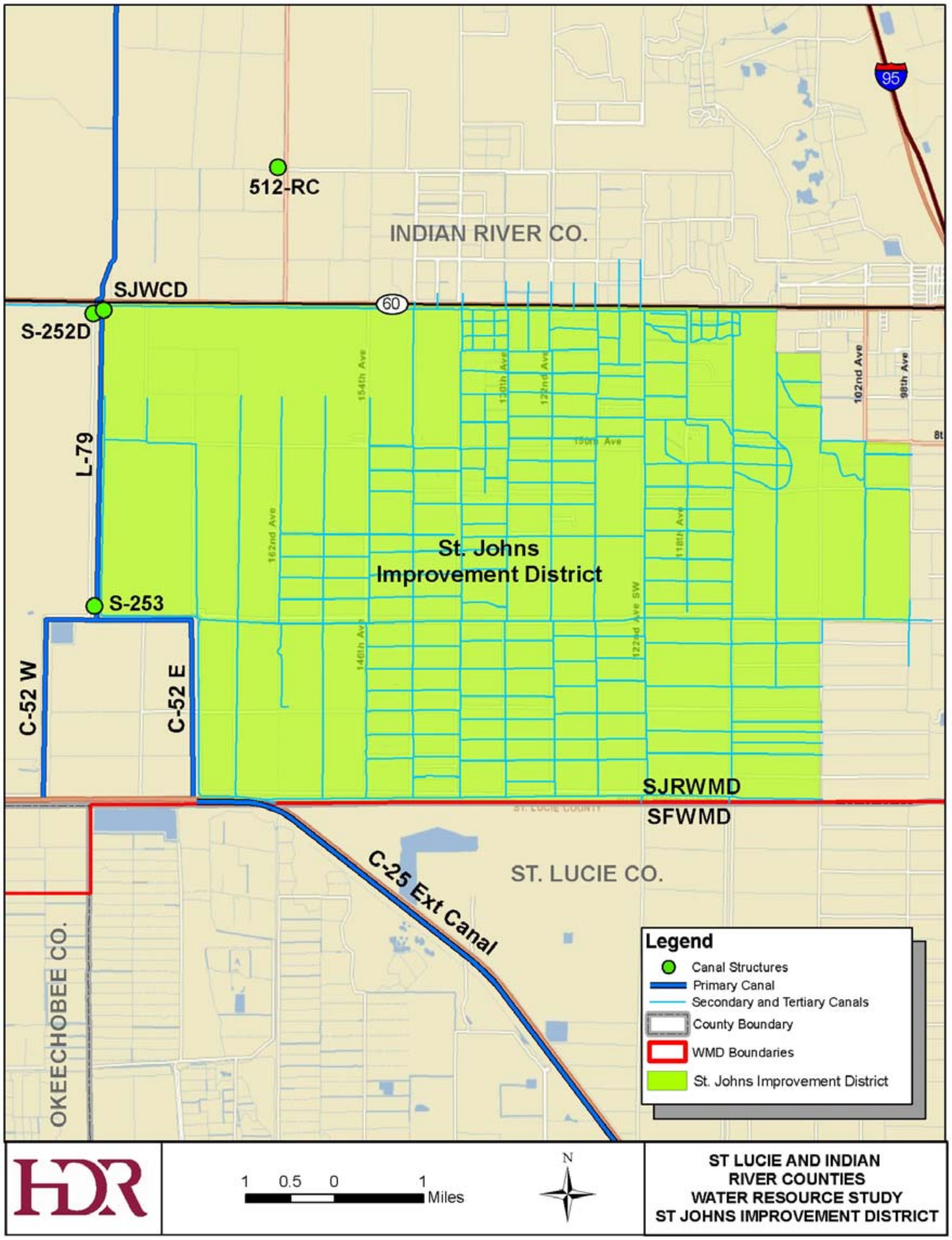



**Figure 14. St. Johns Improvement District map.**

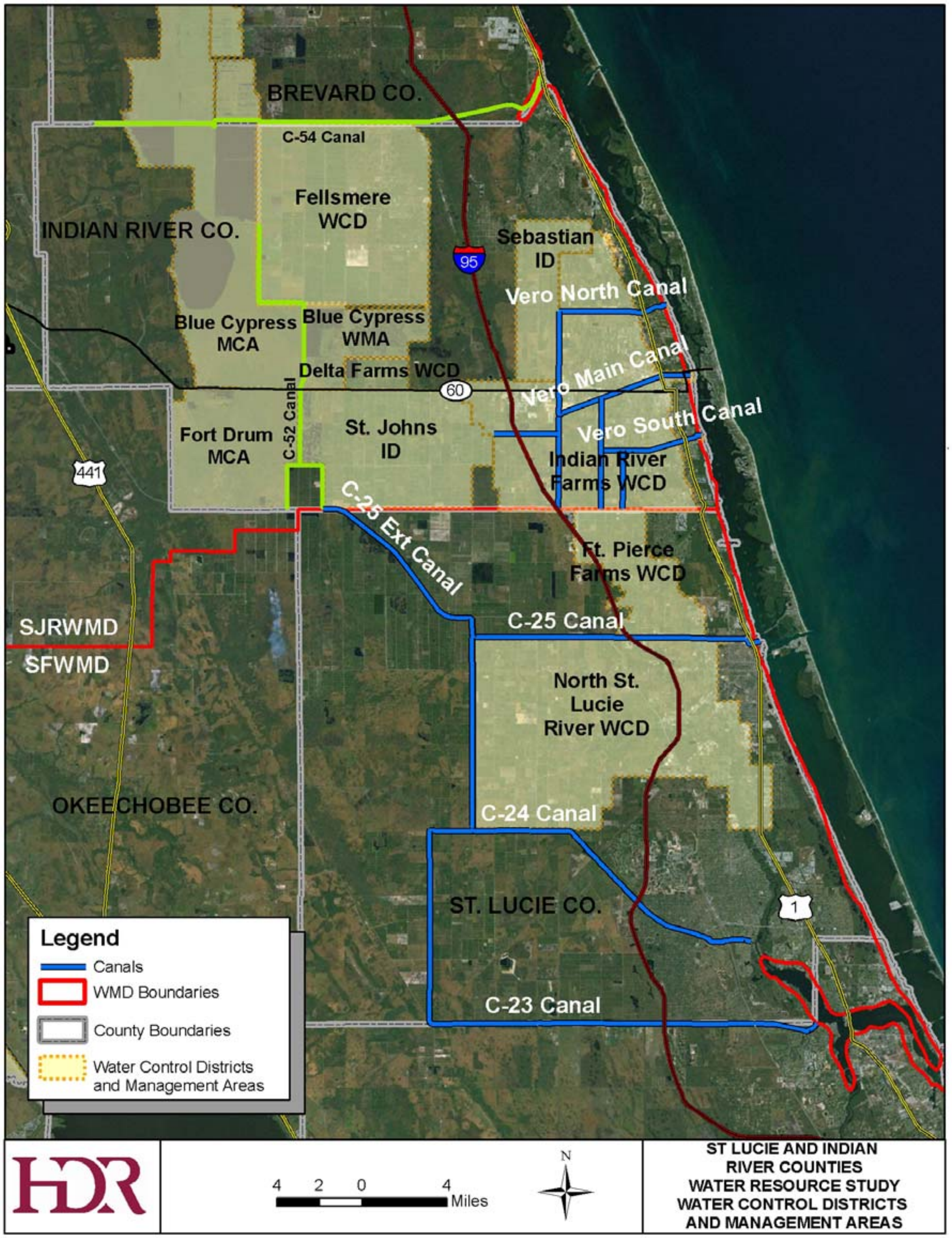



**Figure 15. Water Control Districts in Indian River and St. Lucie Counties.**

## FELLSMERE WATER CONTROL DISTRICT

A portion of the original Fellsmere Water Control District (FWCD) has been converted to St. Johns Water Management Area (SJWMA) as part of the Upper St. Johns River Basin Project. Without the SJWMA the FWCD covers about 46,100 acres (***Figure 15***). Primary land uses are citrus and sod production in addition to the town of Fellsmere. On rare occasions, when conditions allow, water may be taken from the Blue Cypress WMA to provide freeze protection of citrus crops in the FWCD. A 14,700 acre portion of the FWCD called FWCD East discharges excess surface water to the IRL via the FWCD Main canal which runs parallel to C-54. The Main canal discharges to the C-54 canal downstream of S-157. FWCD East canals called Lateral U and Park Lateral carry water to the Main Canal. The remaining FWCD area currently drains into the SJWMA or the Blue Cypress WMA, entering the Upper St. Johns River Basin Project (Carter 2000b).

## UPPER ST. JOHNS RIVER BASIN PROJECT

The Upper St. Johns River Basin Project (USJRBP) was constructed by the USACE for flood protection and environmental restoration (***Figure 5***). The project consists of culverts, weirs, spillways and levees that control the water as it moves through a system of Marsh Conservation Areas (MCA) and Water Management Areas (WMA) on its way northward to the St. Johns River. The MCAs provide temporary storage of floodwaters but primarily preserve natural wetland habitat. The WMAs provide temporary storage of floodwaters and long-term irrigation supply and water quality improvements. The structural elements of the USJRBP were designed for the Standard Project Flood (USACE 2005).

The southern-most unit of the USJRBP is the Fort Drum Marsh Conservation Area (FDMCA) which is approximately 20,635 acres. Water is discharged from the FDMCA northward into the Blue Cypress MCA (BCMCA) through the S-252 structures. The water level inside of the FDMCA can reach as high as 31.0 ft, NGVD during a Standard Project Flood (SPF) event. The BCMCA is approximately 28,796 acres including the area of Blue Cypress Lake. Water levels inside the BCWMA can rise to 26.6 ft, NGVD. The preferred BCMCA discharge is northward into the St. Johns MCA (SJMCA) through the S-250 structures or through S-96C. However, if necessary, BCMCA may discharge to the C-54 canal and east for flood control through the C-54 Retention Area.

The Blue Cypress WMA (BCWMA) is located east of the BCMCA and north of the SJID and Delta Farms Water Control District (DFWCD). The BCWMA is divided into eastern and western cells by L-77E levee and County Road 512. The sources of water are the DFWCD, SJID, C-52 Canal Basin, and FWCD. Surface water in the BCWMA generally moves from east to west and is conveyed through L-77E by S-251. During a severe storm event, when water levels in the BCWMA are too high, BCWMA can overflow into BCMCA through S-254. The BCWMA normally discharges water into C-65 between the L-76 and L-75 levees.

C-65 conveys water north to the St. Johns WMA (SJWMA). The SJWMA is approximately 6,500 acres. In addition to BCWMA discharge, the SJWMA also takes inflow from the FWCD. The SJWMA is designed to discharge into Three Forks Marsh Conservation Area (TFMCA) through S-96B. During a severe storm event, C-54 Retention Area can provide some additional storage and S-96/C-54 Canal can also provide emergency discharge into the IRL.

## C-25 Extension Basin

The C-25 Extension basin is shown ***Figure 5*** as a part of the Upper St. Johns River Basin. It is about 10,500 acres in size and is located south of the Florida Turnpike and Fort Drum Marsh Conservation Area. This basin is split roughly 50/50 between the SFWMD and SJRWMD. Flows are collected in a north/south Ft. Drum Creek Flow-way and conveyed northward to the Turnpike Canal. Flows then move to the east in the Turnpike Canal where it crosses under the Turnpike and continues in an easterly direction to the C-52 West Canal (***Figure 16***). C-52 West discharges to C-52 via the S-253 structure (Tai, 2009b). The total permitted pump discharge to the Ft. Drum Creek Flow-way is 316 cfs. C-52 East receives flow from three parcels within the SFWMD (***Figure 17***). These parcels mainly discharge to the south to C-25 but also have pumps that can discharge northward to an unnamed east/west flow-way that discharges westward to the C-52 East Canal. The total permitted pump discharge to C-52 East is 357 cfs.

Historically (prior to about 1980), discharges from the C-25 Extension Basin flowed around the west, north, and east borders of the Evans Property and were passed southward across the Turnpike via a 10' X 10' box culvert to C-25. These flows were then discharged to IRL via S-99 and S-50. However, C-25 has been plugged diverting this flow to C-52 (***Figure 18***) (Tai, 2009b). Conveyance features in the Upper St. Johns River Basin Project are not designed for flows from the C-25 Extension Basin. During severe storms, such as Tropical Storm Faye in 2008, flows from the C-25 Extension Basin exacerbate flood problems within and adjacent to the Upper St. Johns River Basin Project in Indian River County. Additionally, limited conveyance capacity results in flooding within the C-25 Extension Basin.

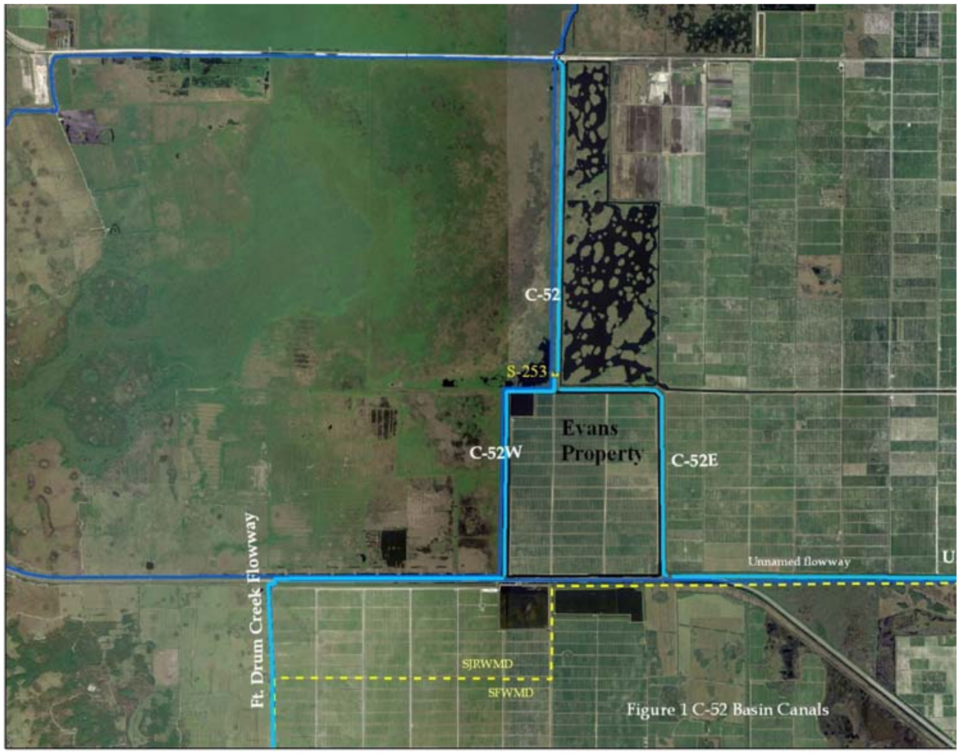


**Figure 16. Ft. Drum Creek Flowway connection to the C-52W Canal (Figure 1 from Tai, 2009b)**

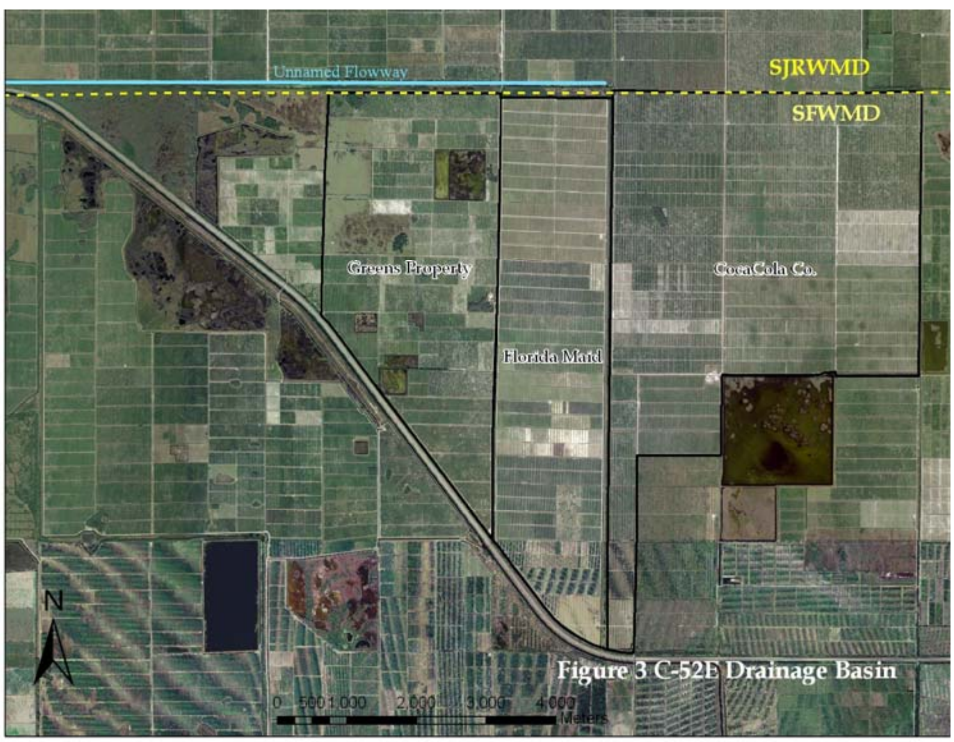


**Figure 17. C-52E drainage area (Figure 3 from Tai, 2009b).**


**Figure 18. Historic (pre-1980) connection of the C-25 Extension Basin (via C-52 East) and C-25 (Figure 5 from Tai, 2009b).**

## WATER CONTROL STRUCTURES

***Table 6*** provides design and operating information for major water control structures in the study area.

**Table 6. Water control structure design and physical descriptions.**

| Structure_Name | Levee | Design (cfs) | Design Head Water (ft, NGVD) | Design Tailwater (ft, NGVD) | Weir Crest Elevation (ft, NGVD) | **Basin** | Length (ft) | Structure Type | Number | Gated | Dimensions (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S-157 | | 6500 | 15.5 | 3.9 | 7.5 | USJRB | | Spillway | 2 | y | 25.0 x 12.5 |
| S-96(A) | L-74E | 6000 | 22.2 | 20 | 11.2 | USJRB | | Spillway | 2 | y | 25.0 x 14.3 |
| S-96B | L-74E | 1000 | 22 | 21 | 13.1 | USJRB | | Spillway | 1 | y | 20.0 x 10.9 |
| S-96C | L-74W | 1500 | 25.2 | 24.6 | 11.8 | USJRB | | Spillway | 1 | y | 25.0 x 13.7 |
| S-96D | L-75, L-76 | 1000 | 26.3 | 25.4 | 15.3 | USJRB | | Spillway | 1 | y | 15.0 x 12.6 |
| S-3 | L-75, L-76 | | | | | USJRB | | Culvert | | | |
| S-251 | L-77E | 400 | 27.6 | 27.1 | 18 | USJRB | | CMP Culvert w/ riser | 4 | | 6 |
| S-250A/B/C | L-74W | 100 | 25 | 23 | 15.5 | USJRB | | CMP Culvert w/ riser | 1 | | |
| S-250A/B/C | L-74W | 516 | 26.6 | 23.7 | 25 | USJRB | | Weir | 1 | | 135 |
| S-254 | L-77W | 2737 | 27.5 | 25.4 | 26.6 | USJRB | | Weir | 1 | | 1500 |
| S-258 | L-74E | | | | | USJRB | | Culvert | | y | |
| S-259 | L-75 | | | | | USJRB | | | | | |
| S-252A | L-78 | 300 | 27.5 | 24.4 | 16 | USJRB | | CMP Culvert | 2 | y | 5 |
| S-252B | L-78 | 200 | 26.1 | 24.2 | 16 | USJRB | | CMP Culvert | 2 | n | 5 |
| S-252C | L-78 | 100 | 26.1 | 24.2 | 16 | USJRB | | CMP Culvert | 1 | n | 5 |
| S-252D | L-79 | | | | | USJRB | | | | | |
| S-252E | L-78 | | | | | USJRB | | | | | |
| S-252F | L-78 | | | | | USJRB | | | | | |
| S-253 | L-79 | | | | 25.2 | USJRB | | Weir | | | |
| SJWCD | L-79 | | | 26.5 | | SJID | | Spillway | 1 | y | 20 |
| S-NC | | | 16 | | 8.65 | IRFWCD | | Spillway | 3 | y | 7.5 x 12.0 |
| S-MC | | | 16 | | 8.01 | IRFWCD | | Spillway | 4 | y | 8.0 x 16.0 |
| S-SC | | | 16 | | 7.24 | IRFWCD | | Spillway | 3 | y | 9.0 x 12.0 |
| S-LC | | | 19 | | 12.25 | IRFWCD | | Spillway | 3 | y | 7.5 x 12.0 |
| G-78 | | | | | 17 | C-23, C-24 | 50 | CMP Culvert | 1 | y | 6 |
| G-79 | | 195 | 22 | 20.9 | 15.75 | C-24 | 46 | CMP Culvert | 3 | y | 6 |
| G-81 | | | | | 8 | C-24, C-25 | 92 | Concrete Box-Culvert | 2 | y | 10.0 x 8.0 |
| S-50 | | 3800 | 16 | 0.7 | 12 | C-25 East | 126 | Weir | 1 | | |
| S-49 | | 4680 | 16.3 | 2.4 | 4.4 | C-24 | 34 | Spillway | 2 | y | 16.66 x 17.75 |
| S-48 | | 5035 | 13 | 0.7 | 8 | C-23 | 113 | Weir | 1 | | |
| S-97 | | 5035 | 18.5 | 14 | 7.8 | C-23 | 44 | Spillway | 2 | y | 14.2 x 22.8 |
| S-99 | | 3860 | 20 | 19.5 | 5.6 | C-25 | 50 | Spillway | 2 | y | 15.4 x 25.8 |
| S-1 | | | | | 13.6 | FPFWCD | | Spillway | 4 | y | |

# Flow Characteristics

## AVAILABLE FLOW DATA

Daily discharge data for the C-23, C-24, and C-25 Canals were downloaded from DBHYDRO, South Florida Water Management District's environmental database which stores hydrologic, meteorologic, hydrogeologic, and water quality data. Whenever more than one flow record was available for the same structure, the records were inserted or appended as needed to fill gaps or extend the period of record to the maximum extent possible. ***Table 7*** displays the selected stations and the dates of missing records. The table also provides the DBKEY used to identify a record in the DBHYDRO database.

Daily discharge data for the Indian River Farms Water Control District (IRFWCD) North, Main, and South Canals were downloaded from the U.S. Geological Survey National Water Information System (NWIS). ***Table 7*** below displays the selected stations and the dates of missing record.

Basin 1 is composed of the Ft Pierce Farms Water Control District (FPFWCD) and surrounding areas. Stormwater runoff from Basin 1 is collected and managed by the FPFWCD water management system. The FPFWCD's main discharge structure is the "Phillip C. Gates" structure, or Structure No. 1. There are no recorded flow data available for this structure.

**Table 7. Available flow data from January 1, 1965 to December 31, 2008 for study area canals in the SFWMD.**

| Canal | Structure | DBKEY(s) | Dates of Missing Record[1] | Dates of Blank Entries[2] |
|---|---|---|---|---|
| C-23 | S-48 | 4382 and JM106 | 12/24/1969 – 8/14/1995 | 9/8/1968 – 10/22/1968; 11/4/1969 – 11/11/1969; 12/24/1969 – 1/21/1970 |
| C-23 | S-97 | JW225 | None | 10/1/1968 - 10/9/1968; 3/18/1969 – 4/3/1969; 1/23/1970 – 9/30/1976; 7/18/1978 – 8/1/1978; 8/29/1978 - 9/13/1978; 5/26/1980 - 6/1/1980; 9/24/1981 - 10/15/1981; 12/28/1982 – 1/24/1983; 1/1/1990 - 3/14/1990; 5/16/1990 – 11/14/1990; 10/3/1993 - 10/18/1993 |
| C-24 | S-49 | JW223 | None | 6/16/1977 – 7/11/1977; 12/7/1978-12/13/1978; 12/28/1982 – 1/24/1983 |
| C-25 | S-50 | 4388 and 16535 | 5/18/1995 – 5/30/1995 | 7/5/1979 - 7/9/1979; 12/28/1982 – 1/24/1983; 6/5/1986 – 6/22/1986; 11/28/1993 – 12/14/1993 |
| C-25 | S-99 | 4856, 7744, and 15783 | 4/29/94 - 5/19/94 | 6/11/1981 – 6/15/1981; 12/28/1982 – 1/24/1983; 9/23/1987 – 9/27/1987; 6/1/1992 – 1/11/1993 |

**Table 8. Available flow data from January 1, 1965 to December 31, 2008 for study area canals in the SJRWMD.**

| Canal | Station ID | Dates of Missing Record[1] |
|---|---|---|
| North | 2252500 | None |
| Main | 2253000 | 10/1/2008 – 12/31/2008 |
| South | 2253500 | None |
| [1] Missing record indicates no line item exists in the record for that date. | | |

Water levels downstream of the St. Johns Improvement District are monitored at USGS Station ID 005000113, St. Johns River Headwaters at Ft. Drum. Neither the USGS nor the SJRWMD have collected discharge measurements at this location. There is no information available to create a stage-discharge rating (Email from David Clapp and Charles Tai, SJRWMD, 3-24-09).

# FLOW STATISTICS

The available flow data was compiled and analyzed on a daily and annual basis. ***Figures 19 and 20*** show the percent of time that flow rates are exceeded for the period of record at each of the structures. ***Tables 9 through 11*** report basic statistics for average daily flows on a yearly basis and for average annual flow volumes. Seasonal flow is presented in ***Tables 12 and 13*** to determine available wet season (June 1 through September 30) and dry season (October 1 through May 31) flows.

Runoff from basins in St. Lucie County appears to be more regulated than the runoff from basins in Indian River County. The median of historic daily discharges from the C-23, C-24 and C-25 basins is nearly zero, compared to the median discharges from the IRFWCD North, Main and South Canals which range between about 20 and 40 cfs (***Figures 19 and 20***).

The similarity of the daily flow-exceedance curves and the median annual and seasonal discharges for C-23, C-24 and C-25 basins (***Figure 20 and Tables 9 through 11***) also indicates that the runoff from the basins is managed collectively to discharge similar rates and volumes even though the drainage areas vary by 240% (***Table 4***). In contrast, the flow records for the three primary IRFWCD canals indicate similar historic discharge rates and volumes from the North and South Canals, which when combined, approximate the historic discharge from the Main Canal.

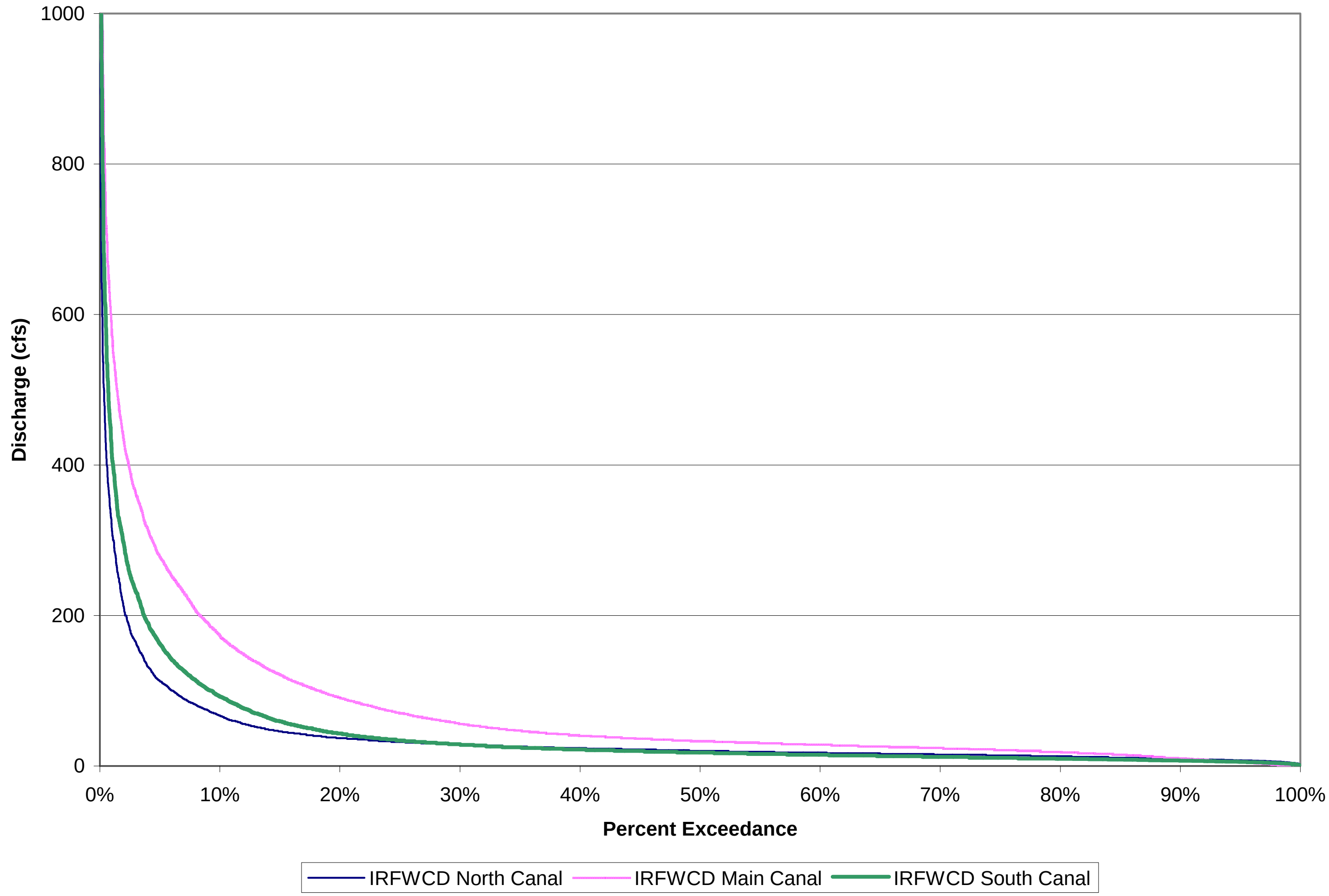



**Figure 19. Flow exceedances for discharges to the Indian River Lagoon from the North, Main, and South Canals in the IRFWCD.**

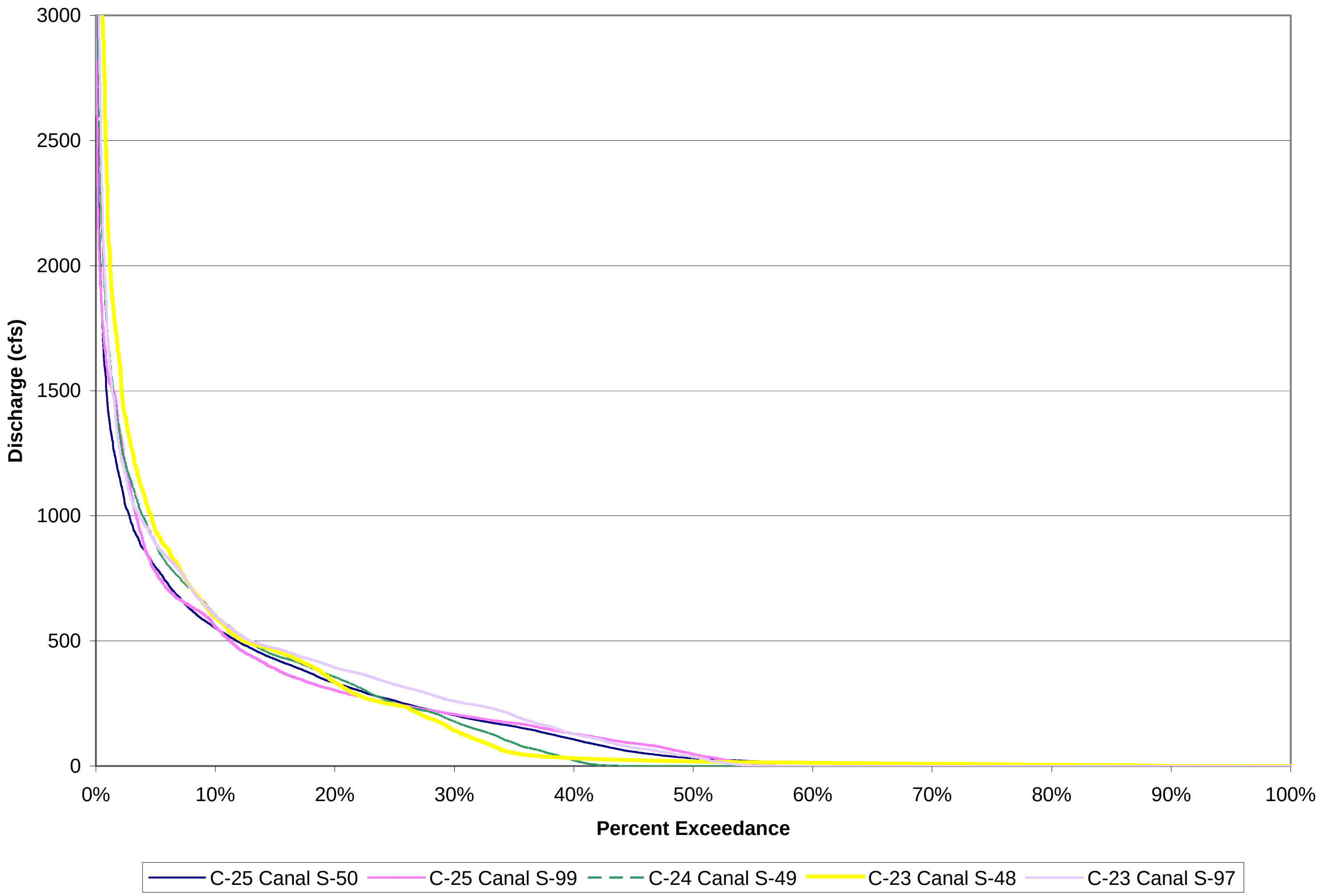



**Figure 20. Flow exceedances for discharges to the Indian River Lagoon and St. Lucie Estuary from the C-25, C-24, and C-23 Canals in the SFWMD. Maximum discharge of 5,165 cfs is not depicted.**

## Table 9. Daily flow statistics (cubic ft. per second) for canals in the SJRWMD.

| | North Canal | | | | | Main Canal | | | | | South Canal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Min | Max | Median | St Dev | Avg | Min | Max | Median | St Dev | Avg | Min | Max | Median | St Dev | Avg |
| 1965 | 4.2 | 298.0 | 8.7 | 34.3 | 20.8 | 3.0 | 500.0 | 65.0 | 70.2 | 80.1 | 2.2 | 400.0 | 15.0 | 54.3 | 37.6 |
| 1966 | 5.8 | 1020.0 | 17.0 | 104.9 | 52.2 | 4.0 | 1560.0 | 80.0 | 163.1 | 120.7 | 3.0 | 1160.0 | 43.0 | 111.7 | 65.1 |
| 1967 | 0.6 | 267.0 | 9.8 | 29.7 | 19.5 | 5.9 | 274.0 | 58.0 | 36.8 | 62.9 | 3.4 | 236.0 | 15.0 | 31.9 | 26.6 |
| 1968 | 3.6 | 929.0 | 15.0 | 108.2 | 55.0 | 4.2 | 1180.0 | 66.0 | 178.4 | 122.9 | 3.3 | 1040.0 | 14.0 | 120.2 | 54.7 |
| 1969 | 2.0 | 770.0 | 27.0 | 89.6 | 50.2 | 3.7 | 1080.0 | 75.0 | 125.3 | 109.0 | 5.0 | 668.0 | 28.0 | 84.2 | 55.3 |
| 1970 | 2.7 | 342.0 | 23.0 | 53.5 | 40.4 | 3.9 | 633.0 | 51.0 | 72.8 | 67.6 | 4.2 | 881.0 | 24.0 | 75.6 | 45.2 |
| 1971 | 5.3 | 285.0 | 17.0 | 30.5 | 24.5 | 5.4 | 359.0 | 39.0 | 59.0 | 58.9 | 1.7 | 374.0 | 15.0 | 55.1 | 33.5 |
| 1972 | 5.6 | 330.0 | 19.0 | 37.8 | 28.6 | 5.4 | 858.0 | 33.5 | 93.5 | 66.7 | 2.2 | 666.0 | 13.0 | 75.8 | 41.0 |
| 1973 | 9.2 | 523.0 | 20.0 | 57.6 | 41.2 | 8.1 | 696.0 | 41.0 | 99.5 | 84.6 | 3.6 | 965.0 | 18.0 | 108.6 | 60.5 |
| 1974 | 5.0 | 337.0 | 16.0 | 30.8 | 23.0 | 1.5 | 670.0 | 36.0 | 89.5 | 74.3 | 3.0 | 448.0 | 14.0 | 59.2 | 33.2 |
| 1975 | 2.6 | 441.0 | 14.0 | 35.3 | 21.5 | 0.3 | 465.0 | 31.0 | 77.7 | 59.6 | 1.5 | 410.0 | 13.0 | 53.0 | 29.6 |
| 1976 | 3.6 | 717.0 | 19.0 | 58.3 | 31.6 | 0.4 | 963.0 | 31.0 | 112.6 | 69.1 | 2.8 | 762.0 | 13.0 | 80.1 | 36.9 |
| 1977 | 6.8 | 360.0 | 18.0 | 29.8 | 23.4 | 0.0 | 721.0 | 30.0 | 99.1 | 65.5 | 3.5 | 513.0 | 11.0 | 56.3 | 23.7 |
| 1978 | 7.1 | 303.0 | 18.0 | 27.6 | 24.1 | 0.4 | 721.0 | 30.0 | 109.7 | 70.5 | 0.5 | 634.0 | 13.0 | 51.8 | 23.8 |
| 1979 | 8.0 | 1070.0 | 24.0 | 85.5 | 43.5 | 0.9 | 1680.0 | 34.0 | 170.3 | 91.9 | 3.5 | 1780.0 | 16.0 | 145.1 | 48.6 |
| 1980 | 7.7 | 244.0 | 15.0 | 20.9 | 20.0 | 0.0 | 425.0 | 26.0 | 71.1 | 49.2 | 3.3 | 340.0 | 11.0 | 35.2 | 18.9 |
| 1981 | 1.6 | 774.0 | 16.0 | 68.6 | 28.5 | 0.0 | 933.0 | 26.0 | 134.1 | 68.0 | 2.0 | 1070.0 | 8.1 | 112.4 | 33.1 |
| 1982 | 7.6 | 640.0 | 24.0 | 61.7 | 41.5 | 0.0 | 1030.0 | 40.0 | 157.4 | 111.1 | 2.7 | 926.0 | 19.0 | 109.7 | 55.6 |
| 1983 | 9.1 | 639.0 | 23.0 | 72.3 | 47.9 | 0.0 | 1120.0 | 33.0 | 136.7 | 91.7 | 7.4 | 1230.0 | 19.0 | 101.4 | 47.8 |
| 1984 | 8.2 | 640.0 | 19.0 | 66.2 | 34.6 | 0.0 | 1240.0 | 28.5 | 146.8 | 75.9 | 4.8 | 1170.0 | 15.0 | 112.8 | 44.5 |
| 1985 | 7.2 | 657.0 | 21.0 | 63.6 | 39.2 | 0.1 | 947.0 | 33.0 | 122.3 | 76.0 | 5.7 | 1250.0 | 20.0 | 112.0 | 50.3 |
| 1986 | 6.5 | 390.0 | 20.0 | 38.9 | 30.5 | 0.3 | 917.0 | 36.0 | 112.6 | 76.4 | 6.9 | 613.0 | 18.0 | 74.1 | 42.0 |
| 1987 | 5.7 | 487.0 | 20.0 | 50.0 | 35.6 | 1.7 | 821.0 | 31.0 | 105.9 | 66.4 | 4.5 | 680.0 | 15.0 | 70.5 | 35.0 |
| 1988 | 4.9 | 257.0 | 15.0 | 29.9 | 23.0 | 1.7 | 487.0 | 26.0 | 78.7 | 52.0 | 5.5 | 375.0 | 16.0 | 47.3 | 29.5 |
| 1989 | 2.1 | 341.0 | 14.0 | 29.2 | 20.4 | 0.1 | 805.0 | 28.0 | 93.4 | 56.5 | 2.4 | 461.0 | 15.0 | 43.6 | 25.5 |
| 1990 | 4.9 | 519.0 | 15.0 | 49.1 | 25.2 | 0.6 | 777.0 | 30.0 | 98.9 | 60.2 | 3.8 | 482.0 | 15.0 | 51.8 | 29.5 |
| 1991 | 8.8 | 1030.0 | 30.0 | 87.0 | 57.7 | 0.0 | 995.0 | 41.0 | 128.1 | 88.0 | 6.5 | 726.0 | 25.0 | 81.5 | 50.1 |
| 1992 | 3.4 | 412.0 | 17.0 | 42.9 | 28.6 | 3.0 | 1010.0 | 30.0 | 135.5 | 73.4 | 3.7 | 827.0 | 19.0 | 109.7 | 48.5 |
| 1993 | 7.6 | 739.0 | 23.0 | 66.3 | 39.0 | 3.6 | 1340.0 | 34.0 | 130.5 | 76.0 | 6.7 | 909.0 | 22.0 | 93.3 | 50.0 |
| 1994 | 11.0 | 630.0 | 28.0 | 64.8 | 47.3 | 5.7 | 1250.0 | 38.0 | 141.6 | 95.1 | 4.4 | 1270.0 | 24.0 | 118.7 | 59.5 |
| 1995 | 9.2 | 348.0 | 20.0 | 35.5 | 30.6 | 2.9 | 682.0 | 24.0 | 93.1 | 57.5 | 6.9 | 553.0 | 22.0 | 67.2 | 41.4 |
| 1996 | 5.1 | 460.0 | 20.0 | 48.7 | 35.5 | 2.9 | 778.0 | 24.0 | 111.7 | 64.2 | 11.0 | 573.0 | 24.0 | 77.8 | 49.8 |
| 1997 | 8.6 | 400.0 | 23.0 | 43.5 | 36.7 | 1.5 | 593.0 | 22.0 | 77.6 | 49.8 | 1.6 | 536.0 | 17.0 | 55.4 | 33.9 |
| 1998 | 8.1 | 647.0 | 28.0 | 74.1 | 46.3 | 1.1 | 960.0 | 28.0 | 121.2 | 71.9 | 4.4 | 623.0 | 18.0 | 82.4 | 48.3 |
| 1999 | 4.3 | 800.0 | 21.0 | 84.4 | 41.8 | 0.6 | 1360.0 | 27.0 | 126.3 | 62.4 | 1.2 | 1190.0 | 10.0 | 97.6 | 36.3 |
| 2000 | 13.0 | 1210.0 | 20.0 | 86.3 | 35.7 | 2.1 | 730.0 | 26.0 | 75.4 | 43.3 | 2.1 | 1250.0 | 17.0 | 79.6 | 30.7 |
| 2001 | 13.0 | 522.0 | 23.0 | 58.8 | 40.8 | 4.4 | 585.0 | 32.0 | 89.9 | 61.8 | 1.1 | 453.0 | 18.0 | 60.9 | 35.9 |
| 2002 | 11.0 | 650.0 | 25.0 | 75.6 | 50.7 | 4.2 | 735.0 | 30.0 | 115.8 | 73.6 | 3.7 | 700.0 | 23.0 | 72.6 | 48.7 |
| 2003 | 11.0 | 419.0 | 25.0 | 42.1 | 36.6 | 0.9 | 736.0 | 38.0 | 85.4 | 64.0 | 3.5 | 418.0 | 20.0 | 58.1 | 39.3 |
| 2004 | 7.1 | 851.0 | 26.0 | 72.6 | 40.2 | 2.3 | 1930.0 | 38.0 | 229.4 | 102.8 | 1.8 | 2100.0 | 19.0 | 194.3 | 71.9 |
| 2005 | 13.0 | 627.0 | 36.0 | 52.9 | 49.6 | 1.4 | 1170.0 | 54.0 | 123.8 | 96.1 | 0.3 | 676.0 | 35.0 | 79.4 | 57.9 |
| 2006 | 7.5 | 422.0 | 19.0 | 27.9 | 24.6 | 1.0 | 345.0 | 29.0 | 34.4 | 34.7 | 0.5 | 344.0 | 27.0 | 35.4 | 36.0 |
| 2007 | 9.4 | 588.0 | 34.0 | 46.2 | 43.4 | 0.2 | 850.0 | 17.0 | 78.3 | 46.3 | 0.7 | 609.0 | 22.0 | 52.4 | 36.6 |
| 2008 | 7.9 | 915.0 | 30.0 | 85.5 | 49.9 | 0.0 | 768.0 | 4.1 | 73.1 | 17.1 | 1.0 | 783.0 | 31.0 | 93.4 | 58.8 |
| Avg. | 6.7 | 573.9 | 20.8 | 55.9 | 35.9 | 2.0 | 879.1 | 35.8 | 108.8 | 71.9 | 3.5 | 774.4 | 18.8 | 80.5 | 42.3 |

**Table 10. Daily flow statistics (cubic ft. per second) for canals in the SFWMD. Blank cells indicated insufficient flow data to compute statistics.**

| | C-25 S-50 | | | | | C-25 S-99 | | | | | C-24 S-49 | | | | | C-23 S-48 | | | | | C-23 S-97 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Min | Max | Median | St Dev | Avg | Min | Max | Median | St Dev | Avg | Min | Max | Median | St Dev | Avg | Min | Max | Median | St Dev | Avg | Min | Max | Median | St Dev | Avg |
| 1965 | 0.0 | 1343.1 | 44.9 | 176.6 | 121.1 | 0.0 | 832.6 | 0.0 | 114.8 | 64.3 | 0.0 | 1071.7 | 0.0 | 158.4 | 60.2 | 0.3 | 1069.4 | 15.7 | 178.9 | 99.1 | 0.0 | 1493.0 | 0.0 | 234.1 | 126.9 |
| 1966 | 0.0 | 1845.0 | 258.5 | 280.1 | 317.7 | 0.0 | 1424.2 | 132.4 | 206.2 | 181.6 | 0.0 | 2449.9 | 0.0 | 341.5 | 185.8 | 5.6 | 2895.6 | 153.9 | 433.1 | 325.3 | 0.0 | 2790.0 | 117.0 | 439.8 | 322.1 |
| 1967 | 0.0 | 1263.8 | 13.0 | 195.4 | 111.8 | 0.0 | 791.0 | 0.0 | 115.7 | 55.5 | 0.0 | 2832.0 | 0.0 | 215.0 | 59.7 | 1.1 | 1142.4 | 19.5 | 174.5 | 89.3 | 0.0 | 1097.0 | 11.0 | 171.4 | 87.3 |
| 1968 | 0.0 | 2045.1 | 72.2 | 354.9 | 244.5 | 0.0 | 2196.7 | 66.7 | 747.3 | 620.9 | 0.0 | 2971.1 | 1.4 | 477.4 | 225.4 | 0.0 | 3030.9 | 26.6 | 479.2 | 238.4 | 0.0 | 3171.0 | 0.0 | 464.1 | 243.1 |
| 1969 | 0.0 | 1616.9 | 249.7 | 321.0 | 336.7 | 0.0 | 1830.3 | 71.4 | 268.8 | 186.9 | 0.0 | 2579.4 | 204.7 | 467.7 | 390.1 | 13.9 | 3546.0 | 156.9 | 460.0 | 344.6 | 0.0 | 3256.0 | 160.5 | 396.7 | 288.2 |
| 1970 | 0.0 | 1387.8 | 115.5 | 200.0 | 166.1 | 0.0 | 1309.7 | 642.6 | 286.9 | 542.1 | 0.0 | 2708.3 | 42.9 | 360.4 | 228.7 | | | | | | 0.0 | 1403.8 | 511.4 | 382.9 | 507.7 |
| 1971 | 0.0 | 1033.9 | 28.0 | 231.3 | 181.7 | 0.0 | 860.5 | 422.5 | 214.5 | 422.6 | 0.0 | 1024.3 | 0.0 | 209.6 | 121.5 | | | | | | | | | | |
| 1972 | 0.0 | 1365.6 | 26.7 | 205.5 | 133.4 | 0.0 | 793.8 | 39.3 | 111.0 | 80.9 | 0.0 | 1117.0 | 18.2 | 167.8 | 97.8 | | | | | | | | | | |
| 1973 | 0.0 | 1020.5 | 165.7 | 269.1 | 266.7 | 0.0 | 1471.7 | 173.2 | 262.4 | 199.3 | 0.0 | 1091.4 | 72.7 | 200.9 | 158.6 | | | | | | | | | | |
| 1974 | 0.0 | 1305.2 | 34.1 | 343.3 | 226.4 | 0.0 | 1401.5 | 32.5 | 228.8 | 140.9 | 0.0 | 1110.0 | 0.0 | 287.3 | 161.2 | | | | | | | | | | |
| 1975 | 0.0 | 918.7 | 91.6 | 167.0 | 145.4 | 0.0 | 700.6 | 47.4 | 116.5 | 87.0 | 0.0 | 1156.8 | 0.0 | 192.5 | 118.7 | | | | | | | | | | |
| 1976 | 0.0 | 1253.2 | 17.1 | 217.6 | 145.8 | 0.0 | 754.8 | 105.7 | 159.1 | 140.8 | 0.0 | 1705.3 | 26.6 | 224.2 | 138.6 | | | | | | 0.0 | 711.8 | 2.7 | 151.0 | 86.8 |
| 1977 | 0.0 | 1155.5 | 2.3 | 148.9 | 69.3 | 0.0 | 1145.3 | 0.0 | 267.8 | 169.1 | 0.0 | 1381.0 | 0.0 | 169.1 | 80.3 | | | | | | 0.0 | 1507.6 | 13.6 | 219.8 | 130.6 |
| 1978 | 0.0 | 1065.5 | 23.6 | 175.6 | 120.2 | 0.0 | 1605.8 | 90.2 | 290.8 | 185.4 | 0.0 | 1125.6 | 0.0 | 167.2 | 97.5 | | | | | | 0.0 | 1530.7 | 55.2 | 193.5 | 141.5 |
| 1979 | 0.0 | 2034.8 | 7.1 | 332.8 | 193.1 | 0.0 | 1159.1 | 119.9 | 174.0 | 157.5 | 0.0 | 2899.2 | 117.2 | 407.2 | 244.7 | | | | | | 0.0 | 1821.6 | 181.0 | 229.8 | 235.7 |
| 1980 | 0.0 | 731.5 | 0.0 | 101.8 | 46.2 | 0.0 | 690.9 | 6.6 | 116.7 | 89.0 | 0.0 | 977.7 | 0.0 | 112.0 | 38.8 | | | | | | 193.7 | 821.0 | 311.5 | 97.3 | 331.0 |
| 1981 | 0.0 | 1151.0 | 0.7 | 183.1 | 71.1 | 0.0 | 658.3 | 0.0 | 137.7 | 94.6 | 0.0 | 1784.1 | 0.0 | 197.1 | 62.7 | | | | | | 0.0 | 1615.3 | 367.4 | 236.2 | 315.2 |
| 1982 | 0.0 | 1493.9 | 178.6 | 280.9 | 251.7 | 0.0 | 958.9 | 185.7 | 152.5 | 203.1 | 0.0 | 3022.0 | 142.7 | 462.4 | 339.5 | | | | | | 0.0 | 3147.0 | 269.1 | 348.9 | 327.0 |
| 1983 | 0.0 | 1665.1 | 220.2 | 273.5 | 264.8 | 0.0 | 913.9 | 86.6 | 155.3 | 133.3 | 0.0 | 2865.3 | 73.9 | 379.4 | 265.8 | | | | | | 26.2 | 1942.4 | 131.1 | 282.6 | 239.7 |
| 1984 | 0.0 | 1317.1 | 32.1 | 183.6 | 137.2 | 0.0 | 842.2 | 111.1 | 139.5 | 145.7 | 0.0 | 1665.7 | 0.0 | 261.0 | 142.2 | | | | | | 0.0 | 1219.3 | 109.9 | 133.7 | 125.3 |
| 1985 | 0.0 | 2138.7 | 19.2 | 284.5 | 167.4 | 0.0 | 1129.0 | 86.9 | 161.7 | 127.3 | 0.0 | 2653.7 | 0.0 | 339.2 | 176.3 | | | | | | 0.0 | 2312.9 | 81.8 | 241.0 | 180.9 |
| 1986 | 0.0 | 1771.1 | 17.3 | 252.8 | 147.4 | 0.0 | 1186.4 | 128.0 | 168.2 | 153.7 | 0.0 | 1465.7 | 0.0 | 244.5 | 137.4 | | | | | | 0.0 | 1915.9 | 531.8 | 299.0 | 597.3 |
| 1987 | 0.0 | 1989.2 | 6.0 | 238.4 | 124.4 | 0.0 | 1344.2 | 97.9 | 207.8 | 164.0 | 0.0 | 2182.3 | 0.0 | 293.9 | 121.9 | | | | | | 0.0 | 2739.0 | 115.3 | 445.6 | 328.9 |
| 1988 | 0.0 | 1034.0 | 3.5 | 172.3 | 96.4 | 0.0 | 1380.9 | 101.1 | 198.4 | 154.8 | 0.0 | 899.0 | 0.0 | 169.7 | 74.3 | | | | | | 0.0 | 790.4 | 26.6 | 165.3 | 105.1 |
| 1989 | 0.0 | 1146.0 | 0.1 | 174.5 | 91.9 | 0.0 | 1312.6 | 0.0 | 204.8 | 134.6 | 0.0 | 1831.8 | 0.0 | 219.3 | 87.5 | | | | | | 0.0 | 982.6 | 0.0 | 155.3 | 76.6 |
| 1990 | 0.0 | 1750.6 | 4.6 | 304.6 | 171.3 | 0.0 | 2045.3 | 0.0 | 332.2 | 178.0 | 0.0 | 2934.1 | 0.0 | 430.3 | 189.7 | | | | | | 0.0 | 1.6 | 0.0 | 0.2 | 0.0 |
| 1991 | 0.0 | 1615.0 | 187.0 | 269.2 | 253.4 | 0.0 | 1867.0 | 196.0 | 299.7 | 251.8 | 0.0 | 1632.9 | 172.8 | 356.3 | 282.2 | | | | | | 0.0 | 1465.6 | 56.7 | 313.8 | 236.9 |
| 1992 | 0.0 | 3195.2 | 10.1 | 399.9 | 205.2 | 0.0 | 867.4 | 0.0 | 107.9 | 17.7 | 0.0 | 2553.4 | 0.0 | 415.3 | 221.0 | | | | | | 0.0 | 3600.1 | 67.3 | 497.2 | 292.2 |
| 1993 | 0.0 | 2579.1 | 95.7 | 378.6 | 244.6 | 0.0 | 1448.6 | 0.0 | 213.0 | 113.8 | 0.0 | 2579.2 | 79.9 | 408.5 | 271.3 | | | | | | 0.0 | 2150.7 | 120.0 | 370.1 | 246.1 |
| 1994 | 0.0 | 2413.4 | 199.6 | 334.4 | 305.9 | 0.0 | 2197.5 | 199.7 | 344.4 | 305.6 | 0.0 | 2771.6 | 310.4 | 435.1 | 392.3 | | | | | | 0.0 | 3327.7 | 243.7 | 485.3 | 387.5 |
| 1995 | 0.0 | 2557.0 | 93.4 | 439.4 | 289.5 | 0.0 | 2083.0 | 98.6 | 377.0 | 253.7 | 0.0 | 3900.5 | 2.1 | 590.8 | 348.5 | 8.9 | 4606.4 | 41.9 | 1062.7 | 739.3 | 0.0 | 4550.0 | 0.0 | 755.3 | 350.9 |
| 1996 | 0.0 | 2249.1 | 19.2 | 275.6 | 146.9 | 0.0 | 1846.4 | 0.0 | 283.6 | 151.3 | 0.0 | 2107.8 | 0.0 | 287.1 | 145.4 | 2.7 | 2468.9 | 18.2 | 274.0 | 132.2 | 0.0 | 2401.7 | 0.0 | 265.1 | 114.3 |
| 1997 | 0.0 | 1946.6 | 45.5 | 290.8 | 202.7 | 0.0 | 1993.9 | 0.0 | 311.8 | 197.6 | 0.0 | 1969.7 | 1.7 | 318.5 | 216.5 | 3.2 | 1202.9 | 19.3 | 228.9 | 144.4 | 0.0 | 1162.4 | 0.0 | 228.0 | 132.1 |
| 1998 | 1.2 | 2285.9 | 53.5 | 348.1 | 238.0 | 0.0 | 2474.2 | 0.0 | 373.2 | 223.9 | 0.0 | 2323.2 | 2.2 | 393.7 | 257.2 | 0.7 | 3125.6 | 23.0 | 390.1 | 191.1 | 0.0 | 3125.7 | 0.0 | 380.3 | 172.3 |
| 1999 | 0.0 | 3110.6 | 14.6 | 475.8 | 262.3 | 0.0 | 4554.6 | 0.0 | 522.9 | 268.2 | 0.0 | 3379.7 | 0.0 | 496.0 | 285.6 | 0.0 | 4173.5 | 13.0 | 532.9 | 241.7 | 0.0 | 3740.1 | 0.0 | 504.4 | 223.8 |
| 2000 | 0.0 | 1303.1 | 2.7 | 151.1 | 56.3 | 0.0 | 1330.4 | 0.0 | 150.5 | 51.8 | 0.0 | 1644.0 | 0.0 | 202.5 | 69.2 | 0.0 | 1779.5 | 3.8 | 158.0 | 55.3 | 0.0 | 1716.6 | 0.0 | 155.4 | 49.2 |
| 2001 | 0.0 | 2313.3 | 9.3 | 451.1 | 249.1 | 0.0 | 2361.2 | 0.0 | 478.4 | 251.6 | 0.0 | 2459.1 | 2.1 | 478.1 | 272.7 | 0.0 | 2408.8 | 22.4 | 342.9 | 185.0 | 0.0 | 2440.7 | 0.0 | 323.3 | 166.5 |
| 2002 | 0.0 | 2053.4 | 9.0 | 404.1 | 208.6 | 0.0 | 2311.0 | 0.0 | 447.7 | 211.7 | 0.0 | 1905.3 | 0.0 | 362.1 | 212.1 | 0.0 | 1652.9 | 11.6 | 300.3 | 163.5 | 0.0 | 1556.1 | 0.0 | 293.7 | 154.0 |
| 2003 | 0.0 | 1499.1 | 30.7 | 272.5 | 163.5 | 0.0 | 1665.6 | 0.0 | 288.8 | 152.1 | 0.0 | 1774.3 | 0.0 | 338.6 | 220.0 | 1.9 | 2294.9 | 15.0 | 333.4 | 203.5 | 0.0 | 2225.5 | 0.0 | 328.0 | 194.6 |
| 2004 | 0.0 | 4565.5 | 8.7 | 793.5 | 316.7 | 0.0 | 4008.8 | 0.0 | 624.1 | 278.1 | 0.0 | 4003.5 | 0.0 | 712.5 | 302.1 | 0.0 | 4843.1 | 7.5 | 772.8 | 284.9 | 0.0 | 5165.6 | 0.0 | 740.0 | 257.4 |
| 2005 | 0.0 | 2565.1 | 164.4 | 462.0 | 347.7 | 0.0 | 2719.4 | 165.0 | 488.4 | 339.8 | 0.0 | 3448.0 | 221.4 | 568.2 | 386.8 | 0.0 | 3974.6 | 254.3 | 624.3 | 437.1 | 0.0 | 4141.5 | 239.0 | 617.0 | 416.2 |
| 2006 | 0.0 | 658.7 | 10.1 | 118.0 | 53.9 | 0.0 | 712.5 | 0.0 | 108.9 | 40.1 | 0.0 | 1370.9 | 0.0 | 181.3 | 69.1 | 0.0 | 1721.3 | 5.7 | 228.5 | 86.4 | 0.0 | 1400.2 | 0.0 | 178.5 | 62.4 |
| 2007 | 0.0 | 2017.8 | 47.7 | 284.6 | 177.1 | 0.0 | 1983.6 | 0.0 | 276.7 | 147.7 | 0.0 | 2123.6 | 0.0 | 304.4 | 150.2 | 0.0 | 1657.9 | 9.0 | 238.7 | 126.6 | 0.0 | 1492.0 | 0.0 | 229.3 | 117.6 |
| 2008 | 0.0 | 2963.1 | 40.2 | 467.3 | 215.0 | 0.0 | 2836.2 | 0.0 | 447.3 | 172.1 | 0.0 | 3629.1 | 0.0 | 514.7 | 196.9 | 0.6 | 4442.2 | 16.8 | 502.1 | 163.8 | 0.0 | 3857.1 | 0.0 | 447.8 | 140.7 |
| Avg. | 0.0 | 1789.4 | 60.8 | 288.3 | 188.3 | 0.0 | 1590.9 | 77.4 | 265.5 | 187.3 | 0.0 | 2160.9 | 33.9 | 330.0 | 188.7 | 2.1 | 2738.8 | 43.9 | 406.1 | 223.8 | 5.6 | 2199.7 | 95.5 | 318.0 | 218.2 |

**Table 11. Annual flow statistics (acre-ft.). Blank cells indicate insufficient flow data to compute statistics.**

| Year | North Canal | Main Canal | South Canal | C-25 Canal S-50 | C-25 Canal S-99 | C-24 Canal S-49 | C-23 Canal S-48 | C-23 Canal S-97 |
|---|---|---|---|---|---|---|---|---|
| 1965 | 15,059 | 57,996 | 27,234 | 87,655 | 46,551 | 43,571 | 71,748 | 91,892 |
| 1966 | 37,772 | 87,419 | 47,140 | 229,987 | 131,463 | 134,484 | 235,526 | 233,188 |
| 1967 | 14,110 | 45,550 | 19,256 | 80,951 | 39,954 | 43,205 | 64,618 | 63,232 |
| 1968 | 39,899 | 89,205 | 39,735 | 177,480 | 448,290 | 163,615 | 151,792 | 172,155 |
| 1969 | 36,311 | 78,910 | 40,022 | 243,784 | 135,288 | 282,414 | 238,515 | 198,898 |
| 1970 | 29,217 | 48,959 | 32,744 | 120,259 | 392,436 | 165,587 | | |
| 1971 | 17,765 | 42,650 | 24,271 | 131,515 | 305,948 | 87,932 | | |
| 1972 | 20,770 | 48,421 | 29,729 | 96,825 | 58,749 | 70,970 | | |
| 1973 | 29,859 | 61,256 | 43,787 | 193,054 | 144,270 | 114,833 | | |
| 1974 | 16,652 | 53,788 | 24,043 | 163,896 | 101,989 | 116,675 | | |
| 1975 | 15,534 | 43,155 | 21,424 | 105,278 | 62,984 | 85,902 | | |
| 1976 | 22,921 | 50,139 | 26,780 | 105,858 | 102,226 | 100,627 | | |
| 1977 | 16,960 | 47,400 | 17,173 | 50,168 | 122,392 | 53,977 | | 94,557 |
| 1978 | 17,418 | 51,071 | 17,204 | 86,994 | 134,260 | 69,205 | | 93,718 |
| 1979 | 31,499 | 66,527 | 35,169 | 137,884 | 114,045 | 177,192 | | 170,656 |
| 1980 | 14,547 | 35,713 | 13,742 | 33,524 | 64,603 | 28,135 | | 235,668 |
| 1981 | 20,633 | 49,265 | 23,969 | 51,490 | 67,585 | 45,414 | | 214,455 |
| 1982 | 30,064 | 80,437 | 40,285 | 180,216 | 145,418 | 243,091 | | 234,119 |
| 1983 | 34,686 | 66,413 | 34,606 | 179,127 | 90,128 | 179,780 | | 162,123 |
| 1984 | 25,123 | 55,071 | 32,274 | 99,593 | 105,790 | 103,204 | | 90,941 |
| 1985 | 28,377 | 55,006 | 36,423 | 121,230 | 92,172 | 127,627 | | 130,245 |
| 1986 | 22,080 | 55,314 | 30,422 | 101,479 | 111,280 | 99,503 | | 432,446 |
| 1987 | 25,775 | 48,049 | 25,317 | 90,057 | 115,485 | 88,266 | | 238,082 |
| 1988 | 16,726 | 37,752 | 21,422 | 69,958 | 112,377 | 53,943 | | 76,289 |
| 1989 | 14,781 | 40,914 | 18,486 | 66,511 | 97,451 | 63,343 | | 55,479 |
| 1990 | 18,227 | 43,582 | 21,335 | 124,014 | 128,904 | 137,366 | | |
| 1991 | 41,790 | 63,724 | 36,292 | 183,422 | 182,279 | 204,326 | | 171,516 |
| 1992 | 20,777 | 53,285 | 35,180 | 148,961 | | 160,427 | | 212,130 |
| 1993 | 28,247 | 54,991 | 36,174 | 168,343 | 76,771 | 196,383 | | 170,363 |
| 1994 | 34,267 | 68,879 | 43,048 | 221,429 | 207,907 | 283,986 | | 280,539 |
| 1995 | 22,166 | 41,621 | 30,001 | 202,127 | 183,693 | 252,271 | 203,824 | 254,032 |
| 1996 | 25,754 | 46,624 | 36,118 | 106,659 | 109,872 | 105,520 | 95,970 | 82,968 |
| 1997 | 26,555 | 36,046 | 24,578 | 146,741 | 143,070 | 156,766 | 104,576 | 95,665 |
| 1998 | 33,549 | 52,086 | 34,937 | 172,311 | 162,106 | 186,205 | 138,365 | 124,718 |
| 1999 | 30,240 | 45,147 | 26,275 | 189,892 | 194,196 | 206,768 | 174,989 | 162,010 |
| 2000 | 25,910 | 31,427 | 22,281 | 40,899 | 37,635 | 50,256 | 40,155 | 35,717 |
| 2001 | 29,507 | 44,738 | 25,960 | 180,361 | 182,184 | 197,447 | 133,958 | 120,528 |
| 2002 | 36,675 | 53,259 | 35,222 | 151,001 | 153,244 | 153,572 | 118,349 | 111,492 |
| 2003 | 26,492 | 46,333 | 28,460 | 118,395 | 110,085 | 159,271 | 147,305 | 140,904 |
| 2004 | 29,210 | 74,644 | 52,181 | 228,688 | 201,353 | 219,330 | 206,791 | 186,876 |
| 2005 | 35,927 | 69,540 | 41,936 | 251,711 | 246,002 | 280,010 | 316,428 | 301,308 |
| 2006 | 17,843 | 25,150 | 26,093 | 39,043 | 29,015 | 50,003 | 62,523 | 45,173 |
| 2007 | 31,454 | 33,508 | 26,416 | 128,237 | 106,951 | 108,719 | 91,640 | 85,134 |
| 2008 | 36,198 | 9,267 | 42,553 | 156,096 | 124,966 | 142,921 | 118,942 | 102,160 |
| Minimum | 14,110 | 9,267 | 13,742 | 33,524 | 29,015 | 28,135 | 40,155 | 35,717 |
| Maximum | 41,790 | 89,205 | 52,181 | 251,711 | 448,290 | 283,986 | 316,428 | 432,446 |
| Median | 26,201 | 49,702 | 29,865 | 129,876 | 115,485 | 131,055 | 133,958 | 151,457 |
| Std. Deviation | 7,826 | 15,829 | 8,869 | 57,940 | 84,657 | 70,760 | 71,701 | 84,158 |
| Average | 26,030 | 52,051 | 30,629 | 135,525 | 137,753 | 136,228 | 142,948 | 157,538 |

## Table 12. Wet season flow volume statistics (acre-ft.) for June 1 through September 30. Blank cells indicate insufficient data to compute statistics.

| Year | North Canal | Main Canal | South Canal | C-25 Canal S-50 | C-25 Canal S-99 | C-24 Canal S-49 | C-23 Canal S-48 | C-23 Canal S-97 |
|---|---|---|---|---|---|---|---|---|
| 1965 | 7,029 | 21,155 | 13,507 | 33,258 | 17,214 | 16,972 | 24,519 | 38,585 |
| 1966 | 21,719 | 35,579 | 20,894 | 108,143 | 66,387 | 60,094 | 120,435 | 119,682 |
| 1967 | 7,992 | 16,451 | 11,174 | 64,417 | 33,745 | 30,036 | 39,182 | 43,576 |
| 1968 | 24,946 | 54,054 | 28,623 | 133,083 | 328,911 | 126,352 | 130,362 | 147,069 |
| 1969 | 11,800 | 24,979 | 12,366 | 88,553 | 45,931 | 122,672 | 106,459 | 86,911 |
| 1970 | 11,931 | 13,395 | 9,910 | 29,973 | 166,706 | 32,570 | | |
| 1971 | 7,613 | 18,857 | 12,004 | 84,125 | 79,324 | 54,528 | | |
| 1972 | 11,294 | 23,209 | 15,343 | 77,356 | 34,175 | 36,536 | | |
| 1973 | 16,727 | 33,477 | 27,333 | 128,053 | 93,672 | 68,409 | | |
| 1974 | 8,333 | 30,915 | 14,399 | 143,290 | 87,132 | 107,591 | | |
| 1975 | 7,824 | 20,120 | 10,931 | 71,211 | 43,652 | 62,693 | | |
| 1976 | 12,598 | 24,973 | 15,764 | 77,696 | 63,640 | 68,508 | | |
| 1977 | 7,093 | 23,243 | 7,387 | 29,940 | 54,713 | 28,264 | | 39,767 |
| 1978 | 6,726 | 21,191 | 6,050 | 53,187 | 80,961 | 32,427 | | 28,991 |
| 1979 | 15,347 | 33,047 | 18,213 | 69,329 | 52,248 | 94,930 | | 77,388 |
| 1980 | 4,150 | 12,563 | 2,269 | 16,011 | 14,149 | 13,708 | | 84,592 |
| 1981 | 12,092 | 29,923 | 18,291 | 43,298 | 36,458 | 43,738 | | 95,356 |
| 1982 | 9,990 | 34,281 | 17,768 | 102,322 | 48,672 | 158,414 | | 107,837 |
| 1983 | 11,923 | 22,040 | 8,619 | 75,263 | 23,356 | 47,538 | | 43,780 |
| 1984 | 7,078 | 20,969 | 10,357 | 47,229 | 20,664 | 53,774 | | 28,393 |
| 1985 | 14,386 | 32,379 | 21,228 | 95,511 | 55,462 | 98,187 | | 51,523 |
| 1986 | 7,493 | 25,760 | 15,548 | 67,713 | 42,002 | 80,047 | | 142,953 |
| 1987 | 6,816 | 16,906 | 6,631 | 23,768 | 12,407 | 21,593 | | 12,145 |
| 1988 | 6,449 | 18,787 | 11,043 | 50,465 | 50,970 | 39,497 | | 39,287 |
| 1989 | 4,078 | 17,386 | 5,715 | 34,421 | 41,792 | 45,260 | | 32,496 |
| 1990 | 7,371 | 26,021 | 11,335 | 79,861 | 80,961 | 67,411 | | |
| 1991 | 18,833 | 25,626 | 14,460 | 101,350 | 98,533 | 115,124 | | 109,830 |
| 1992 | 11,758 | 33,639 | 22,461 | 128,239 | | 135,234 | | 157,355 |
| 1993 | 5,174 | 13,595 | 7,378 | 34,393 | 23,054 | 44,199 | | 40,775 |
| 1994 | 13,036 | 33,334 | 15,850 | 103,784 | 94,745 | 124,156 | | 124,548 |
| 1995 | 9,961 | 18,920 | 14,079 | 98,180 | 86,460 | 121,079 | 88,729 | 129,013 |
| 1996 | 8,424 | 16,332 | 13,418 | 56,011 | 63,815 | 47,049 | 39,259 | 34,745 |
| 1997 | 12,585 | 18,742 | 12,013 | 107,511 | 99,210 | 108,448 | 78,675 | 75,063 |
| 1998 | 12,908 | 21,773 | 14,334 | 56,178 | 52,002 | 65,077 | 40,803 | 33,201 |
| 1999 | 8,029 | 15,442 | 10,620 | 112,194 | 108,759 | 122,361 | 90,972 | 84,817 |
| 2000 | 9,965 | 16,944 | 8,848 | 27,984 | 26,630 | 33,134 | 25,873 | 24,035 |
| 2001 | 15,582 | 27,601 | 16,259 | 153,534 | 157,469 | 146,712 | 90,546 | 83,362 |
| 2002 | 23,370 | 37,487 | 23,493 | 140,667 | 146,331 | 135,206 | 109,047 | 105,505 |
| 2003 | 12,264 | 24,387 | 17,268 | 95,101 | 92,588 | 125,769 | 116,636 | 114,379 |
| 2004 | 13,580 | 53,811 | 37,564 | 179,154 | 156,630 | 181,521 | 169,080 | 151,593 |
| 2005 | 12,919 | 26,947 | 19,817 | 119,864 | 116,033 | 114,625 | 140,807 | 131,709 |
| 2006 | 8,445 | 12,349 | 12,555 | 30,903 | 23,499 | 41,609 | 50,619 | 35,898 |
| 2007 | 12,899 | 19,283 | 11,006 | 77,021 | 67,783 | 61,823 | 47,435 | 45,415 |
| 2008 | 18,004 | 6,260 | 23,383 | 132,165 | 116,305 | 121,664 | 101,515 | 91,419 |
| Minimum | 4,078 | 6,260 | 2,269 | 16,011 | 12,407 | 13,708 | 24,519 | 12,145 |
| Maximum | 24,946 | 54,054 | 37,564 | 179,154 | 328,911 | 181,521 | 169,080 | 157,355 |
| Median | 11,526 | 22,624 | 13,793 | 77,526 | 63,640 | 66,244 | 90,546 | 80,375 |
| Std. Deviation | 4,834 | 9,716 | 6,732 | 40,088 | 56,725 | 43,754 | 42,046 | 42,965 |
| Average | 11,330 | 24,412 | 14,716 | 81,402 | 74,538 | 78,558 | 84,787 | 77,583 |

**Table 13. Dry season flow volume statistics (acre-ft.) for October 1 through May 31. Blank cells indicate insufficient data to compute statistics.**

| Year | North Canal | Main Canal | South Canal | C-25 Canal S-50 | C-25 Canal S-99 | C-24 Canal S-49 | C-23 Canal S-48 | C-23 Canal S-97 |
|---|---|---|---|---|---|---|---|---|
| 1965 | 11,626 | 41,034 | 23,475 | 90,438 | 47,604 | 66,588 | 98,771 | 102,698 |
| 1966 | 12,071 | 40,234 | 14,734 | 68,746 | 35,054 | 31,413 | 57,545 | 52,120 |
| 1967 | 7,668 | 33,024 | 10,154 | 20,081 | 12,113 | 26,321 | 27,262 | 23,060 |
| 1968 | 20,802 | 44,501 | 16,460 | 93,075 | 157,275 | 79,894 | 49,961 | 38,125 |
| 1969 | 24,762 | 49,348 | 29,043 | 156,119 | 140,797 | 200,737 | 95,867 | 114,059 |
| 1970 | 12,259 | 24,956 | 16,965 | 37,844 | 313,641 | 39,502 | | |
| 1971 | 9,830 | 29,141 | 16,100 | 64,417 | 67,224 | 56,091 | | |
| 1972 | 11,601 | 23,281 | 14,574 | 19,181 | 25,640 | 25,945 | | |
| 1973 | 10,784 | 24,957 | 11,817 | 48,971 | 27,081 | 27,413 | | |
| 1974 | 8,311 | 23,106 | 10,408 | 25,212 | 19,504 | 18,830 | | |
| 1975 | 7,800 | 25,198 | 10,672 | 46,992 | 41,038 | 38,664 | | |
| 1976 | 11,109 | 21,771 | 8,464 | 10,681 | 10,529 | 12,094 | | 31,576 |
| 1977 | 9,674 | 29,914 | 9,991 | 34,439 | 99,810 | 40,968 | | 76,496 |
| 1978 | 16,206 | 36,018 | 19,065 | 65,199 | 57,528 | 58,448 | | 70,239 |
| 1979 | 11,593 | 23,655 | 12,360 | 36,605 | 63,046 | 54,284 | | 134,060 |
| 1980 | 8,143 | 19,096 | 6,615 | 4,295 | 27,198 | 304 | | 183,140 |
| 1981 | 18,081 | 37,278 | 17,649 | 47,918 | 69,280 | 64,767 | | 59,475 |
| 1982 | 18,710 | 41,631 | 18,640 | 100,064 | 81,959 | 99,461 | | 149,888 |
| 1983 | 16,684 | 32,125 | 22,155 | 64,934 | 78,525 | 77,927 | | 79,575 |
| 1984 | 18,020 | 33,939 | 20,162 | 35,201 | 65,670 | 36,061 | | 36,484 |
| 1985 | 13,463 | 22,177 | 15,557 | 24,794 | 38,952 | 23,453 | | 197,606 |
| 1986 | 16,654 | 32,376 | 16,058 | 47,957 | 92,140 | 31,297 | | 303,886 |
| 1987 | 18,114 | 29,784 | 17,461 | 62,866 | 101,923 | 65,073 | | 108,080 |
| 1988 | 8,026 | 18,678 | 11,009 | 13,967 | 34,959 | 2,231 | | 14,645 |
| 1989 | 9,791 | 17,699 | 10,674 | 25,216 | 35,745 | 24,773 | | 14,956 |
| 1990 | 22,935 | 37,683 | 21,996 | 94,866 | 101,497 | 120,414 | | 40,105 |
| 1991 | 10,579 | 18,448 | 11,531 | 30,284 | 27,925 | 29,923 | | 21,711 |
| 1992 | 21,262 | 43,920 | 25,519 | 117,794 | | 134,975 | | 171,787 |
| 1993 | 15,136 | 22,853 | 18,772 | 77,086 | 65,836 | 107,895 | | 89,513 |
| 1994 | 19,566 | 32,952 | 26,459 | 115,353 | 114,359 | 128,308 | | 93,295 |
| 1995 | 14,031 | 29,271 | 18,560 | 91,153 | 82,436 | 132,492 | 152,557 | 142,699 |
| 1996 | 17,058 | 24,370 | 21,411 | 42,801 | 36,140 | 50,870 | 33,920 | 27,044 |
| 1997 | 18,351 | 26,319 | 17,448 | 111,298 | 117,439 | 104,340 | 75,980 | 70,813 |
| 1998 | 12,722 | 19,299 | 9,142 | 24,166 | 20,923 | 39,321 | 34,620 | 31,149 |
| 1999 | 23,963 | 27,037 | 16,836 | 75,246 | 80,259 | 82,442 | 84,058 | 77,929 |
| 2000 | 15,206 | 15,419 | 15,054 | 12,887 | 10,986 | 17,099 | 12,459 | 10,236 |
| 2001 | 15,914 | 18,573 | 10,990 | 28,879 | 25,034 | 60,757 | 48,668 | 40,234 |
| 2002 | 12,956 | 17,172 | 10,418 | 17,575 | 16,280 | 24,855 | 20,399 | 17,062 |
| 2003 | 14,753 | 21,587 | 10,620 | 23,179 | 15,614 | 25,411 | 18,827 | 15,769 |
| 2004 | 19,014 | 32,258 | 17,777 | 75,296 | 70,268 | 62,948 | 65,503 | 62,564 |
| 2005 | 19,165 | 28,551 | 23,664 | 102,878 | 102,136 | 139,954 | 154,632 | 148,208 |
| 2006 | 8,809 | 8,624 | 6,703 | 2,866 | 0 | 269 | 754 | 0 |
| 2007 | 21,019 | 14,081 | 24,484 | 59,672 | 42,822 | 50,441 | 49,597 | 42,213 |
| Minimum | 7,668 | 8,624 | 6,615 | 2,866 | 0 | 269 | 754 | 0 |
| Maximum | 24,762 | 49,348 | 29,043 | 156,119 | 313,641 | 200,737 | 154,632 | 303,886 |
| Median | 14,753 | 26,319 | 16,100 | 47,918 | 52,566 | 50,441 | 49,779 | 62,564 |
| Std. Deviation | 4,749 | 9,128 | 5,610 | 36,229 | 54,770 | 44,214 | 44,025 | 65,404 |
| Average | 14,749 | 27,752 | 15,992 | 54,616 | 63,671 | 58,494 | 60,077 | 78,176 |

# Water Supply Demands

The water management districts manage and protect water resources of the region by balancing and improving water quality, flood control, natural systems, and water supply. Each of the water management districts in Florida perform water supply planning to satisfy provisions of Chapter 373, Florida Statutes (F.S.). The water management districts serve local governments by supporting efforts to safeguard existing natural resources and meet future water demands.

Water supply plans are prepared to effectively support planning initiatives and address local issues. The regional water supply plans encompass a minimum 20-year future planning horizon and are updated every five years. The planning process focuses on areas where projected water supply demands cannot be met by the continued use of existing water sources without unacceptable impacts to water resources and related natural systems. The water supply planning process includes planning and assessment; data collection, analysis and issue identification; evaluation of water source options; and water supply development. In addition, the updates include a minimum flows and levels component.

Water demand estimates for the study area are typically investigated for six categories of water use. Urban use is broken into five of the six categories of land use: public water supply, commercial/industrial self-supply, recreational self-supply, domestic self-supply and small public supply systems, and thermoelectric power generation self-supply. The sixth category, being agricultural use, includes all self-supplied irrigation water used for crop irrigation, livestock watering, and aquaculture.

Environmental demand, such as for coastal and wetland areas, are also considered. Public water supply typically includes all potable water supplied by water treatment facilities reporting average pumpages greater than 0.1 MGD, whether for a residential or other type of customer. Similarly, commercial and industrial use refers to self-supplied business operations using 0.1 MGD or more. Recreational self-supply includes those water needs for landscape (including parks, cemeteries, and other related needs 0.1 MGD and above) and golf courses (both groundwater and surface water, but not reclaimed water) irrigation. The domestic self-supply category includes households whose primary sources of water are private wells and households served by small utilities (less than 100,000 GPD). Thermoelectric power generation water refers to self-supplied replacement for cooling water losses at electrical plants, but does not include facilities using ocean water. Agricultural use includes any irrigation demand for citrus, vegetables, melons, berries, nursery and field crops, ornamentals, sod, and pasture.

As reported within the Draft 2008 Water Supply Assessment (WSA) Report for the SJRWMD, the extreme southern portion of Brevard County and all of Indian River County have been identified as potential priority water resource cautions areas (PWRCAs). This designation indicates that these areas may not be able to meet all future water demands without objectionable impacts to water resources and related natural systems. There have been no PWRCAs identified within the SFWMD portion of the study area.

Within the whole of the SJRWMD, population is expected to increase by 106 percent between 1995 and 2030, the period addressed by the WSA report. Total water use (urban and agricultural) is projected to increase by 29 percent, from 1.35 billion gallons per day in 1995 to 1.74 billion gallons per day in 2030 (SJRWMD 2009).

Within the SFWMD Upper East Coast Planning Area, population was estimated to increase by 82 percent between 2000 and 2025, the time period addressed in the 2006 Water Supply Plan Amendment for the Upper East Coast (UEC). However, the March 2009 BEBR projections for this planning area have declined since 2006 by approximately 4% for 2025. This plan includes the C-23, C-24, and C-25 Basins, as well as Basin 1 which fall in the study area. Total water use is projected to increase by 30 percent, from 290 MGD in 2000 to 378 MGD in 2025.

Since land use is an accepted water management component in water resources planning, it becomes important to consider how land use and related water demand trends may affect potential future water supply plans. Urban water demands are increasing and agricultural water demands are decreasing in the study area. The trends shown in ***Table 14*** are based on reported water demands from SJRWCD and SFWMD water supply/assessment plans. An increasing trend is indicated by (+) and a decreasing trend is indicated by (-). There is a transition in land use from urban in the east to agricultural in the west. As development continues, agricultural lands are slowly coming out of service. Each of these land types demands are discussed in more detail below.

**Table 14. Water supply demand trends in Indian River County and the C-23, C-24, and C-25 Basins and Basin 1.**

| Category | Land Type | Trend | |
|---|---|---|---|
| | | Indian River County SJRWMD Study Area | C-23/23/25, Basin 1 SFWMD Study Area |
| Urban | Public Water Supply | + | + |
| | Domestic Self-Supply | + | - |
| | Commercial & Industrial | + | + |
| | Recreational Self-Supply | + | + |
| | Thermoelectric | n/a | + |
| Agriculture | Crops, Sod, Pasture, Etc. | - | - |

Source: SJRWMD and SFWMD Water Supply Assessment Plans

## URBAN WATER SUPPLY DEMANDS

Urban water demands are increasing in the study area. The surficial aquifer system is a source of water for potable public supply within the study area, and it is also used as a source of water for domestic self-supply. The driving force behind urban demand is population.

### Public Water Supply and Domestic Self-Supply

Within the SFWMD portion of the study area, public water supply is expected to grow 179 percent – an increase from 13 percent to 27 percent of the total water use (SFWMD 2006). District-wide, the SJRWMD public supply demand is projected to increase by 118 percent (SJRWMD 2009), representing the most significant increase in water use. Brevard County, in particular, is predicted to have the greatest county-level population increase, which assists to increase public water demand. This area includes Melbourne, Palm Bay, and the upper St. Johns River Basin Area. The C-23, C-24, C-25, North Fork Basins, and Basin 1, contain mostly agricultural and natural lands, but the increasing population near the coastal regions continues to account for an increasing public water supply demand.

Domestic self-supply is expected to decrease in the future within the SFWMD portion of the study area. Self supply includes residents not living within areas served by utilities for public water supply; residents living within areas served by utilities, but who are not connected to a utility; and, residents served by utilities with demands of less than 0.1 MGD (i.e. utility customers using irrigation wells for outdoor purposes which do not require a District water use permit (WUP) due to small size and low volume.). SFWMD estimates that about 29 percent of the 2000 population was self-supplied, but this will decrease to about 3 percent by 2025, due to residents connecting to regional utilities (SFWMD 2006). SJRWMD predicts that domestic self-supply may increase but it could be in part due to expansions of small utility service areas and would contribute to increases in public supply as a whole.

## Commercial & Industrial Self-Supply

Demands for this use category have been historically small and are projected to remain so, as most commercial and industrial establishments in the planning areas are and will continue to be served by water utilities. As a whole, the SJRWMD contains a large commercial and industrial self-supply demand, but it is concentrated outside the study area, near Jacksonville. The majority of the commercial and industrial demand with the SFWMD planning areas are not self-supplied and are contained within the public water supply or agriculture (i.e. food processing) categories.

## Recreational Self-Supply

Demands for this use category are expected to increase in the study area. However, there is potential for reductions in this category in the future due to the possibility of using reclaimed water or stormwater as a source. District-wide, the SJRWMD area currently reports using 35.21 MGD and demand is projected to increase to 61.35 MGD from 2005 to 2030 (SJRWMD 2009). District-wide, the SFWMD reports using 12.8 MGD and demand is projected to increase to 23.8 MGD from 2000 to 2025 (SFWMD 2006).

Lawn and landscape irrigation can account for more than 50% of total water use at residential and commercial locations, and much demand is driven by home-owners associations or zoning requirements. Both the SFWMD and SJRWMD have worked to establish permanent year-round conservation rules in order to guarantee efficient and effective use of water for lawn and landscape irrigation. Landscape irrigation may be limited, in the future, to no more than two days per week, with some exceptions.

## Thermoelectric

Within the SFWMD portion of the study area, thermoelectric power generation shows the largest projected increase (386 percent) in urban water demand over the next 20 years (SFWMD 2006). To meet the region's growing energy needs, three new power generation facilities were projected, which would increase the water requirement projections for this use category for the Year 2025 to 47.6 MGD.

Within the SJRWMD area, deregulation of the electric power utilities, expected to occur within a few years, has led to significant regional uncertainty in water use projections for thermoelectric power plants (SJRWMD 2009). Relatively little water is consumed by thermoelectric power generation in this area, and the projected increase for this category is also modest. This water use category is projected to increase by only about 3.5 mgd from 2005 to 2030 (SJRWMD 2009).

## AGRICULTURAL WATER SUPPLY DEMANDS

Though agricultural water demands have a decreasing trend, it is still the largest demand in the SFWMD UEC area at 212.8 MGD in 2000 (SFWMD 2006). Within the whole of SJRWMD, agricultural use accounted for 380.41 MGD of the total water demand in 2005 (SJRWMD 2009). In Indian River County, agricultural demand is slightly higher than public water supply demands. The overall decreasing trend is attributed, in most part, to land being converted to other uses, such as residential or commercial. Additional cropland is being lost to disease as explained below.

Most of the agriculture in the study area utilizes surface water or the Upper Floridan aquifer (UFA) for water supply. Citrus is the largest agricultural land use in the study area. The UFA is getting saltier and is approaching a level that citrus may not be able to tolerate. Within the SFWMD and SJRWMD study areas, more than 120,000 acres of viable citrus land is currently in production in Indian River, St. Lucie, and Martin Counties. Also, the citrus in C-24 Basin and Basin 1 is by far the more prevalent irrigated crop in the planning area. In speaking with landowners, one citrus tree may require 50 gallons of water per day during the growing season, and many groves contain 130-140 trees per acre. Even so, about 100,000 acres of citrus land has been lost from production because of greening and canker problems, and this does not include lands coming out of citrus production related to implementation of the Comprehensive Everglades Restoration Plan (CERP). Additionally, there is a large inventory of juice being held by the producers which has driven the prices of citrus to very low levels.

Some farmers have abandoned their operations for economic reasons. District-wide, the SJRWMD area currently projects that agricultural water demand will fall from 380.41 MGD in 2005 to 332.28 MGD in 2030 (SJRWMD 2009). The SFWMD projects a reduction in agricultural water demand from 212.8 MGD in 2000 to 197.1 MGD in 2025 (SFWMD 2006) for the Upper East Coast Planning Area.

## ENVIRONMENTAL WATER SUPPLY DEMANDS

Natural systems water needs eventually lead to withdrawal constraints in water resource supply planning. As described, estimation of future water supply needs requires assessment of future population, agricultural activity, and commercial and industrial activities within the planning area, as well as within individual water supply service areas. It also requires estimation of the environmental and hydrologic conditions necessary to maintain healthy natural systems within the natural areas, such as lakes, rivers, springs, and wetlands. Withdrawal constraints include minimum flows and levels (MFLs), native vegetation, and groundwater quality.

The North Fork of the St. Lucie River has a MFL that specifies that mean monthly flows should not fall below 28 cfs to be delivered at the Gordy Road Structure. The C-23 and C-24 Canals discharge to the estuarine portion of the North Fork downstream of this point. When the C-23/24 North and South Reservoirs and STA are in place, discharges will be to the riverine North Fork via ten Mile Creek. .

For the IRL-S Project, SFWMD is in the process of establishing a water reservation for the natural system pursuant to state law. Section 373.223(4), F.S., provides that through the rule-making authority of the Governing Board, water may be reserved from use by permit applicants, whether by location, quantity, or season of the year in support of environmental uses, though existing legal users of water will be protected. Currently, a water reservation is being finalized to establish appropriate quantity, timing, and distribution of water dedicated and managed for the natural system for the IRL-S Project area. The rule development is scheduled to be completed in October 2009.

# WATER SUPPLY CONDITIONS

## SFWMD

The 2008 Basis of Review for Water Use Applications within the South Florida Water Management District documents contains provisions addressing concerns that water availability in the C-23, C-24, and C-25 Basins is limited. The guidelines state that no additional surface water will be allocated from District canals or any connected canal systems over and above existing allocations in these basins. No increase in surface water pump capacity will be recommended. Furthermore, restrictions are placed on pumps on Floridan aquifer wells in Martin and St. Lucie Counties. No pumps will be allowed on a flowing Floridan aquifer well unless; 1) it was in place and operational prior to 1974, 2) the pump is required to increase pressure and not to increase flow over what naturally emanates from the well; 3) a study is performed that shows that pump withdrawals will not interfere with any existing legal use; 4) the pump is installed temporarily to assist with freeze protection; or 5) the pump will temporarily assist in meeting allowable withdrawals for the duration of a water shortage.

## SJRWMD

In SJRWMD's 2008 Draft Water Supply Assessment, all of Indian River County is identified as a potential Priority Water Resource Caution Area (PWRCA). The PWRCA designation is an indication that it may not be possible to meet all future water demands without unacceptable impacts to water resources and related natural systems. This designation may be finalized based on further analyses to be performed in the 2010 Water Supply Planning process now being initiated. The Water Supply Planning process will focus on identifying additional water sources to meet the demands.

# Water Quality

Alternatives to be considered in the study will be designed to avoid water quality degradation or violation of a water quality standard in the receiving water body.

## IMPAIRED WATER BODIES

Water quality standards are established by FDEP to protect the water body's designated use. The Upper St. Johns River Basin from the Brevard/Indian River County line southward to SR 60 is designated a Class I water body with potable water supply as its designated use. Most of the IRL in Indian River County and roughly the southern half of IRL in St. Lucie County is a Class II water body with shell fish propagation or harvesting as its designated use. All other water bodies in the study area are classified as Class III water bodies with the designated use as recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

In accordance with Section 303(d) of the Clean Water Act, FDEP has identified impaired water bodies that do not meet applicable water quality standards. ***Tables 15 and 16*** show the water bodies in the study area that have been listed by FDEP as impaired in Indian River and St. Lucie Counties, respectively.

**Table 15. FDEP listed impaired waters in the study area within Indian River County.**

| Planning Unit | Water Segment Name | Parameters Assessed Using the Impaired Waters Rule (IWR) | Concentration Causing Impairment | Comments (# of Exceedances/ # of Samples) PP=Planning Period VP=Verified Period |
|---|---|---|---|---|
| South Central Indian River Lagoon | NORTH CANAL | Dissolved Oxygen | < 5.0 mg/L | PP = 38 / 175, Impaired; VP = 33 / 157, Impaired. DO met the verification threshold, and BOD was identified as the causative pollutant. 109 TN values, median 1.01 mg/L. 113 TP values, median value 0.21 mg/L. 25 BOD observations, median value is 2.4 mg/L. |
| South Central Indian River Lagoon | NORTH CANAL | Fecal Coliform | > 400 per 100mL | PP = 0 / 1 Insufficient data; VP = 7 / 25, Impaired |
| South Central Indian River Lagoon | MAIN CANAL | Dissolved Oxygen | < 5.0 mg/L | PP = 25 / 179, impaired; VP = 39 / 164, impaired. DO met the IWR verification threshold, and BOD was identified as the causative pollutant. 140 TN measurements, median 1.09 mg/L. 144 TP measurements, median 0.18 mg/L. 30 BOD measurements, median 2.5 mg/L. |
| South Central Indian River Lagoon | MAIN CANAL | Fecal Coliform | > 400 per 100mL | PP = 2 / 3 Insufficient data; VP = 10 / 31, Impaired |
| South Central Indian River Lagoon | MAIN CANAL | Dissolved Oxygen | < 5.0 mg/L | PP = 32 / 116, Impaired; VP = 49 / 167, Impaired. DO met verification threshold of IWR, and BOD was identified as the causative pollutant. 195 TN values, median 1.20 mg/L. 199 TP values, median 0.18 mg/L. 28 BOD observations, median value is 3.0 mg/L. |
| South Central Indian River Lagoon | SOUTH CANAL | Fecal Coliform | > 400 per 100mL | PP = 1 / 3 Insufficient data; VP = 12 / 31, Impaired |

**Table 16. FDEP listed impaired waters in the study area within St. Lucie County.**

| Water Segment Name | Parameters Assessed Using the 2001 Impaired Surface Waters Rule (IWR) | Exceeded Criterion or Threshold Concentration | Comments |
|---|---|---|---|
| C-23 | Dissolved Oxygen | $\leq$ 5.0 mg/L | Part of the SLE TMDL currently in progress. Impaired based on DO criterion and TP and BOD are the causitive pollutants. TP exceeded the IWR threshold of 0.22 mg/L. BOD exceeded the IWR threshold of 2.0 mg/L. |
| C-23 | Nutrients (Chla) | < 20.0 ug/L | Part of the SLE TMDL currently in progress. The annual average Chla value exceeded the IWR threshold in 2002. |
| C-24 | Conductance | > 1275 uohm/cm | New listing from cycle 2 |
| C-24 | Dissolved Oxygen | $\leq$ 5.0 mg/L | Part of the SLE TMDL currently in progress. Impaired based on DO criterion and TP and BOD are the causitive pollutants. TP exceeded the IWR threshold of 0.22 mg/L. BOD exceeded the IWR threshold of 2.0 mg/L. |
| C-24 | Nutrients (Chla) | < 20.0 ug/L | Part of the SLE TMDL currently in progress. The annual average Chla value exceeded the IWR threshold in 2005. |
| C-25 CANAL WEST (ST. JOHNS MARSH) | Conductance | > 1275 uohm/cm | New listing from cycle 2 |
| C-25 CANAL WEST (ST. JOHNS MARSH) | Dissolved Oxygen | $\leq$ 5.0 mg/L | DO is verified impaired but unable to determine the causative pollutants. TN, TP, BOD did not exceed their respective IWR thresholds. New listing from cycle 2 TMDL proposed by EPA 9-30-06 |
| FT. PIERCE FARM CANAL (BELCHER CAN / TAYLOR) | Conductance | > 1275 uohm/cm | New listing from cycle 2 |
| FT. PIERCE FARM CANAL (BELCHER CAN / TAYLOR) | Dissolved Oxygen | $\leq$ 5.0 mg/L | DO is verified impaired but unable to determine the causative pollutants. TN, TP, BOD did not exceed their respective IWR thresholds. TMDL proposed by EPA 9-30-06 |
| FT. PIERCE FARM CANAL (BELCHER CAN / TAYLOR) | Mercury (based on fish consumption) | Exceeds DOH threshold (>0.5 mg/kg) | Limited consumption advisory based on mercury impairments. |
| FT. PIERCE FARM CANAL (BELCHER CAN / TAYLOR) | Nutrients (Chla) | < 20.0 ug/L | The annual average Chla value did not exceed the IWR threshold of 20.0 ug/L in 2002, 2005, and 2006. The annual average Chla value exceeded the IWR threshold in 2003 and 2004. TMDL proposed by EPA 9-30-06 |
| C-25 EAST SEGMENT | Conductance | > 1275 uohm/cm | New listing from cycle 2 |
| C-25 EAST SEGMENT | Dissolved Oxygen | $\leq$ 5.0 mg/L | DO is verified impaired but unable to determine the causative pollutants. TN and TP did not exceed their respective IWR thresholds. No BOD data available. |
| C-25 EAST SEGMENT | Nutrients (Chla) | < 20.0 ug/L | The annual average Chla value exceeded the IWR threshold in 2002. |

# TOTAL MAXIMUM DAILY LOADS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for listed impaired water bodies. TMDLs establish the maximum amount of a pollutant that a water body can assimilate without causing exceedances of water quality standards. To date, the only TMDL that has been established in the study area is for the St. Lucie Estuary. FDEP has a schedule for development of TMDLs for all other impaired water bodies in the state.

C-23 and C-24 discharge into the St. Lucie Estuary (SLE). The goal of the SLE TMDL is to reduce nutrient loading to achieve a 0.72 mg/l total nitrogen (TN) concentration and a 0.081 mg/l total phosphorus (TP) concentration in the estuary. The TMDLs established for the C-23 and C-24 canals (***Table 17***) were developed to protect the estuary. Similar TMDLs were established for other tributaries to the SLE.

The C-23 and C-24 canals transport loads of nutrients and eroded sediment to the estuary with slugs of freshwater that create fluctuations in estuarine salinity levels. Urban and residential areas continue to expand in the coastal areas with urban stormwater runoff and seepage from septic tanks also contributing to the water quality problems in the streams and canals. As a result of C-23 and C-24 inflows, parts of the SLE are impaired for nutrients and dissolved oxygen (DO).

**Table 17. Loading limits for C-23 and C-24 from the St. Lucie Estuary TMDL (FDEP 2008).**

| Water Body | Parameter | TMDL (daily) |
|---|---|---|
| St Lucie Estuary | TN | 0.72 mg/l |
| | TP | 0.081 mg/l |
| C-24 | TN | 956 lbs |
| | TP | 108 lbs |
| | BOD | 2.0 mg/l |
| C-23 | TN | 664 lbs |
| | TP | 75 lbs |

A draft TMDL report has been published by FDEP for the Upper St. Johns River Basin for nutrients and DO (FDEP 2006). The TMDL document shows the spatial distribution of TP, DO, and biological oxygen demand (BOD) (***Figures 21, 22, and 23***, respectively). The TP target was set at 0.09 mg/l, the DO target was set at 5.0 mg/l, and the BOD target was set at 2.0 mg/l.

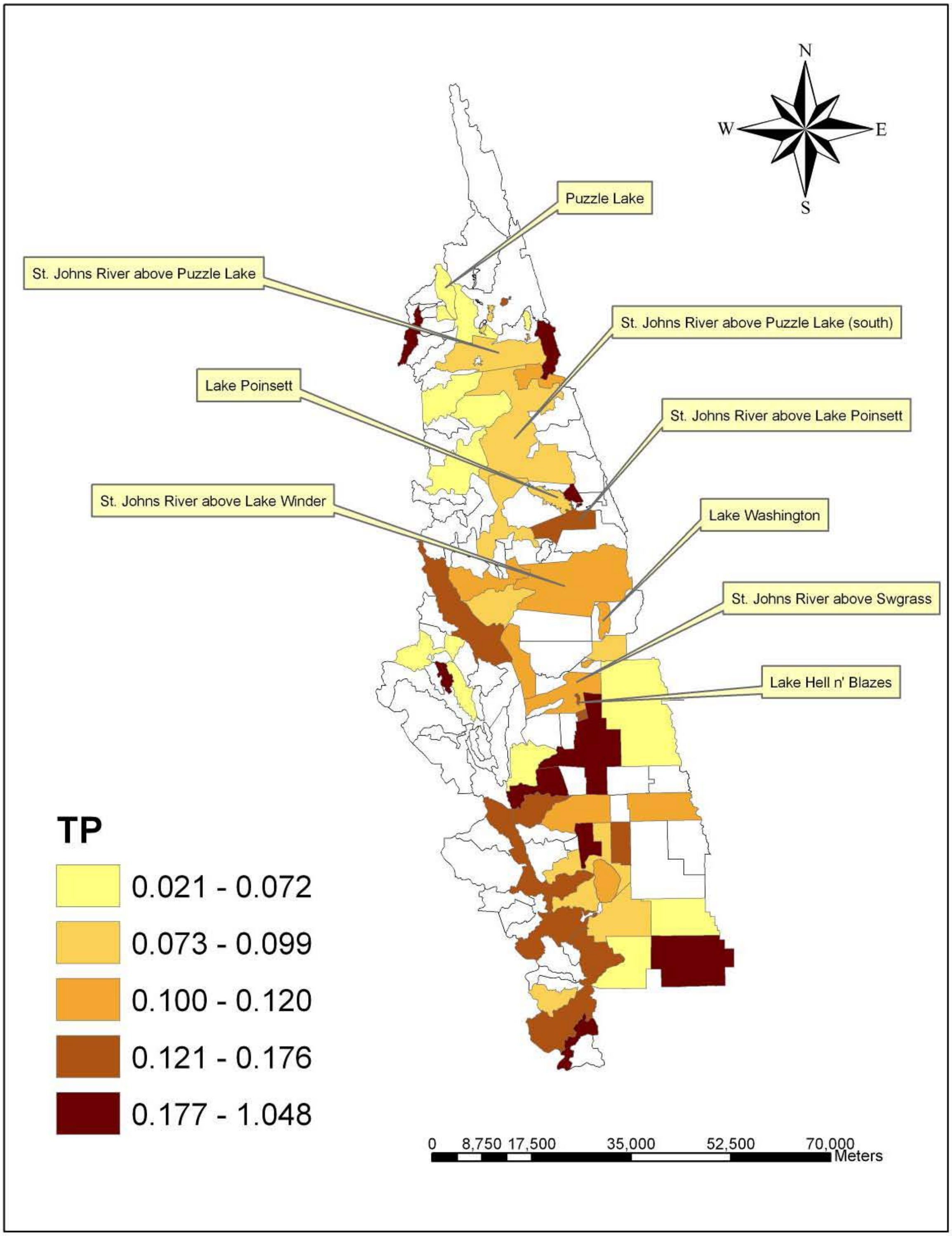



**Figure 21. Spatial distribution of Total Phosphorus (TP) in mg/l in the Upper St. Johns River Basin (FDEP 2006).**

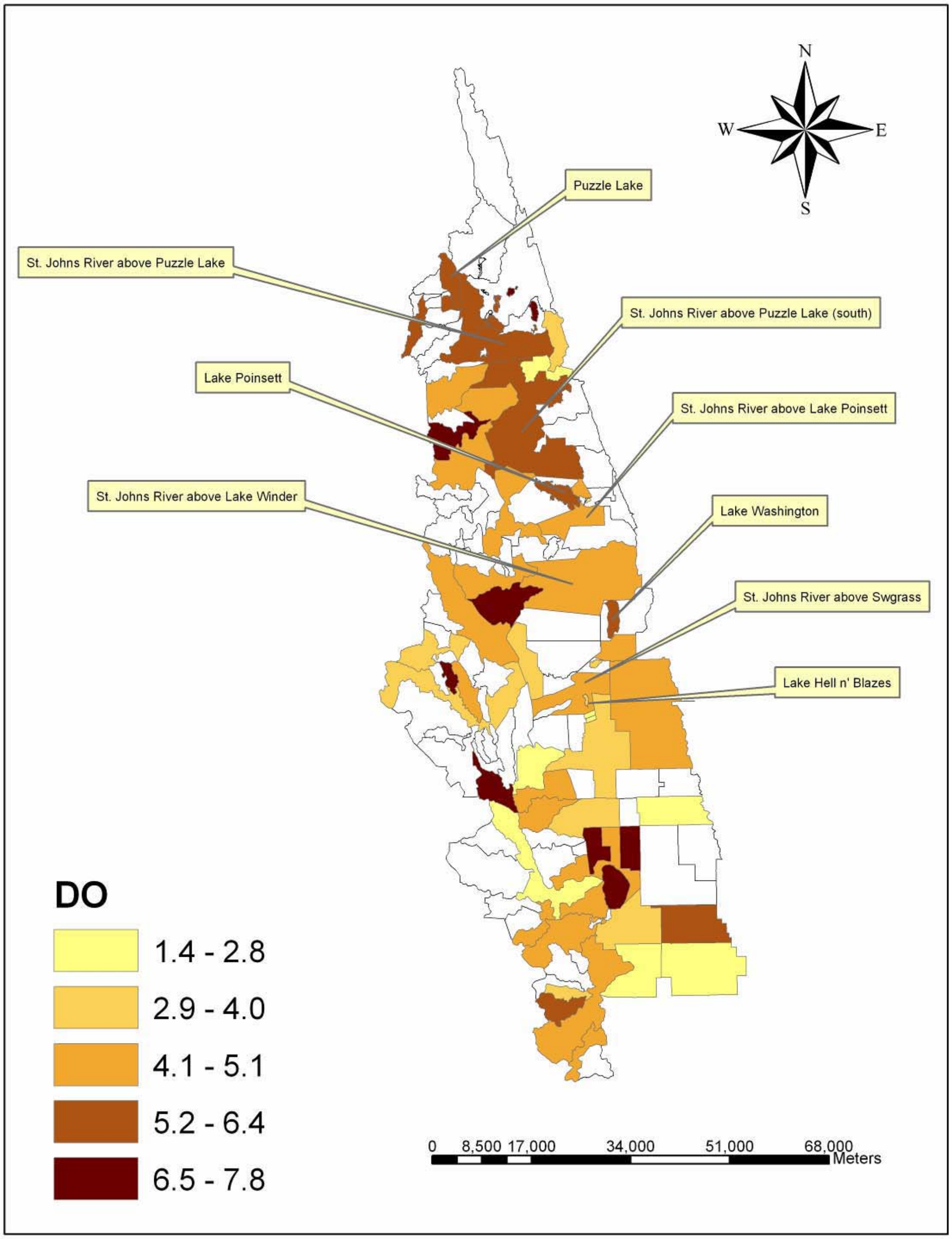



**Figure 22. Spatial distribution of Dissolved Oxygen (DO) in mg/l in the Upper St. Johns River Basin (FDEP 2006).**

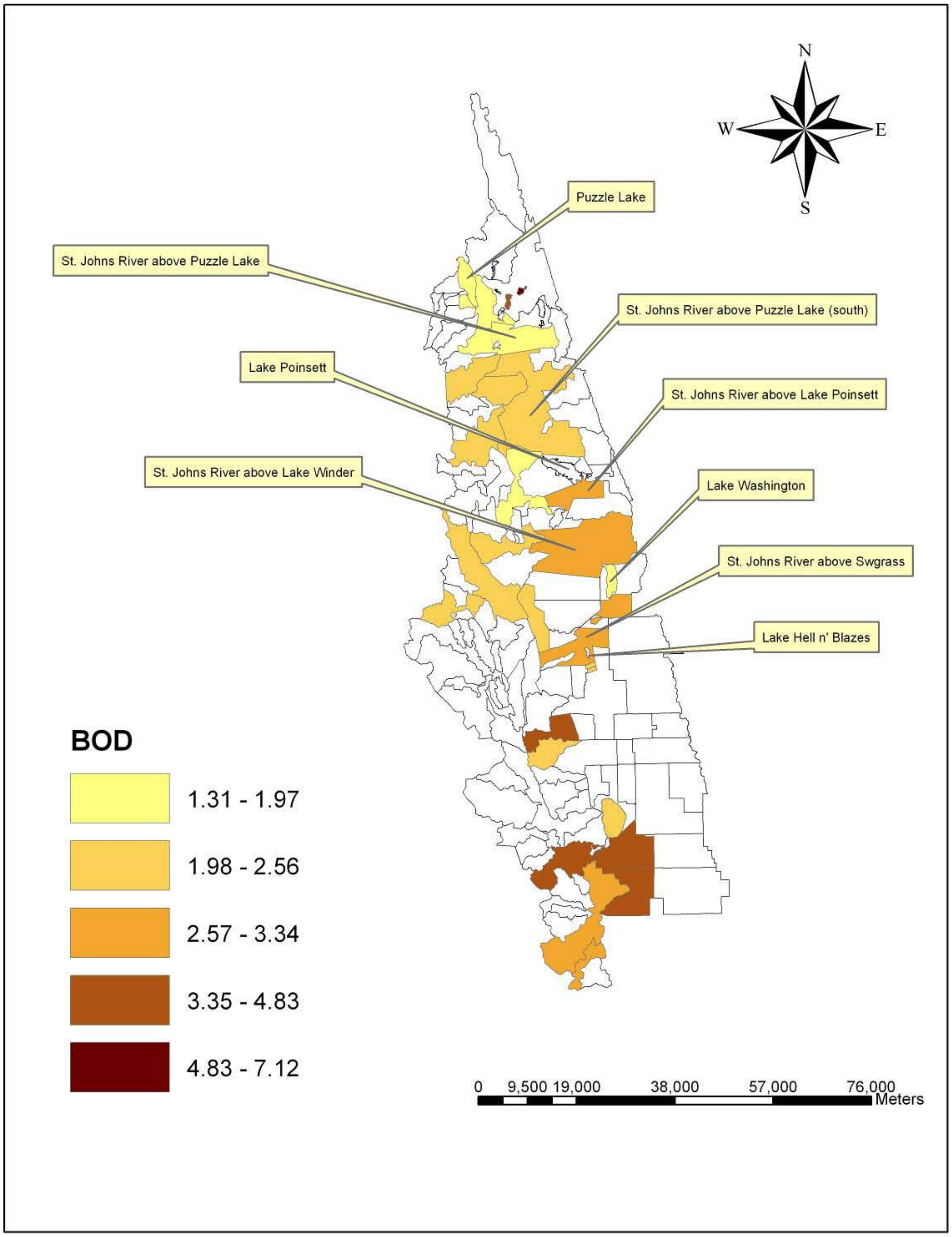



**Figure 23. Spatial distribution of Biochemical Oxygen Demand (BOD) in mg/l in the Upper St. Johns River Basin Project (FDEP 2006).**

# WATER QUALITY CHARACTERISTICS

## St. Lucie County Canals Water Quality Characterization

The C-23, C-24, C-25, and Fort Pierce Water Control District canals are listed as impaired water bodies under the regulations put forth in Impaired Waters Rule (IWR) (FDEP 2007). This rule addresses several parameters and sets quantitative thresholds used to classify waters as impaired. DO, TP, TN, and specific conductivity are parameters on which impairment was based. Data for these four parameters have been evaluated for C-23, C-24, and C-25 for their common periods of record (1979-present) and compared to the standards set forth in the IWR as well as one another. In addition, various dissolved metals have been examined.

Fort Pierce Farms Water Control District Canal (FPFWCD) water quality data was collected for the period beginning in 1999. This data is stored in DBHYDRO starting in 2001. A separate comparison was done for the period of record from 2001-present for all four FPFWCD canals.

### Dissolved Oxygen – C-23, C-24, and C-25 Canals

Data for these canals was obtained from SFWMD's DBHYDRO. Water quality data was measured at Structures 48, 49, and 50 which are the downstream structures in C-23, C-24, and C-25, respectively. ***Table 18*** provides DO statistics for these canals.

The target for minimum dissolved oxygen (DO) concentration is 5 mg/l. In C-23, where a large amount of runoff is received from citrus groves, increased nitrogen and phosphorus loads result in algal blooms and the associated depressed nighttime dissolved oxygen concentrations which stress fish and other aquatic organisms (FDEP, 2000b). C-24 and C-25 have displayed similar results in the form of massive fish kills. C-25 delivers a greater volume of water than C-23 and C-24 and therefore contributes a larger share of the overall nutrient load the IRL.

According to the IWR, for sample sizes this large (at least 350 samples), a water body would be categorized as impaired if just over ten percent of the readings are below the criterion (5 mg/l). All three canals have been classified as impaired with a high level of confidence.

DO measurements exhibit a distinct seasonal variation. The majority of low readings occur in the months between July-October, when temperatures are high and the solubility of dissolved oxygen in water is low, and conditions are favorable for algal blooms. ***Figure 24*** shows the monthly average DO concentrations for the C-23, C-24, and C-25 canals.

**Table 18. Dissolved oxygen (DO) statistics for C-23, C-24, and C-25 based on data measured at S-48, S-49, and S-50, respectively.**

| Dissolved Oxygen in mg/L | | | |
|---|---|---|---|
| Canal | C-23 | C-24 | C-25 |
| Count | 358 | 365 | 350 |
| Mean (mg/l) | 5.7 | 4.7 | 5.0 |
| Median (mg/l) | 5.5 | 4.8 | 5.1 |
| Range (mg/l) | 0.45-12 | .29-10.7 | .32-12.79 |
| Standard Deviation | 1.79 | 2.35 | 2.35 |
| % Below 5 mg/L | 37.15 % | 54.25 % | 50.57 % |

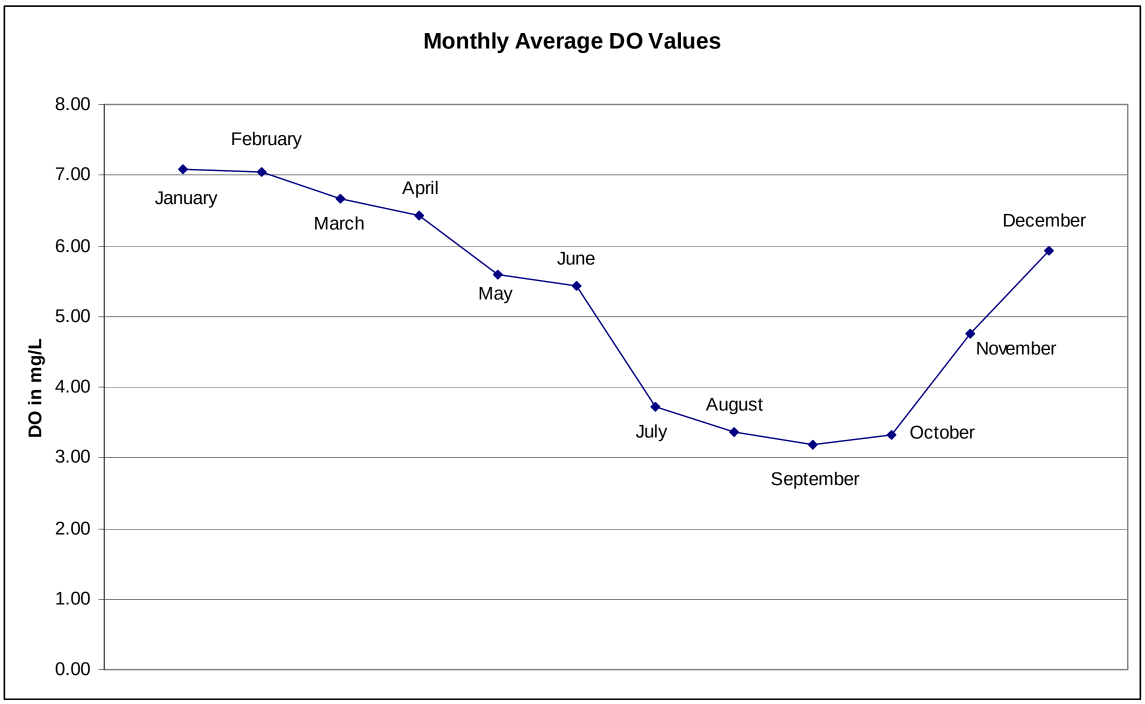



**Figure 24. Average monthly dissolved oxygen (DO) concentrations (mg/l) for C-23, C-24, and C-25 based on data measured at S-48, S-49, and S-50, respectively.**

### Total Phosphorus - C-23, C-24, and C-25 Canals

Total phosphorus (TP) concentrations were obtained from DBHYRO for C-23, C-24, and C-25 for the period of record from 1979 to present. The IWR threshold for TP is below 0.22 mg/l. In the case of a large sample size, the IWR recommends using a test for normal distribution. ***Table 19*** shows a comparison of actual percent of measured data falling above the TP threshold with the percentage calculated using a statistical method (Z-scoring). For large sample sizes, Z-scoring assumes a normally distributed data set and calculates the number of readings greater than the threshold value (0.22 mg/l).

All three canals are classified as impaired based on TP, although C-25 has significantly lower TP concentrations. When all the data is plotted and a linear regression analysis is performed, a general upward trend is seen (***Figures 25, 26, and 27***).

**Table 19. Total phosphorus (TP) concentration (mg/l) statistics for C-23, C-24, and C-25 Canals based on data measured at S-48, S-49, and S-50, respectively.**

| C-23 Canal | | C-24 Canal | | C-25 Canal | |
|---|---|---|---|---|---|
| Mean | 0.325 | Mean | 0.27 | Mean | 0.176 |
| Range | 0.033-1.4 | Range | 0.031-1.02 | Range | 0.002-1.046 |
| % of readings over 0.22 | 65.4% | % of readings over 0.22 | 59.8% | % of readings over 0.22 | 29.2% |
| % over 0.22 assuming normal curve | 71.2% | % over 0.22 assuming normal curve | 63.7% | % over 0.22 assuming normal curve | 38.2% |

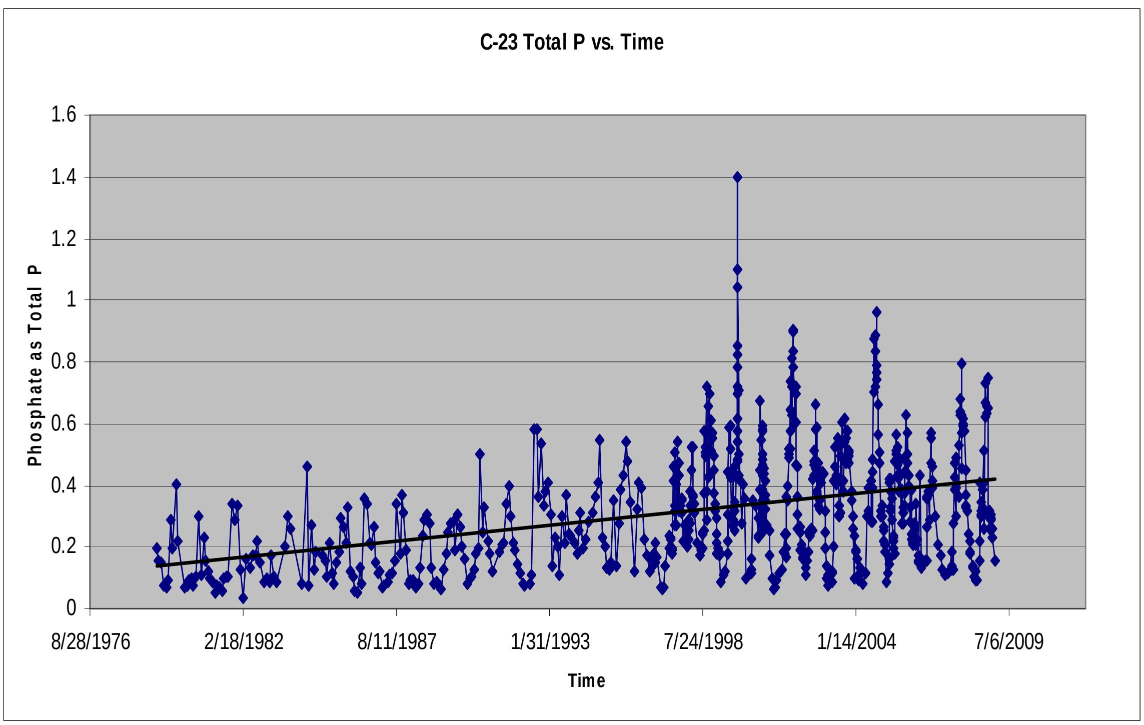



**Figure 25. Average total phosphorus (TP) concentrations (mg/l) for C-23 for the period of record from 1979 through 2008 as measured at S-48.**

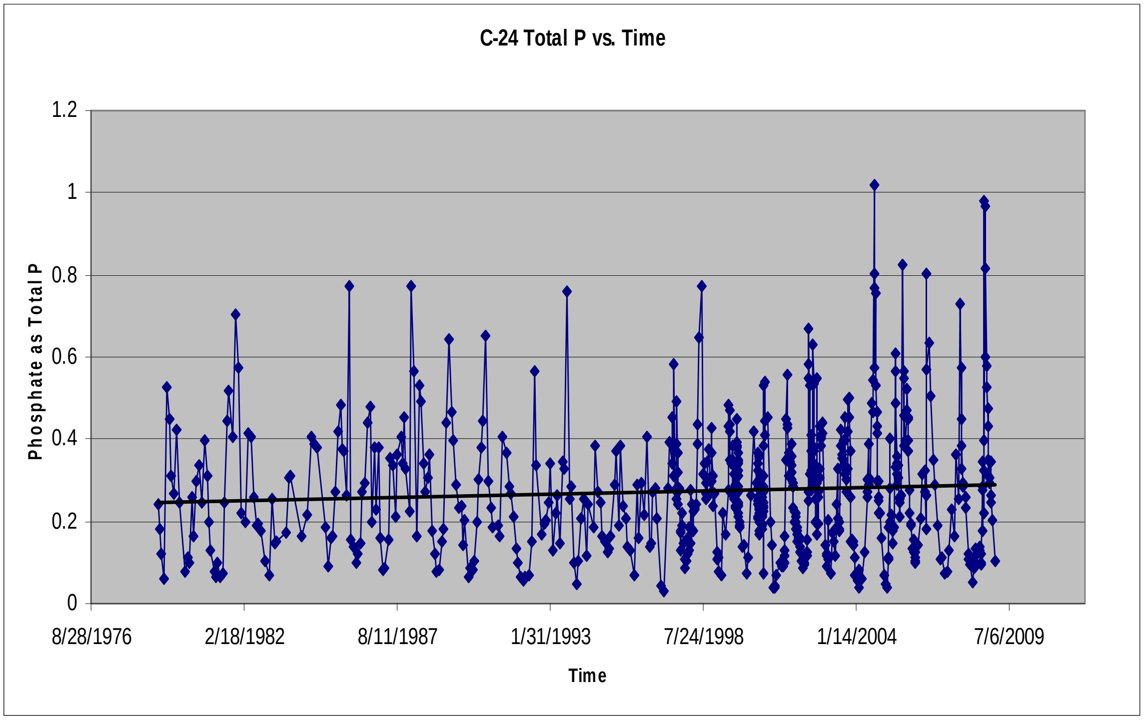



**Figure 26. Average total phosphorus (TP) concentrations (mg/l) for C-24 for the period of record from 1979 through 2008 as measured at S-49.**

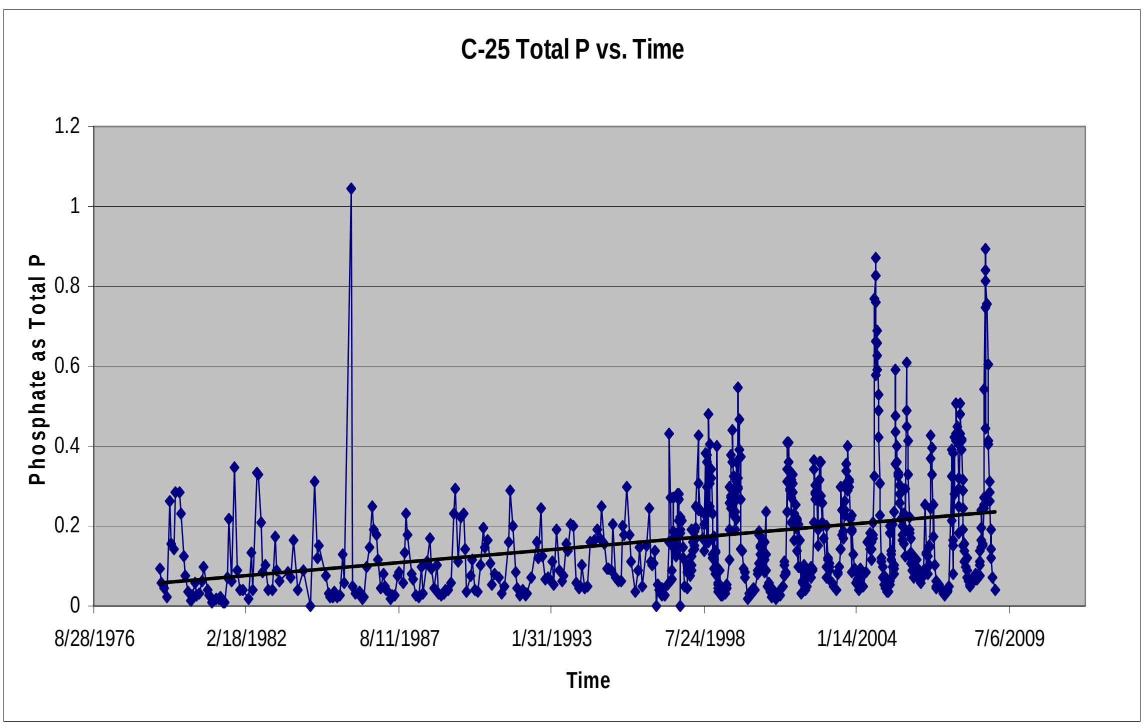



**Figure 27. Average total phosphorus (TP) concentrations (mg/l) for C-25 for the period of record from 1979 through 2008 as measured at S-50.**

### Total Nitrogen Concentration – C-23, C-24, and C-25

Total nitrogen was calculated by summing the total Kjeldahl nitrogen with the nitrate and nitrite as N. ***Figures 28 through 30*** show total nitrogen concentration in C-23, C-24, and C-25, respectively for the period from 1979 through 2008. The IWR uses both narrative and numeric standards for nitrate. The rule states that values shall not exceed 10 mg/L, but it also states that "In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna". Several FDEP Eco-Summaries (FDEP 1998, 2000a, 2000b) indicate that all three of these canals are experiencing adverse affects from nutrients. There is no apparent trend in TN values for C-23 or C-25 (***Figures 28 and 30***), but a distinct downward trend can be seen for C-24 in ***Figure 29***.

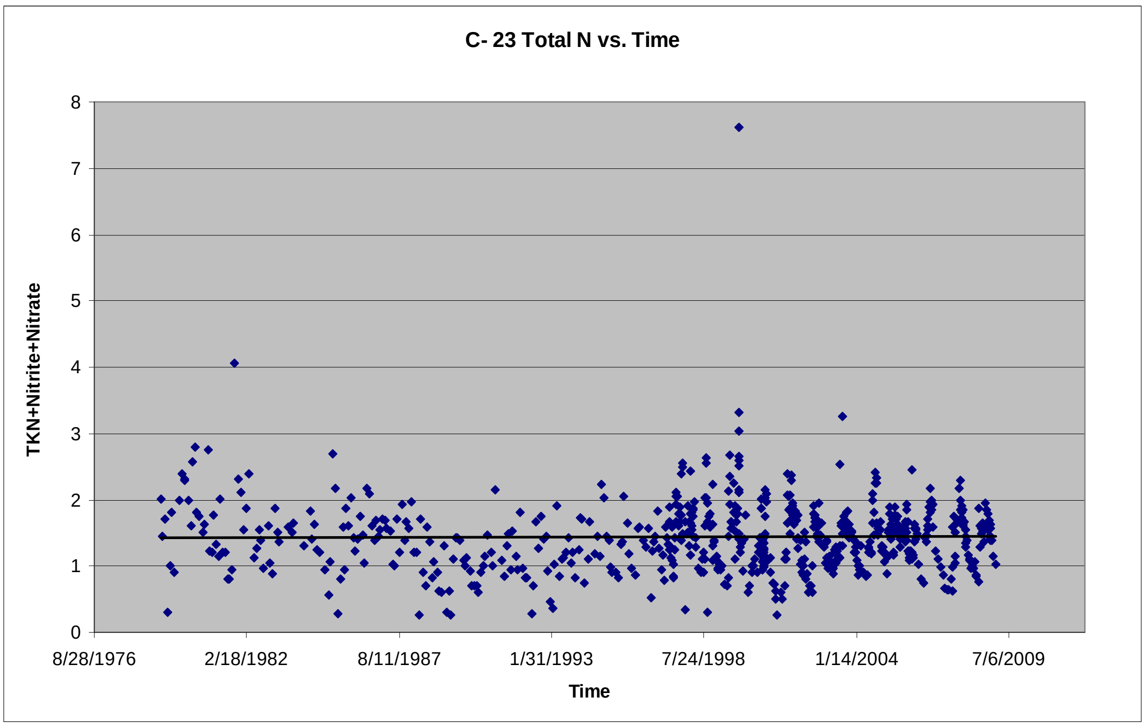



**Figure 28. Average total nitrogen (TN) concentrations (mg/l) for C-23 for the period of record from 1979 through 2008 as measured at S-48.**

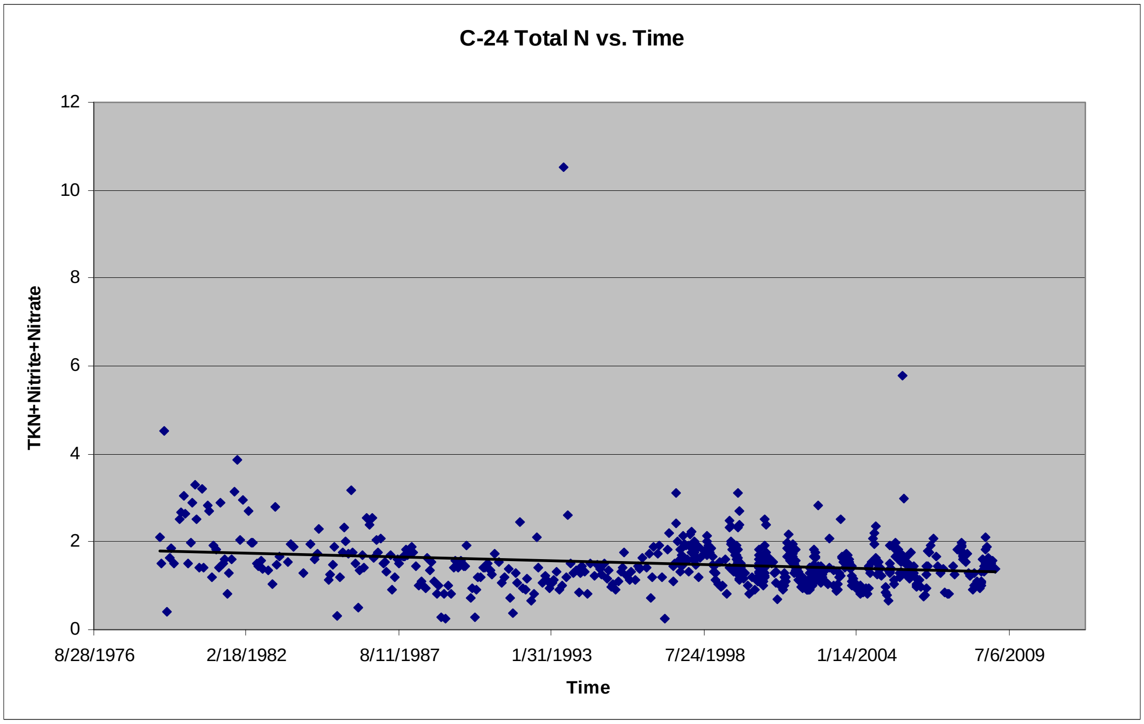



**Figure 29. Average total nitrogen (TN) concentrations (mg/l) for C-24 for the period of record from 1979 through 2008 as measured at S-49.**

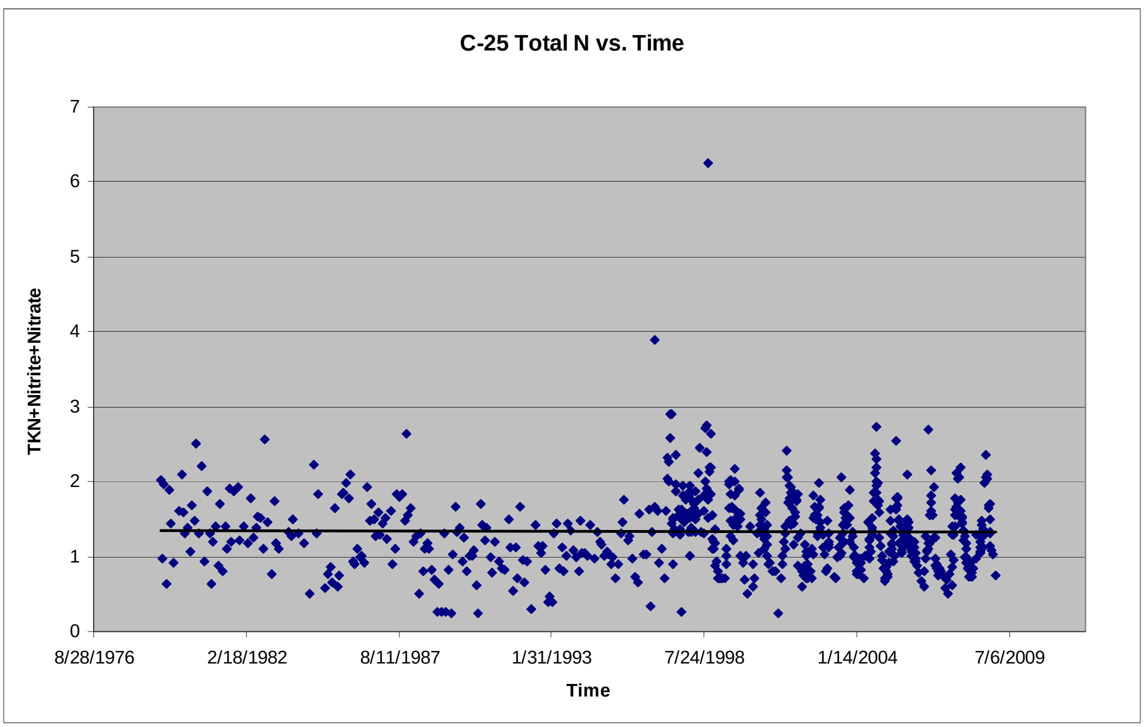



**Figure 30. Average total nitrogen (TN) concentrations (mg/l) for C-25 for the period of record from 1979 through 2008 as measured at S-50.**

## Specific Conductivity - C-23, C-24, and C-25

Specific Conductivity is measured in micro-siemens/cm (µS/cm) and according to the IWR, concentrations should not exceed 1,275 µS/cm. Specific conductivity values and statistics for C-23, C-24, and C-25 are shown in ***Table 20***. Based on DBHYDRO data from 1979 through 2008, specific conductivity concentrations in C-24 and C-25 canals exceed that standard and therefore, they are listed as impaired water bodies.

**Table 20. Specific conductivity (µS/cm) data and statistics for C-23, C-24, and C-25 for the period of record from 1979 through 2008 based on data measured at S-48, S-49, and S-50, respectively.**

| SPECIFIC CONDUCTIVITY | | | |
|---|---|---|---|
| Structure Name | C-23 | C-24 | C-25 |
| Count | 358.00 | 365.00 | 350.00 |
| Mean | 766.74 | 1164.43 | 1050.47 |
| Std. Deviation | 260.22 | 442.83 | 292.36 |
| 303d Rule | | 1275.00 | |
| Percent Exceeding Rule | 4.75% | 39.45% | 21.14% |

***Figures 31 through 33*** show specific conductivity concentrations in C-23, C-24, and C-25 for the period of record from 1979 through 2008. A slight downward trend in specific conductivity can be observed for all three canals. The downward trend in specific conductivity is interesting because it indicates the salt content in the discharges is declining. However the conductivity of the Upper Floridan Aquifer which is a primary source for citrus irrigation is increasing.

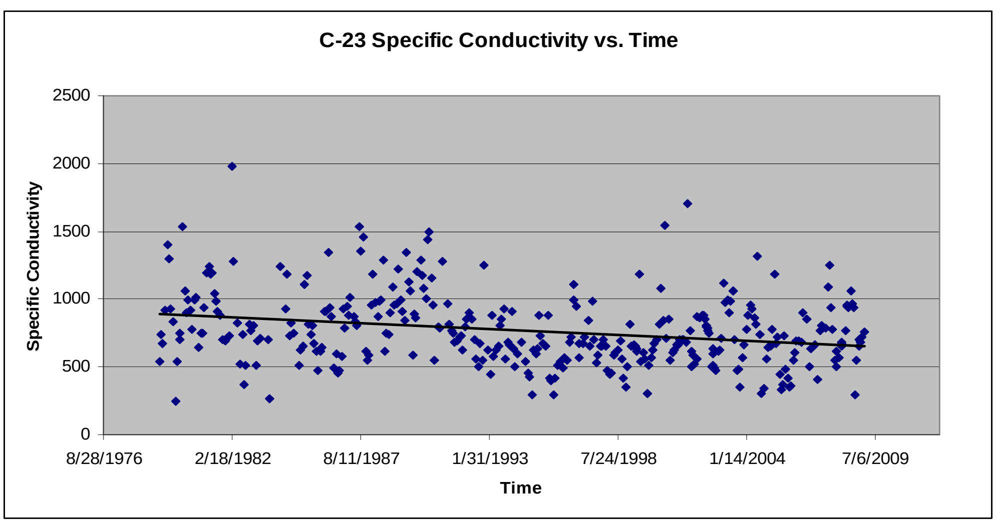



**Figure 31. Specific conductivity for C-23 (µS/cm) for the period of record from1979 through 2008 based on measurements at S-48.**

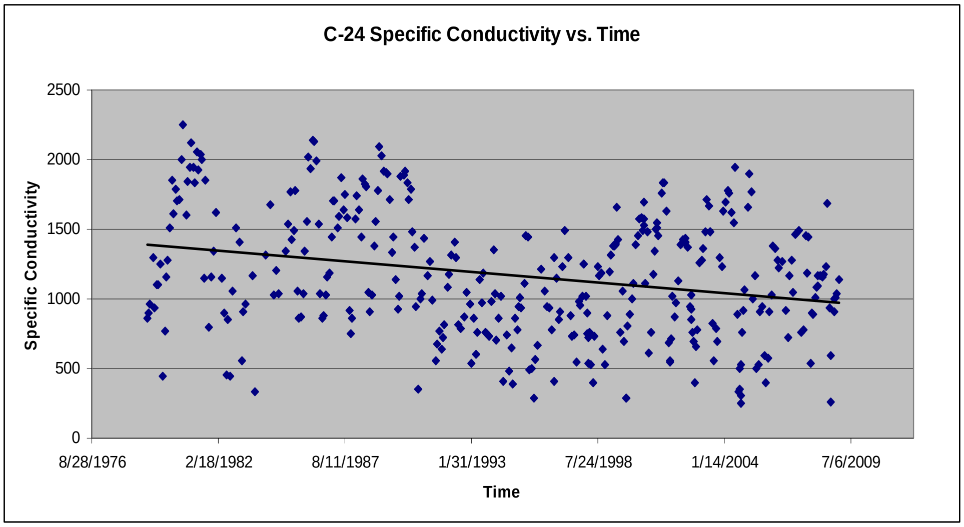



**Figure 32. Specific conductivity for C-24 (µS/cm) for the period of record from1979 through 2008 based on measurements at S-49.**

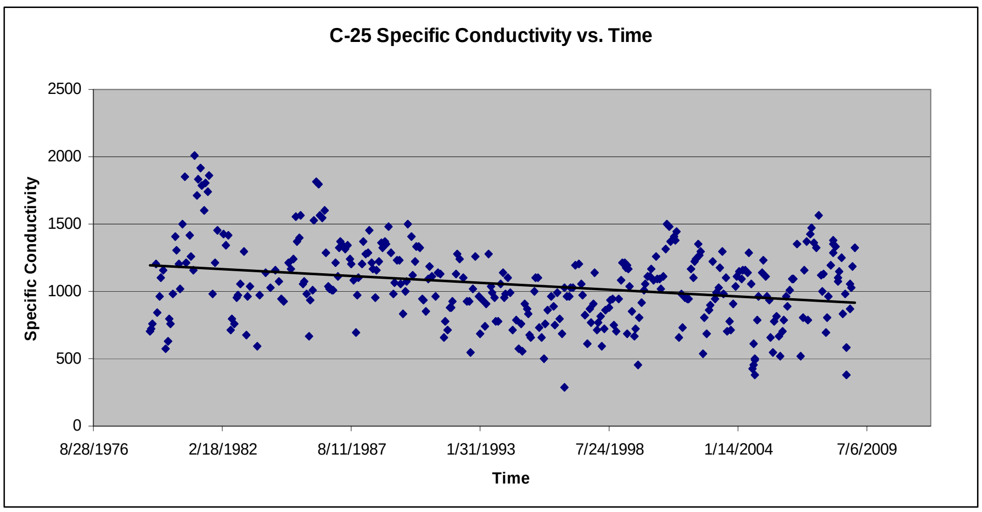



**Figure 33. Specific conductivity for C-25 (µS/cm) for the period of record from1979 through 2008 based on measurements at S-50.**

### Arsenic and Mercury – C-23, C-24, and C-25

Arsenic concentrations in C-23, C-24, and C-25 show no instance where total arsenic is above the threshold for potable water(<10 µg/L). Averages are well below the threshold and individual readings never exceed that value. The minimum detection limit for mercury readings in DBHYDRO is greater than the water quality standard. As a result, it is not possible to determine if the mercury concentrations in these canals violate water quality standards.

## Basin 1 (Fort Pierce Farms Water Control District Canal)

Information on the canal is limited to DEP Eco-summary (FDEP 2000c) and DBHYDRO data beginning in late 2001. ***Table 21*** shows phosphate for total phosphorus data for FPFWCD and C-23, C-24, and C-25 from DBHYDRO for the period of record from November 2001 through 2008. ***Table 22*** provides dissolved oxygen data for FPFWCDC and C-23, C-24, and C-25.

**Table 21. Phosphate concentrations (mg/l) as total phosphorus for the Ft Pierce Farms Water Control District Canal and C-23, C-24, and C-25 for the period of record from November 2001 through 2008.**

| FPWCDC | | C-23 | | C-24 | | C-25 | |
|---|---|---|---|---|---|---|---|
| Sample Size | 170 | Sample Size | 316 | Sample Size | 276 | Sample Size | 322 |
| Values > .22 | 36.47% | Values > .22 | 75.00% | Values > .22 | 56.52% | Values > .22 | 36.96% |
| Median | 0.178 | Median | 0.338 | Median | 0.261 | Median | 0.1585 |
| Mean | 0.219 | Mean | 0.359 | Mean | 0.287 | Mean | 0.215 |
| STDEV | 0.161 | STDEV | 0.176 | STDEV | 0.181 | STDEV | 0.176 |

**Table 22. Dissolved oxygen concentration (mg/l) for Ft Pierce Farms Water Control District Canal and C-23, C-24, and C-25 for the period of record from 2001 through 2008.**

| | FPFWCDC | C-23 | C-24 | C-25 |
|---|---|---|---|---|
| Sample Size | 165 | 99 | 104 | 97 |
| Values Below 5 mg/L | 23.03% | 24.24% | 43.27% | 31.96% |
| Median | 5.8 | 6.15 | 5.41 | 6.47 |
| Mean | 6.059 | 6.134 | 5.154 | 5.758 |
| STDEV | 1.698 | 1.908 | 2.465 | 2.831 |

## North, Main, and South Canals in Indian River County

All of these canals are impaired based on fecal coliforms. The North and Main Canals are also impaired based on dissolved oxygen. Limited data is available on the USEPA STORET database to quantify the degree of impairment. ***Tables 23 and 24*** summarize the findings for the parameters listed.

**Table 23. Fecal coliform statistics for the North, South, and Main Canals in the Indian River Farms Water Control District based on a period of record from 1975 through 1985 and 2005 through 2008.**

| | North | South | Main |
|---|---|---|---|
| Sample Size | 2 | 22 | 43 |
| Mean (#/100ml) | 1,072.50 | 298.90 | 428.41 |
| Median (#/100ml) | 1,072.50 | 270 | 160 |
| Range (#/100ml) | 745-1,400 | 3-1,375 | 0-2,880 |
| Standard Deviation (#/100ml) | 463.15 | 312.38 | 692.97 |
| % Over 400 | 100.00% | 36.36% | 27.91% |

**Table 24. Dissolved oxygen statistics for the North, Main, and South Canals in the Indian River Farms Water Control District for the period of record from 1982 through 1998.**

| | North | Main | South |
|---|---|---|---|
| Sample Size | 134 | 17 | 37 |
| Mean (mg/l) | 6.33 | 6.25 | 5.62 |
| Median (mg/l) | 6.30 | 6.70 | 5.50 |
| Range (mg/l) | 1.4-11.4 | 2.7-8.7 | 2.8-8.4 |
| Standard Deviation (mg/l) | 1.53 | 1.49 | 1.47 |
| % Under 5 | 17.16% | 23.53% | 35.14% |

# Evaluation Criteria and Design Factors

## EVALUATION CRITERIA

It is important to develop evaluation criteria early in the planning process. The evaluation criteria provide the tools for measuring how well alternatives satisfy the project objectives. It is helpful to have a good understanding of how alternatives will be evaluated when preliminary alternatives are being identified. With this knowledge, the ability to identify alternatives that most effectively meet the project objectives will be enhanced.

Descriptions of the evaluation criteria used for plan formulation and evaluation follow:

- Discharge Delivery Rate: This is the water supply delivery discharge that an alternative plan can maintain with 90% reliability. In other words, an alternative will be capable of maintaining a constant discharge for water supply at the discharge delivery rate for 90% of the days in the period of analysis. The goal is to maximize this discharge rate.

- Reduction in flow to IRL: By withdrawing canal flows for water supply, reductions in harmful discharges to IRL will result. The goal is to maximize the reductions in flow to IRL.

- Present Value Life Cycle Cost: The present value of the total capital cost (including design, land acquisition, construction, and construction management) and operations and maintenance cost over a 60 year period of analysis with a 5.125% discount rate. While cost was not used as a constraint in this study, the goal was to provide a cost effective alternative.

## DESIGN FACTORS

A set of design factors were adopted to guide the formulation of alternatives for the purposed of avoiding unacceptable impacts. In some cases, these design factors cannot be addressed at this time because they require field data collection and engineering design that is beyond the scope of this study. Design factors include the following:

## Flood Protection

While this study is not addressing improvements to flood protection, alternatives must maintain the existing level of service for flood control. In general, the nature of the alternatives being considered will not adversely impact regional flood control. Avoidance of local flood protection impacts must be addressed during detailed design that will not be included in this study.

## Water Quality

Many of the water bodies in the study area are on FDEP's list of impaired water bodies indicating that the quality of water is not adequate to meet the water body's intended use. In some cases, TMDLs have been established by FDEP to restore the water quality. Alternatives will be designed to avoid contributing to a violation of a water quality standard or degradation of the quality of the receiving body. Water quality treatment measures will be included in alternatives to satisfy this design factor if necessary.

## Minimum Flows and Levels and Water Reservations

Minimum flows and levels (MFLs) are intended to maintain adequate water flows and levels to protect the values of the natural system. The Water Resources Development Act (WRDA) 2000 requires quantification and protection of water made available for natural systems by CERP through the adoption of water reservations under state law. One MFL and a water reservation exist in the study are for the North Fork of the St. Lucie River. Alternatives evaluated for this study will be designed so that withdrawals of water for storage will be limited to avoid violations of the MFL and water reservation.

# Preliminary Alternatives

Preliminary alternatives were identified through a series of meetings with stakeholders and individuals that are knowledgeable of the water resources issues in the study and input from the project team. The goal was to identify a large number of alternatives that represent a variety of concepts in terms of their scale and types of approaches. No attempt was made to evaluate the alternatives at this point – all alternatives were retained.

Preliminary alternatives fall into two categories: Inter-District transfer alternatives and other alternatives. The Inter-District transfer alternatives enable the exchange of water between SFWMD and SJRWMD. This concept could be applied at a number of scales with and without storage being included. The other alternatives are generally intended to impact more localized areas.

***Appendix A*** provides schematic descriptions of the preliminary alternatives.

## PRELIMINARY INTER-DISTRICT CONNECTION ALTERNATIVES

Inter-District connection alternatives will provide the capability to move water across the Florida Turnpike between SFWMD and SJRWMD. This concept could be implemented with, or without storage. If no storage is included, water supply benefits would be limited to those periods when there was water available in one region that could be transferred to meet a demand in another. Knowledgeable individuals indicate that conditions do occur occasionally when such opportunistic benefits would be possible, but a simple Inter-District Connection would not provide reliable water supply benefits. Including a storage reservoir with an inter-district connection would enable the temporary storage of excess water until there is a water demand in the service area.

This category of alternatives would rely largely on the use of existing canals and structures although improvements would be required in some cases. The alternatives generally vary in the size of the service area. New alternatives were formed by incrementally adding features to expand the size of the service area.

Plan formulation was based on the assumption that the components of the IRL-S Project would be in place. The IRL-S Project includes reservoirs and an STA in the C-23 and C-24 Basins. Land acquisition is complete and design is underway for these features. It was not possible to acquire the lands required for the footprints of the reservoirs and STA as conceived in the IRL-S Project Implementation Report.

It is assumed that structure and canal improvements included in these features will enable inter-basin discharges of water between the C-23 and C-24 Basins. It is also assumed that the STA will treat water to a level that will enable inter-basin transfers to C-25 without further treatment.

Design has not been initiated for the C-25 Reservoir component of the IRL-S Project and land acquisition has not been initiated. Therefore, it is assumed that any alternatives that include a reservoir in the C-25 basin could be integrated into the IRL-S Project.

Descriptions of inter-district connection alternative plan components are provided in ***Table 25***.

**Table 25. Inter-District connection alternative plan components.**

| Component Name | Purpose and Description |
|---|---|
| Inter-District Connection | **Purpose** – to enable flow between SFWMD and SJRWMD.<br>**Description** - removal of the plug that separates C-25 Extension, south of the Turnpike, from C-52E, north of the Turnpike. The plug will be replaced by a water control structure. |
| C-25 Basin Connectivity | **Purpose** – to improve the capacity to convey water between the western C-25 basin (west of S-99) and C-52E.<br>**Description** - improve C-25 Extension (Turnpike Canal) from its confluence with C-25 westward to the plug at the Turnpike and add a pump station at S-253 to move water northward to the Blue Cypress WMA. |
| C-23 and C-24 Basin Connectivity | **Purpose** – to expand the area that could be served by Inter-District transfers by improving the hydraulic connectivity of C-25 with the C-23 and C-24 Basins.<br>**Description** – improve the north/south portion of C-25. It is assumed that hydraulic connectivity between C-23 and C-24 Basins will be provided by the IRL-S Project. A pump station will be added at G-81 to move excess water from C-23 and C-24 northward to the central reservoir. |
| Basin 1/FPFWCD Connectivity | **Purpose** – to expand the area that could be served by Inter-District transfers to include Basin 1.<br>**Description** – improve the north/south canal within Ft Pierce Farms Water Control District and replace the S-C21 structure with a gated water control structure. Add a pump station adjacent to S-99 to lift water from the eastern C-25 to the western leg of C-25. |
| Central Reservoir | **Purpose** – to provide storage capacity for excess water from the service area – which will vary based on the extent of connectivity.<br>**Description** – an above ground reservoir with an inflow pump station. Inflows will be provided by the service area and discharges will be made to meet water supply demands in SJRWMD or SFWMD (service area). |
| C-25 Extension Connectivity | **Purpose -** to provide a direct connection between the C-25 Extension Basin (aka C-52 West Basin) and C-25.<br>**Description -** an existing unnamed flow-way connecting Cowbone Creek and Gomez Creek with C-25 via the Orange Avenue Canal would be improved. |

## Inter-District Connection Alternatives Without Additional Storage (IC)

Providing a hydraulic connection for flows between SFWMD and SJRWMD without storage represents an option for achieving water supply benefits with minimal costs. This would provide water managers with the flexibility to move water between the water management districts. When there was water available that could be moved to meet a demand in another area, this alternative would enable water managers to take advantage of the opportunity. Three configurations of Inter-District Connection (IC) alternatives were conceived (IC-01, IC-02, and IC-03). These alternatives incrementally expand the area that would be hydraulically inter-connected. ***Table 26*** shows the alternative components (from ***Table 25***) that would comprise the Inter-District connection without storage alternatives. Although this approach would be relatively low in cost, it would not provide a reliable water supply benefit.

**Table 26. Inter-District connection alternatives without storage.**

| Name | Inter-District Connect | C-25 Connect | C-23 & C-24 Connect | Storage | Basin 1/FPFWCD | C-25 Ext. |
|---|---|---|---|---|---|---|
| IC-01 | X | | | | | |
| IC-02 | X | X | | | | |
| IC-03 | X | X | X | | | |

## Inter-District Connection Alternatives with Storage (ICS)

The addition of an above ground storage reservoir with a pumped inflow to the Inter-District connection alternatives would significantly improve the potential water supply benefits. Inter-District connection alternatives with storage have been designated as ICS alternatives. Two configurations of ICS alternatives were formulated (ICS-01 and ICS-02). Excess water could be captured and stored until there was a demand in the service area. The location of the storage reservoir should be near the Inter-District connection to provide efficient conveyance to the north or south. The storage capacity of the reservoir would be based on the size of the service area. ***Table 27*** provides descriptions of the components (from ***Table 25***) that comprise the Inter-District connection alternatives with storage.

**Table 27. Inter-District connection alternatives with storage.**

| Name | Inter-District Connect | C-25 Connect | C-23 & C-24 Connect | Storage | Basin 1/FPFWCD | C-25 Ext. |
|---|---|---|---|---|---|---|
| ICS-01 | X | X | | X | | |
| ICS-02 | X | X | X | X | | |

## Inter-District Connection Alternatives with Storage and Basin 1/FPFWCD Connection (ICSB)

A hydraulic connection with Basin 1(which includes Ft. Pierce Farms Water Control District (FPFWCD)) could be added to the Inter-District connection alternatives with storage (ICSB alternatives). This would add Basin 1/FPFWCD and the C-25 East sub-basin (between S-99 and S-50) to area from which flows could be obtained. Establishing a hydraulic connection between Basin 1/FPFWCD and the canal system west of S-99 would require canal improvements, a water control structure to control flows between Basin 1 and C-25, and a pump station at S-99. ***Table 28*** shows the alternative components (from ***Table 25***) that would comprise the Inter-District connection alternatives with storage and Basin 1/FPFWCD connectivity.

**Table 28. Inter-District connection alternatives with storage and Basin 1/FPFWCD connectivity.**

| Name | Inter-District Connect | C-25 Connect | C-23 & C-24 Connect | Storage | Basin 1/FPFWCD | C-25 Ext. |
|---|---|---|---|---|---|---|
| ICSB-01 | X | X | | X | X | |
| ICSB-02 | X | X | X | X | X | |

## Inter-District Connection Alternatives with Storage and C-25 Extension Connectivity (ICSC)

An existing flow-way currently conveys excess water from the west portion of the C-25 Basin to C-25. Construction of a canal about 1 mile in length could connect an unnamed flow-way to the Ft Drum Creek flow-way that drains about 6 square miles of agricultural land in the C-25 Extension (Ext) Basin (***Figure 34***). This area historically drained to C-25 until a plug was constructed in the Turnpike Canal more than 20 years ago. The local topography slopes relatively sharply to the east which would facilitate gravity flows. A water control structure would be required in the new canal so that increased flows to C-25 would not exacerbate flooding problems and/or increase flows to IRL during storm events. This component would only be implemented in conjunction with central storage so that diverted flows could be captured rather than discharged to IRL.

The Inter-District connection alternatives with storage and connectivity with C-25 Extension Basin have been designated as ICSC alternatives. Four configurations of the ICSC alternative have been developed (ICSC-01, ICSC-02, ICSC-03, and ICSC-04) by incrementally adding features to expand the drainage area. ***Table 29*** shows the alternative components (from ***Table 25***) that would comprise the Inter-District connection alternatives with storage and C-25 Ext connectivity.

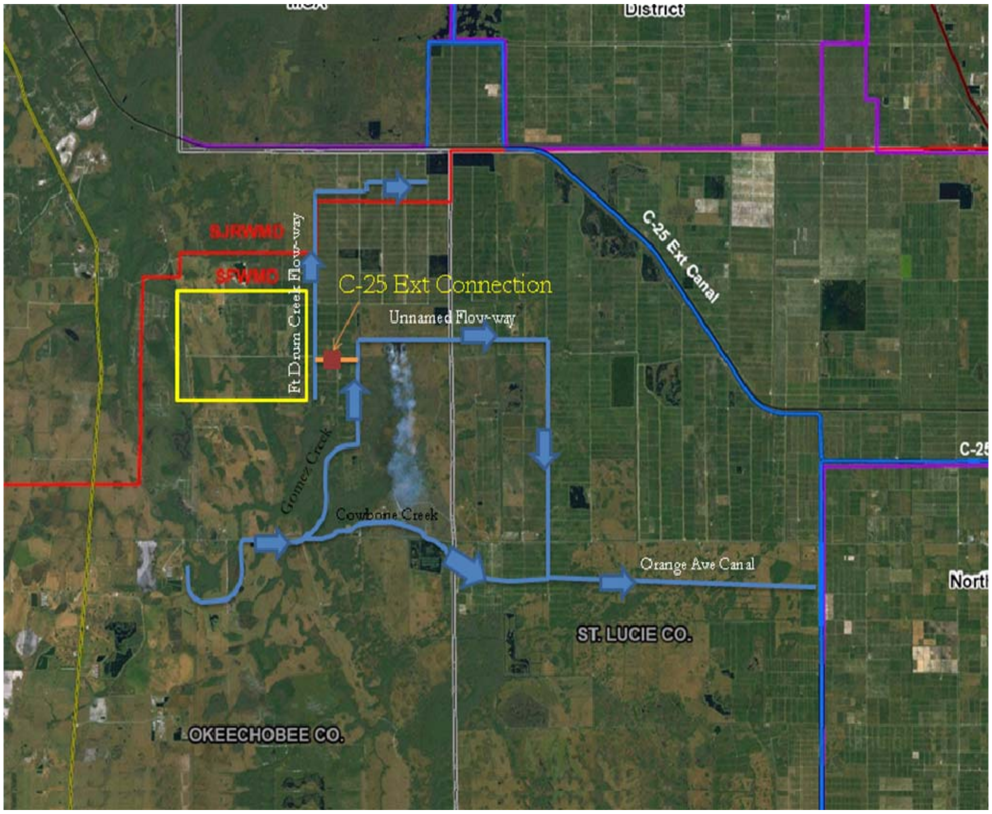



**Figure 34. C-25 Extension Basin (outlined in yellow) connection with C-25 via unnamed flow-way.**

**Table 29. Inter-District connection alternatives with storage and C-25 Extension connectivity.**

| Name | Inter-District Connect | C-25 Connect | C-23 & C-24 Connect | Storage | Basin 1/FPFWCD | C-25 Ext. |
|---|---|---|---|---|---|---|
| ICSC-01 | X | X | | X | | X |
| ICSC-02 | X | X | X | X | | X |
| ICSC-03 | X | X | | X | X | X |
| ICSC-04 | X | X | X | X | X | X |

## OTHER PRELIMINARY ALTERNATIVES

In addition to the Inter-District connection alternatives, other alternatives were identified that are more local in nature. These alternatives could be implemented individually or combined with each other or the Inter-District connection alternatives.

## Indian River Farms Water Control District Reservoir (IRFWCD-R)

The Indian River Farms Water Control District's (IRFWCD's) water management system is not connected to the regional system. All excess flows from this area are currently discharged to IRL via the North, Main, and South Canals. An above ground reservoir with pumped inflows from IRFWCD could be constructed immediately to the west of the district. With canal improvements to the IRFWCD internal canals, excess water from IRFWCD could be captured and stored. A pump station would be required within IRFWCD to lift water from the middle basin to the upper basin. This would provide access to canal flows within both the middle and upper basins of the district. A second pump station would be required for inflows to the reservoir. Water stored in the reservoir could then be provided to IRWCD to meet water supply demands. Additionally, alternative sites exist that would enable the reservoir to be connected to SJID and/or the Upper St Johns River Basin Project. This would expand the area to which water supply could be provided from the reservoir.

## Dispersed Storage/Water Farming

This alternative would consist of compensating land owners for pumping excess water onto their land, storing it, and making releases to satisfy demands. There are an estimated 60,000 acres of fallow agricultural land in the study area that represent potential sites for water farming. In many cases, infrastructure (pumps, berms, reservoirs, etc) already exist, but in other cases, additional infrastructure would be required.

Contracts for water farming would include operational guidelines to insure that management of the region's water resources during flood and drought is in the public interest. Contracts would be established between the land owner and the water management district. Reimbursement to the landowner would be based on current net agricultural revenue (about $400 to $600 per acre – based on input from land owners at a April 30, 2009 meeting), capital cost of required improvements amortized over the contract period, and operation and maintenance cost.

### Long-term Dispersed Storage/Water Farming

This evaluation has determined that dispersed storage/water farming would not provide a reliable long-term solution. There are numerous factors beyond the control of the land owner or the government that could result in the need to terminate or modify a long-term water farming contract. Additionally, the following factors will preclude evaluation of dispersed storage/water farming and comparison with other alternatives:

- The cost of dispersed storage/water farming is uncertain. The capital cost will depend on the existing infrastructure that can be utilized. An engineering analysis would be required for each potential site to determine whether the existing infrastructure could be safely utilized and/or to develop designs and cost estimates for additional improvements, as required.

- The extent of land-owner participation is unknown. The number of willing owners of sites that have suitable locations cannot be predicted.

### Interim Dispersed Storage/Water Farming

Greening and canker problems have caused many citrus growers to temporarily halt operations on all or parts of their lands. It is estimated that new resistant varieties of citrus can be developed, planted, and productive in the next 10 to 15 years. In the interim, these citrus lands could be utilized for dispersed storage/water farming. Interim dispersed storage/water farming would be most suitable for agricultural lands that would require minimal capital improvements. It would allow citrus growers an alternative source of revenue until they can resume agricultural operations.

The dispersed storage/water farming approach could provide benefits prior to implementation of long-term measures. However, before dispersed storage/water farming could be implemented, the following issues must be addressed:

- A process is needed for identifying and evaluating water farming proposals to insure that the best candidates are selected. The process should include:
    - an engineering analysis to insure the integrity of the existing infrastructure and proposed designs for additional features
    - investigation of potential contaminants in the soil that could cause water quality problems.
- Contractual conditions and methods for reimbursement of landowners must be developed. The issue of liability must be addressed in a mutually satisfactory manner.

## Ft. Pierce Farms Water Control District Flow-way

This alternative was formulated during a planning charrette sponsored by St. Lucie County. It has been submitted to the St. Lucie River Issues Team for a 2009 grant application. The alternative would consist of culvert replacements, construction of a new water control structure, and scrapping down and/or grading and contouring lands adjacent to the FPFWCD Canal No. 3. The objectives of the alternative are to store and treat stormwater runoff before it enters IRL.

## Floridan Aquifer System Well Decommissioning

This alternative was submitted by the Treasure Coast Resource Conservation and Development Commission for a grant application to the St. Lucie River Issues Team. It consists of decommissioning Floridan Aquifer System (FAS) wells that are abandoned on citrus groves. Water from the FAS is used to supplement surface water for irrigation on many citrus groves in the study area. In some groves, FAS water is the only source of irrigation. When the FAS wells are no longer used, especially when groves change ownership, their locations are often forgotten. This is especially true with the recent hurricanes and citrus diseases that have caused much of the industry to sell their groves for development.

Unused FAS wells eventually begin leaking into surface canals or their casings deteriorate allowing subsurface migration into other aquifers. Drainage from areas irrigated with FAS water often reaches the primary canal system. The high chloride content of the FAS water can significantly impact the water quality of the receiving water bodies. Additionally, surface erosion often results from wells that are leaking underground.

Decommissioning unused FAS wells would prevent further degradation of surface and ground water, as well as stopping surface erosion. Funding for this project has been provided through grants from the St. Lucie River Issues Team in 2005, 2006, and 2008. To date, 83 wells have been decommissioned and work is still underway. The cost of decommissioning is about $4,000 per well. A 2009 grant application for $200,000 was submitted by the Treasure Coast RC&D Council for decommissioning between 40 and 50 wells.

## IRFWCD and SJID Connection (IR-SJ-C)

Indian River Farms Water Control District and the St. Johns Improvement District share a common border for about 6 miles. A north/south canal could be constructed along this border that would provide a hydraulic connection between the two areas. This would allow local water managers to take advantage of opportunities to meet a water supply need in one area when there is water available in the other. Likewise, under flood conditions a connection would provide more flexibility to minimize damages.

# PRELIMINARY ALTERNATIVE EVALUATION

Three preliminary alternatives, Ft. Pierce Farms Flow-way, Floridan Aquifer Well Decommissioning, and the IRFWCD and SJID Connection were dropped from further consideration. The Ft. Pierce Farms Flow-way project is designed to improve water quality, create fish and wildlife habitat, and conserve water. However, the project is not designed to make additional water available for either urban or agricultural water supply. Decommissioning Floridan aquifer wells will help conserve existing groundwater supplies and protect surface water quality. However, this project is not intended to increase the availability of surface water supplies for urban and agricultural uses. Both the Ft. Pierce Farms Flow-way and the Well Decommissioning Projects are being undertaken by others. Moreover, implementation of both projects would be compatible with the objectives of this study. The interconnection of IRFWCD and SJID would provide water supply and flood control benefits but it would not increase the availability of water supply to meet regional demands.

The remaining preliminary alternatives were evaluated based on a set of qualitative screening criteria. The screening criteria represent approximate measures of benefits and costs. Benefits were approximated in terms of the average annual volume of water that could potentially be captured in a storage facility. Costs were evaluated in terms of the relative magnitude of infrastructure that would be required and whether water quality treatment would be required.

## PRELIMINARY ALTERNATIVE POTENTIAL WATER STORAGE VOLUMES

For each of the preliminary alternatives, the potential average annual flow volumes were estimated by applying the runoff rate (in acre-ft/acre) to the contributing drainage area. The runoff rates for the C-23, C-24, and C-25 Basins and the Indian River Farms Water Control District were calculated based on recorded flows to IRL and the applicable contributing drainage areas (***Table 30***).

**Table 30. Average annual flows per acre of drainage area.**

| Basin | Structure | Avg. Annual Flow (acre-ft) | Basin Area (acres) | Annual Flow per Acre (ft) |
|---|---|---|---|---|
| **IRFWCD**[1] | n/a | 108,710 | 65,500 | 1.7 |
| **C-23** | S-97[2] | 157,538 | 112,300 | 1.4 |
| **C-24** | S-49 | 136,228 | 87,600 | 1.6 |
| **C-25** | S-50 | 135,525 | 112,100 | 1.2 |

[1] **North, Main, & South Canal flows were combined for the Indian River Farms Water Control District.**

[2] **S-97 discharges were used for C-23 because data is more complete than S-49.**

No flow data exists for the C-25 Extension Basin or for Basin 1/FPFWCD. Therefore, an average value of 1.4 acre-ft/acre was used to estimate average annual flow from these areas. It should be noted that the flows shown in ***Table 31*** for the C-23 and C-24 Basins represent an approximation of conditions when the IRL-S Project features are constructed in the C-23 and C-24 Basins. When those facilities are implemented, the C-23 and C-24 flows will decline significantly. For this qualitative comparison, it is assumed that the operation of the IRL-S reservoirs and STA in the C-23 and C-24 Basins will reduce existing discharges to IRL by 80%.

The average annual flows that could potentially be captured by the drainage areas included in each of the preliminary alternatives were estimated and are shown in ***Table 32***. It should be noted that these flows do not account for the water reservation for the North Fork of the St. Lucie River or the impacts of construction of the IRL-S Project.

**Table 31. Average annual flows by canal reach**

| Canal reach | Description | Drainage Area (acres) | Average Annual Runoff (acre-ft) |
|---|---|---|---|
| **C-25W** | C-25 drainage area west of S-99 and north of G-81 | 98,600 | 118,300 |
| **C-23 & C-24** | C23 and C-24 basins controlled by S97 and S-49, respectively | 199,900 | 59,500 |
| **Basin 1/C-25E** | All of Basin 1 plus the C-25 drainage area between S-99 and S-50 | 32,200 | 45,100 |
| **IRFWCD** | The upper and middle pools of IRFWCD | 38,100 | 64,800 |
| **C-25 Extension** | Six sections of land in the southern portions of the C-25 Ext Basin | 3,800 | 4,600 |

**Table 32. Water storage potential (average annual acre-ft) for preliminary alternatives.**

| Preliminary Alternative | Potential Additional Storage (acre-ft per year) |
|---|---|
| **IC-01** | 0 |
| **IC-02** | 0 |
| **IC-03** | 0 |
| **ICS-01** | 135,000 |
| **ICS-02** | 194,000 |
| **ICSB-01** | 180,000 |
| **ICSB-02** | 239,000 |
| **ICSC-01** | 135,000 |
| **ICSC-02** | 194,000 |
| **ICSC-03** | 180,000 |
| **ICSC-04** | 239,000 |
| **IRFWCD-R** | 65,000 |

## PRELIMINARY ALTERNATIVE CAPITAL IMPROVEMENTS

Information was developed to enable a relative comparison of the potential capital costs of the preliminary alternatives. The extent of construction was estimated for each component of the preliminary alternatives in terms of miles of canal improvements on existing right-of-way, miles of canal improvements on new right-of-way, miles of new canals, number of new or improved structures, pumps, and storage reservoirs (***Table 33***). The preliminary alternatives are composed of various combinations of the components described in ***Tables 25 through 29***.

**Table 33. Structural elements of the preliminary alternative plan components.**

| | Inter-District Connect | C-25 Connect | C-23 & C-24 Connect | Storage | Basin 1/FPFWCD | C-25 Ext | IRFWCD |
|---|---|---|---|---|---|---|---|
| # New/Improved Structures | 1 | | | | 1 | 1 | |
| Miles Improved Canal - Existing ROW | | 1 | 1 | | | | |
| Miles Improved Canal - New ROW | | 1 | | | 1 | | 5 |
| Miles of New Canal | | | | | | 17 | 5 |
| Storage Reservoir | | | | 1 | | | 1 |
| # Pump Sations | | 1 | 1 | 1 | 1 | | 2 |

In order to provide a rough basis for comparison of the capital costs of the alternative plans, rough approximations of the types of structural features that would be required were assembled. ***Table 34*** shows the estimated infrastructure improvements required for each alternative. These estimates were made without the benefit of field data or engineering analyses. They are intended for comparative use only and would not be appropriate for cost estimating. The following assumptions were used:

The entire length of C-25 Extension from its intersection with the west end of C-25 to the Turnpike will require improvement in order to convey flows.

About 2 miles of the north/south section of C-25 north of G-81 will require improvement in order to convey adequate flows to and from C-23 and C-24.

It is assumed that the C-23 and C-24 Reservoir and STA and other improvements included in the IRL-S Project will be in place and will allow inter-basin transfers between C-23 and C-24 Basins.

Removal of an existing plug at the C-25 Extension and Turnpike and construction of a water control structure will be required to establish the ability to discharge water between SJRWMD and SFWMD.

The IRL-S Project STA will improve water quality so that no additional treatment will be required to move water from C-23 and C-24 into C-25.

**Table 34. Comparison of required infrastructure and relative capital cost scale preliminary alternatives.**

| | # of New/Improved Struct | Miles of Improved Canal - Existing ROW | Miles of Improved Canal - New ROW | Miles of New Canal | Storage Reservoir | # of Pump Stations |
|---|---|---|---|---|---|---|
| IC-01 | 1 | | | | | |
| IC-02 | 1 | 1 | 1 | | | 1 |
| IC-03 | 1 | 2 | 1 | | | 2 |
| ICS-01 | 1 | 1 | 1 | | 1 | 2 |
| ICS-02 | 1 | 2 | 1 | | 1 | 3 |
| ICSB-01 | 2 | 1 | 2 | | 1 | 3 |
| ICSB-02 | 2 | 2 | 2 | | 1 | 4 |
| ICSC-01 | 2 | 1 | 1 | 17 | 1 | 2 |
| ICSC-02 | 2 | 2 | 1 | 17 | 1 | 2 |
| ICSC-03 | 3 | 1 | 2 | 17 | 1 | 3 |
| ICSC-04 | 3 | 2 | 2 | 17 | 1 | 4 |
| IRFWCD | | | 1 | 5 | 1 | 2 |
| IR-SJ-C | 2 | | | 6 | | |

# PRELIMINARY ALTERNATIVES WATER QUALITY TREATMENT

The design standard adopted for this study requires that water quality treatment facilities be provided when the diversion of water would degrade the existing quality of the receiving water body or would contribute to violation of a water quality standard. Total phosphorus concentrations were used as an indication of whether water quality treatment would be required for transfers of water between basins. ***Table 35*** shows that, between C-23, C-24, and C-25, total phosphorus (TP) concentrations are lowest in C-25 and then increase to the south. It is assumed that the IRL-S Project STA associated with the C-23 and C-24 reservoirs will provide sufficient treatment to allow discharges into C-25. TP concentrations in the Ft. Pierce Farms Water Control District canals are comparable to those in C-25.

The TP concentration target used for discharges to the Upper St. Johns River Basin Project, including the Blue Cypress Water Management Area, is 0.080 mg/l. As a result, any discharges from canals in the SFWMD across the Turnpike to the north will require treatment. STAs would be required for the ICS, ICSB, and ICSC alternatives.

**Table 35. Total phosphorus concentrations (mg/l) in Ft. Pierce Farms Water Control District (Basin 1) and C-23, C-24, and C-25.**

| | FPFWCDC | C-23 | C-24 | C-25 |
|---|---|---|---|---|
| **Sample Size** | 170 | 316 | 276 | 322 |
| **Median** | 0.178 | 0.338 | 0.261 | 0.159 |
| **Mean** | 0.219 | 0.359 | 0.287 | 0.215 |
| **STDEV** | 0.161 | 0.176 | 0.181 | 0.176 |

In Indian River Farms Water Control District, FDEP collected TP data during 2006. The TP concentrations ranged between 0.064 mg/l to 0.12 mg/l. It is assumed that if water were moved from Indian River Farms Water Control District to a storage reservoir, the improvements in water quality associated with the reservoir storage would be sufficient to meet the 0.08 mg/l TP concentration target for inflows to Blue Cypress Water Management Area no further treatment would be required.

# Final Alternative Plans

Three of the preliminary alternatives were filtered out during the initial screening process: Ft. Pierce Farms Water Control District Flow-way, Floridan Aquifer System Well Decommissioning, and IRFWCD and SJID Connection. The Ft. Pierce Farms Water Control District Flow-way and Floridan Aquifer System Well Decommissioning projects are being undertaken by others and are not designed to address the same objectives as this study. The projects are designed to achieve water quality and water conservation benefits (the flow-way will also provide habitat benefits). However, neither project will substantially increase the availability of water supply. Connection of the FPFWCD and SJID would enhance water management operations for the two areas but would not contribute to increased water supply.

***Table 36*** summarizes the conclusions of the comparison of the preliminary alternatives and identifies the final alternatives that were carried forward for more detailed evaluation.

**Table 36. Summary of Preliminary Alternatives and identification of Final Alternatives.**

| Retain? | Name | Description | Comments |
|---|---|---|---|
| NO | IC-01 | C-25 plug removal | • Minimal structural measures/cost<br>• Provides Inter-District connection<br>• Opportunistic benefits |
| NO | IC-02 | C-25 plug removal, connection with C-25 | • Provides Inter-District connection<br>• Opportunistic benefits<br>• Water quality treatment for discharge to USJRB |
| NO | IC-03 | C-25 plug removal, connection with C-25 and C-23 and C-24 | • Provides Inter-District connection<br>• Opportunistic benefits<br>• Water quality treatment for discharge to USJRB<br>• Water quality treatment for C-24 to C-25 discharge |
| **YES** | ICS-01 | C-25 plug removal, central storage, connection with C-25 | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Water quality treatment for discharge to USJRB |
| **YES** | ICS-02 | C-25 plug removal, central storage, connection with C-25 and C-23 and C-24 | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Water quality treatment for discharge to USJRB<br>• Water quality treatment for C-24 to C-25 discharge |
| **YES** | ICSB-01 | C-25 plug removal, central storage, connection with C-25 and Basin 1/FPFWCD | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Captures excess water from Basin1<br>• Water quality treatment for discharge to USJRB |
| NO | ICSB-02 | C-25 plug removal, central storage, connection with C-25, Basin 1/FPFWCD, and C-23 and C-24 | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Captures excess water from Basin1<br>• Water quality treatment for discharge to USJRB<br>• Water quality treatment for C-24 to C-25 discharge |

**Table 36 (continued). Summary of Preliminary Alternatives and identification of Final Alternatives.**

| Retain? | Name | Description | Comments |
|---|---|---|---|
| NO | ICSC-01 | C-25 plug removal, central storage, connection with C-25 and C-25 Ext | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Captures excess water from 6 sections in C-25 Ext Basin<br>• Extensive new conveyance features required<br>• Water quality treatment for discharge to USJRB |
| NO | ICSC-02 | C-25 plug removal, central storage, connection with C-25, C-25 Ext, and C-23 and C-24 | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Captures excess water from 6 sections in C-25 Ext Basin<br>• Extensive new conveyance features required<br>• Water quality treatment for discharge to USJRB<br>• Water quality treatment for C-24 to C-25 discharge |
| NO | ICSC-03 | C-25 plug removal, central storage, connection with C-25, Basin 1/FPFWCD, and C-25 Ext | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Captures excess water from 6 sections in C-25 Ext Basin<br>• Captures excess water from Basin1<br>• Extensive new conveyance features required<br>• Water quality treatment for discharge to USJRB |

**Table 36 (continued). Summary of Preliminary Alternatives and identification of Final Alternatives.**

| Retain? | Name | Description | Comments |
|---|---|---|---|
| NO | ICSC-04 | C-25 plug removal, central storage, connection with C-25, Basin 1/FPFWCD, C-25 Ext, and C-23 and C-24 | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Captures excess water from 6 sections in C-25 Ext Basin<br>• Captures excess water from Basin1<br>• Extensive new conveyance features required<br>• Water quality treatment for discharge to USJRB<br>• Water quality treatment for C-24 to C-25 discharge |
| **YES** | IRFWCD-R | Storage reservoir between IRFWCD and Blue Cypress WMA to capture excess water from IRFWCD – supplemental water source for Blue Cypress and/or IRFWCD | • Provides Inter-District connection<br>• Provides water supply benefits<br>• Within SJRWMD<br>• Minimal/no water quality treatment for discharge to USJRB |
| **Interim Measure** | Dispersed Storage/ Water Farming | Compensating land owners for managing excess water on private property. | • Provides water supply benefits<br>• Likely to be cost effective<br>• Could be implemented quickly – interim or long-term<br>• Scalable |
| NO | FPFWCD Flow-way | Creation of a wetland flow-way along Canal No. 3 | • No increase in water supply availability<br>• Being undertaken by others<br>• Water quality improvement<br>• Habitat creation |
| NO | Well Decom. | Decommissioning abandoned Florida Aquifer artesian wells | • No increase in water supply availability<br>• Being undertaken by others<br>• Water quality improvement<br>• Protection of existing water resources |
| NO | IR-SJ-C | Creating a connection between the Indian River Farms Water Control District and the St. Johns Improvement District | • No increase in water supply availability<br>• Opportunistic benefits for water supply<br>• Opportunistic benefits for flood control<br>• No impact on regional water management system |

## C-25 CENTRAL RESERVOIR (ICS-01)

This alternative would enable the capture and storage of excess flows from the western C-25 Basin and C-25 Extension Basin in a central above-ground storage reservoir (***Figure 35***) with a pumped inflow. This would, with some conveyance modifications/improvements, make gravity releases possible. The existing plug in the Turnpike Canal that prevents flow to pass between SJRWMD and SFWMD would be replaced with a gated water control structure. This would enable flows to be exchanged between C-25 Extension (SFWMD) and C-52 East (SJRWMD).

Excess water from the western C-25 Basin that would otherwise be discharged to tide would be captured in the reservoir. With removal of the Turnpike Canal plug, it would also be possible to capture excess stormwater from the C-25 Extension Basin in the reservoir.

Gravity discharges from the reservoir could be conveyed southward to meet water supply demands in the C-25 Basin. Water supply demands in the C-25 Extension Basin could be met by transferring water via C-52 East and C-52 West to the Ft. Drum Flow-Way.

A pump station at S-253 would be added to transfer water discharged from the reservoir northward to the Blue Cypress Water Management Area (BCWMA). Discharges from the BCWMA can be made to meet agricultural water supply demands in the SJRWMD. Operational limitations associated with the BCWMA regulation schedule and environmental conditions would control when water can be discharged into, or out of the BCWMA. The target for the USJRB is to maintain TP concentrations at, or below 80 ppb. Since TP concentrations in C-25 average 176 ppb, an STA would be required to avoid degrading the quality of water in the USJRB Project.

## C-23, C-24, AND C-25 CENTRAL RESERVOIR (ICS-02)

This alternative would contain all of the components of the C-25 Central Reservoir Alternative in addition to canal improvements to the north/south section of C-25 from its junction with the east/west section of C-25 to G-81 (***Figure 36***). G-81 has been replaced by SFWMD and would have the capacity to discharge water between C-25 and C-24. A pump station would be added at G-81 to pump excess flows from C-23 and C-24 northward for storage in the reservoir when gravity flows are not possible. The canal improvements would enable the connection of C-25 with C-23 and C-24. It is assumed that the C-23 and C-24 reservoirs and STA components of the IRL-S Project will be in place. With these features in place, the conveyance capacities of C-23 and C-24 and G-79 and G-78 will be improved so that no further modifications will be necessary to enable inter-basin transfers between C-23 and C-24. This would allow the central reservoir to capture all excess water from the western C-23, C-24, and C-25 Basins. The excess water from the C-23 and C-24 Basins would be calculated based on the assumption that the IRL-S reservoirs are operational. It is also assumed that the IRL-S STA will treat water sufficiently to allow inter-basin transfers of water without degrading the receiving water body.

## C-25/BASIN 1 CENTRAL RESERVOIR ALTERNATIVE (ICSB-01)

This alternative includes all the components of the C-25 Central Reservoir Alternative plus a connection with Basin 1 (Ft. Pierce Farms Water Control District) (***Figure 37***). An existing canal would be improved from C-25 to the main FPFWCD canal. A water control structure would be constructed in the canal to control flows. This would allow excess water from Basin 1 to be discharged into the lower section of C-25 between S-99 and S-50. A pump station would be constructed adjacent to S-99 to discharge water from the lower pool of C-25 (downstream of S-99) to the upper pool (upstream of S-99). Once this water is pumped to the upper C-25 pool, it can then be pumped into a central reservoir. This would expand the available drainage area from which excess flows could be captured beyond what is included in the C-25 Central Reservoir Alternative.

## INDIAN RIVER FARMS WATER CONTROL DISTRICT RESERVOIR (IRFWCD-R)

This alternative includes the addition of an above ground reservoir (***Figure 38***) with pumped inflow immediately west of the western IRFWCD boundary. Excess water from IRFWCD could be captured and stored in the reservoir. The borrow canal for the perimeter levee of the IRFWCD would be improved to convey excess water from a main lateral canal to the reservoir. A pump station would be required to pump water from the middle to the upper pool within the IRFWCD. Water stored in the reservoir could be discharged back to IRFWCD to provide supplemental water supply. Additionally, the reservoir could be connected to the west with the Upper St. Johns River Basin Project or to the St. Johns Improvement District main canal although this connection is not included in the alternative evaluated in this report.

## DISPERSED STORAGE/WATER FARMING

This alternative represents a potentially viable interim means of addressing the study objectives. It is scalable and could be implemented quickly on an interim basis pending the design, budgeting, and implementation of regional measures. In general, dispersed storage/water farming would consist of the provision of water management services by landowners for compensation by a public agency, presumably a water management district. The concept consists of shallow storage of water on private property using existing water management infrastructure with minimal or no additional capital improvements being required. Typically, existing agricultural pumps, drainage ditches, and levees/berms would be utilized by the land owner to store excess water during wet periods and release it to supplement regional water supply during dry periods. Land owners would be reimbursed based on services provided.

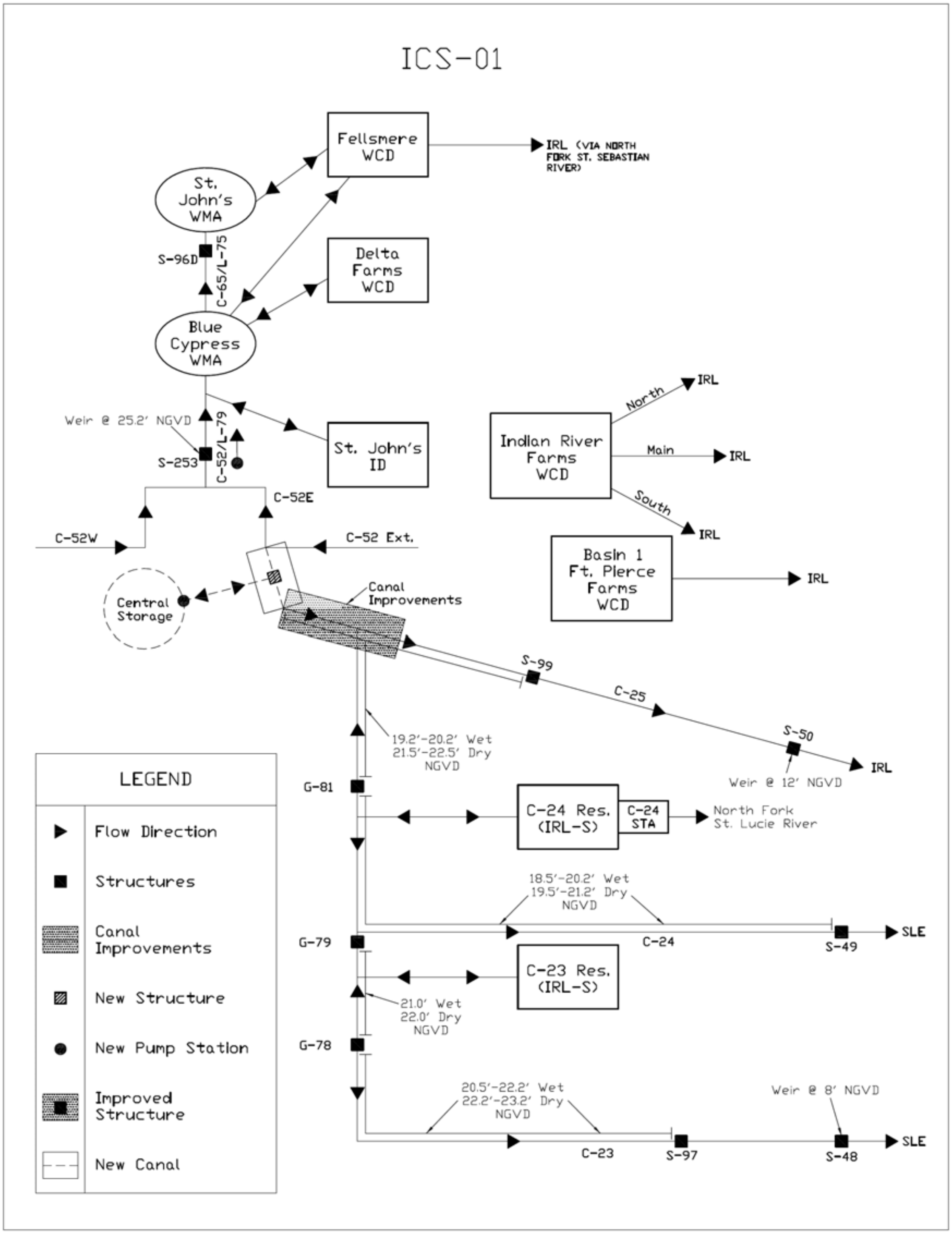



**Figure 35. Schematic of the C-25 Central Reservoir Alternative (ICS-01)**

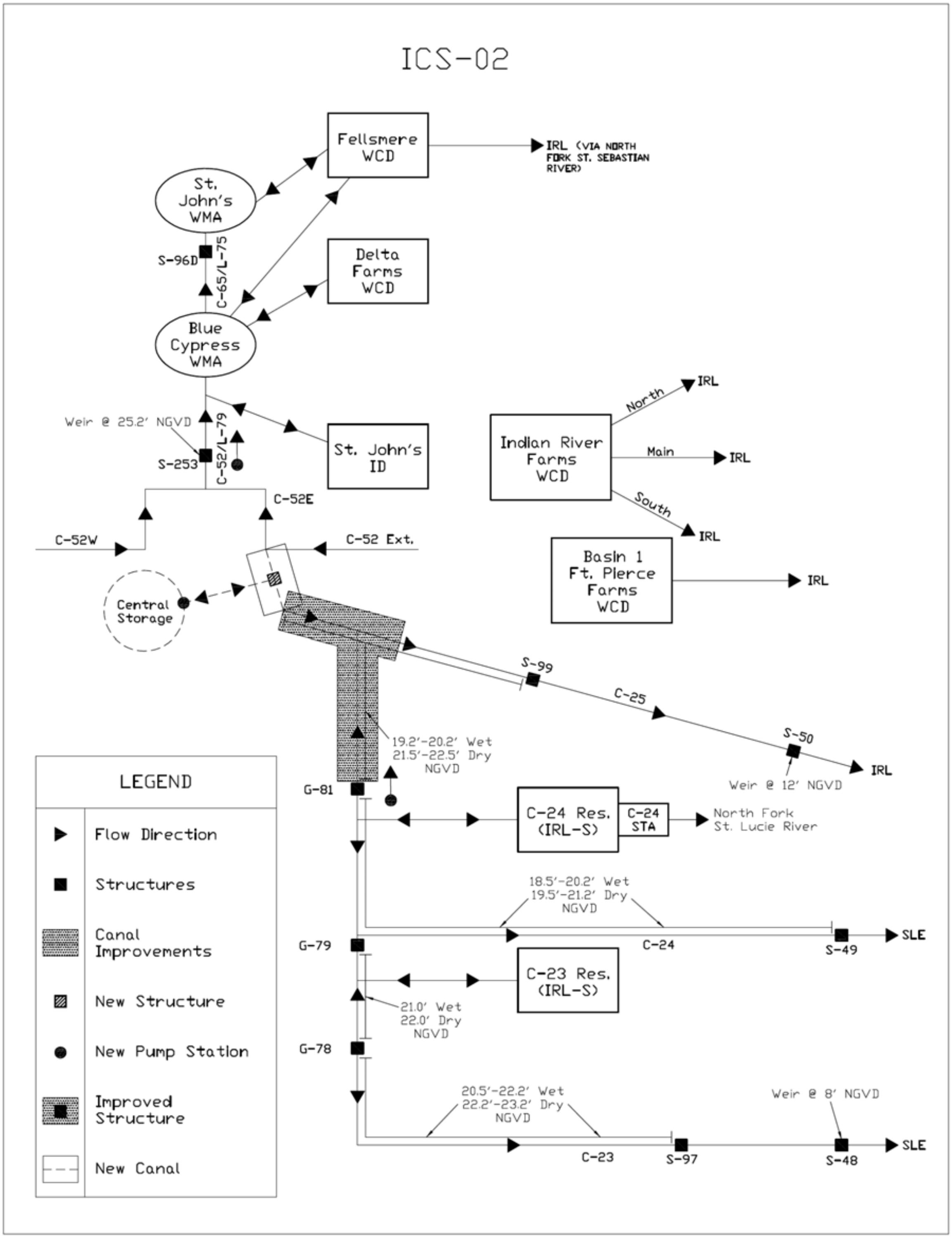



**Figure 36. Schematic of the C-23,24,and 25 Central Reservoir Alternative**

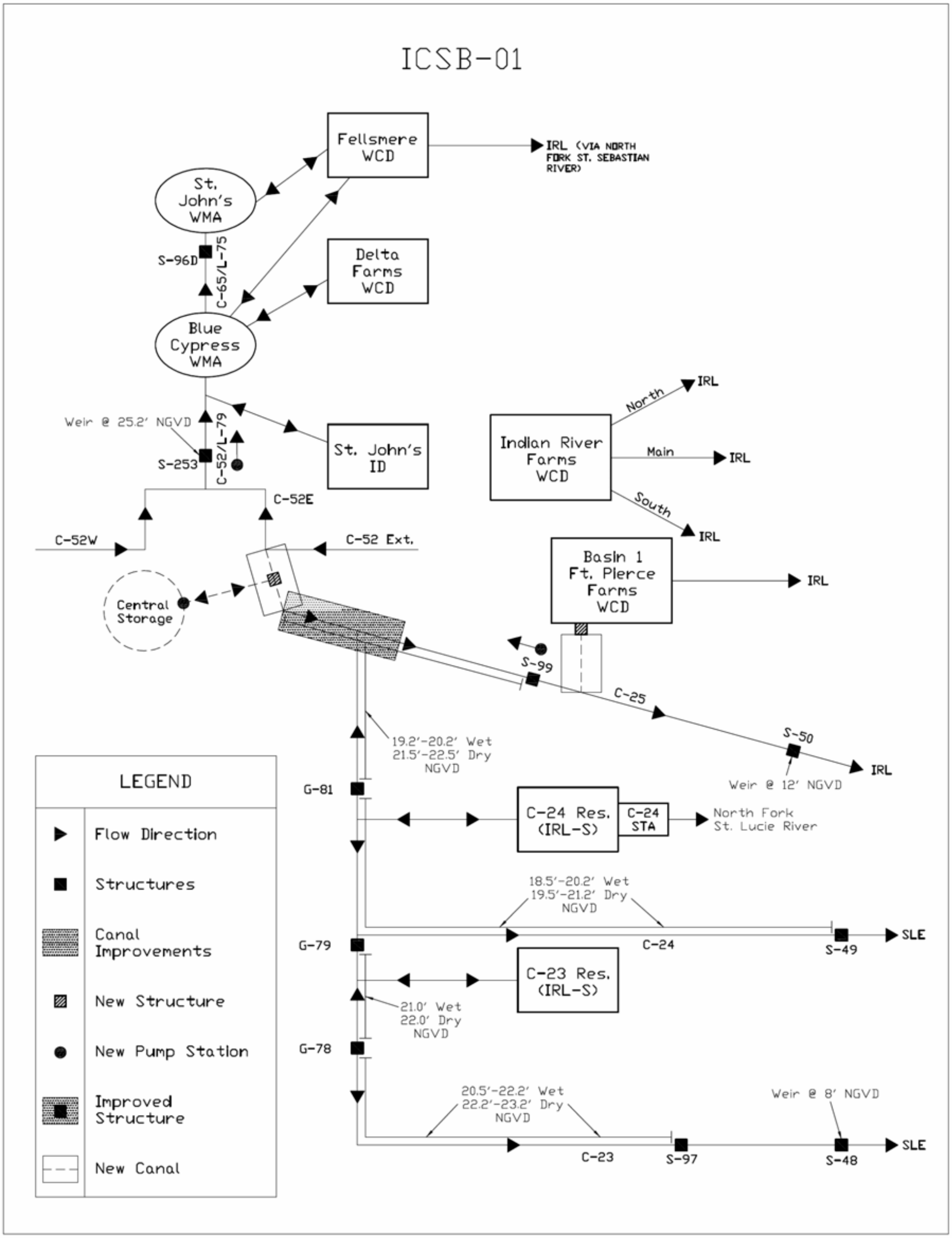



**Figure 37. Schematic of the C-25/Basin 1 Central Reservoir Alternative.**

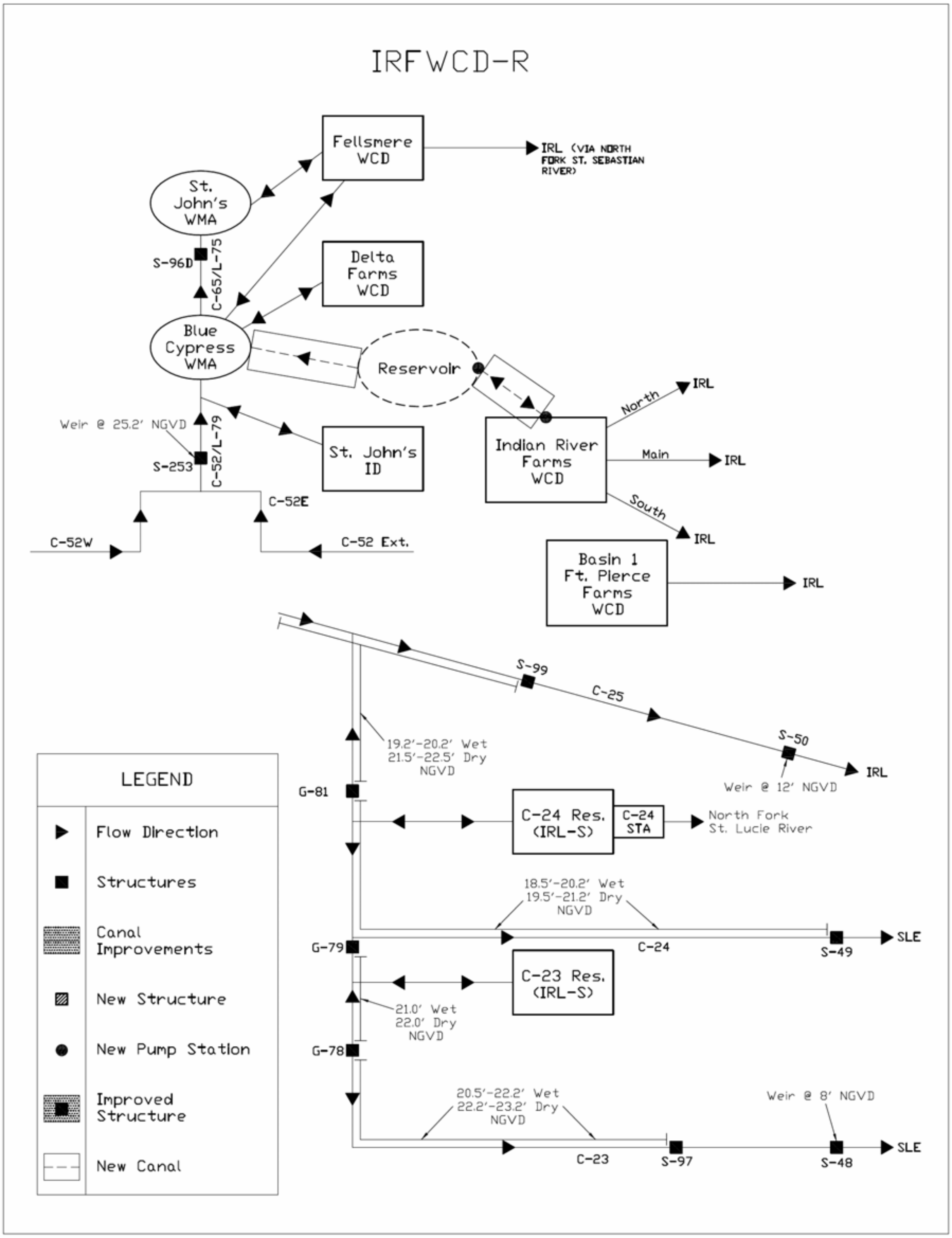



**Figure 38. Schematic of the Indian River Farms Water Control District Reservoir Alternative.**

# Alternative Plan Preliminary Designs and Cost Estimates

Preliminary designs and cost estimates were prepared to enable comparisons between the alternative plans. A simplified approach was developed to enable estimating the costs of large numbers of alternative plan configurations.

## RESERVOIRS AND INFLOW PUMP STATIONS

In order to develop a reasonable estimate of cost per acre-foot of storage for reservoirs, data was collected from a number of CERP Project Implementation Reports. A total of nine reservoirs were selected from the following CERP projects.

- Broward County Water Preserve Areas
- Caloosahatchee River (C-43) West Basin Storage Reservoir
- Indian River Lagoon – South
- Restoration Plan for Site 1 Impoundment
- Lake Okeechobee Watershed

All cost estimates used were based on the Corps of Engineers' Micro-Computer Aided Cost Estimating System (MCACES) estimates. The data collected is summarized in ***Table 37***. The overall reservoir construction costs were separated from the pump plant costs. Reservoir construction cost line items primarily consisted of Reservoirs, Channels & Canals, Levees & Floodwalls, and Flood Control & Diversion Structures. Non-Construction costs including Engineering & Design (E&D) and Supervision & Administrative (S&A) (aka construction management) were also included.

The reservoir footprint acreage and overall storage capacity (in acre-feet) were recorded for each reservoir as well as the maximum storage depth and inflow pump capacity. Cost per acre-foot of storage was calculated. Some variations in how cost estimates were organized and their content were observed. However, these differences appeared to be negligible relative to the overall project costs. In order to adjust costs for inflation, an escalation of 3% per year was added to all estimates created before 2008 to adjust their costs to 2008 price levels. Similarly, the Caloosahatchee River (C-43) Reservoir Report also indicated an escalation cost of 2.7% to adjust the 2006 values to 2007 values.

# Table 37. CERP Project Reservoir and Pump Station Cost Estimates

| Project / Year | Construction (w/o Pump Plant) | Reservoir Cost | Pump Plant | Pump Cost | Total Cost | Escalated Cost | Site Area (ac) | Reservoir Size (ac-ft) | Cost per Ac-ft storage | Max Storage Depth (ft) | Inflow Pump Capacity (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Brwd Co WPA** | Construction Cost (CC) | $90,876,750 | Pump Plant (PP) | $25,091,000 | $167,608,653 | 172,636,913 | 1,641 | 7,056 | $24,466 | 4.3 | 1,075 |
| **C-9 Impoundment** | E&D$^{CC}$ (10%) | $9,101,943 | E&D$^{PP}$ (10%) | $2,513,039 | | | | | | | |
| **(Feb 07)** | S&A$^{CC}$ (9.5%) | $8,646,650 | S&A$^{PP}$ (9.5%) | $2,387,333 | | | | | | | |
| | Contingency$^{CC}$ (25%) | $22,719,188 | Contingency$^{PP}$ (25%) | $6,272,750 | | | | | | | |
| | **Total Construction Cost** | **$131,344,530** | **Total Pump Plant Cost** | **$36,264,123** | | | | | | | |
| **Brwd Co WPA** | Construction Cost (CC) | $115,426,750 | Pump Plant (PP) | $25,459,000 | $203,551,732 | 209,658,284 | 1,068 | 4,592 | $45,653 | 4.3 | 1,050 |
| **C-11 Impoundment** | E&D$^{CC}$ (10%) | $11,531,132 | E&D$^{PP}$ (10%) | $2,543,354 | | | | | | | |
| **(Feb 07)** | S&A$^{CC}$ (9.5%) | $10,953,999 | S&A$^{PP}$ (9.5%) | $2,416,059 | | | | | | | |
| | Contingency$^{CC}$ (25%) | $28,856,688 | Contingency$^{PP}$ (25%) | $6,364,750 | | | | | | | |
| | **Total Construction Cost** | **$166,768,568** | **Total Pump Plant Cost** | **$36,783,163** | | | | | | | |
| **Caloosahatchee C-43 Reservoir** | Construction Cost (CC) | $218,862,792 | Pump Plant (PP) | $57,357,560 | $429,311,293 | 442,190,632 | 10,500 | 170,000 | $2,601 | 17.0 | 1,500 |
| **(Jul 07)** | E&D$^{CC}$ (13.6%) | $29,830,999 | E&D$^{CC}$ (13.6%) | $7,817,835 | | | | | | | |
| | S&A$^{CC}$ (7.8%) | $17,115,070 | S&A$^{CC}$ (7.8%) | $4,485,361 | | | | | | | |
| | Escalation$^{CC}$ (2.7%) | $5,979,331 | Escalation$^{CC}$ (1.6%) | $896,596 | | | | | | | |
| | Contingency$^{CC}$ (26.3%) | $69,827,988 | Contingency$^{PP}$ (25.4%) | $14,563,084 | | | | | | | |
| | Contingency E&D$^{CC}$ (18.6%) | $5,545,583 | Contingency E&D$^{PP}$ (18.6%) | $1,453,336 | | | | | | | |
| | Contingency S&A$^{CC}$ (25%) | $4,278,768 | Contingency S&A$^{PP}$ (25%) | $1,121,340 | | | | | | | |
| | **Total Construction Cost** | **$341,616,180** | **Total Pump Plant Cost** | **$87,695,113** | | | | | | | |
| **IRL South** | Construction Cost (CC) | $34,935,000 | Pump Plant (PP) | $12,552,000 | $70,381,088 | 79,214,534 | 4,399 | 48,500 | $1,633 | 12.0 | 900 |
| **C23/24 Res. N.** | E&D$^{CC}$ (12.7%) | $4,436,745 | E&D$^{CC}$ (12.7%) | $1,594,104 | | | | | | | |
| **(Mar 04)** | S&A$^{CC}$ (8%) | $2,794,800 | S&A$^{CC}$ (8%) | $1,004,160 | | | | | | | |
| | Contingency$^{CC}$ (23.8%) | $8,312,993 | Contingency$^{PP}$ (20%) | $2,510,400 | | | | | | | |
| | Contingency E&D$^{CC}$ (22.8%) | $1,011,489 | Contingency E&D$^{PP}$ (22.8%) | $363,424 | | | | | | | |
| | Contingency S&A$^{CC}$ (22.8%) | $637,075 | Contingency S&A$^{PP}$ (22.8%) | $228,898 | | | | | | | |
| | **Total Construction Cost** | **$52,128,102** | **Total Pump Plant Cost** | **$18,252,986** | | | | | | | |
| **IRL South** | Construction Cost (CC) | $38,516,000 | Pump Plant (PP) | $9,866,000 | $72,153,742 | 81,209,673 | 4,155 | 43,400 | $1,871 | 12.0 | 900 |
| **C23/24 Res. S** | E&D$^{CC}$ (12.7%) | $4,891,532 | E&D$^{CC}$ (12.7%) | $1,252,982 | | | | | | | |
| **(Mar 04)** | S&A$^{CC}$ (8%) | $3,081,280 | S&A$^{CC}$ (8%) | $789,280 | | | | | | | |
| | Contingency$^{CC}$ (24.5%) | $9,423,710 | Contingency$^{PP}$ (20%) | $1,973,200 | | | | | | | |
| | Contingency E&D$^{CC}$ (23.6%) | $1,152,641 | Contingency E&D$^{PP}$ (23.6%) | $295,253 | | | | | | | |
| | Contingency S&A$^{CC}$ (23.6%) | $725,919 | Contingency S&A$^{PP}$ (23.6%) | $185,946 | | | | | | | |
| | **Total Construction Cost** | **$57,791,081** | **Total Pump Plant Cost** | **$14,362,661** | | | | | | | |
| **Lake Okechobee Watershed** | Construction Cost (CC) | $185,564,697 | Pump Plant (PP) | $6,600,000 | $238,284,224 | 238,284,224 | 5,416 | 79,560 | $2,995 | 16.0 | 500 |
| **Reservoir I-17** | E&D$^{CC}$ (4%) | $7,422,588 | E&D$^{PP}$ (4%) | $264,000 | | | | | | | |
| **(Oct 08)** | S&A$^{CC}$ (5%) | $9,278,235 | S&A$^{PP}$ (5%) | $330,000 | | | | | | | |
| | Contingency$^{CC}$ (15%) | $27,834,705 | Contingency$^{PP}$ (15%) | $990,000 | | | | | | | |
| | **Total Construction Cost** | **$230,100,224** | **Total Pump Plant Cost** | **$8,184,000** | | | | | | | |
| **Lake Okechobee Watershed** | Construction Cost (CC) | $314,621,423 | Pump Plant (PP) | $19,800,000 | $414,682,565 | 414,682,565 | 5,110 | 74,216 | $5,588 | 16.0 | 1,000 |
| **Reservoir KISS-04 (K42)** | E&D$^{CC}$ (4%) | $12,584,857 | E&D$^{PP}$ (4%) | $792,000 | | | | | | | |
| **(Oct 08)** | S&A$^{CC}$ (5%) | $15,731,071 | S&A$^{PP}$ (5%) | $990,000 | | | | | | | |
| | Contingency$^{CC}$ (15%) | $47,193,213 | Contingency$^{PP}$ (15%) | $2,970,000 | | | | | | | |
| | **Total Construction Cost** | **$390,130,565** | **Total Pump Plant Cost** | **$24,552,000** | | | | | | | |
| **Lake Okechobee Watershed** | Construction Cost (CC) | $116,507,210 | Pump Plant (PP) | $8,800,000 | $155,380,940 | 155,380,940 | 2,075 | 32,000 | $4,856 | 18.0 | 400 |
| **Reservoir T-26** | E&D$^{CC}$ (4%) | $4,660,288 | E&D$^{PP}$ (4%) | $352,000 | | 155,380,940 | | | | | |
| **(Oct 08)** | S&A$^{CC}$ (5%) | $5,825,361 | S&A$^{PP}$ (5%) | $440,000 | | | | | | | |
| | Contingency$^{CC}$ (15%) | $17,476,082 | Contingency$^{PP}$ (15%) | $1,320,000 | | | | | | | |
| | **Total Construction Cost** | **$144,468,940** | **Total Pump Plant Cost** | **$10,912,000** | | | | | | | |
| **Site 1 Impoundment** | Construction Cost (CC) | $16,886,000 | Pump Plant (PP) | $18,878,000 | $47,999,912 | 47,999,912 | 1,660 | 13,280 | $3,614 | 8.0 | 1,350 |
| **(Mar 06)** | E&D$^{CC}$ (9.5%) | $1,605,352 | E&D$^{CC}$ (9.5%) | $1,794,731 | | | | | | | |
| | S&A$^{CC}$ (7.6%) | $1,284,180 | S&A$^{CC}$ (7.6%) | $1,435,672 | | | | | | | |
| | Contingency$^{CC}$ (16.95%) | $2,862,008 | Contingency$^{PP}$ (14.96%) | $2,823,960 | | | | | | | |
| | Contingency S&A$^{CC}$ (15.8%) | $203,029 | Contingency S&A$^{PP}$ (15.8%) | $226,980 | | | | | | | |
| | **Total Construction Cost** | **$22,840,569** | **Total Pump Plant Cost** | **$25,159,343** | | | | | | | |

Notes: Total Cost does not include Lands and Damages

Once the necessary data was collected and analyzed, a plot of storage capacity vs. construction cost was created using all of the reservoir sites. Looking at the data more closely revealed that the Broward County Water Preserve Area reservoirs (C-9 and C-11) provided a skewed estimate of storage capacity per cost compared to the other reservoirs. These shallow ponds resulted in relatively high cost per storage capacity values ($24,466 and $45,653 per acre-foot, for C-9 and C-11 respectively) when compared to the other reservoirs, which varied between $1,633 to $5,588 per acre-foot. These reservoirs were designed for different purposes and for different conditions. Therefore, the C-9 and C-11 reservoirs were removed from consideration. The remainder of the reservoir data was used to develop a cost / storage relationship, shown in ***Figure 39***. The resulting fitted regression line has an $R^2$ value of 0.7239 which shows a reasonable relationship between storage capacity and construction cost.

A similar comparison of pump capacity and cost was performed using the data compiled in ***Table 37.*** The pump capacities vs. pump costs were plotted and fitted with a curve ($R^2$ = .7769) as shown in ***Figure 40***.

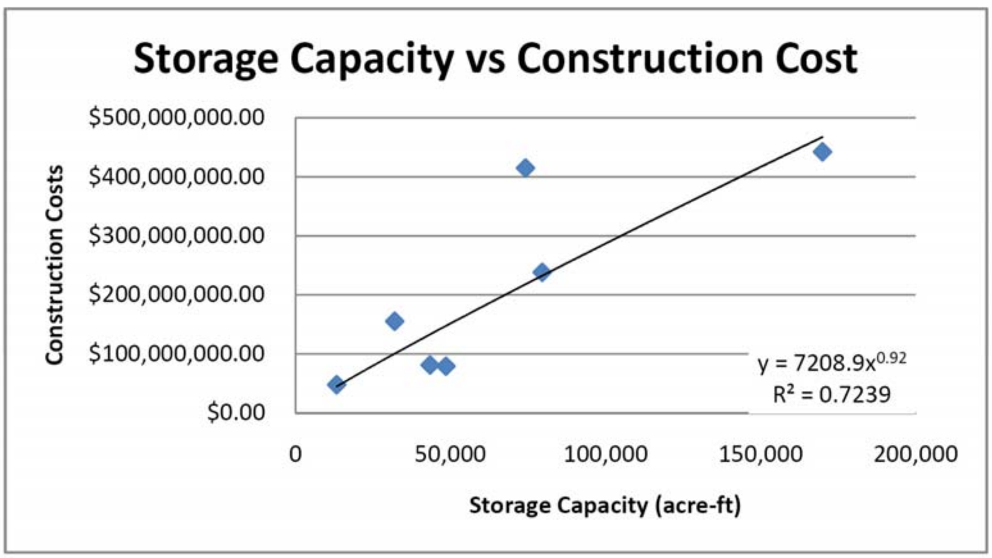



**Figure 39. Reservoir storage capacity vs. construction cost.**

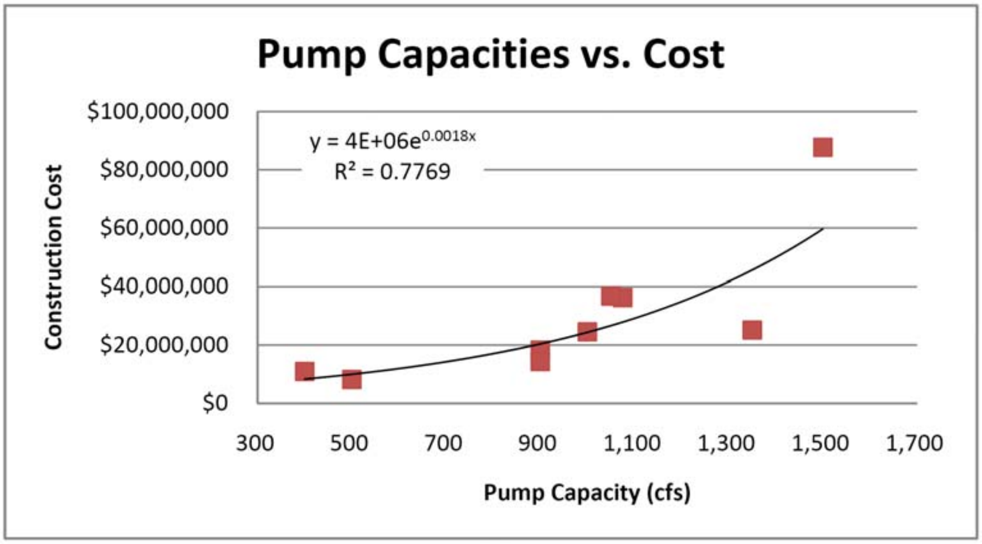



**Figure 40. Reservoir inflow pump station costs vs. capacities.**

## STA CONCEPTUAL DESIGN AND COST

An STA would be required for the three alternatives (ICS-01, ICS-02, and ICSB-01) that would be capable of discharging to the Upper St. Johns River Basin Project. The purpose of the STA would be to reduce total phosphorus concentrations to 80 ppb to avoid violating the water quality target for the USJRB Project. The source of the water to be treated would be the western C-25 Basin which has a historical average TP concentration of 176 ppb. The flow rate to be treated by the STA would be the discharge delivery rate for the alternative. The Indian River Farms Water Control District Reservoir (IRFWCD-R) alternative would not involve transfers of water that would require water quality treatment.

The STA would treat water from the reservoir and the tributary canal. Discharges from the STA would be conveyed northward through the structure that would replace the C-25 plug and then would be pumped northward at the proposed pump station at S-253 (***Figure 41***). Southward discharges at S-253 would still be possible across the weir when water levels on the north side of the structure exceed the crest elevation of 25.2 ft, NGVD.

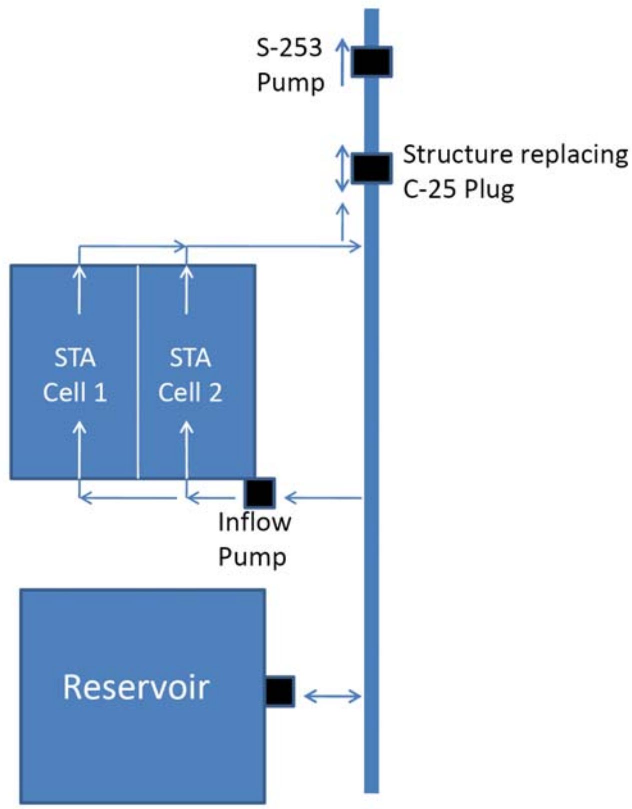



**Figure 41. Conceptual STA and reservoir schematic.**

## STA Cost Estimating Methodology

The Lake Okeechobee Watershed Project developed cost estimates for a final set of 10 alternatives. These alternatives included 5 STAs. A plot of construction cost vs. STA area shows a linear relationship for these STAs. This relationship was used to facilitate estimation of conceptual level costs for STAs (HDR 2008) (***Figure 42***). STA costs include inflow pumps and all other ancillary features.

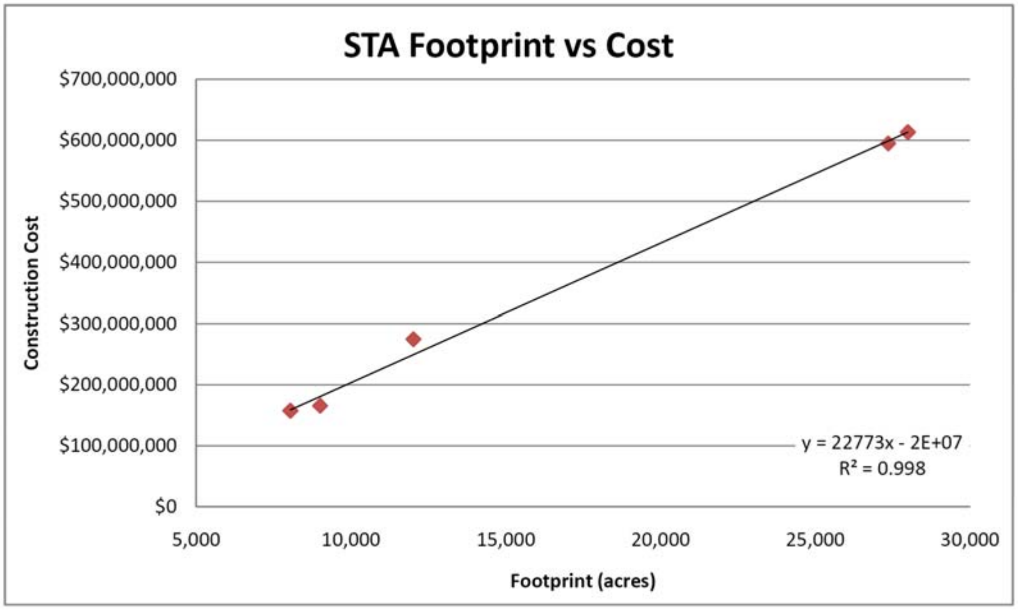



**Figure 42. STA footprint area vs. cost.**

## STA Conceptual Design

An initial design was developed for an assumed flow rate of 100 cfs. The Dynamic Model for Stormwater Treatment Areas Version 2 (DMSTA2) was used to determine the STA size needed to treat inflow with a phosphorus concentration 176 ppb (based on average concentrations in C-25) to an outflow concentration of 80 ppb. A set of constant DMSTA2 input parameters was maintained for multiple simulations of various STA sizes. Assumptions used for this analysis follow:

- 2 parallel STA cells that would each accept half of the 100 cfs inflow
- depth of flow in the cells was 1.5 feet (45.72 cm)
- a fixed broad crested outflow weir would serve as the outflow control structure for each cell
- the heights of the outflow weirs were set to 1.5 feet, measured from the cell bottom
- the broad crested weir coefficient and exponent were both set at 1.5
- seepage from the STA was estimated at a rate of 0.005 cm/day/cm of distance to the water table from the ground surface
- the water table was 10 cm below the ground surface - the maximum phosphorus concentration of the seepage was set to 50 ppb

➢ the length of each STA cell was assumed to be twice the width

## STA Cost Estimate

The results of multiple DMSTA2 simulations showed that, for the assumed conditions, an STA of 10 km2 (approximately 2,500 acres) total area would be sufficient to reduce the phosphorus concentration to 80 ppb (***Figure 43***). Using the cost estimating algorithm described above, the cost of the STA would be $51,932,500.

STA sizes will vary for the reservoir alternatives being considered based on the discharge delivery rate that can be achieved with 90% reliability. Therefore, to simplify cost estimating requirements, the cost of the STA designed to treat 100 cfs proportionally increased or reduced based on the discharge delivery rate calculated for each of the reservoir and pump combinations that were evaluated.

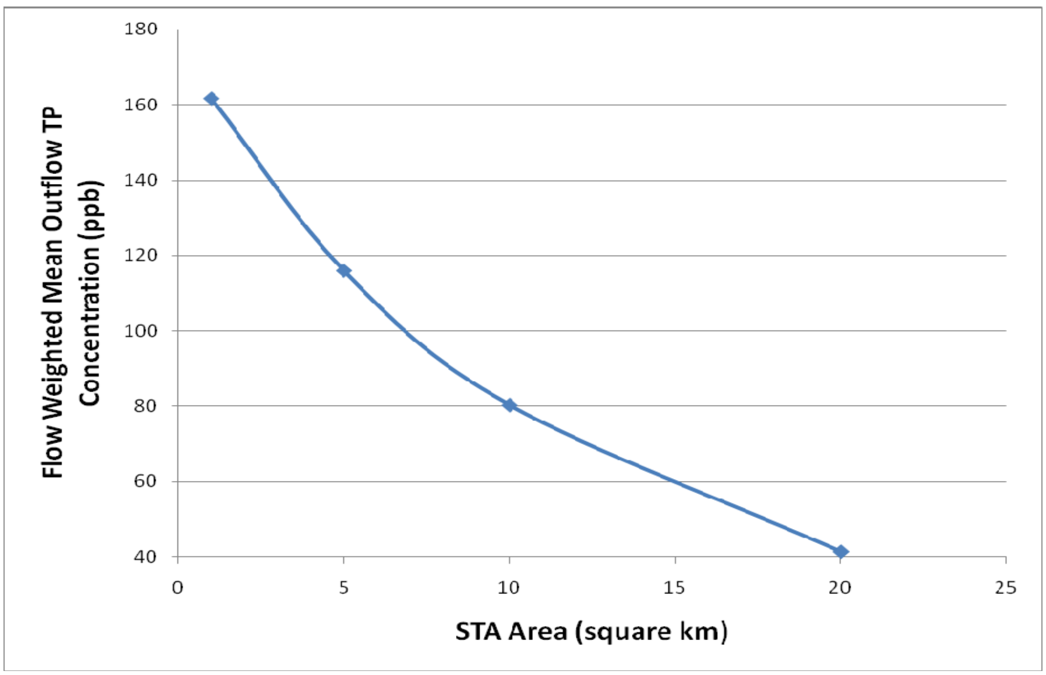



**Figure 43. Flow weighted mean TP outflow concentrations based on STA area - inflow concentration = 176 ppb, outflow concentration of = ppb, and flow rate = 100 cfs.**

## Real Estate Costs

Real estate costs were estimated at $6,000 per acre for reservoirs and STAs. This per acre cost was based on input from real estate specialists at SFWMD and SJRWMD.

## Replace C-25 Plug with Gated Structure

The existing plug, which is located in the Turnpike Canal on the north side of the Turnpike, would be removed and replaced with a gated water structure. It is an earthen plug in the canal about 1,600 feet in length.

The structure discharge capacity of 300 cfs was selected based on the discharge exceedance relationship shown in ***Figure 44.*** This capacity would enable rerouting all but the most extreme daily flows in the period of record that would otherwise flow northward via S-253 during flood conditions. Rerouted flows would be pumped into the storage reservoir. This would provide relief to the USJR Basin Project during flood conditions when there is no capacity available to handle such flows and would increase the availability of water supply storage.

Water would be released from reservoir storage and moved northward through the new structure during dry conditions when there was a need in the USJR Basin Project. It is assumed that construction could be accomplished without acquiring additional land interests.

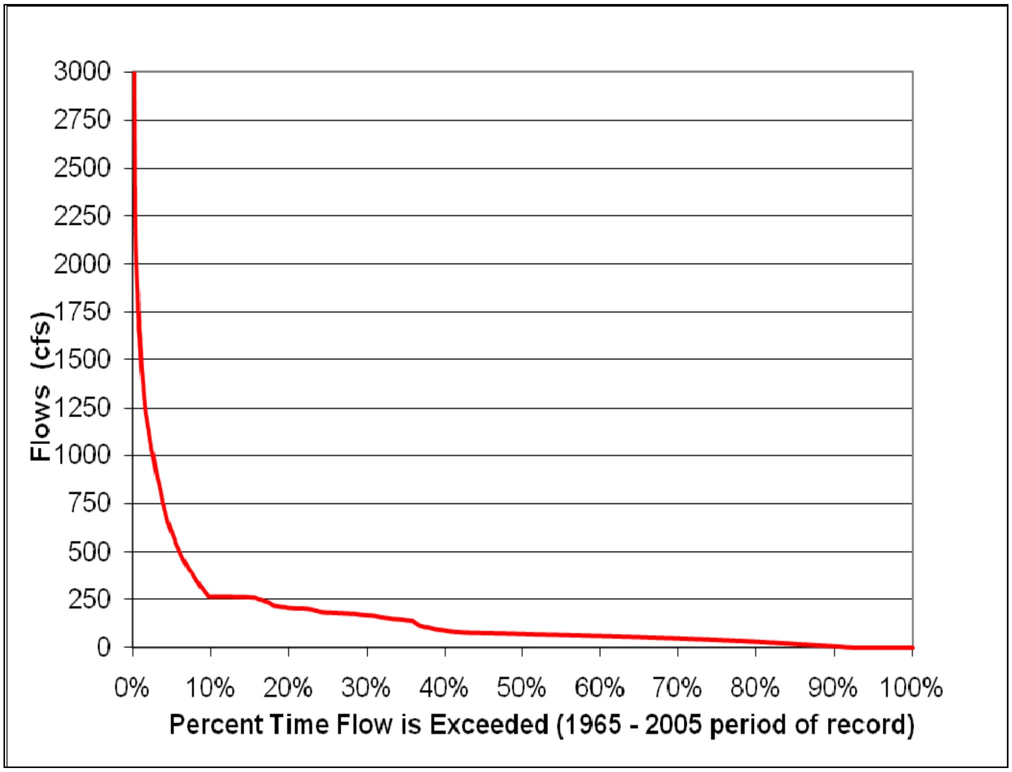



**Figure 44. S-253 discharge exceedance relationship.**

### Conceptual Design Assumptions

- Canal Length =1,600 LF
- Canal 80 ft wide top width
- Canal side slopes 2H:1V

- Assume plug 7 ft high
- Seed & Mulch top 8 ft
- Gate capacity 300 cfs

### Cost Estimate

| Item | Unit | Qty | $/Unit | | TOTAL | |
|---|---|---|---|---|---|---|
| Excavation | CY | 14,105 | $ | 5 | $ | 70,525 |
| Seed & Mulch | SY | 5700 | $ | 1 | $ | 5,700 |
| Mobilization | LS | 1 | $ | 10,000 | $ | 10,000 |
| Vertical Lift Gate Structure | LS | 1 | $ | 440,000 | $ | 440,000 |
| Sub-Total | | | | | $ | 526,225 |
| Engineering Design (8%) | | | | | $ | 42,098 |
| Construction Management (7%) | | | | | $ | 36,836 |
| Contingency (30%) | | | | | $ | 157,868 |
| TOTAL | | | | | $ | 763,026 |

## Improve C-25 Extension

The C-25 Extension Canal would be improved from its intersection with the east/west portion of C-25 westward to the bridge crossing under the Turnpike just west of C-52 East (***Figure 45***). The existing canal has a top width of between 20 and 30 feet at its western extent to about 120 feet at its intersection with C-25. It is assumed that the existing canal is at a depth of 20 feet with one on two side slopes. The canal would be improved to provide a cross section adequate to convey 200 cfs.

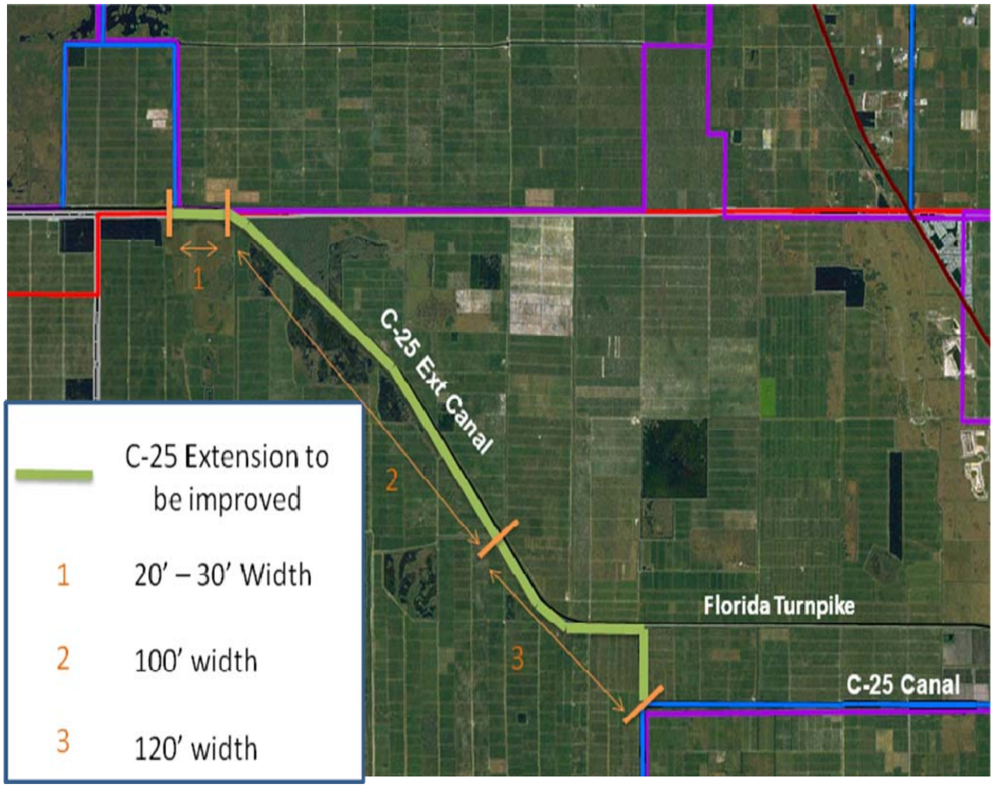


**Figure 45. C-25 Extension Improvements.**

### Conceptual Design Assumptions

- Section 1 (***Figure 45***) improvement length 5,800 LF
- Sections 2 and 3 (***Figure 45***) require no improvement
- Canal sides lopes 2H:1V
- Cross section to provide 200 cfs at 0.8 ft/sec

### Cost Estimate

| Item | Unit | Qty | $/Unit | TOTAL |
|---|---|---|---|---|
| Excavation | CY | 241,667 | $ 5 | $ 1,208,333 |
| Seed & Mulch | SY | 18,044 | $ 1 | $ 18,044 |
| Mobilization | LS | 1 | $ 5,000 | $ 5,000 |
| Sub-Total | | | | $ 1,231,378 |
| Engineering Design (8%) | | | | $ 98,510 |
| Construction Management (7%) | | | | $ 86,196 |
| Contingency (30%) | | | | $ 369,413 |
| TOTAL | | | | $ 1,785,498 |

## Improve Western C-25

The north/south section of C-25 would be improved from its intersection with the east/west section of C-25 to G-81 (***Figure 46***). At its intersection with the east/west section of C-25, the existing western C-25 has a bottom width of about 50 feet, one on two side slopes, and a depth of about 20 feet below natural ground elevation. At G-81, the canal bottom width is about 20 feet with one on two side slopes and a depth of 20 feet below natural ground elevation. It would be improved to convey 200 cfs.

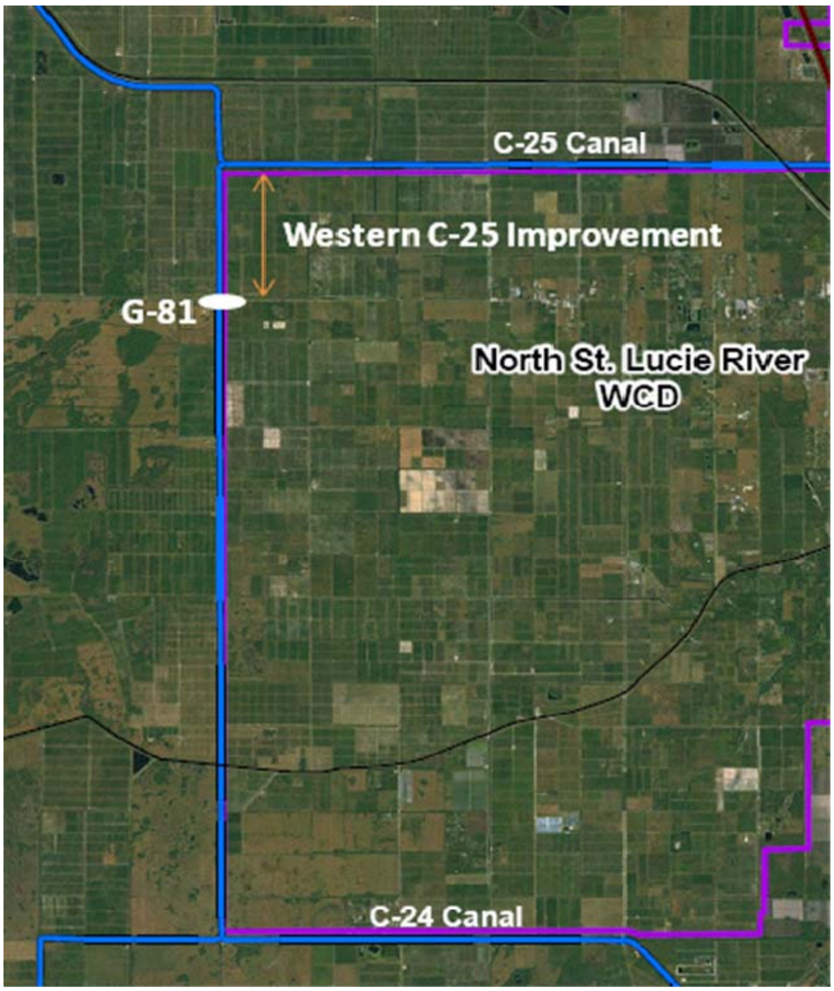



**Figure 46. Western C-25 Improvements.**

### Conceptual Design Assumptions

- Length of canal to be regraded 8,140 LF
- 50 ft bottom width
- 2H:1V side slopes

### Cost Estimate

| Item | Unit | Qty | $/Unit | TOTAL |
|---|---|---|---|---|
| Excavation | CY | 179,080 | $ 5 | $ 895,400 |
| Seed & Mulch | SY | 16,116 | $ 1 | $ 16,116 |
| Mobilization | LS | 1 | $ 5,000 | $ 5,000 |
| Sub-Total | | | | $ 916,516 |
| Engineering Design (8%) | | | | $ 73,321 |
| Construction Management (7%) | | | | $ 64,156 |
| Contingency (30%) | | | | $ 274,955 |
| TOTAL | | | | $ 1,328,948 |

## Basin 1 Canal and Structure

A canal would be constructed to connect C-25 and the Basin 1 (Ft. Pierce Farms Water Control District) main canal. The canal would be designed to convey 200 cfs (***Figure 47***). A gated water control structure would be provided to control flows from Basin 1 to C-25. The structure would have a 200 cfs capacity.

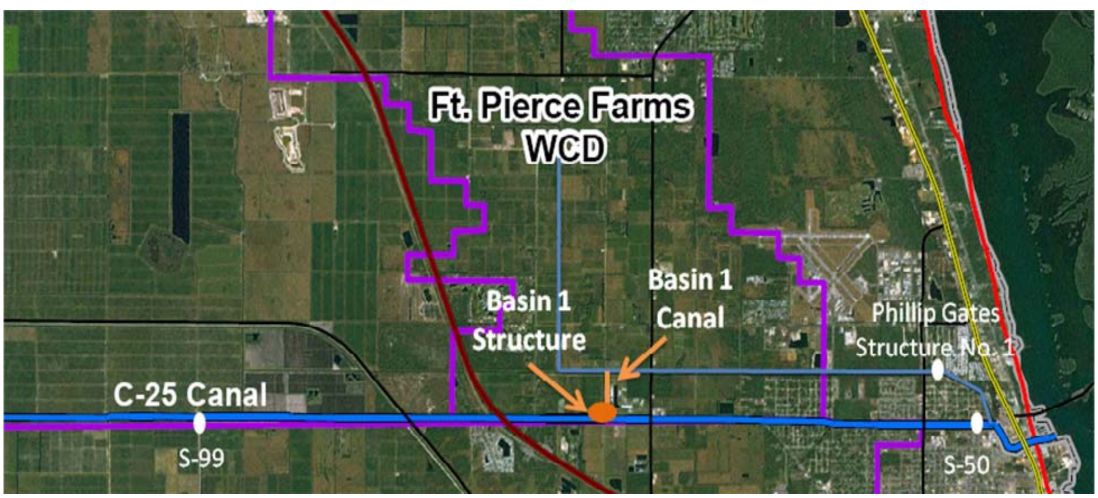



**Figure 47. Basin 1 structure and canal.**

### Conceptual Design Assumptions

- Re-grade 2,400 LF of existing canal
- Existing top width 20 ft, assumed bottom 3 ft wide and 4 ft deep
- Proposed section 10 ft deep, 20 ft bottom width
- 200 cfs capacity
- Assume 6 -10'W x 4'H Vertical Lift Gates

### Cost Estimate

| Item | Unit | Qty | $/Unit | TOTAL |
|---|---|---|---|---|
| Excavation | CY | 31,467 | $ 5 | $ 157,333 |
| Seed & Mulch | SY | 2,133 | $ 1 | $ 2,133 |
| Mobilization | LS | 1 | $ 5,000 | $ 5,000 |
| Vertical Lift Gate Structure | LS | 1 | $ 360,000 | $ 360,000 |
| Sub-Total | | | | $ 524,467 |
| Engineering Design (8%) | | | | $ 41,957 |
| Construction Management (7%) | | | | $ 36,713 |
| Contingency (30%) | | | | $ 157,340 |
| TOTAL | | | | $ 760,477 |

## Indian River Farms Water Control District Canal Improvements and Intermediate Pump

The Indian River Farms Water Control District Reservoir (IRFWCD-R) Alternative includes a reservoir and inflow pump station in addition to canal improvements and an intermediate pump station that would be required to convey water to and from the reservoir. The conceptual designs and cost estimates for these features were developed using the approaches described earlier in this report. This section addresses the required canal improvements and the intermediate pump station that would also be required.

Several improvements are required to the Indian River Farms Water Control District water management system to enable reservoir construction and conveyance of flows. There are at least two alternative reservoir sites. Each of these sites would require different canal improvements and conveyance paths. It was assumed that improvements would be required to the following canals: Lateral B, Range Line, North, Main, South, and a western borrow canal. A 200 cfs intermediate pump station would be constructed to lift flows from the middle pool to the upper pool. The reservoir inflow pump would have a 500 cfs capacity and the canal segment between the 200 cfs intermediate pump station and reservoir would convey water at this rate.

### Conceptual Design Assumptions

- Required 200 cfs pump station on Range Line Canal to pump from middle to upper pool.
- Regrade 12,900 LF of Lateral B Canal, 20 ft bottom width and 10 ft depth.
- Regrade Upper Subbasin Canal, between Range Line and Reservoir for a 500 cfs capacity (40 ft bottom and 10 ft depth).

### Cost Estimate

| Item | Unit | Qty | $/Unit | TOTAL |
|---|---|---|---|---|
| Excavation | CY | 398,351 | $ 5 | $ 1,991,754 |
| Seed & Mulch | SY | 74,838 | $ 1 | $ 74,838 |
| Mobilization | LS | 1 | $ 10,000 | $ 10,000 |
| 200 cfs Pump Station | LS | 1 | $ 5,733,000 | $ 5,733,000 |
| Sub-Total | | | | $ 7,809,591 |
| Engineering Design (8%) | | | | $ 624,767 |
| Construction Management (7%) | | | | $ 546,671 |
| Contingency (30%) | | | | $ 2,342,877 |
| TOTAL | | | | $ 11,323,908 |

## Dispersed Storage/Water Farming

The costs associated with dispersed storage/water farming would vary greatly since they are dependent upon the nature and configuration of existing facilities. For this analysis, a "typical" storage area size of 640 acres with a 4 ft maximum depth was used. To contain a 4 foot storage depth, the levee should be approximately 8 ft high, with 3:1 side slopes and 12 ft top width. A 50 cfs capacity was selected for the inflow pump because no significant increases in the discharge delivery rate (at 90% reliability) would be achieved with a larger pump (***Table 38***). The discharge structure would be a single 10 ft wide by 4 ft vertical lift gate.

### Conceptual Design Assumptions

- Costs associated with development of a single 640 acre section
- Perimeter 21,120 LF
- 8 ft high berm with 12 ft top width
- 50 cfs pump
- Single gate discharge structure

**Table 38. Water Farming alternative pump capacities and 90% reliability release rates.**

| Reservoir Capacity (acre-ft) | Pump Capacity (cfs) | Release Rate (cfs) @ 90% Reliability | Ave Annual Delivery (acre-ft) |
|---|---|---|---|
| 2,560 | 50 | 11 | 7,251 |
| 2,560 | 40 | 10 | 7,051 |
| 2,560 | 30 | 10 | 6,765 |
| 2,560 | 20 | 9 | 6,127 |
| 2,560 | 10 | 6 | 4,358 |
| 2,560 | 5 | 4 | 2,451 |

## Conceptual Cost Estimate

| Item | Unit | Qty | $/Unit | | TOTAL | |
|---|---|---|---|---|---|---|
| Berm (fill) 8 ft height | CY | 225,280 | $ | 10 | $ | 2,252,800 |
| Clear and Grub | AC | 640 | $ | 2,000 | $ | 1,280,000 |
| Seed & Mulch | SY | 84,480 | $ | 1 | $ | 84,480 |
| Mobilization | LS | 1 | $ | 25,000 | $ | 25,000 |
| Pump 50 cfs | LS | 1 | $ | 2,000,000 | $ | 2,000,000 |
| Vertical gate discharge 1-10' gate | LS | 2 | $ | 160,000 | $ | 320,000 |
| Sub-Total | | | | | $ | 5,962,280 |
| Engineering Design (8%) | | | | | $ | 476,982 |
| Construction Management (7%) | | | | | $ | 417,360 |
| Contingency (30%) | | | | | $ | 1,788,684 |
| TOTAL | | | | | $ | 8,645,306 |

The cost estimate described above for dispersed storage/water farming is based on construction of all required water management facilities. If levees, berms, structures, and/or pumps are available and do not need to be constructed, the costs would be reduced. It is believed that many agricultural operations have existing infrastructure that could be used as is, or with minimal additional improvements. Therefore, it is assumed in this study that 30% of the total cost estimated above, or $2,594,000 would be required for implementation of a water farming project on 640 acres.

# HYDROLOGIC EVALUATIONS

Three models were utilized to develop conceptual designs for the alternatives: WaSh, OPTI6, and RESOPT. All models simulated the period of record from 1965 through 2005. The WaSh Model was utilized to calculate flows in the C-25 Basin and Basin 1. The OPTI6 Model was used to calculate flows in the C-23 and C-24 Basins assuming: 1) the IRL-South Project was in place, and 2) proposed water reservations for the North Fork of the St. Lucie River were in effect. The RESOPT Model used output from the WaSh and OPTI6 Models to simulate the reliability and yield of reservoirs based on the availability of excess water from the applicable drainage areas. ***Appendix B*** provides a more detailed description of the WaSh Model calibration and verification and how the flow time series were derived for the alternative plans.

USGS measured flow data for the North, Main, and South Canals was used in the evaluation of the IRFWCD-Reservoir Alternative. There is no recorded flow data for discharges from Basin 1. Therefore, it was not possible to calibrate a model to simulate the Basin 1 hydrology. The C-25 Basin WaSh Model was used to simulate flows that would be expected from Basin 1 based on the same sized area with similar land use and water management facilities.

## WaSh Modeling

Between 1994 and 1998, Version 12 of the Hydrological Simulation Program Fortran (HSPF) was developed for southern Florida hydrology. This model was implemented in the St. Lucie Estuary (North and South Forks of St. Lucie River, C-23, C-24, and C-44). The results were used for the IRL-South Feasibility Study.

In order to model watershed water quality and overcome the shortcoming of the lumped nature of HSPF, the SFWMD initiated another project in 1999 to develop the Watershed Water Quality Model (WaSh). The WaSh model is useful for simulating conditions characterized by high groundwater tables and dense drainage systems (Wan et al. 2003). The WaSh model uses the HSPF algorithms to replicate surface water hydrology, a two-dimensional groundwater model to represent the surficial aquifer, and a full dynamic channel routing model to simulate structure operation and the canal network flow routing. An irrigation routine in the model allows for simulation of irrigation demand. The fundamental time step for the model is one day and the output is provided in daily increments. Certain model algorithms operate at shorter time steps to provide accurate representations of physical processes and ensure numerical stability. The domain of the WaSh model is the entire St. Lucie Watershed.

The WaSh Model has previously been used by SFWMD and DEP for several initiatives, including the C-44 Reservoir Project, water quality evaluations, and the development of the St. Lucie Watershed Protection Plan (SFWMD 2008) for the Northern Everglades Estuary Protection Program.

Most recently, the WaSh Model has been used in the development of a proposed water reservation for the North Fork of the St. Lucie River. In the development of the proposed water reservation, the WaSh model was applied to produce a flow time series to represent the 2050 Future without Project Conditions. This simulation included the proposed IRL-S reservoirs in the C-23 and C-24 Basins. This time series was used in turn to estimate the quantity of water available in the future (SFWMD 2009).

Existing WaSh Models of the C-23, C-24, and C-25 Basins were used for this study (HSW 2009). The models were calibrated and verified. The period of record was expanded to include 1965 through 2008.

## OPTI6 Model

Based on long-term biological monitoring and research in the St. Lucie Estuary, the SFWMD identified a desirable salinity envelop that is conducive to juvenile marine fish and shellfish, oysters, and submerged aquatic vegetation in the estuary. Maintaining watershed flows to the estuary between 350 and 2,000 cfs will maintain salinity concentrations within the desirable envelope. Acceptable violations of this desired range, particularly in the high flow range, are defined by the frequency distribution of historic monthly inflows from the pre-drained watershed. To recapture the target monthly flow distribution, the Indian River Lagoon- South Feasibility Study proposed large storage reservoirs. The reservoirs would contribute to ecosystem restoration by storing basin runoff that would be harmful to the estuary and releasing it for water supply or to the estuary when it could be accommodated without violating the salinity envelop.

The OPTI model was developed to simulate the delivery of the flows in the reservoirs to meet the target flow distributions (Labadie, 1997). The model determined optimal size and operating rules for detention reservoirs in the SLE watershed that: (1) achieve the target frequency distribution of flows to the Estuary, (2) supply water from the reservoirs to satisfy the Floridan irrigation demands for at least a specified reliability, and (3) minimize the required capacities of the detention reservoirs.

The OPTI6 model is Version 6 of the OPTI model developed for the restoration of the St. Lucie Estuary ecosystem. Details of the theory and the application of the model can be found in Wan et al (2006). The OPTI6 model was used, in conjunction with the WaSh Model in the development of a proposed water reservation for the North Fork of the St. Lucie River. The daily flow time series (the 2050 Future with and without Project Conditions) produced by the model applications were converted to monthly mean values and used to construct volume probability curves. The 2050 Future with Project Condition was compared against the North Fork flow target. The water to be reserved for protection of fish and wildlife was identified as the portion of available water delivered by the 2050 Future with Project Condition up to, but not exceeding, the North Fork target flow. In the dry season the target typically equals the 2050 Future with Project Condition when the project delivers 130 cfs or less.

OPTI6 output files developed for the water reservations were provided by SFWMD. Based on this output, the excess water from the C-23 and C-24 Basins was identified based on the assumptions that the C-23 and C-24 reservoirs and STA are operational and the water reservation for the North Fork of the St. Lucie River is in effect.

### RESOPT Model

The RESOPT Model was developed by HDR for the Lake Okeechobee Watershed Study for the purpose of optimizing reservoir capacities. It is a water budget model with a daily computational time-step. Stream withdrawals are limited by the available flow or the user defined inflow pump capacity. If appropriate, withdrawals can also be limited to maintain a minimum in-stream flow. The RESOPT Model accounts for ET, direct rainfall, infiltration/seepage losses, reservoir discharges and overflows (***Figure 48***).

Maximum storage depth and reservoir area are defined in RESOPT by the user. Once the storage depth is reached in the reservoir, stream withdrawals are discontinued and any additional inflow (rainfall) is discharged as reservoir overflow. When water levels fall below 1 foot in the reservoir, discharges are discontinued until rainfall and stream withdrawals are adequate to raise levels above a 1 foot depth. The user defined discharge rate is held constant through the period of record.

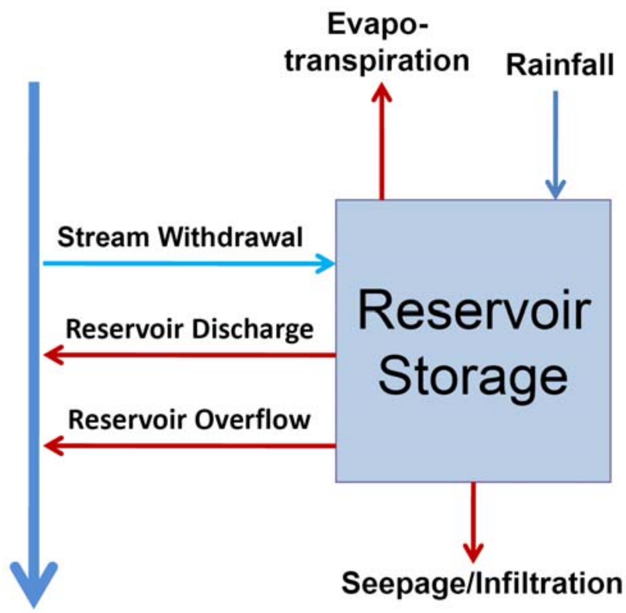



**Figure 48. RESOPT water budget components.**

## Flow Time Series for Alternative Plans

Determination of the available streamflow to the reservoir for each alternative is described below. The appropriate time series of available flow was used for the RESOPT simulations of each alternative to evaluate reservoir storage capacities, inflow pump capacities, reductions in flows to IRL, and discharge delivery rates at 90% reliability.

### C-25 Basin Central Storage Reservoir (ICS-01) Alternative

The C-25 Central Storage Reservoir (ICS-01) Alternative would capture and store excess flows from the western C-25 Basin and C-25 Extension Basin. The C-25 WaSh Model developed for this project provided the daily flows for structures S-99, S-50, and S-253. Since S-253 flows that currently go north would be rerouted into the C-25 Extension Canal, all S-253 flow was considered available to the reservoir. To represent the flows originating from the C-25 Basin west of S-99 that are lost to the Indian River Lagoon, a rule was applied to the WaSh output for S-99 and S-50 flows. When S-50 flow was greater than S-99 flow, all of the S-99 flow was available for storage; when S-50 flow was less than S-99 flow, the S-50 flow was available for storage. In other words, S-99 flows made to maintain desirable canal stages upstream of S-50 were not available for storage in the resevoir. The resulting available flow was added to all S-253 flow to develop the available flow time series for RESOPT.

### C-23, C-24, and C-25 Basin Central Storage Reservoir (ICS-02) Alternative

The C-23, C-24, and C-25 Central Storage Reservoir (ICS-02) Alternative would include all flows from Alternative 1 in addition to water delivered north through a proposed pump station at structure G-81 from the C-23 and C-24 basins. The Indian River Lagoon – South Project components for the C-23 and C-24 basins, as well as water reservation rules for the North Fork of the St. Lucie River, were assumed to be in place. The District's OPTI-6 model included these components and generated the available flows from these basins that are lost to the estuary. These excess flows include water that would bypass the proposed C-23 Reservoir and C-24 Reservoir/STA and would otherwise be discharged to tide. The proposed pump at structure G-81 would limit transfer of these flows to the C-25 Basin to a maximum daily rate of 260 cfs. A flow exceedance curve for the combined C-23 and C-24 basin excess flows was used to select a reasonable pump size. The selected pump capacity was applied to the flow time series and the result was added to Alternative 1's flows to produce the final available flow time series that would be available for storage.

### C-25/Basin 1 Central Storage Reservoir (ICSC-01) Alternative

The C-25 Basin/Basin 1 Central Storage Reservoir (ICSB-01) Alternative would include all flows from Alternative 1 in addition to water from the C-25 East Basin and Basin 1 (Ft. Pierce Farms Water Control District). C-25 East and Basin 1 are located downstream of S-99. A pump would be required to transfer water to the upstream side of S-99. Basin 1 is not in the C-25 WaSh model and there are no observed data available to generate a time series of flow. An area similar in size, topography, and land use already included in the WaSh C-25 Basin model was delineated (***Figure 49***) and used to estimate daily flows for Basin 1. The Basin 1 flow was added to the C-25 East flow and a flow exceedance curve was generated to choose a capacity (200 cfs) for the proposed pump at S-99. The maximum daily flow rate (corresponding to the pump capacity) was applied to the combined Basin 1/ C-25 East time series and then added to the Alternative 1 flow time series for the final flow available to the reservoir.

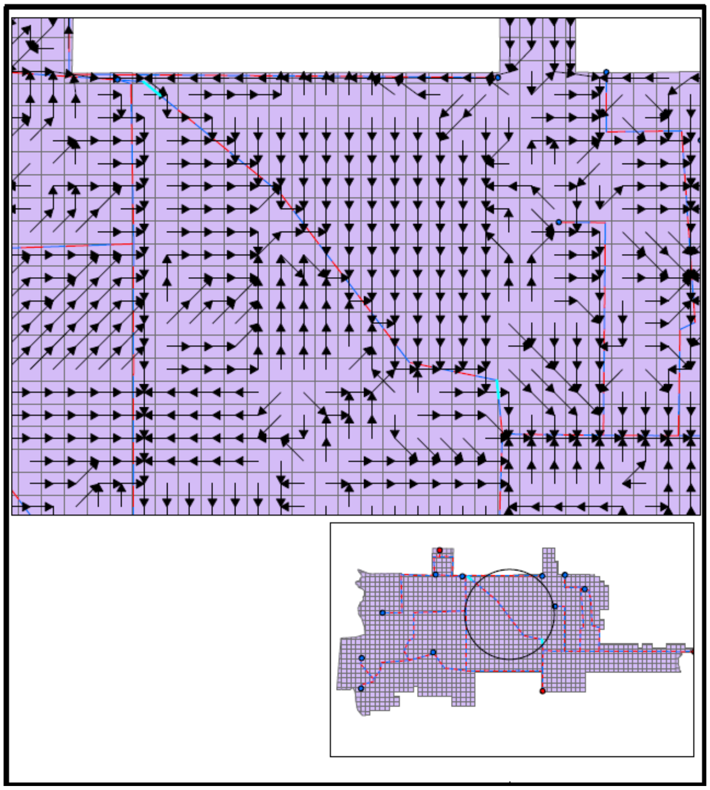


**Figure 49. Basin 1 (Ft. Pierce Farms WCD) approximation as represented in the C-25 Basin WaSh model for the C-25/Basin 1 Central Storage Reservoir (ICSC-01) Alternative.**

### Indian River Farms Water Control District Reservoir (IRFWCD-R) Alternative

The Indian River Farms Water Control District Reservoir (IRFWCD-R) Alternative would capture water from the canals in the Upper and Middle pools of the IRFWCD. The canals in each pool are interconnected and held at a constant stage. A pump would be required to transfer water from the Middle Pool to the Upper Pool. Measured flow data collected by the USGS for the period of record (1965 – 2008) for the North, Main, and South Canals discharges to IRL was used.

According to David Gunter of the IRFWCD, a minimum flow of 50 to 150 cfs is currently maintained when possible in both, the Main and South canals. The Vero Beach water treatment plant is on the Main Canal and the Indian River County water treatment plant is on the South Canal. Each water treatment plant discharges brine (a by-product of reverse osmosis water treatment) into the adjacent canal. A minimum flow is required in each canal to maintain a mixing zone at its outflow to the IRL. Mr. Robert Bolton, Director of the Vero Beach Water Treatment Plant indicated that within 1 to 1.5 years, a deep injection well will be operable and surface discharges of brine to the Main Canal will no longer be necessary except during rare events. Therefore, for this evaluation, it is assumed that a minimum of 50 cfs would be required only in the South Canal to maintain a mixing zone.

To determine the flow that would be available for the reservoir, the lower pool area was divided by the total IRFWCD area. The resulting fraction was applied to the sum of the USGS flows in the three canals, thereby approximating the flow from the lower pool and coastal areas in the IRFWCD. Assuming that the discharges from the lower pool would be first to provide the minimum flow for the mixing zone. The discharges from the middle and upper pools would then be provided only when runoff from the lower pool was not adequate to maintain the 50 cfs discharge required for the mixing zone. The remainder of the flows from the upper and middle pools was considered to be available for reservoir storage, after applying a cap on middle pool flows for the pump (300 cfs) between the middle and upper pools.

### Dispersed Storage/Water Farming Alternative

The Dispersed Storage/Water Farming Alternative was evaluated based on the same daily flow time series applied to the C-25 Central Storage Reservoir (ICS-01) Alternative. Water farming would consist of shallow storage on private property using existing agricultural pumps, drainage ditches, and levees/berms to the extent available. It was assumed that a section of land, (640) acres would be available for a 4-ft deep reservoir.

# RESERVOIR AND PUMP SIZING

In order to compare and evaluate the final alternatives, reservoir and pump sizing was necessary. It was assumed that future water supply demands will exceed available supplies. As a result, there will be a demand for any additional water supply that can be provided. Therefore, the goal was to identify the combination of reservoir storage capacity and inflow pump capacity for each alternative that maximize the discharge delivery rate in a cost effective manner.

## Methodology

Hydrologic modeling and analyses were performed to identify reservoir size and pump capacity configurations that maximized the discharge delivery rate that could be maintained with 90% reliability for each of the alternatives. The general approach for hydrologic evaluation of the five alternatives for this project was as follows:

- The RESOPT Model was used with a 41 year period of record (1965 to 2005). A maximum reservoir depth of 10 ft was utilized. For each alternative, the inflow time series was developed based on the approaches described in the previous section. The reservoir inflow time series was input to RESOPT.

- The rainfall data from the C-25 WaSh model at a location near each alternative's potential reservoir location was applied to RESOPT. Potential evaporation time series was obtained from DBHYDRO and input to RESOPT. A pan coefficient of 0.8 was applied.

- The flow time series calculated for each of the alternatives accounted for minimum flow requirements in the canal (e.g. the water reservation for the North Fork of the St. Lucie River and flow required for a mixing zone at the IRFWCD South Canal).

- Initial values for reservoir area, pump capacity, and reservoir release rate were used for the first trial in the evaluation process using RESOPT. The initial reservoir area was determined by calculating annual average flow and dividing by an assumed 10-ft depth. The initial pump capacity was set equal to the breakpoint in the flow exceedance curve for each alternative's available flows. The median flow for the period of record was used for an initial reservoir discharge delivery rate. Other reservoir sizes, inflow pump capacities, and release rates were also evaluated on an iterative basis.

- For each reservoir, a range of reservoir sizes, pump capacities, and discharge delivery rates were simulated. For each reservoir size, the objective was to identify the pump capacity that provided the greatest discharge delivery rate with 90% reliability over the 41-year period of record.

- For all configurations evaluated for each alternative, the reservoir, STA, pump, and associated real estate costs were tabulated along with the RESOPT modeling results. This enables comparisons of costs with reservoir performance measured in terms of discharge delivery rate with 90% reliability and reductions in flows to IRL (***Tables 39 through 42).***

- Reservoir costs vs. performance in terms of discharge delivery rate with 90% reliability were plotted to identify plans that met the project objectives in the most cost effective manner (***Figures 50 through 53***). In each graph, alternatives that fell along the line (delineating the lower right envelop) were cost effective. The break points in the slope of the envelop curve indicated increasing incremental costs for incremental improvements in performance. In other words, a steepening slope in the envelop curve indicates that an additional improvement in performance is disproportionately more expensive.

The results of RESOPT runs for the final alternatives are provided in **Appendix C**. Cost effectiveness graphs are shown in ***Figures 50 through 53***. Reservoir size and pump capacity configurations were selected for each alternative based on breakpoints in the cost effectiveness envelop slopes.  In some cases, two alternative configurations were selected if the breakpoints were not obvious.

**Table 39. C-25 Central Storage Reservoir (ICS-01) cost and performance.**

| Reservoir Capacity (acre-ft) | Pump Capacity (cfs) | Reservoir Cost | Land Cost | Pump Cost | STA Cost | Reservoir & STA Cost | Release Rate @ 90% Reliability (cfs) | Ave Annual Delivery (acre-ft) |
|---|---|---|---|---|---|---|---|---|
| 160,000 | 900 | $442,241,389 | $96,000,000 | $20,212,361 | $95,036,475 | $653,490,225 | 183 | 119,046 |
| 160,000 | 800 | $442,241,389 | $96,000,000 | $16,882,783 | $93,478,500 | $648,602,672 | 180 | 117,042 |
| 160,000 | 700 | $442,241,389 | $96,000,000 | $14,101,686 | $90,881,875 | $643,224,950 | 175 | 114,152 |
| 160,000 | 600 | $442,241,389 | $96,000,000 | $11,778,718 | $87,765,925 | $637,786,032 | 169 | 109,855 |
| 160,000 | 500 | $442,241,389 | $96,000,000 | $9,838,412 | $83,092,000 | $631,171,801 | 160 | 104,106 |
| 108,000 | 800 | $308,048,328 | $64,800,000 | $16,882,783 | $85,169,300 | $474,900,411 | 164 | 106,965 |
| 108,000 | 700 | $308,048,328 | $64,800,000 | $14,101,686 | $83,611,325 | $470,561,339 | 161 | 104,852 |
| 108,000 | 600 | $308,048,328 | $64,800,000 | $11,778,718 | $81,014,700 | $465,641,746 | 156 | 101,445 |
| 108,000 | 400 | $308,048,328 | $64,800,000 | $8,217,733 | $72,186,175 | $453,252,236 | 139 | 90,455 |
| 108,000 | 300 | $308,048,328 | $64,800,000 | $6,864,027 | $64,396,300 | $444,108,656 | 124 | 80,550 |
| 108,000 | 200 | $308,048,328 | $64,800,000 | $5,733,318 | $52,451,825 | $431,033,471 | 101 | 65,554 |
| 70,000 | 900 | $206,708,911 | $42,000,000 | $20,212,361 | $75,821,450 | $344,742,722 | 146 | 95,414 |
| 70,000 | 700 | $206,708,911 | $42,000,000 | $14,101,686 | $74,263,475 | $337,074,071 | 143 | 93,058 |
| 70,000 | 500 | $206,708,911 | $42,000,000 | $9,838,412 | $70,108,875 | $328,656,198 | 135 | 88,115 |
| 60,000 | 700 | $179,377,576 | $36,000,000 | $14,101,686 | $70,108,875 | $299,588,137 | 135 | 88,004 |
| 60,000 | 600 | $179,377,576 | $36,000,000 | $11,778,718 | $69,070,225 | $296,226,519 | 133 | 86,520 |
| 60,000 | 500 | $179,377,576 | $36,000,000 | $9,838,412 | $66,992,925 | $292,208,914 | 129 | 84,182 |
| 60,000 | 400 | $179,377,576 | $36,000,000 | $8,217,733 | $63,876,975 | $287,472,284 | 123 | 80,301 |
| 60,000 | 300 | $179,377,576 | $36,000,000 | $6,864,027 | $49,855,200 | $272,096,804 | 96 | 73,015 |
| 60,000 | 200 | $179,377,576 | $36,000,000 | $5,733,318 | $48,816,550 | $269,927,444 | 94 | 61,000 |
| 45,000 | 600 | $137,665,309 | $27,000,000 | $11,778,718 | $60,241,700 | $236,685,727 | 116 | 75,754 |
| 45,000 | 500 | $137,665,309 | $27,000,000 | $9,838,412 | $59,722,375 | $234,226,096 | 115 | 74,783 |
| 45,000 | 300 | $137,665,309 | $27,000,000 | $6,864,027 | $54,529,125 | $226,058,461 | 105 | 68,404 |
| 30,000 | 700 | $94,802,667 | $18,000,000 | $14,101,686 | $46,739,250 | $173,643,603 | 90 | 58,657 |
| 30,000 | 600 | $94,802,667 | $18,000,000 | $11,778,718 | $46,739,250 | $171,320,635 | 90 | 58,472 |
| **30,000** | **500** | **$94,802,667** | **$18,000,000** | **$9,838,412** | **$46,739,250** | **$169,380,330** | **90** | **58,442** |
| 30,000 | 200 | $94,802,667 | $18,000,000 | $5,733,318 | $42,065,325 | $160,601,310 | 81 | 52,842 |
| 20,000 | 700 | $65,285,479 | $12,000,000 | $14,101,686 | $34,794,775 | $126,181,940 | 67 | 43,850 |
| 20,000 | 600 | $65,285,479 | $12,000,000 | $11,778,718 | $34,794,775 | $123,858,973 | 67 | 43,853 |
| **20,000** | **300** | **$65,285,479** | **$12,000,000** | **$6,864,027** | **$34,794,775** | **$118,944,282** | **67** | **43,710** |
| 20,000 | 200 | $65,285,479 | $12,000,000 | $5,733,318 | $34,275,450 | $117,294,247 | 66 | 43,026 |
| 10,000 | 600 | $34,503,965 | $6,000,000 | $11,778,718 | $21,292,325 | $73,575,008 | 41 | 26,555 |
| 10,000 | 400 | $34,503,965 | $6,000,000 | $8,217,733 | $21,292,325 | $70,014,023 | 41 | 26,563 |
| 10,000 | 200 | $34,503,965 | $6,000,000 | $5,733,318 | $20,253,675 | $66,490,957 | 39 | 26,535 |
| 5,000 | 400 | $18,235,657 | $3,000,000 | $8,217,733 | $13,502,450 | $42,955,839 | 26 | 16,631 |
| 5,000 | 200 | $18,235,657 | $3,000,000 | $5,733,318 | $13,502,450 | $40,471,424 | 26 | 16,581 |

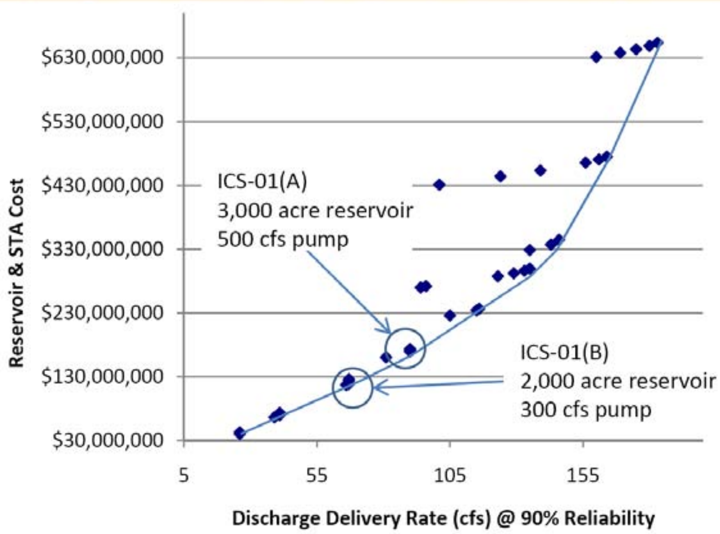



**Figure 50. C-25 Central Storage Reservoir (ICS-01) cost vs. delivery rate.**

**Table 40. C-23, C-24, and C-25 Central Storage Reservoir (ICS-02) cost and performance.**

| Reservoir Capacity (acre-ft) | Pump Capacity (cfs) | Reservoir Cost | Land Cost | Pump Cost | STA Cost | Reservoir & STA Cost | Release Rate @ 90% Reliability (cfs) | Ave Annual Delivery (acre-ft) |
|---|---|---|---|---|---|---|---|---|
| 241,000 | 1000 | $644,651,029 | $144,600,000 | $24,198,590 | $155,797,500 | $969,247,119 | 300 | 195,551 |
| 241,000 | 900 | $644,651,029 | $144,600,000 | $20,212,361 | $152,681,550 | $962,144,940 | 294 | 191,412 |
| 241,000 | 700 | $644,651,029 | $144,600,000 | $14,101,686 | $142,814,375 | $946,167,090 | 275 | 179,360 |
| 241,000 | 500 | $644,651,029 | $144,600,000 | $9,838,412 | $128,273,275 | $927,362,717 | 247 | 160,732 |
| 160,000 | 900 | $442,241,389 | $96,000,000 | $20,212,361 | $144,372,350 | $702,826,100 | 278 | 181,122 |
| 160,000 | 700 | $442,241,389 | $96,000,000 | $14,101,686 | $137,621,125 | $689,964,200 | 265 | 172,901 |
| 160,000 | 500 | $442,241,389 | $96,000,000 | $9,838,412 | $123,599,350 | $671,679,151 | 238 | 154,984 |
| 160,000 | 100 | $442,241,389 | $96,000,000 | $4,788,869 | $45,181,275 | $588,211,533 | 87 | 56,481 |
| 100,000 | 900 | $286,991,478 | $60,000,000 | $20,212,361 | $129,311,925 | $496,515,764 | 249 | 162,478 |
| 100,000 | 700 | $286,991,478 | $60,000,000 | $14,101,686 | $126,195,975 | $487,289,139 | 243 | 158,342 |
| 100,000 | 500 | $286,991,478 | $60,000,000 | $9,838,412 | $116,848,125 | $473,678,016 | 225 | 146,697 |
| 100,000 | 300 | $286,991,478 | $60,000,000 | $6,864,027 | $93,478,500 | $447,334,006 | 180 | 117,383 |
| 100,000 | 100 | $286,991,478 | $60,000,000 | $4,788,869 | $44,142,625 | $395,922,973 | 85 | 55,483 |
| 80,000 | 700 | $233,728,563 | $48,000,000 | $14,101,686 | $117,367,450 | $413,197,699 | 226 | 147,658 |
| 80,000 | 500 | $233,728,563 | $48,000,000 | $9,838,412 | $112,174,200 | $403,741,176 | 216 | 140,764 |
| 80,000 | 300 | $233,728,563 | $48,000,000 | $6,864,027 | $91,920,525 | $380,513,116 | 177 | 115,506 |
| 80,000 | 100 | $233,728,563 | $48,000,000 | $4,788,869 | $44,142,625 | $330,660,058 | 85 | 54,984 |
| **50,000** | **700** | **$151,677,585** | **$30,000,000** | **$14,101,686** | **$96,075,125** | **$291,854,396** | **185** | **120,379** |
| 50,000 | 500 | $151,677,585 | $30,000,000 | $9,838,412 | $93,997,825 | $285,513,822 | 181 | 118,294 |
| 50,000 | 300 | $151,677,585 | $30,000,000 | $6,864,027 | $86,207,950 | $274,749,562 | 166 | 108,036 |
| 50,000 | 100 | $151,677,585 | $30,000,000 | $4,788,869 | $43,103,975 | $229,570,429 | 83 | 54,161 |
| 30,000 | 700 | $94,802,667 | $18,000,000 | $14,101,686 | $72,705,500 | $199,609,853 | 140 | 91,318 |
| **30,000** | **500** | **$94,802,667** | **$18,000,000** | **$9,838,412** | **$72,705,500** | **$195,346,580** | **140** | **91,318** |
| 30,000 | 100 | $94,802,667 | $18,000,000 | $4,788,869 | $42,584,650 | $160,176,187 | 82 | 53,143 |
| 20,000 | 700 | $65,285,479 | $12,000,000 | $14,101,686 | $59,203,050 | $150,590,215 | 114 | 74,545 |
| 20,000 | 500 | $65,285,479 | $12,000,000 | $9,838,412 | $59,203,050 | $146,326,942 | 114 | 74,547 |
| 20,000 | 100 | $65,285,479 | $12,000,000 | $4,788,869 | $41,546,000 | $123,620,349 | 80 | 52,186 |
| 10,000 | 700 | $34,503,965 | $6,000,000 | $14,101,686 | $43,103,975 | $97,709,626 | 83 | 54,295 |
| 10,000 | 500 | $34,503,965 | $6,000,000 | $9,838,412 | $43,103,975 | $93,446,352 | 83 | 54,294 |
| 10,000 | 67 | $34,503,965 | $6,000,000 | $4,512,694 | $38,949,375 | $83,966,034 | 75 | 48,913 |

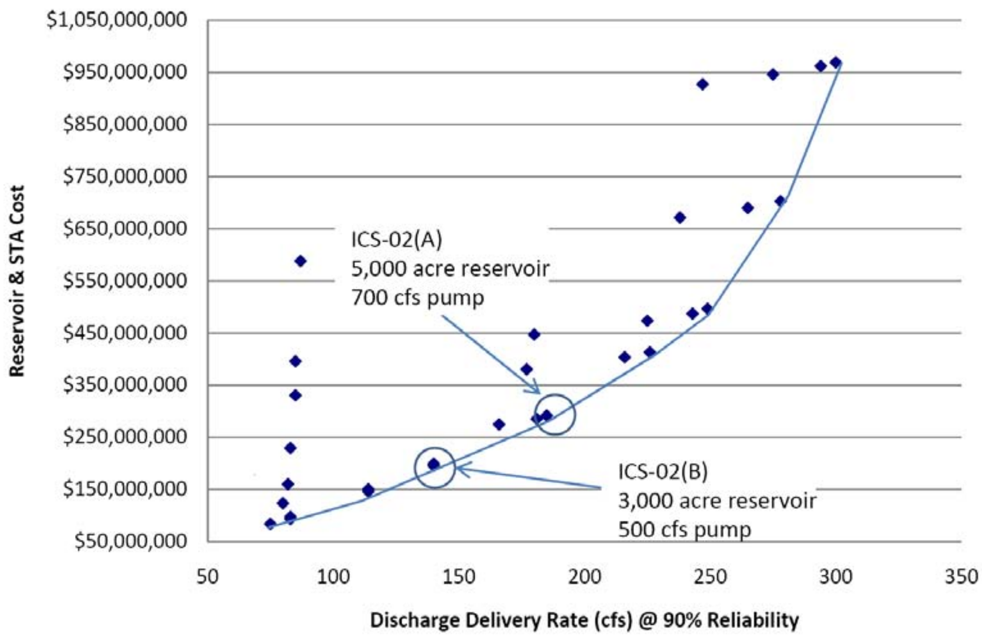



**Figure 51. C-23, C-24, and C-25 Central Storage Reservoir (ICS-02) cost vs. delivery rate.**

**Table 41. C-25/Basin 1 Central Storage Reservoir (ICSB-01) cost and performance.**

| Reservoir Capacity (acre-ft) | Pump Capacity (cfs) | Reservoir Cost | Land Cost | Pump Cost | STA Cost | Reservoir & STA Cost | Release Rate @ 90% Reliability (cfs) | Ave Annual Delivery (acre-ft) |
|---|---|---|---|---|---|---|---|---|
| 198,000 | 800 | $538,023,167 | $118,800,000 | $16,882,783 | $113,732,175 | $787,438,125 | 219 | 142,819 |
| 198,000 | 700 | $538,023,167 | $118,800,000 | $14,101,686 | $109,577,575 | $780,502,427 | 211 | 137,807 |
| 198,000 | 500 | $538,023,167 | $118,800,000 | $9,838,412 | $98,671,750 | $765,333,329 | 190 | 124,111 |
| 150,000 | 700 | $416,747,458 | $90,000,000 | $14,101,686 | $104,384,325 | $625,233,469 | 201 | 131,286 |
| 150,000 | 600 | $416,747,458 | $90,000,000 | $11,778,718 | $100,229,725 | $618,755,901 | 193 | 126,080 |
| 150,000 | 200 | $416,747,458 | $90,000,000 | $5,733,318 | $60,241,700 | $572,722,476 | 116 | 75,814 |
| 100,000 | 700 | $286,991,478 | $60,000,000 | $14,101,686 | $96,075,125 | $457,168,289 | 185 | 120,559 |
| 100,000 | 500 | $286,991,478 | $60,000,000 | $9,838,412 | $88,285,250 | $445,115,141 | 170 | 110,602 |
| 60,000 | 700 | $179,377,576 | $36,000,000 | $14,101,686 | $82,053,350 | $311,532,612 | 158 | 102,630 |
| 60,000 | 600 | $179,377,576 | $36,000,000 | $11,778,718 | $80,495,375 | $307,651,669 | 155 | 100,894 |
| 60,000 | 400 | $179,377,576 | $36,000,000 | $8,217,733 | $74,782,800 | $298,378,109 | 144 | 93,947 |
| 60,000 | 200 | $179,377,576 | $36,000,000 | $5,733,318 | $56,087,100 | $277,197,994 | 108 | 70,439 |
| 45,000 | 700 | $137,665,309 | $27,000,000 | $14,101,686 | $71,147,525 | $249,914,520 | 137 | 89,354 |
| 45,000 | 500 | $137,665,309 | $27,000,000 | $9,838,412 | $70,108,875 | $244,612,596 | 135 | 87,795 |
| 30,000 | 500 | $94,802,667 | $18,000,000 | $9,838,412 | $56,087,100 | $178,728,180 | 108 | 70,289 |
| **30,000** | **400** | **$94,802,667** | **$18,000,000** | **$8,217,733** | **$56,087,100** | **$177,107,500** | **108** | **70,024** |
| 30,000 | 200 | $94,802,667 | $18,000,000 | $5,733,318 | $50,374,525 | $168,910,510 | 97 | 63,381 |
| 20,000 | 300 | $65,285,479 | $12,000,000 | $6,864,027 | $44,142,625 | $128,292,132 | 85 | 55,271 |
| 20,000 | 200 | $65,285,479 | $12,000,000 | $5,733,318 | $43,103,975 | $126,122,772 | 83 | 54,014 |
| 10,000 | 500 | $34,503,965 | $6,000,000 | $9,838,412 | $30,120,850 | $80,463,227 | 58 | 37,984 |
| 10,000 | 200 | $34,503,965 | $6,000,000 | $5,733,318 | $30,120,850 | $76,358,132 | 58 | 37,806 |
| 5,000 | 200 | $18,235,657 | $3,000,000 | $5,733,318 | $22,330,975 | $49,299,949 | 43 | 27,756 |

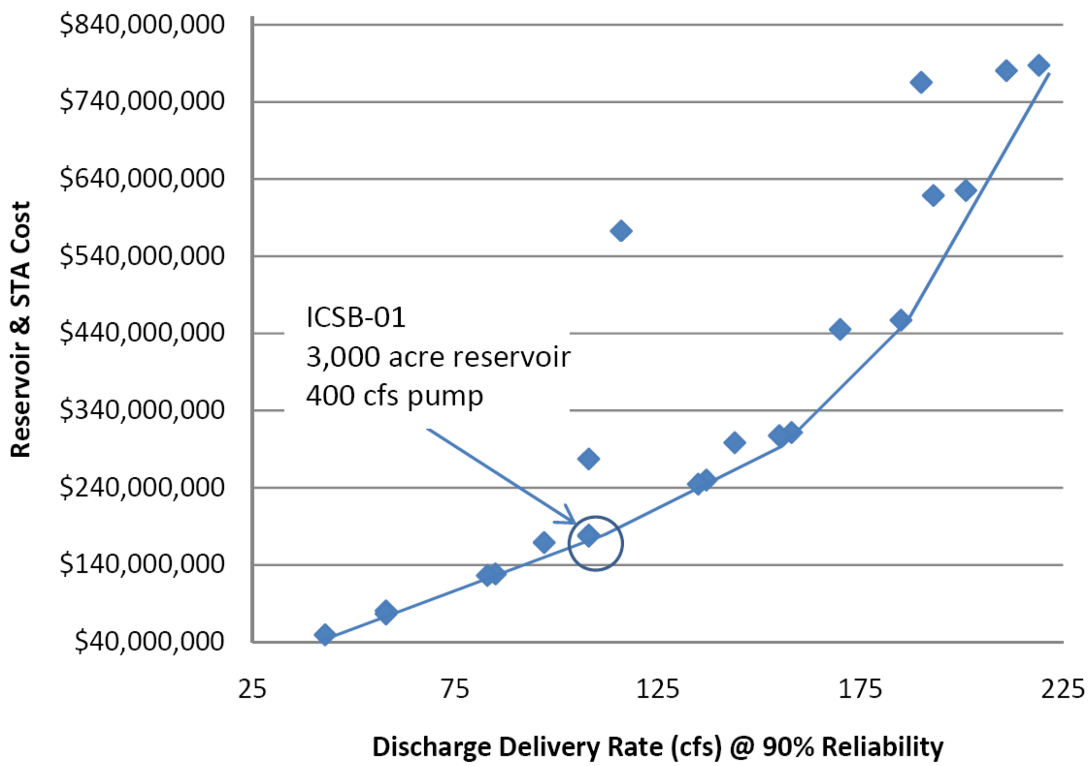



**Figure 52. C-25/Basin 1Central Storage Reservoir (ICSB-01) cost vs. delivery rate.**

**Table 42. Indian River Farms Water Control District Reservoir (IRFWCD-R) costs and performance.**

| Reservoir Capacity (acre-ft) | Pump Capacity (cfs) | Reservoir Cost | Land Cost | Pump Cost | STA Cost | Reservoir & STA Cost | Release Rate @ 90% Reliability (cfs) | Ave Annual Delivery (acre-ft) |
|---|---|---|---|---|---|---|---|---|
| 50,000 | 1000 | $151,677,585 | $30,000,000 | $24,198,590 | $0 | $205,876,175 | 70 | 45,587 |
| 50,000 | 700 | $151,677,585 | $30,000,000 | $14,101,686 | $0 | $195,779,271 | 70 | 45,419 |
| 50,000 | 300 | $151,677,585 | $30,000,000 | $6,864,027 | $0 | $188,541,612 | 64 | 41,304 |
| 50,000 | 200 | $151,677,585 | $30,000,000 | $5,733,318 | $0 | $187,410,903 | 55 | 35,695 |
| 40,000 | 700 | $123,527,654 | $24,000,000 | $14,101,686 | $0 | $161,629,340 | 69 | 44,626 |
| 40,000 | 500 | $123,527,654 | $24,000,000 | $9,838,412 | $0 | $157,366,066 | 68 | 44,180 |
| 40,000 | 300 | $123,527,654 | $24,000,000 | $6,864,027 | $0 | $154,391,681 | 63 | 41,019 |
| 30,000 | 700 | $94,802,667 | $18,000,000 | $14,101,686 | $0 | $126,904,353 | 67 | 43,327 |
| 30,000 | 500 | $94,802,667 | $18,000,000 | $9,838,412 | $0 | $122,641,080 | 66 | 42,991 |
| 30,000 | 100 | $94,802,667 | $18,000,000 | $4,788,869 | $0 | $117,591,537 | 40 | 26,093 |
| **20,000** | **500** | **$65,285,479** | **$12,000,000** | **$9,838,412** | **$0** | **$87,123,892** | **63** | **41,207** |
| 20,000 | 300 | $65,285,479 | $12,000,000 | $6,864,027 | $0 | $84,149,507 | 61 | 39,605 |
| 20,000 | 100 | $65,285,479 | $12,000,000 | $4,788,869 | $0 | $82,074,349 | 40 | 25,993 |
| **10,000** | **500** | **$34,503,965** | **$6,000,000** | **$9,838,412** | **$0** | **$50,342,377** | **53** | **34,608** |
| 10,000 | 200 | $34,503,965 | $6,000,000 | $5,733,318 | $0 | $46,237,282 | 49 | 31,944 |
| 10,000 | 100 | $34,503,965 | $6,000,000 | $4,788,869 | $0 | $45,292,834 | 39 | 25,023 |
| 5,000 | 500 | $18,235,657 | $3,000,000 | $9,838,412 | $0 | $31,074,069 | 42 | 27,565 |
| 5,000 | 100 | $18,235,657 | $3,000,000 | $4,788,869 | $0 | $26,024,526 | 35 | 22,035 |
| 1,000 | 500 | $4,148,289 | $600,000 | $9,838,412 | $0 | $14,586,701 | 25 | 15,818 |

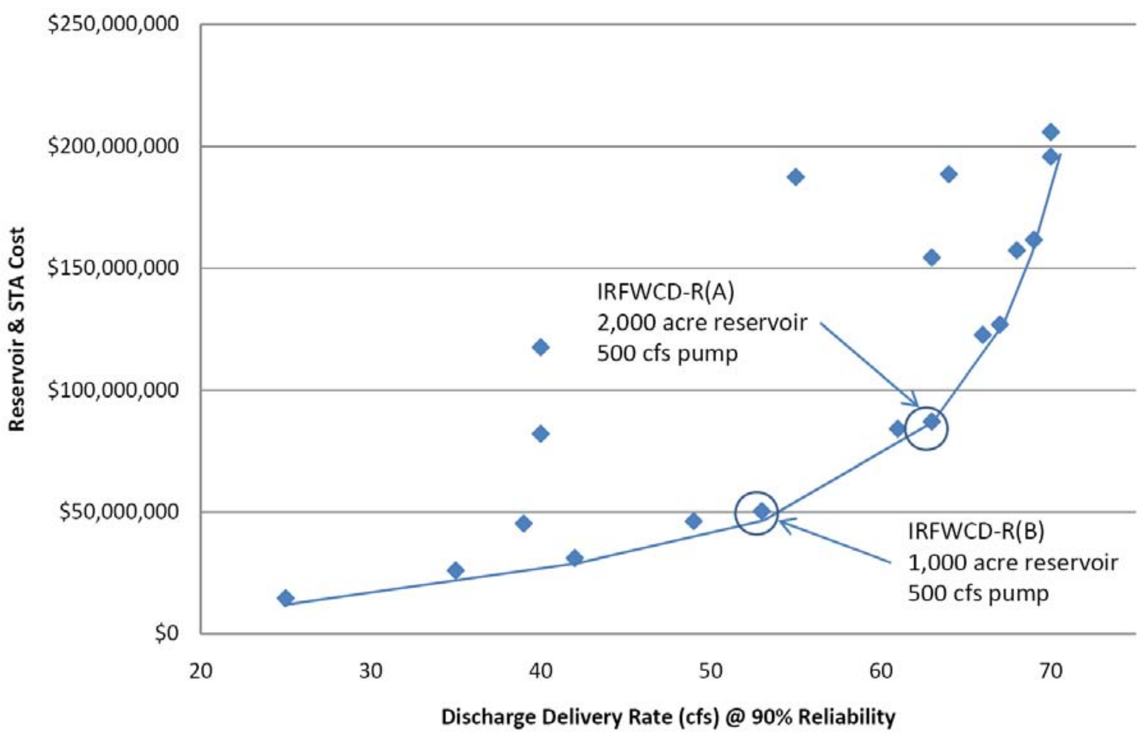



**Figure 53. Indian River Farms Water Control District Reservoir (IRFWCD-R) cost vs. delivery rate.**

# SUMMARY OF ALTERNATIVE PLAN FEATURES AND COSTS

***Table 43*** provides a summary of structure and pump capacities of alternative plan components. ***Table 44*** describes the sizes and capacities of reservoirs, pump stations, and STAs included in the alternative plans. ***Table 45*** summarizes the costs of the alternative plans.

**Table 43. Summary of structure capacities and pumps included in the alternative plans.**

| Structure/Pump | Capacity (cfs) |
|---|---|
| G-81 Pump | 260 |
| S-99 Pump | 200 |
| Basin 1 Structure | 200 |
| C-25 Structure | 300 |
| IRFWCD Intermediate Pump | 200 |

**Table 44. Sizes and capacities of reservoirs, pump stations, and STAs included in alternative plans.**

| | Reservoir Area (acres) | Depth (ft) | Pump Capacity (cfs) | STA Area (acres) |
|---|---|---|---|---|
| ICS-01 (A) | 3,000 | 10 | 500 | 2,250 |
| ICS-01(B) | 2,000 | 10 | 300 | 1,675 |
| ICS-02(A) | 5,000 | 10 | 700 | 4,625 |
| ICS-02(B) | 3,000 | 10 | 500 | 3,500 |
| ICSB-01 | 3,000 | 10 | 400 | 2,700 |
| IRFWCD-R(A) | 2,000 | 10 | 500 | N/A |
| IRFWCD-R(B) | 1,000 | 10 | 500 | N/A |

**Table 45. Summary of alternative plan conceptual cost estimates.**

| Alternative Plan Component | ICS-01(A) | ICS-01(B) | ICS-02(A) | ICS-02(B) | ICSB-01 | IRFWCD-R(A) | IRFWCD-R(B) |
|---|---|---|---|---|---|---|---|
| Replace C-25 plug with gated structure | $763,000 | $763,000 | $763,000 | $763,000 | $763,000 | | |
| Improve C-25 Ext | $1,785,000 | $1,785,000 | $1,785,000 | $1,785,000 | $1,785,000 | | |
| Improve western C-25 | $1,328,000 | $1,328,000 | $1,328,000 | $1,328,000 | $1,328,000 | | |
| Central Reservoir levees, canals, outlet structure, pump | $122,641,080 | $84,149,507 | $195,779,271 | $122,641,080 | $121,020,400 | | |
| G-81 Pump Station | | | $6,387,190 | $6,387,190 | | | |
| S-253 Pump Station | $4,703,441 | $4,512,694 | $5,580,589 | $5,146,384 | $4,858,328 | | |
| Central STA | $46,739,250 | $34,794,775 | $96,075,125 | $72,705,500 | $56,087,100 | | |
| Basin 1 structure & canal | | | | | $760,000 | | |
| S-99 pump station | | | | | $5,733,000 | | |
| IRFWCD Reservoir levees, canals, outlet structure, pump | | | | | | $87,123,892 | $50,342,377 |
| IRFWCD canal & Pump | | | | | | $11,324,000 | $11,324,000 |
| **Total Cost** | $177,959,771 | $127,332,976 | $307,698,175 | $210,756,154 | $192,334,828 | $98,447,892 | $61,666,377 |

# Evaluation Matrix

***Table 46*** shows the results of the evaluation of the final set of alternative plans. Three evaluation criteria were evaluated for each alternative. Descriptions of each of the three criteria are provided below:

- Discharge Delivery Rate: This is the water supply delivery discharge that the alternative plan can maintain through the 41 year period record with 90% reliability. The goal is to maximize this discharge rate.

- Reduction in flow to IRL: By withdrawing canal flows for water supply, reductions in harmful discharges to IRL will result. The goal is to maximize the reductions in flow to IRL.

- Present Value Life Cycle Cost: The present value of the total capital cost (including design, land acquisition, construction, and construction management) and operations and maintenance cost over a 60 year period of analysis with a 5.125% discount rate.

**Table 46. Evaluation results for the final alternatives.**

| Alternative Plan | Discharge Delivery Rate – 90% Reliability (cfs/mgd) | Flow Reductions to IRL (acre-ft/yr) | Present Value Life Cycle Costs |
|---|---|---|---|
| ICS-01(A) | 90/59 | 78,897 | $177,875,000 |
| ICS-01(B) | 67/44 | 58,563 | $127,342,000 |
| ICS-02(A) | 185/120 | 142,236 | $307,641,000 |
| ICS-02(B) | 140/91 | 113,139 | $210,919,000 |
| ICSB-01 | 108/70 | 84,462 | $192,359,000 |
| IRFWCD-R(A) | 63/41 | 44,295 | $98,239,000 |
| IRFWCD-R(B) | 53/34 | 40,214 | $61,656,000 |

# Comparison of Alternatives

## ANALYTICAL HIERARCHY PROCESS

A multiple criteria decision model (Criterium Decision Plus©) was used to facilitate the comparison of alternatives. The Analytical Hierarchy Process (AHP) was used to create a decision model. The AHP, developed by Dr. Thomas Saaty at the Wharton School of Business in the 1970's, is a method of organizing information and judgments to aid in the selection of an alternative. ***Figure 54*** shows the simple hierarchal organization of the decision model used for this analysis. The goal of this analysis is to select the preferred alternative. The objectives are to:

- Maximize the discharge delivery rate (with 90% reliability)
- Maximize the average annual reduction in flows to IRL
- Achieve benefits at the lowest reasonable cost.

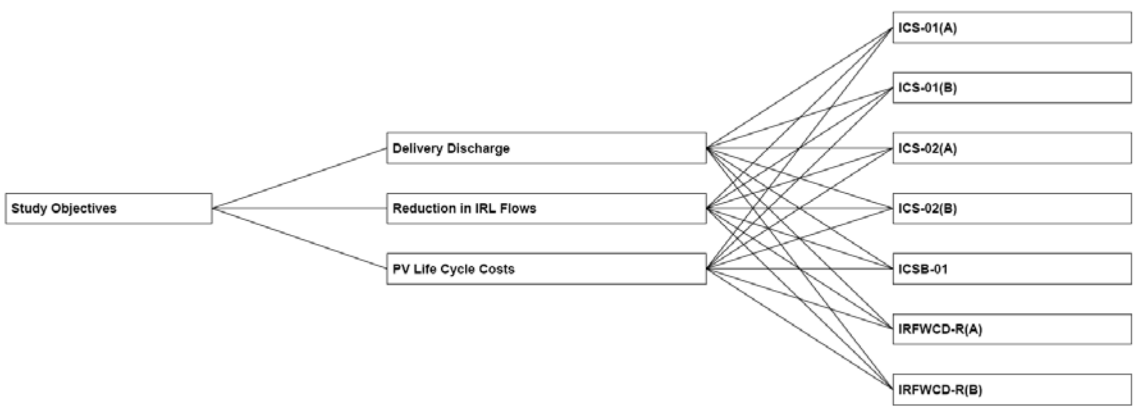



**Figure 54. AHP decision model.**

In selection of the preferred alternative, the level of importance of each objective must be established using weighting factors. Weighting the objectives is subjective. There is no "right" set of weighting factors. Unfortunately, weighting cannot be avoided. Applying no weighting factors implies that all objectives are equally important which is usually not true.

## RESULTS

***Table 47*** shows the weighting factors that were used for this comparison of alternatives. Discharge delivery rate and present value life cycle costs were considered the most important objectives. Therefore, they were weighted equally. Reductions in flows to the IRL was a secondary benefit and was weighted at half the level of importance of other objectives.

Applying these weighting factors, a score was computed for each of the alternatives. The scores, between 0 (worst) and 1 (best), are shown in ***Figure 55.*** ICS-02(A) is the highest ranked alternative followed by ICS-02(B). However, all the alternatives scored within a relatively narrow range with less than 25% difference between the highest and lowest scores.

**Table 47. Weighting factors.**

| Objective | Weighting Factor |
|---|---|
| Discharge delivery rate (90% reliability) | 40 |
| Reduction in IRL flows | 20 |
| Present value life cycle cost | 40 |

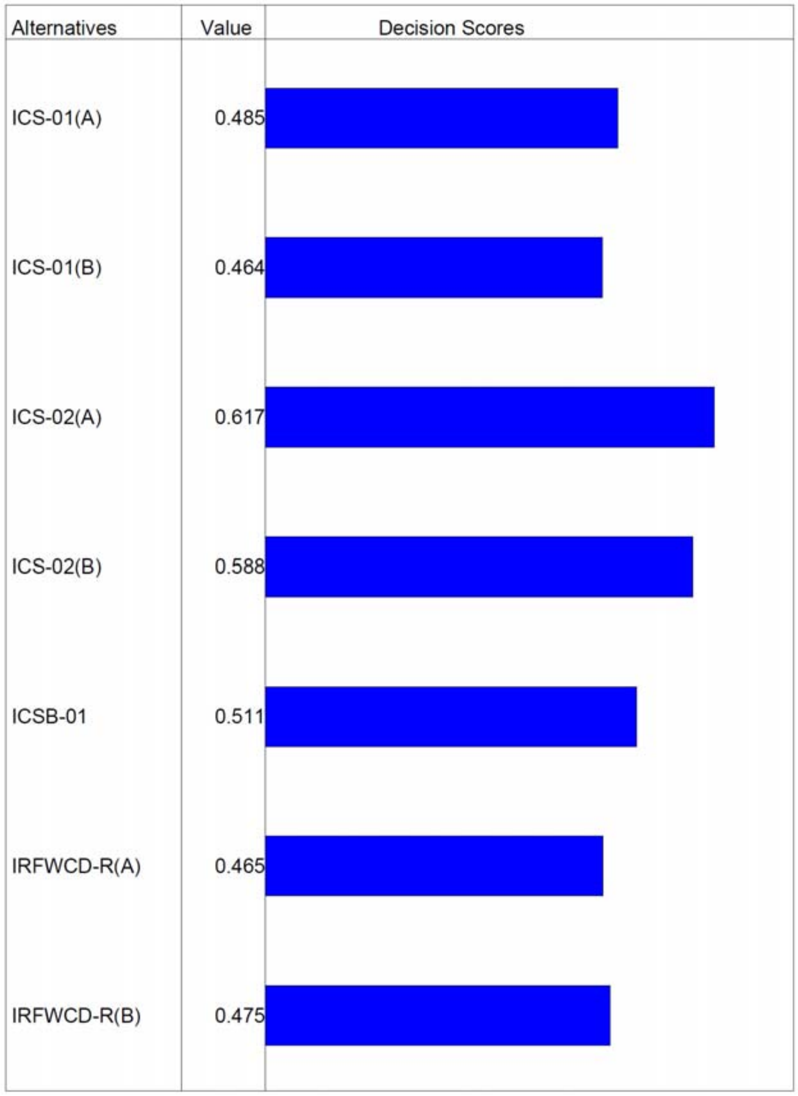



**Figure 55. Alternative scores.**

***Figure 56*** shows the contributions to the total scores by each of the three objectives for the five alternatives with the highest total scores. The high discharge delivery rate provided by ICS-02(A) provided the largest contribution to its score. For ICS-02(B), the discharge delivery rate and the cost were about equal in their contribution to the total score. For the other top five scoring alternatives, present value life cycle cost was the largest contributor to the respective scores. For IRFWCD-R(B), present value life cycle cost contributed more to its score than the other two objectives combined. This indicates that even though IRFWCD-(B) does not provide a large discharge delivery rate, its performance is very efficient. The present value life cycle cost per unit of discharge delivery for IRFWCD-R(B) is the lowest of the top five alternatives.

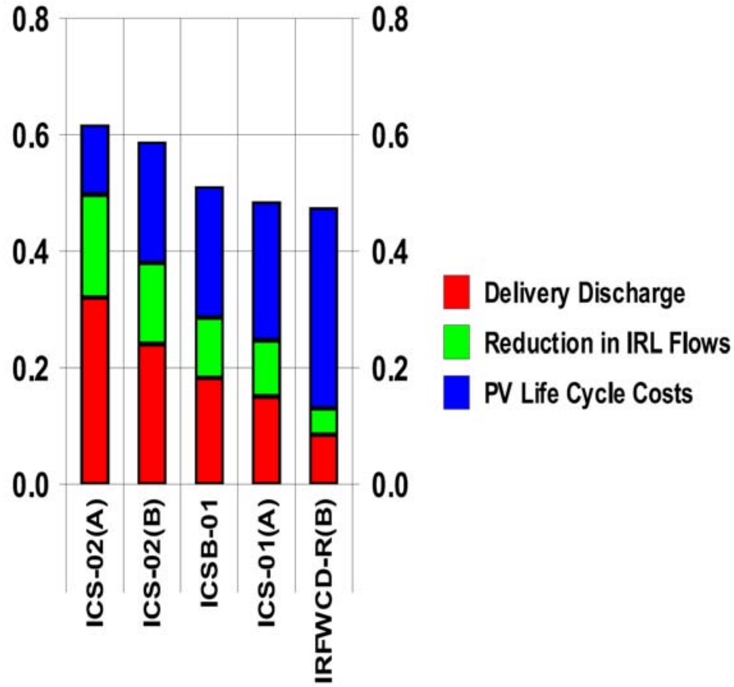



**Figure 56. Contributions of objectives to total alternative scores for the top five alternatives.**

***Figures 57 through 59*** demonstrate the sensitivity of the alternative rankings to changes in the weighting factors applied to the objectives. In each figure, the vertical axis is the score of the alternative from 0 (worst) to 1 (best). The red vertical line represents the weight, or the importance, of the objective in each graph. If the vertical line is shifted left, the weight (or importance) of the objective would be reduced. If the line is shifted to the right, the weight of the objective would be increased. The scores of the alternatives are indicated where the diagonal lines intersect the red vertical line. The diagonal lines for each of the top five scoring alternatives show how the scores and rankings of the alternatives would change with a change in the weighting applied to the objective. The impact of a change in the weighting of an objective can be assessed by moving the red vertical line to the left or right and noting how the ranking of the alternatives change.

If the importance (or weighting) of discharge delivery rate is reduced, the top ranked alternative will change from ICS-02(A) to ICS-02(B) (***Figure 57***). If the importance of discharge delivery rate is further reduced to the point that it is considered trivial, then the IRFWCD-R(B) becomes the top ranked alternative.

The ranking of the alternatives is relatively insensitive to changes in the weighting of reductions in flows to IRL (***Figure 58***). ICS-02(A) would remain the top ranked alternative regardless of how the weighting is changed.

If the importance of present value life cycle cost was increased, the top ranked alternative would shift from ICS-02(A) to ICS-02(B) (***Figure 59***). If the importance of cost was further increased to very important, IRFWCD-R(B) would become the top ranked alternative. ICS-02(A) performs significantly better than IRFWCD-R(B) in discharge delivery rate and reductions in flows to IRL. However, the IRFWCD-R(B) alternative achieves its level of output at a very low cost.

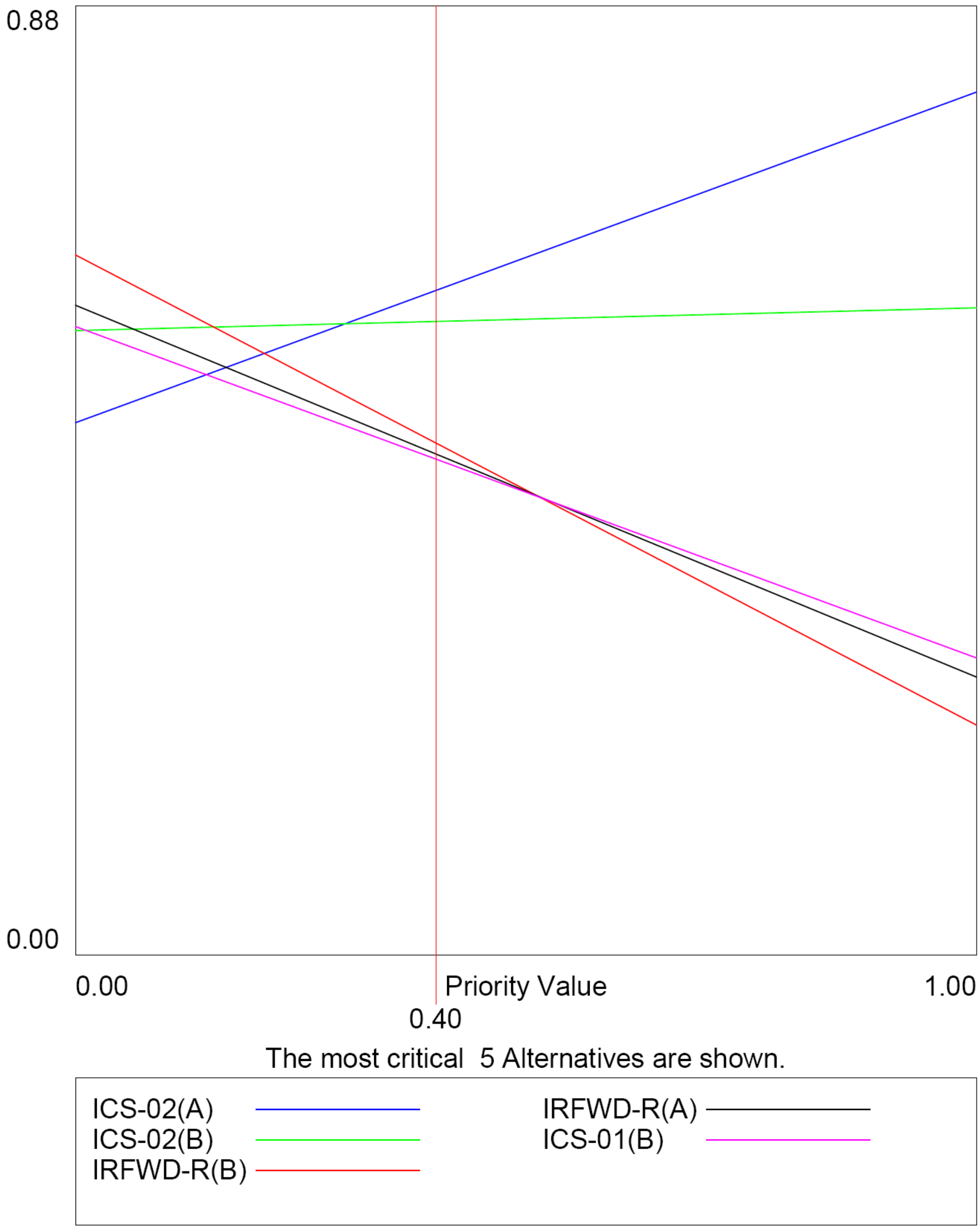



**Figure 57. Sensitivity of alternative scores to the weighting applied to "discharge delivery rate".**

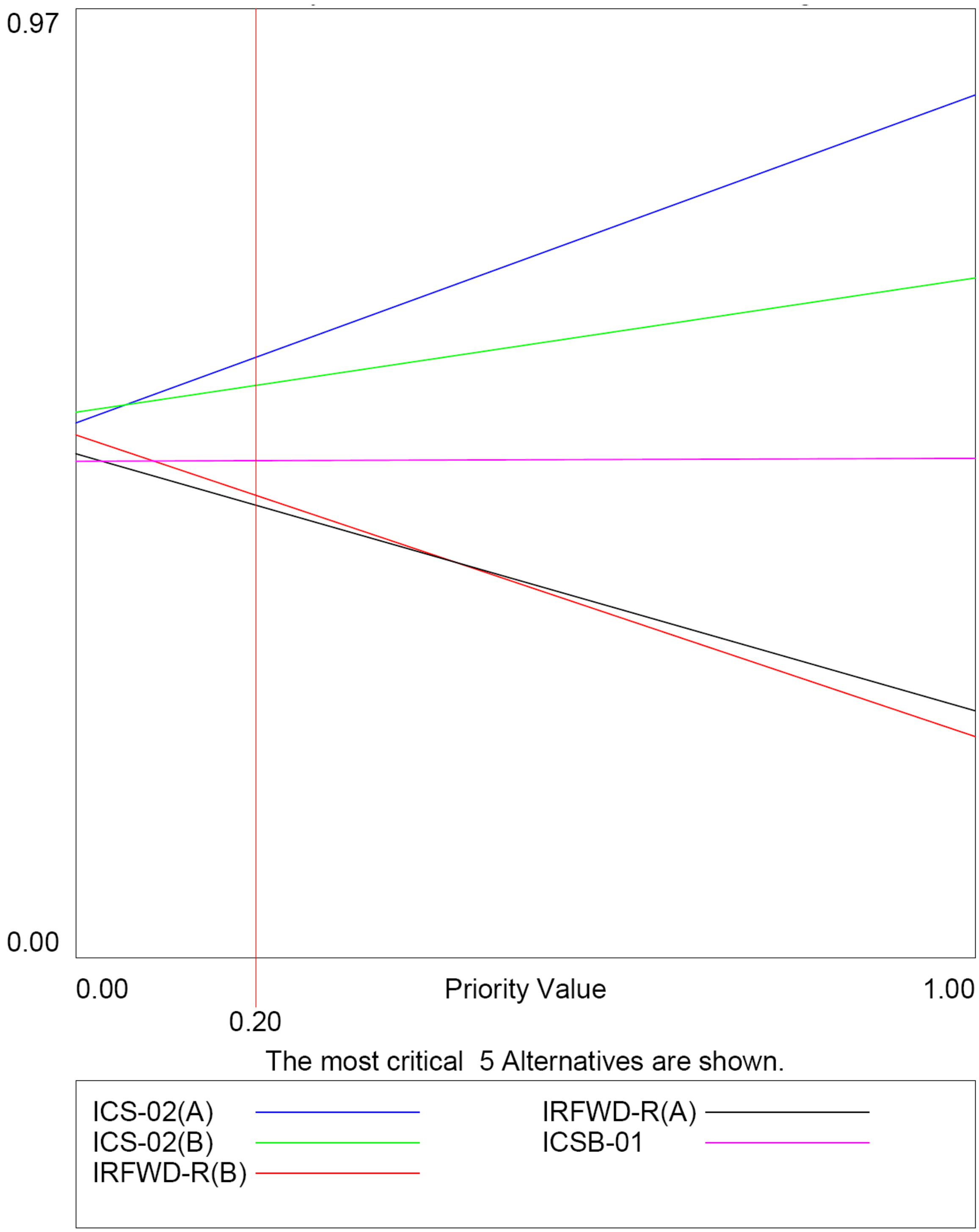



**Figure 58. Sensitivity of alternative scores to the weighting applied to "reduction in flows to IRL".**

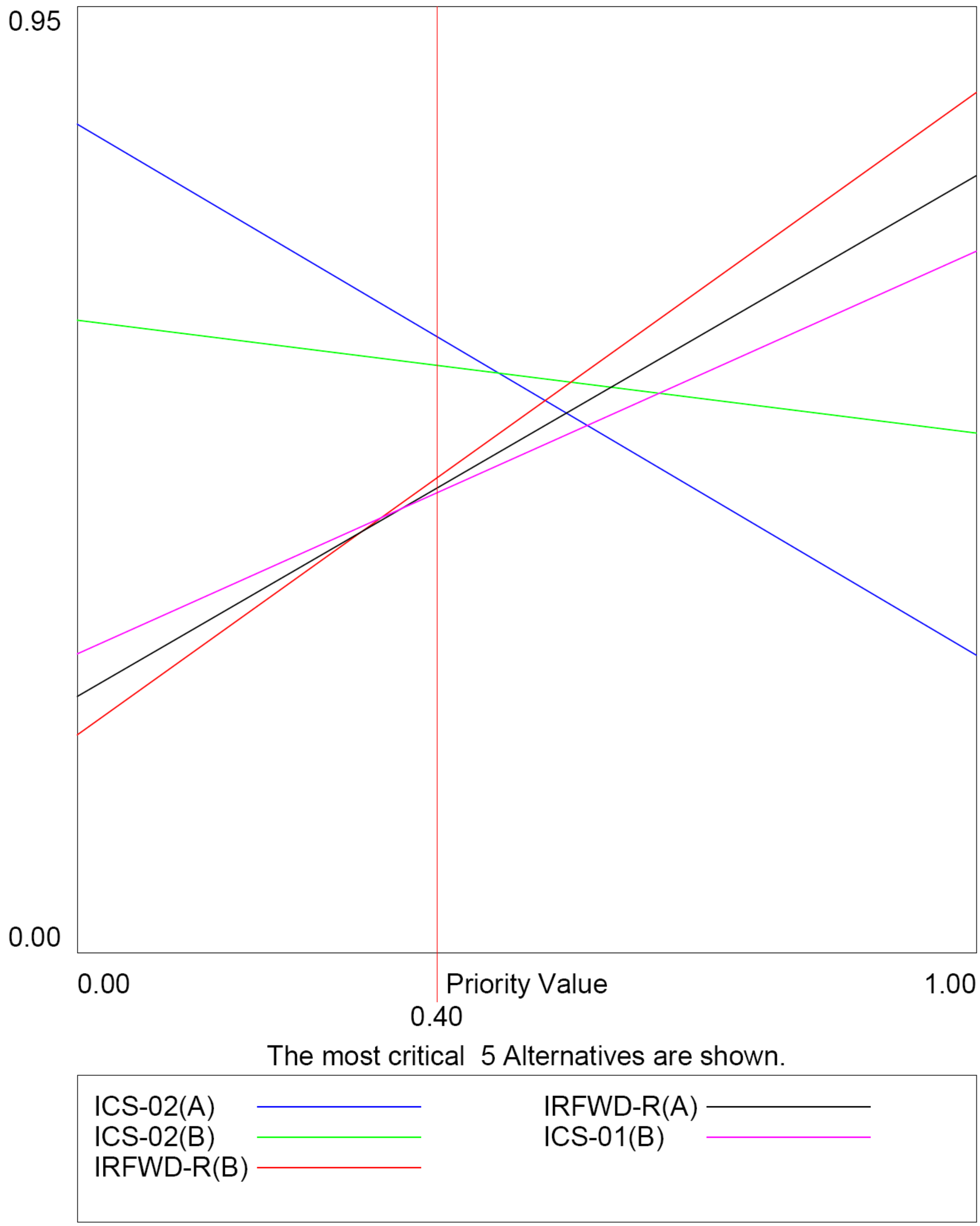



**Figure 59. Sensitivity of alternative scores to the weighting applied to "present value life cycle costs".**

## CONCLUSIONS

- The overall scores of the alternatives are relatively close – less than 25% difference between the scores of the highest and lowest scoring alternatives.

- ICS-02(A) is the highest ranked alternative. This alternative was carried forward for preparation of a more refined conceptual cost estimate and development of an implementation plan.

- The top ranking of ICS-02(A) is relatively insensitive to the weightings applied to the project objectives. ICS-02(B) could become the top ranked alternative with a large increase in the weight applied to cost or a large reduction in the weighting applied to discharge delivery rate.

- ICS-02(A) serves a function very similar to that of the C-25 Reservoir plan which is included in the IRL-S Project. This alternative could potentially be adopted into the IRL-S Project. As a result, Federal cost sharing may be available for its implementation.

- Achieving the full benefits of ICS-02(A) depends upon the construction of the C-23 and C-24 Reservoirs and STA included in the IRL-S Project. If these features are not constructed, flows from the C-23 and C-24 Basins could not be conveyed for storage in the reservoir. Without the IRL-S Project features in place, the area contributing flow to the reservoir would be the same area as the ICS-01(A) and ICS-01(B) alternatives.

- IRFWCD-R(B) is an efficient alternative. The cost per cfs of discharge delivery rate at 90% reliability is the smallest of all alternatives. However, the magnitude of the discharge delivery rate and the flow reductions to IRL are significantly less than either ICS-02(A) or ICS-02(B).

## PREFERRED ALTERNATIVE HYDROLOGIC PERFORMANCE

The preferred plan (ICS-02(A)) includes a 5,000 acre reservoir. RESOPT simulations of the reservoir for the period of record from 1965 through 2005 were performed to assess the alternative's performance. It was found that a discharge from the reservoir of 185 cfs could be maintained for 90% of the period of record. ***Figures 60 through 62*** show simulated water level fluctuations in the reservoir over the period of record with a 185 cfs discharge delivery rate. It should be noted that discharges from the reservoir were discontinued when reservoir depths fell to, or below 1 foot. When reservoir depths reached 10 feet, pumped inflows were discontinued and direct rainfall was discharged from the reservoir.

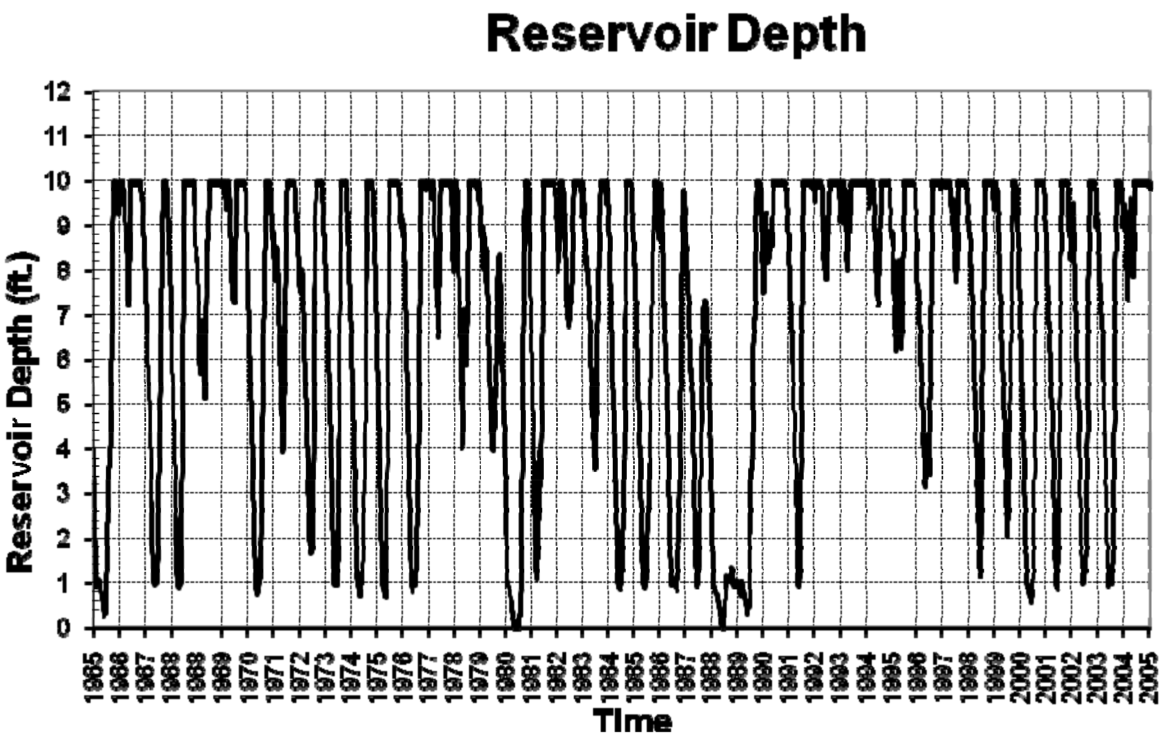



**Figure 60. ICS-02(A) reservoir simulated water levels for the period of record 1965 to 2005 with a discharge delivery rate of 185 cfs.**

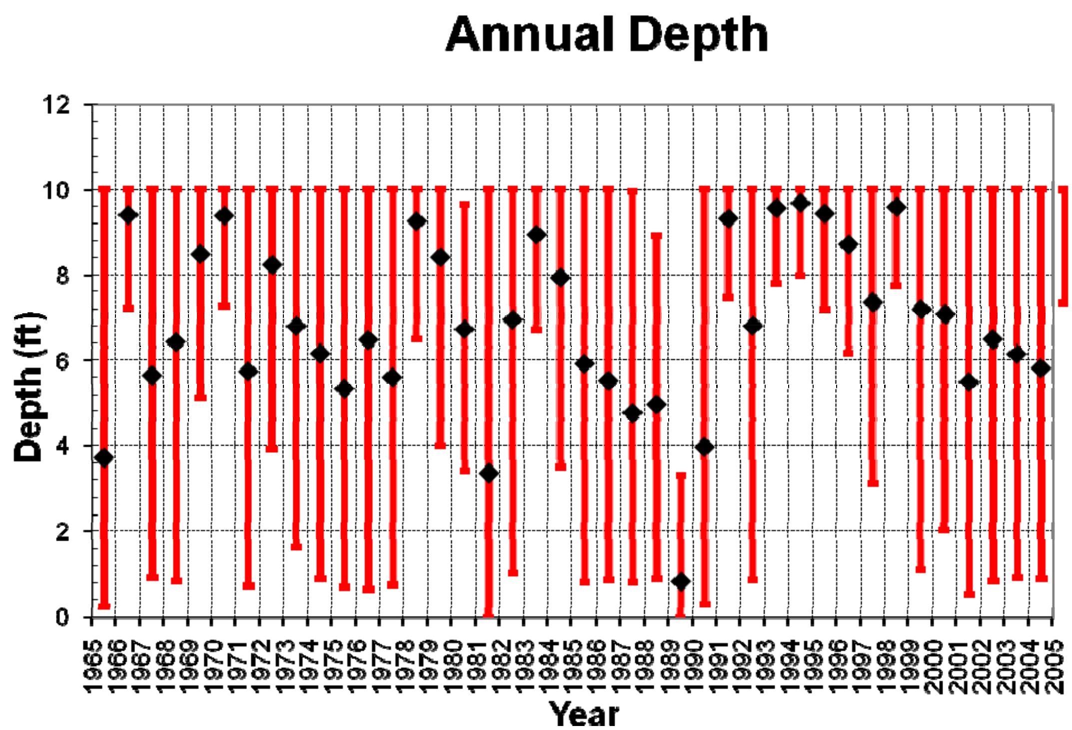



**Figure 61. ICS-02(A) maximum, minimum, and average annual depths with a 185 cfs discharge delivery rate for the period of record 1965 to 2005.**

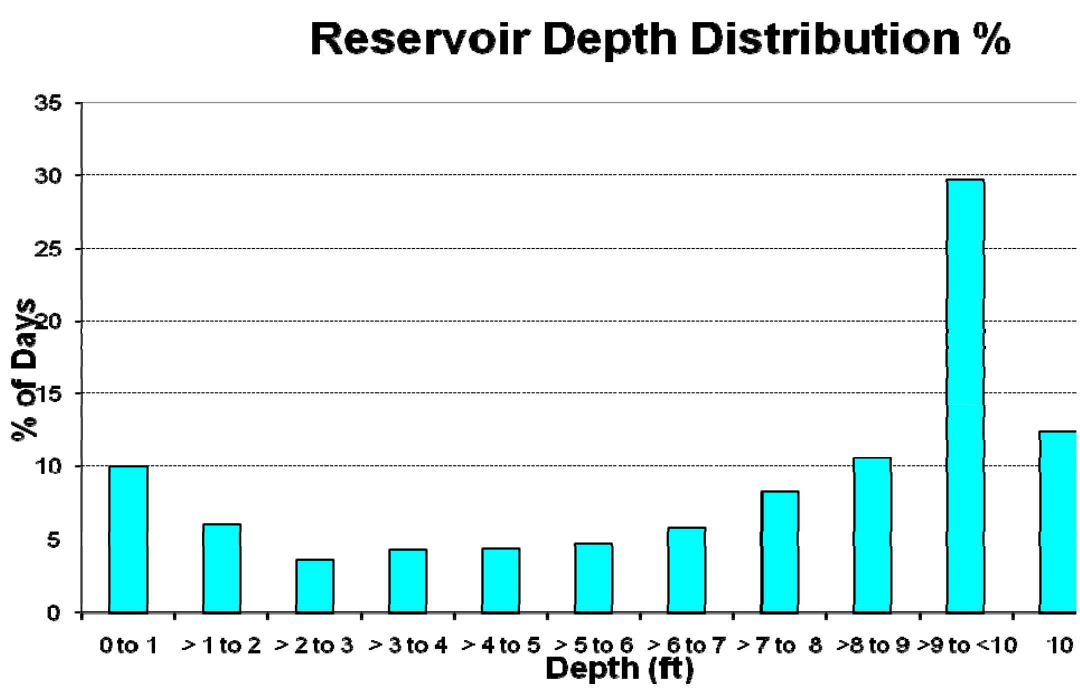



**Figure 62. ICS-02(A) reservoir depth distribution with 185 cfs discharge delivery rate for the period of record 1965 to 2005.**

# COMPONENT DESCRIPTION AND ASSOCIATED COSTS

A refined conceptual cost estimate was prepared to support the preparation of a Basis of Design Report as the next phase of project development. A field visit was conducted to observe the project site and provide a better understanding of the physical conditions and construction requirements. During the trip, the assumptions used for the preliminary designs and cost estimates were verified and modified as appropriate. The design assumptions used in the preliminary design and cost estimates have been revised for the following components:

- Improvements to existing C-25 Canal
- Connect C-25 to C-52E
- 5,000 acre Reservoir
- 5,000 acre STA

## C-25 CANAL IMPROVEMENTS

The field review of the C-25 system and subsequent document review of As-Built drawings by SFWMD staff resulted in the following recommendations to the C-25 canal system to provide adequate conveyance for the project. The canal system east of S-99 was deemed adequate and the 20,700 LF west of S-99 was also considered to be adequate. However the western most 3,500 LF of C-25, North of Orange Avenue and east of Rim Road (Segment A, ***Figures 63 and 64***) will require improvement. The canal should be widened to a bottom width of 25 ft and deepened from its current 5 ft depth to a bottom elevation of 0.6 ft, NGVD, similar to other canal sections. The proposed pump station to be constructed at the G-81 structure would have a capacity of 260 cfs with a SCADA system that is consistent with SFWMD's existing system.

Similarly, the North/South 8,140 ft segment of C-25 north of G-81 (Segment B, ***Figures 63 and 64***) will also require slight improvements by expanding its current bottom width from 20 ft to 25 ft, and maintaining the designed bottom elevation of 0.6 ft, NGVD.

### Conceptual Design Assumptions- C-25 CANAL IMPROVEMENTS

- Section A (***Figure 63***) improvement length 3,500 LF
- Section B (***Figure 63***) improvement length 8,140LF
- Final Canal bottom width 25 ft, elevation 0.6 ft
- Construct 260 cfs pump station at G-81

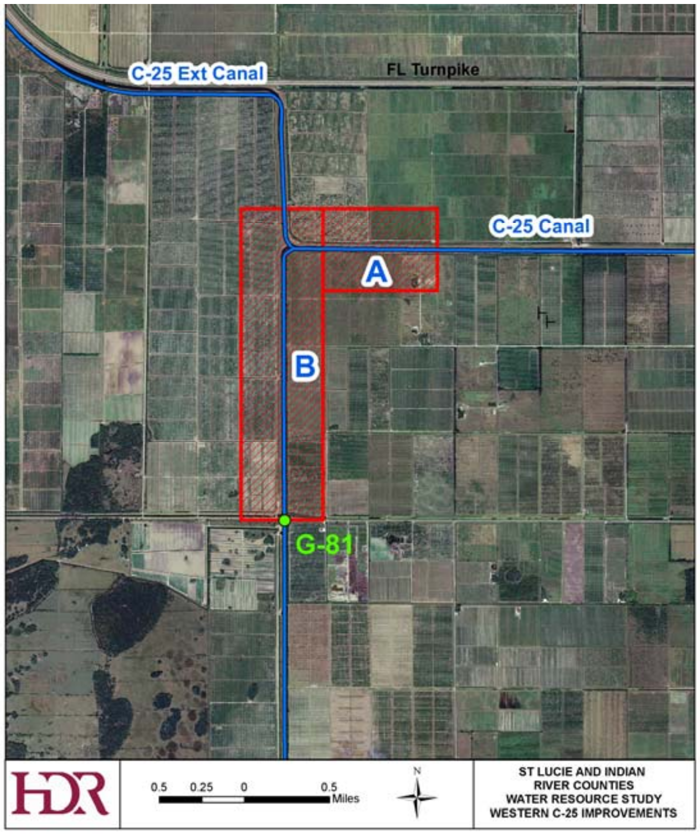
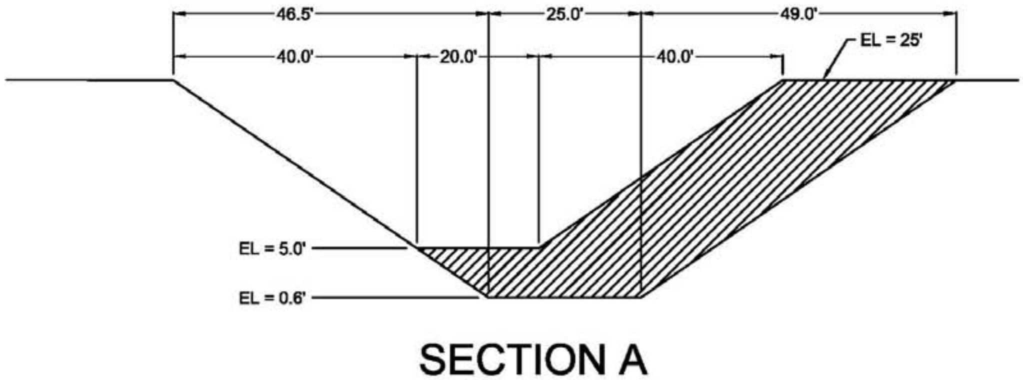



**Figure 63. C-25 Improvements.**



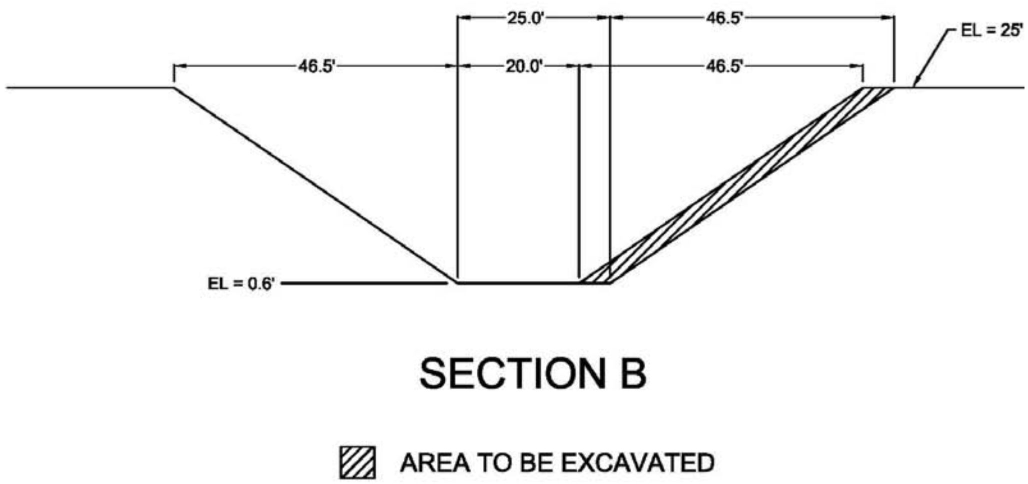




**Figure 64. Proposed canal cross sections for C-25 improvements.**

### Cost Estimate C-25 Canal Improvements

| Item | Unit | Qty | $/Unit | | TOTAL | |
|---|---|---|---|---|---|---|
| Excavation | CY | 225,477 | $ | 5 | $ | 793,375 |
| Seed & Mulch | SY | 8,089 | $ | 1 | $ | 8,089 |
| Dewatering | LS | 1 | $ | 25,000 | $ | 25,000 |
| Pump Station (260 cfs) | LS | 1 | $ | 6,000,000 | $ | 6,000,000 |
| Sub-Total | | | | | $ | 6,826,464 |

## Inter-District (C-25 and C-52E) Connection

The field reconnaissance trip uncovered the need for substantial modification to the design of existing features and the addition of new features required to provide an Inter-district hydraulic connection. In order to make a direct connection between C-52E and C-25, the existing private pump located on the south side of the Florida Turnpike will have to be removed and replaced immediately south of its current location (***Figure 65***). A vertical 8'X8' lift gate with telemetry would be constructed in the Turnpike Canal to control flows between the SJRWMD and SFWMD. The site will require single phase power for the lift gate system. An existing plug in the Turnpike Canal where the private pump station was located would be removed (300 LF of 25 ft bottom width, at 0.6 ft, NGVD). This would connect C-25 with Turnpike Canal, which flows under the Turnpike and terminates on the north side of the Turnpike. New right-of-way will be required (200 ft wide x 1.5 miles) to accommodate a new channel connection to C-52E. Finally the levee between the groves and C-52E must be breached.

- Construct adjustable lift gate (8'x8')
- Remove plug and relocate private pump station
- Purchase 200 ft x 1.5 miles of R/W (38 acres) for new canal north of turnpike
- Construct 1.5 mi of new canal
- Remove 300 ft of 20 ft high levee

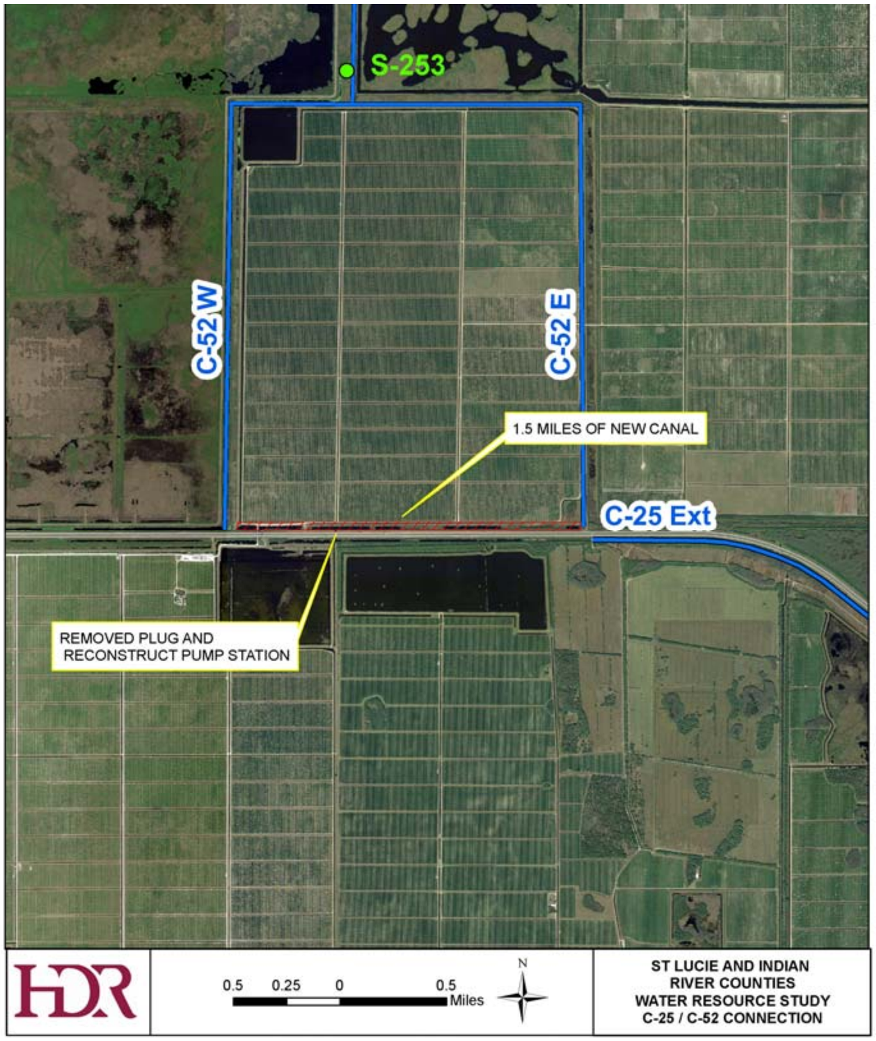



**Figure 65. Canal 25 Connection to C-52E.**

### Cost Estimate for C-25 to C52 connection

| Item | Unit | Qty | $/Unit | | TOTAL | |
|---|---|---|---|---|---|---|
| Purchase R/W | AC | 38 | $ | 6,000 | $ | 228,000 |
| Excavation | CY | 308,000 | $ | 5 | $ | 1,540,000 |
| Seed & Mulch | SY | 17,600 | $ | 1 | $ | 17,600 |
| Dewatering | LS | 1 | $ | 15,000 | $ | 15,000 |
| Remove levy 300' at 20 ft high | CY | 13400 | $ | 5 | $ | 67,000 |
| Remove plug | CY | 12000 | $ | 6 | $ | 72,000 |
| Remove & Reconstruct Pump Station | LS | 1 | $ | 800,000 | $ | 800,000 |
| Construct adjustable Lift Gate (8'x8') | EA | 1 | $ | 185,000 | $ | 185,000 |
| SUB- TOTAL | | | | | $ | 2,924,600 |

# RESERVOIR CONSTRUCTION

## Reservoir levee height conceptual analysis

There were three conceptual reservoirs evaluated in this analysis. The reservoir sizes and calculated side lengths and other associated parameters are listed below in ***Table 48***. The single-cell 5,000 acre reservoir size corresponds to that of the ICS-02(A) reservoir – the preferred alternative. In order to facilitate phased implementation, a reservoir with the same storage capacity provided in two cells (3,000 acres and 2,000 acres) was also evaluated. The assumption made in this analysis was that each of the reservoir cells was square.

**Table 48. Conceptual Level Reservoir Sizes**

| Conceptual Level Reservoir Size (Ac) | Area (sf) | Square Root Area (ft) | Reservoir Side Length Utilized (ft) |
|---|---|---|---|
| 5,000 | 217,800,000 | 14,758.05 | 14,758.10 |
| 3,000 | 130,680,000 | 11,431.54 | 11,431.60 |
| 2,000 | 87,120,000 | 9,333.81 | 9,333.90 |

The approach utilized in calculating the levee heights is based on United States Army Corps of Engineers (USACE) guidelines in the Automated Coastal Engineering System (ACES) Program and the Shore Protection Manual. The following presents a summary of the analysis performed and assumptions used.

The conceptual reservoirs were drawn into CADD utilizing the lengths presented above in ***Table 48***. The 50-year 3-second wind gust was based on the Florida Department of Community Affairs' Florida Building Code which used information generated by the American Society of Civil Engineers Standard ASCE 7-98. This gust was then utilized to determine the eventual design wind speed utilized later in the analysis.

The maximum Stillwater elevation of the reservoir was determined based upon the combination of the normal water level of the reservoir (10 ft above natural ground) and the Probable Maximum Precipitation (PMP). The PMP utilized for this analysis was 4.6 feet. A PMP can be calculated utilizing the HEC-HMS program in conjunction with the USACE HMS-5.2 Manual. The HEC-HMS program is a hydrologic program that calculates flow and stage based upon information on the basin areas, channel cross section, maximum storm events, curve numbers, and time of concentrations.

Fetch was determined by drawing a line diagonally in CADD in each reservoir. Fetch is the maximum straight line over-water distance for a particular wind direction. This line was then copied at 3-degree intervals to get a total of a 24-degree representation. The lengths of each line within the boundary of the reservoir cell were calculated and averaged. The average was utilized for the total fetch distance, in miles, for each conceptual reservoir cell.

Two unitless coefficients, defined as overtopping parameters, were obtained by using Figure 7-29 from the USACE 1984 Shore Protection Manual (SPM). Guidance from USACE staff in previous projects dictated the use of this figure, which governs the parameter use for a stepped structure having a 1:1.5 side slope, for the 1:3 sloped conceptual reservoir cells presented in ***Table 49***.

Upon confirmation of these two coefficients and the fetch distance, the wave run-up and wave overtopping was calculated. Wave run-up is defined as the vertical run of water up the internal side slope of the levee as a result of wave breaking. Wave overtopping is defined as the flow (presented as cubic feet per second per foot of levee length (cfs/ft)) that overtops the interior top of levee.

The calculations of wave run-up and wave overtopping were performed utilizing Microsoft Excel. The calculations were set up to iteratively determine the levee height based upon a certain maximum overtopping rate desired. For the purposes of this analysis, 0.001 cfs/ft was utilized as the maximum wave overtopping desired.

Based on the information summarized above, the resulting levee heights for each reservoir cell are summarized below in ***Table 49***.

**Table 49: Indian River Lagoon Reservoir Summary**

| Calculation Parameter | 5,000 Acre Reservoir | 3,000 Acre Reservoir | 2,000 Acre Reservoir |
|---|---|---|---|
| 50-year, 3-second Gust (mph) | 123 | 123 | 123 |
| Design Wind Speed (mph) | 100 | 100 | 100 |
| Fetch (miles) | 3.58 | 2.78 | 2.27 |
| Normal Water Level | 10 | 10 | 10 |
| PMP (feet) | 4.6 | 4.6 | 4.6 |
| Overtopping Parameter, ⍰ | 0.071 | 0.071 | 0.070 |
| Overtopping Parameter, $Q_o^*$ | 0.024 | 0.023 | 0.025 |
| Wave Run-up (feet) | 5.98 | 5.51 | 5.13 |
| Wave Overtopping (cfs/ft) | 0.00109 | .00104 | .00109 |
| Levee Height (feet) | 26 | 24.85 | 24 |
| Freeboard (feet) | 10 | 9.14 | 8.47 |

## Reservoir Construction

Based upon previous analysis a 5,000 acre reservoir with two cells is being proposed. Cell 1 would be 3,000 acres and Cell 2 would be 2,000 acres. The reservoir would be broken into cells for phasing of the implementation which is discussed in the following section of this report. A preliminary wave run-up analysis indicated that Cell 1 perimeter levee should be a minimum of 24.8 ft above natural ground and the Cell 2 levee should be 24.0 ft above natural ground.

Reservoir construction would include a single 10'X10' vertical lift gate with telemetry between the cells, and two-10'X10' lift gates for each cell to serve as discharge structures. The reservoir would be filled using a 700 cfs pump station. Construction of the pump station would be phased with the reservoir cells. The pump station structure would be constructed to house the pump machinery for 700 cfs in the first phase of construction. Pump units providing only 500 cfs would be constructed with the first reservoir cell. Three phase power will be required for the gates and pump station. The perimeter levee would be assumed to have a configuration similar to ***Figure 66***.

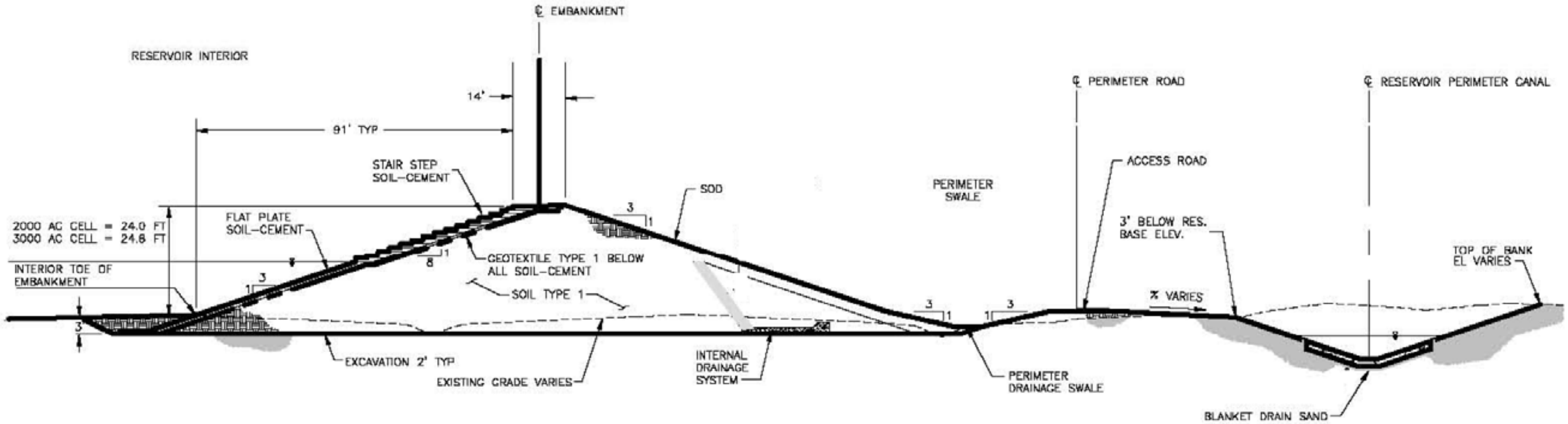



**Figure 66. Typical reservoir levee cross-section.**

Cell 1 of the reservoir would be used as a first priority. Only when cell 1 is full would water be discharged to cell 2. Cell 2 would be the first priority for providing water supply delivery if there was water available in storage. In this way, cell 2 would be emptied on a regular basis and evapo-transpiration losses would be minimized because the water surface area of the two cells would be minimized.

### Cost Estimate for Reservoir Construction

| Item | Unit | Qty | $/Unit | | TOTAL | |
|---|---|---|---|---|---|---|
| Purchase reservoir property | AC | 5,000 | $ | 6,000 | $ | 30,000,000 |
| Clear and Grub | AC | 5,000 | $ | 2,000 | $ | 10,000,000 |
| Berm (Excavation & Placement) | CY | 6,016,000 | $ | 8 | $ | 48,128,000 |
| Seed & Mulch | SY | 760,000 | $ | 1 | $ | 760,000 |
| Pump Station 700 cfs | LS | 1 | $ | 10,000,000 | $ | 10,000,000 |
| Vertical Lift Gate -10' (between cells) | LS | 1 | $ | 185,000 | $ | 185,000 |
| Vertical Lift Gate -20' (Cell Discharge) | LS | 2 | $ | 215,000 | $ | 430,000 |
| Access Rd and Misc. Site Improvements | LS | 1 | $ | 700,000 | $ | 700,000 |
| SUB-TOTAL | | | | | $ | 100,203,000 |

## STA Construction

The STA was sized to provide an outflow phosphorous concentration of 80 ppb. The STA would require a 185 cfs inflow pump, between the supply canal and the upper distribution canal. The STA would be composed of 2 cells, each approximately 2,500 acres in size. The target phosphorous concentration at the outflow is 80 ppb. Each cell would have a 10'x10 adjustable vertical lift gate with remote telemetry compliant with SFWMD systems for remote access and control. The cells would be graded to be nearly level, no more then 1 ft per mile interior slope and each would have a stationary discharge weir between each cell and the lower distribution canal. The lower distribution canal would connect directly to the discharge canal.

- The STA would have two-2,500 acre cells
- Inflow pump of 185 cfs
- Adjustable vertical lift gates at upper end of each cell
- The STA would be graded to provide an interior slope of no more then 1 ft per mile.
- Fixed weir for each cell at lower distribution canal

- Target phosphorous concentration is 80 ppb at the discharge

### Cost Estimate for STA Construction

| Item | Unit | Qty | $/Unit | TOTAL |
|---|---|---|---|---|
| Purchase STA property | AC | 5,000 | $ 6,000 | $ 30,000,000 |
| Berm | CY | 493,333 | $ 8 | $ 3,946,667 |
| Seed & Mulch | SY | 399,600 | $ 1 | $ 399,600 |
| Clear & Grub & Fine grade STA | AC | 5,000 | $ 2,000 | $ 10,000,000 |
| Fine Grade/Internal ditches | AC | 5,000 | $ 500 | $ 2,500,000 |
| Pump Station 185 cfs | LS | 1 | $ 4,880,000 | $ 4,880,000 |
| Vertical Lift Gate -10' Mech. | LS | 2 | $ 185,000 | $ 370,000 |
| Fixed gate discharge (Cell Discharge) | LS | 2 | $ 50,000 | $ 100,000 |
| SUB-TOTAL | | | | $ 52,196,267 |

# Implementation Plan

The C-23, 24, and 25 Central Storage Reservoir (ICS-02(A)) is the preferred alternative. However, in order for this plan to achieve its full level of output – in terms of discharge delivery rate – it is dependent upon the operation of the C-23/24 North and South Reservoirs and STA. The lands required for these features have been acquired by SFWMD and USACE is currently preparing detailed design for construction. The total cost of the C-23/24 Reservoirs and STA was estimated to be just over $332 million (USACE 2004).

The IRL-S Project includes the C-23/24 North and South Reservoirs and STA, in addition to improvements in canal conveyance capacities. These features, along with construction of a pump station at G-81, enable the capture and storage of excess water from the C-23 and C-24 Basins in the ICS-02(A) reservoir. Without these IRL-S Project features, there would be inadequate canal conveyance capacity to discharge water from the C-23 and C-24 Basins to the ICS-02(A) reservoir. Additionally, without the IRL-S project STA, the quality of the C-23 and C-24 flows would degrade the water quality of C-25 and the ICS-02(A) STA would not be adequately sized.

Without the IRL-S Project features in place, the drainage area and flows for the ICS-02(A) reservoir would be the same as another alternative evaluated in this study – ICS-01(A). As a result, the performance of ICS-02(A) would decline dramatically in terms of its ability to provide water supply deliveries.

Since implementation of the IRL-S project features is dependent upon Federal appropriations and is subject to potential delays, a plan for phased implementation of ICS-02(A) has been developed. The goal would be to phase the implementation to provide early benefits, but minimize or avoid the risk that constructed features could not be fully utilized.

The preferred plan can be implemented in two phases. During the design and land acquisition for Phase I, dispersed storage/water farming could provide early benefits at a minimal cost. The first phase of construction would include a smaller reservoir, pump station, and STA. Rather than a single cell 5,000 acre reservoir, two connecting reservoir cells would be constructed; a 3,000 acre cell in Phase I and a 2,000 acre cell in Phase II. Similarly, the STA would be constructed in two 2,500 acre cells; one in each phase. The recommended implementation plan is described below.

## INTERIM MEASURES

Because dispersed storage/water farming would take advantage of existing infrastructure, minimal construction (and cost) would be required to meet the project objectives. With large areas of citrus that have been decimated by canker and greening, it is likely that land owners would be willing to participate. This could provide growers with an alternative source of revenue in the interim while new disease resistant varieties of citrus are being developed. A process for identifying and evaluating potential proposals and methods for compensating land owners is being developed by SFWMD. This process must be completed before the potential costs and benefits of dispersed storage/water farming can be estimated.

## IMPLEMENTATION PHASE I

Phase 1of the implementation process would consist of constructing the features included in the C-25 Central Storage Reservoir alternative (ICS-01(A)). This would consist of all project features that would be required to capture flows from the C-25 and C-25 Extension Basins. It would also include the Inter-District connection of C-25 and C-52E.

With the reduced drainage area and flows available, the size of the reservoir, inflow pump station, and STA would be reduced (***Figure 67 and Table 50***). The reservoir for Phase I would be 3,000 acres with a 500 cfs inflow pump station. This compares to a 5,000 acre reservoir with a 700 cfs pump station for the final project (ICS-02(A)).

Only a portion of the C-25 improvements would be constructed in Phase I.

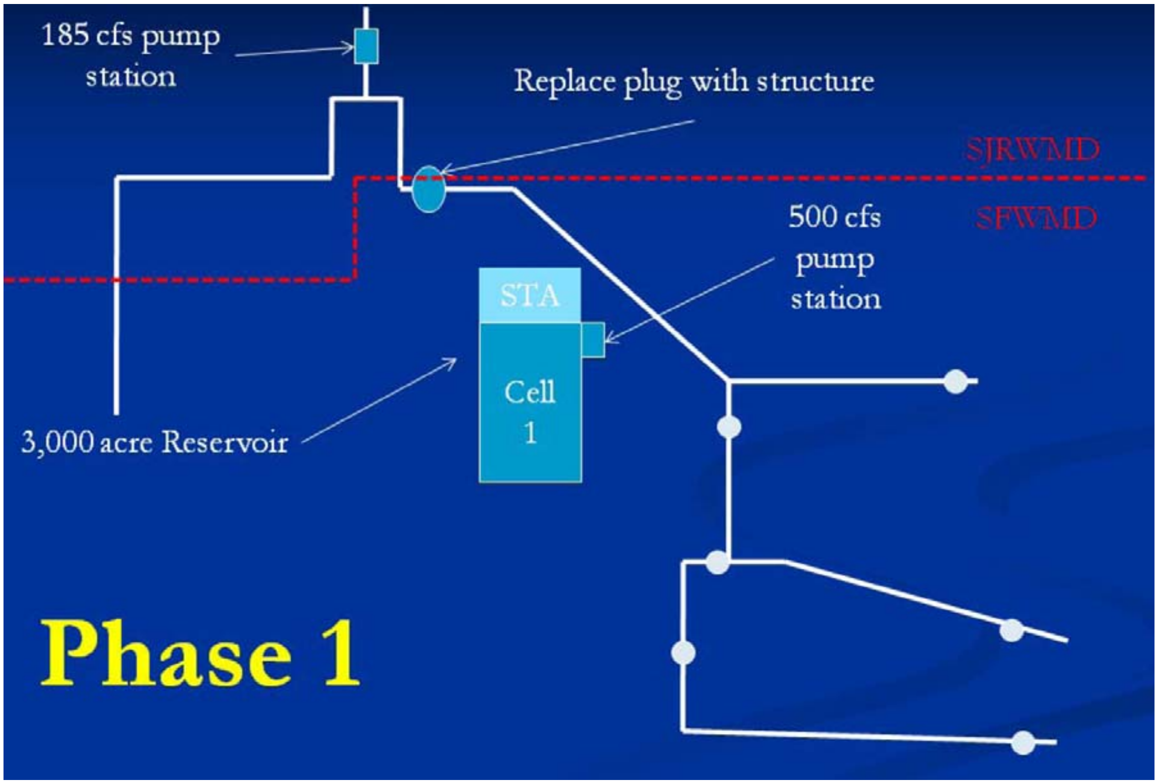



**Figure 67. Implementation Phase I components.**

**Table 50. Phase I and II Reservoirs, Inflow Pump Stations, and STAs.**

| | Phase I | Phase II |
|---|---|---|
| Reservoir size (acres) | Cell 1 = 3,000 | Cell 1 = 3,000<br>Cell 2 = 2,000 |
| Inflow Pump Capacity (cfs) | 500 | 700 |
| STA size (acres) | Cell 1 = 2,500 | Cell 1 = 2,500<br>Cell 2 = 2,500 |

It is assumed that all land acquisition for the final two-cell reservoir (5,000 acres) and STA (5,000 acres) would be completed in Phase I. The pump station structure would be constructed in Phase I to provide enough room to house pump machinery for the ultimate 700 cfs capacity. However, pump units to provide only 500 cfs would be installed during Phase I. The final two-cell reservoir would include a water control structure to enable discharges from cell 1 to cell 2. This structure would be constructed in Phase I, but would not be operated until Phase II. By constructing this structure in Phase I, it would avoid the need to take the reservoir out of operation during construction of Phase II.

## IMPLEMENTATION PHASE II

Phase II would be constructed when the IRL-S Project features (C-23/24 Reservoirs and STA) are operational. It would consist of all remaining components of ICS-02(A) that were not constructed in Phase I (***Figure 68***). Reservoir cell 2 would be constructed adjacent to cell 1. As shown in ***Table 49***, construction of the reservoir in two cells vs. one, allows the levee heights to be reduced. This is because the reduced wind fetch lengths with two cells, causes lower wind tides and wave run-up and requires less levee freeboard. As a result, the additional cost of building more lineal feet of levee for two cells is partially offset by the reduced levee height requirement.

Since additional flows from C-23 and C-24 Basins are available, Phase II will include construction of the G-81 pump station. This will enable the diversion of C-23 and C-24 flows into C-25 for storage in the ICS-02(A) reservoir.

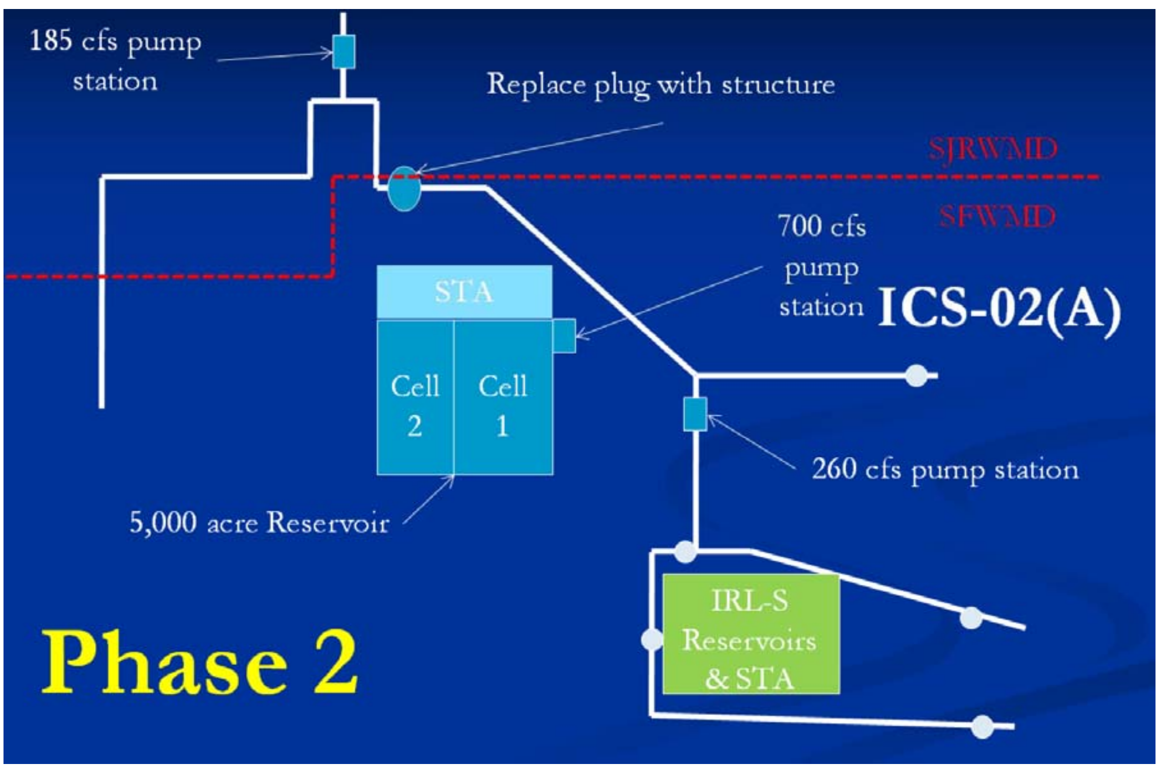



**Figure 68. Implementation Phase II components.**

## PHASING COSTS AND BENEFITS

***Table 51*** shows a breakdown of Phase I and Phase II costs. Costs for Phase I are disproportionately greater than those of Phase II primarily because:

- Land acquisition occurs in Phase I,
- Phase II reservoir and STA cells use levees constructed in Phase I, and
- Pump structures are completed in Phase I and only additional pump machinery is added in Phase II.

The benefits and costs of Phases I and II are shown in ***Table 52***. Phase I benefits are equal to those of the ICS-01(A) alternative.

**Table 51. Phase I and Phase II cost estimates.**

| Item | Phase I | Phase II | Total Cost |
|---|---|---|---|
| Canal Improvements: Section A Only | $ 774,563 | | $774,563 |
| Canal Improvements: Section B Only | | $310,089 | $310,089 |
| Canal Improvements G-81 Pump Station | | $6,826,464 | $6,826,464 |
| C-25 to C52E Connection | $ 2,696,600 | | $2,696,600 |
| Reservoir Construction | $ 45,793,270 | $25,287,004 | $71,080,274 |
| STA Construction | $ 14,221,400 | $7,560,467 | $21,781,867 |
| **Sub-Total - Construction Costs** | **$63,485,833** | **$39,984,024** | **$103,469,857** |
| Mobilization (5%) | $3,174,292 | $1,999,201 | $5,173,493 |
| Engineering Design (8%) | $5,078,867 | $3,198,722 | $8,277,589 |
| Construction Management (7%) | $4,444,008 | $2,798,882 | $7,242,890 |
| Contingency (30%) | $19,045,750 | $11,995,207 | $31,040,957 |
| **Sub-Total Design & Construction** | **$95,228,750** | **$59,976,036** | **$155,204,786** |
| Reservoir Land Purchase | $30,000,000 | | $30,000,000 |
| STA Land Purchase | $30,000,000 | | $30,000,000 |
| **TOTAL COST** | **$155,228,750** | **$59,976,036** | **$215,204,786** |

**Table 52. Summary of benefits and costs for implementation phases.**

| | Discharge Delivery @ 90% Reliability (cfs) | Reductions in Flow to IRL (acre-ft/yr) | Cost |
|---|---|---|---|
| Phase I | 90 | 78,900 | $155,000,000 |
| Phase II | 95 | 63,300 | $60,000,000 |
| Total | 185 | 142,200 | $215,000,000 |

## COST SHARING

The preferred alternative identified in this study (ICS-02(A)) is consistent with the location and purpose of the C-25 reservoir feature in the IRL-S Project. While land acquisition is complete and design is underway for the C-23 and C-24 IRL-S features, there has been no activity related to the C-25 Reservoir since completion of the IRL-S Project Implementation Report (PIR) in 2004.

The C-25 Reservoir recommended in the IRL-S Project is only 741 acres with a maximum storage depth of 8 ft and a 163 acre STA. Its purpose is to attenuate peak flows to the IRL and reduce nutrient loading. According to the PIR (USACE 2004), water captured and stored in the reservoir would be available to augment dry season water supply.

The IRL-S Project has been authorized by Congress for 50/50 cost sharing with the SFWMD. The USACE process provides flexibility in the development of projects, even after authorization. Modifications to the IRL-S Project C-25 Reservoir could be made during the Preconstruction Engineering and Design (PED) phase of the project. Although the SFWMD share of the project cost may increase (above 50%) with the larger reservoir and STA and the addition of other project features, Federal cost sharing might be available for implementation of the preferred alternative. USACE guidelines allow a project sponsor to pay the additional costs for "betterments" or "locally preferred options" that go beyond the authorized plan. The 50/50 cost sharing then applies to the portion of the project that comprises the authorized plan.

# Findings

- Large volumes of stormwater from the C-23, 24, and 25 Basins are currently being discharged to tide in the IRL. These discharges disrupt natural salinity regimes and degrade water quality. Excess flows in these basins represent a significant source of water that could be captured, stored, and made available for beneficial uses.

- The Indian River Farms Water Control District also provides a potential source of water that could be captured and stored for beneficial use. While there is less flow available (because of a smaller drainage area), the flows are more consistent and reliable. This would provide for very efficient utilization of the available water supply. However, the service area benefited by the additional water would be limited to the WCD.

- The top ranking alternative identified in this study was the C-23, 24, and 25 Central Storage Reservoir. It would consist of an Inter-District connection, a 5,000 acre reservoir, a 5,000 acre STA, two pump stations to move water in the canal system, and canal conveyance improvements. The planning level estimate of construction cost is $215 million. This plan would provide the following benefits:

    - 120 MGD discharge delivery rate maintained 90% of the time to meet water supply demands

    - Reductions in flows to IRL of 142,200 acre-ft/yr

- By creating an Inter-District connection between SFWMD and SJRWMD, improved water management flexibility would provide flood control and water supply benefits. Water supply deliveries could be conveyed to much larger service areas. Stormwater discharges from the C-25 Extension Basin currently flow northward to the Upper St. Johns River where they exacerbate flooding. An inter-District connection would allow these flows to be conveyed to C-25 for storage in the reservoir.

- Because the full benefits of the preferred alternative are dependent on the operation of the C-23/24 Reservoirs and STA components of the IRL-S Project, implementation could be phased. Initially, dispersed storage/water farming options could be considered for implementation prior to initiation of construction. Then, construction could be completed in two phases; Phase I to be implemented first and Phase II to be implemented when the IRL-S Project features are constructed.

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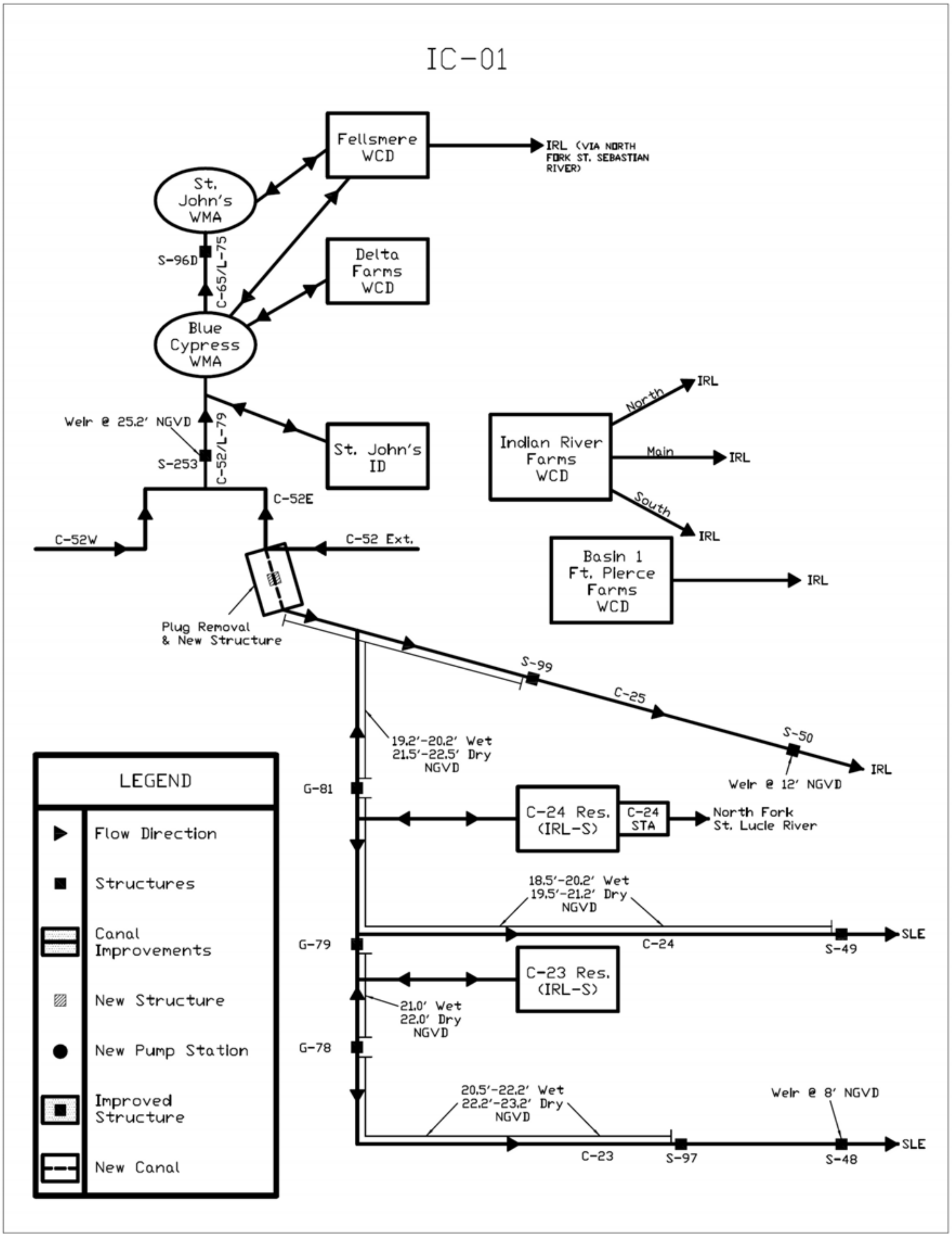
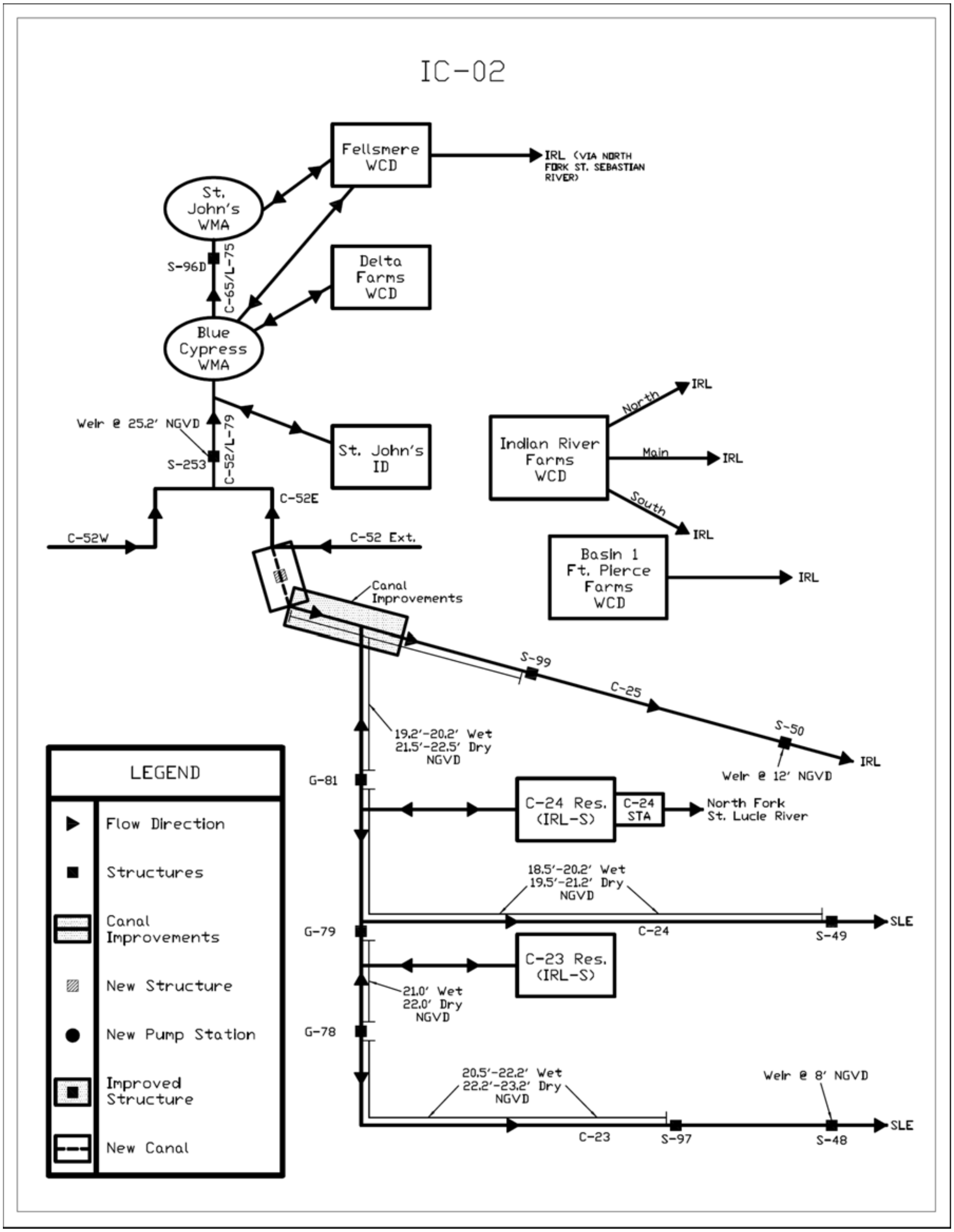
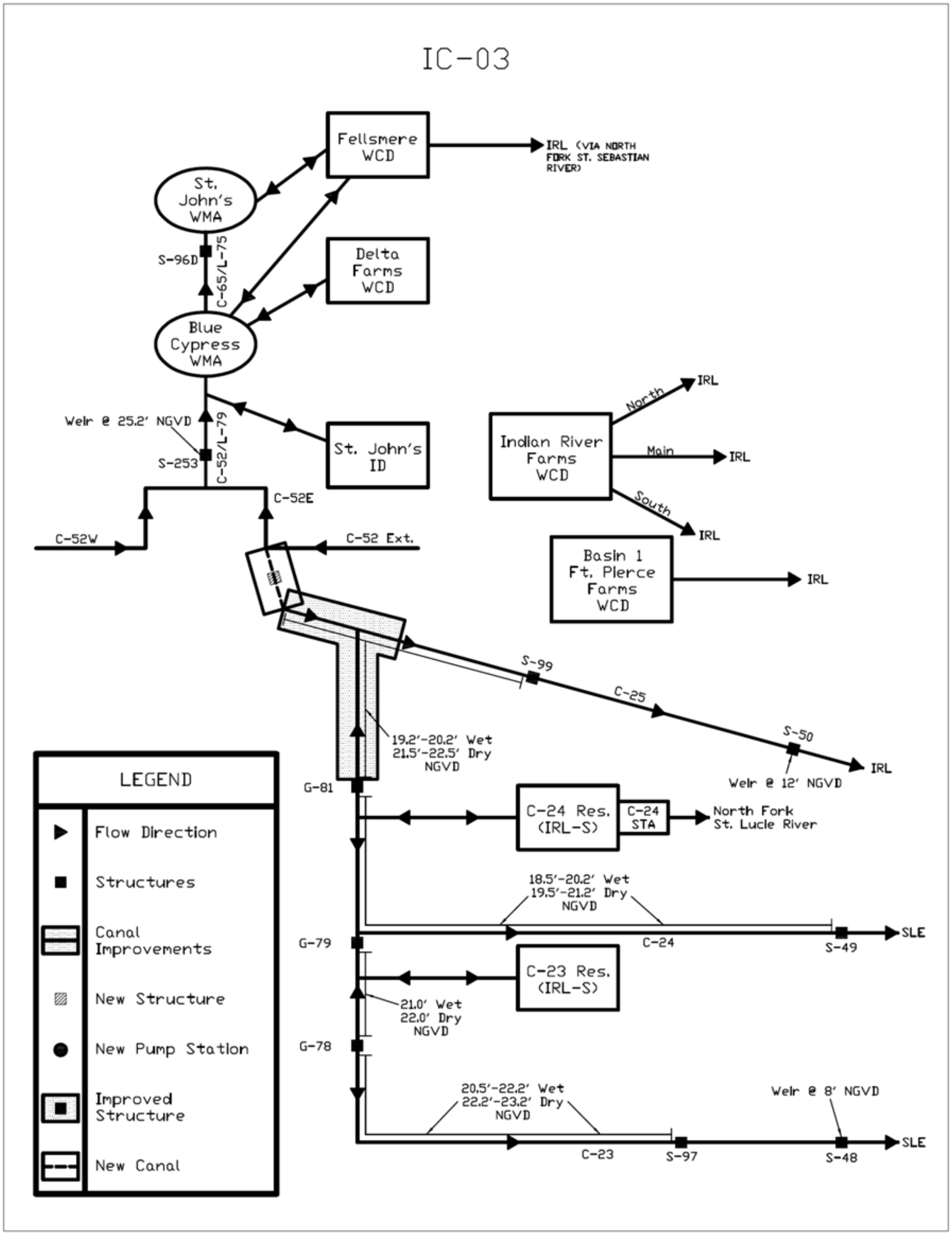
# Appendix A – Preliminary Alternative Plan schematics

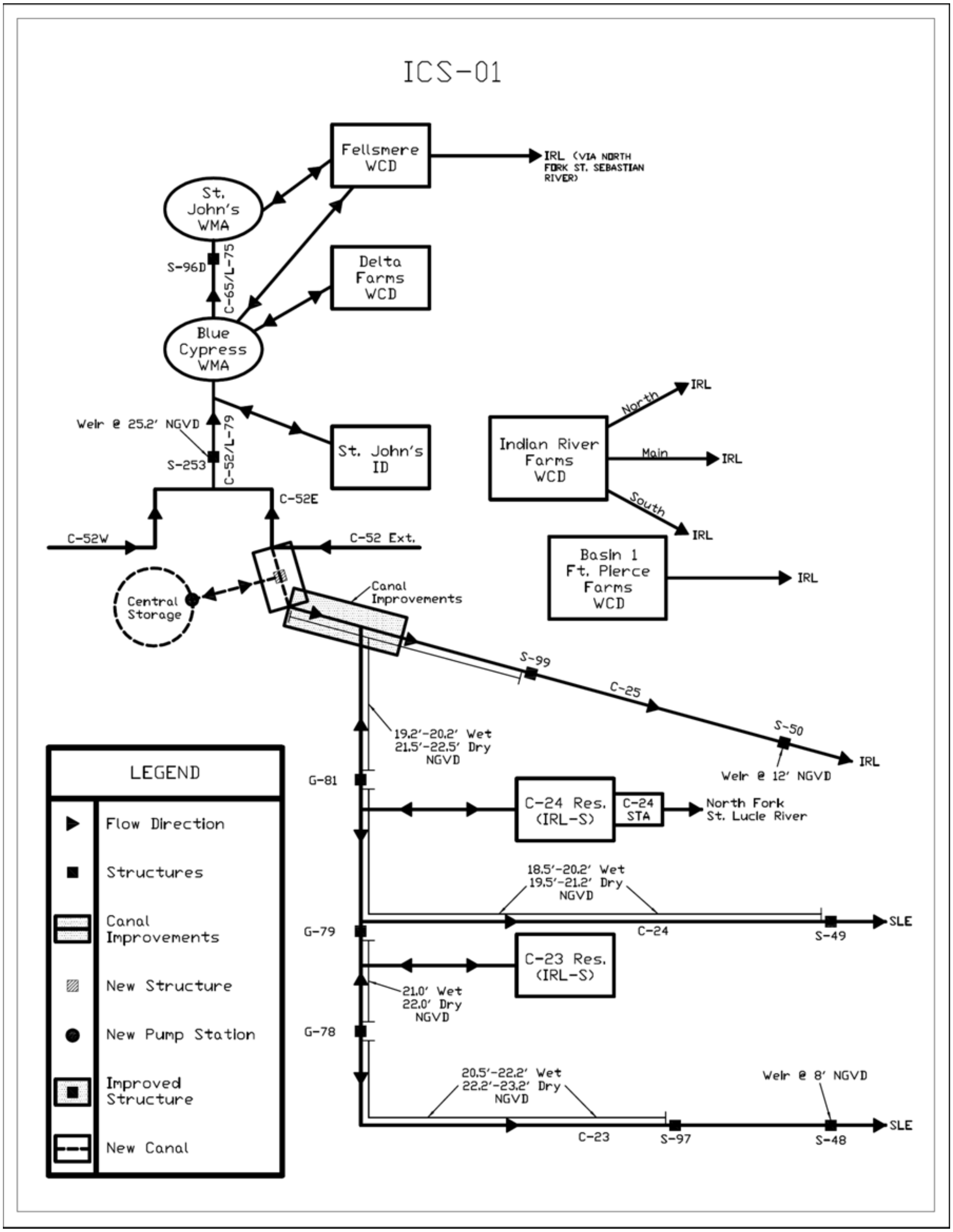

IC-01
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
Basin 1 Ft. Pierce Farms WCD
C-52E
C-52W
C-52 Ext.
Plug Removal & New Structure
S-99
C-25
S-50
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal

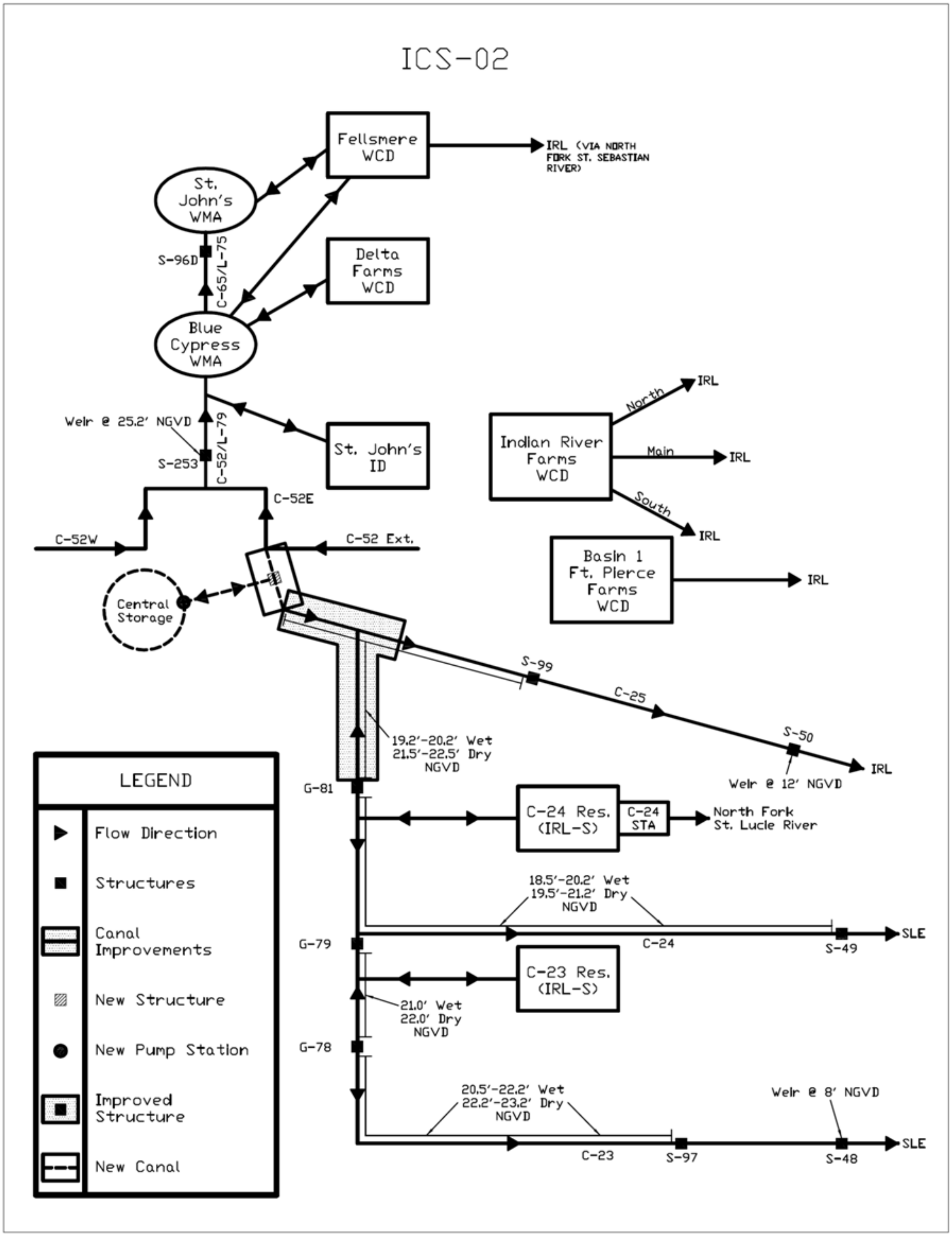


IC-02
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
IRL
Main
IRL
South
IRL
Basin 1 Ft. Pierce Farms WCD
IRL
C-52W
C-52E
C-52 Ext.
Canal Improvements
S-99
C-25
S-50
IRL
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal

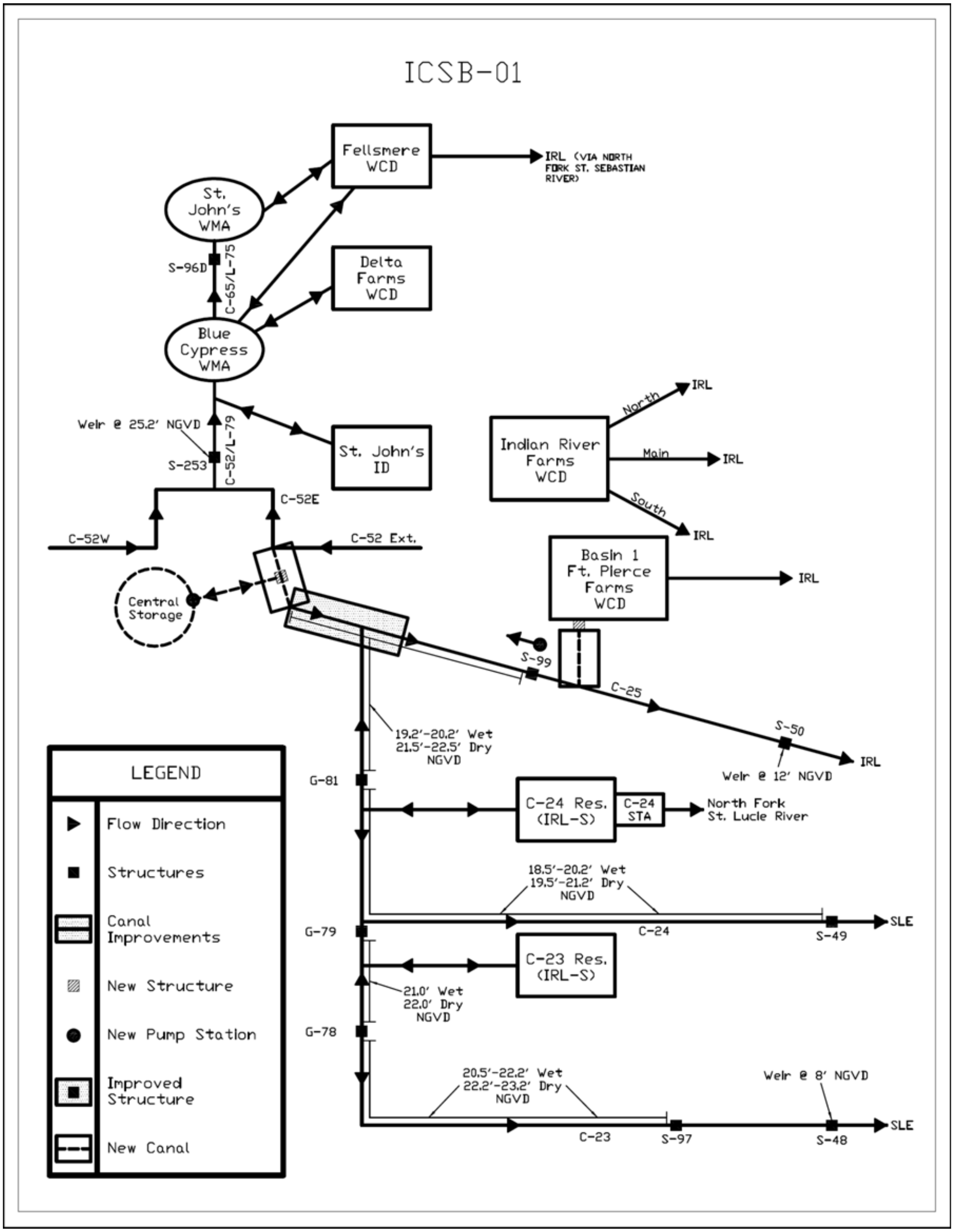


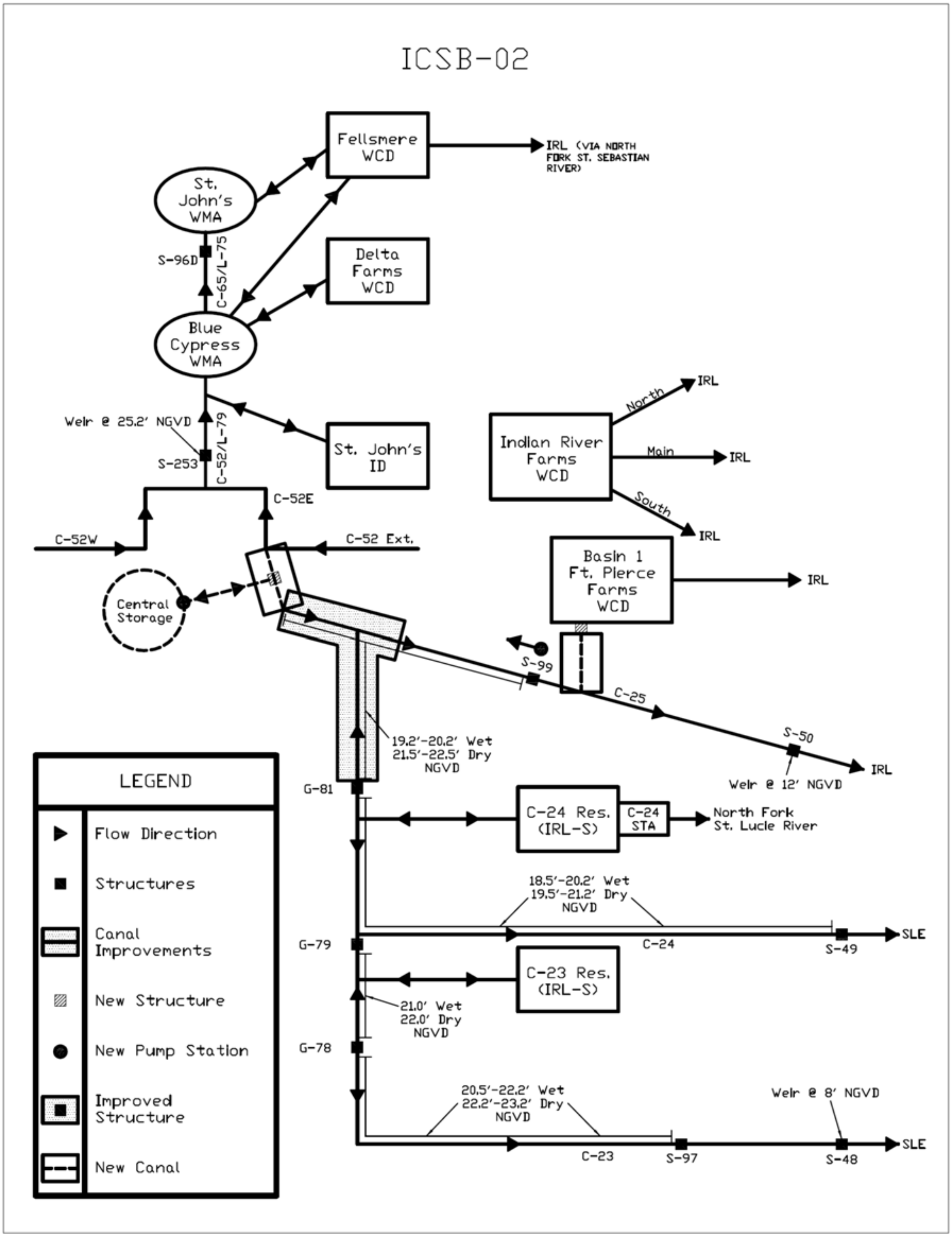
IC-03
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
IRL
IRL
C-52E
C-52W
C-52 Ext.
Basin 1 Ft. Pierce Farms WCD
IRL
S-99
C-25
S-50
IRL
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal

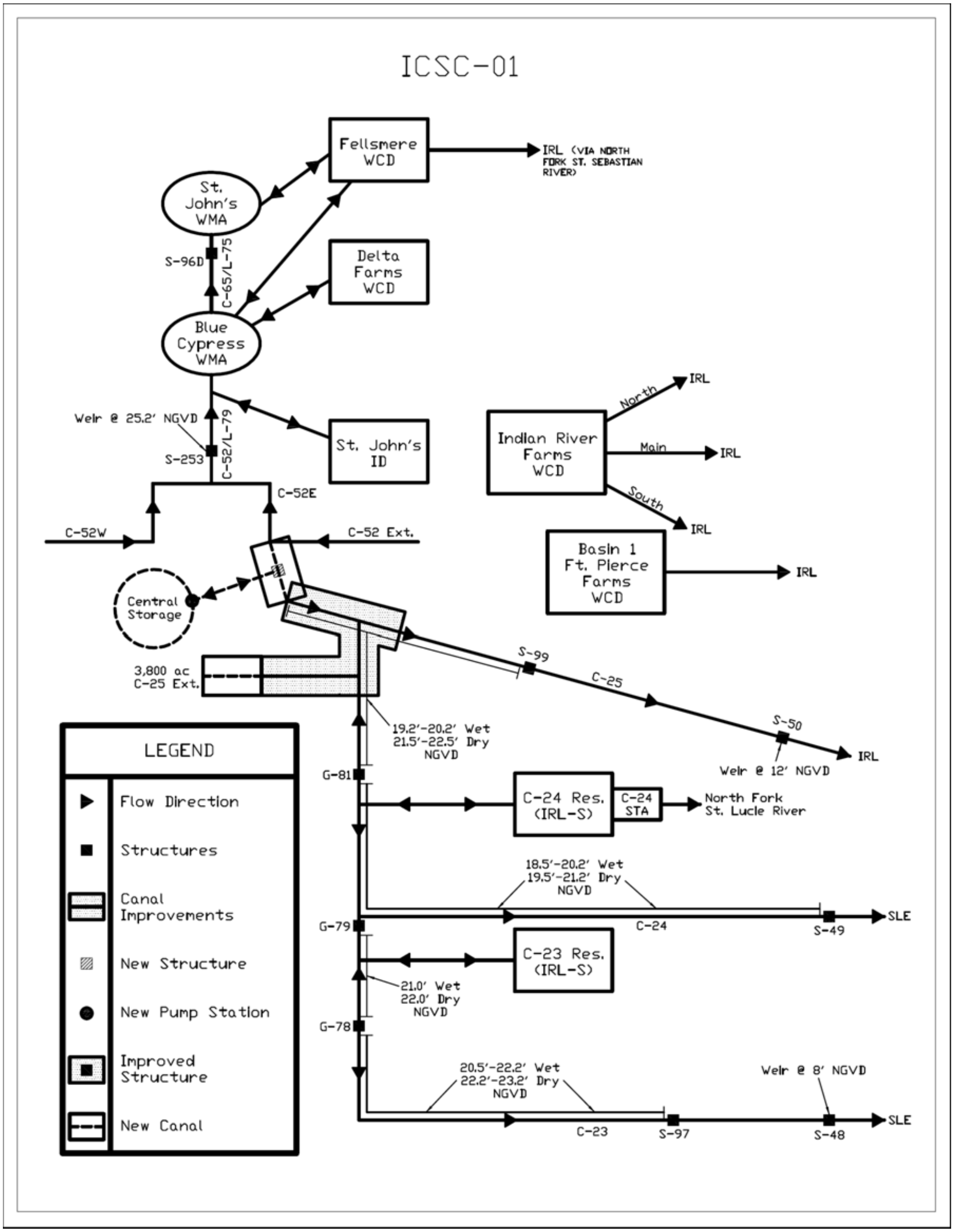

ICS-01
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
C-52E
C-52W
C-52 Ext.
Basin 1 Ft. Pierce Farms WCD
Central Storage
Canal Improvements
S-99
C-25
S-50
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
C-24
S-49
SLE
G-79
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal

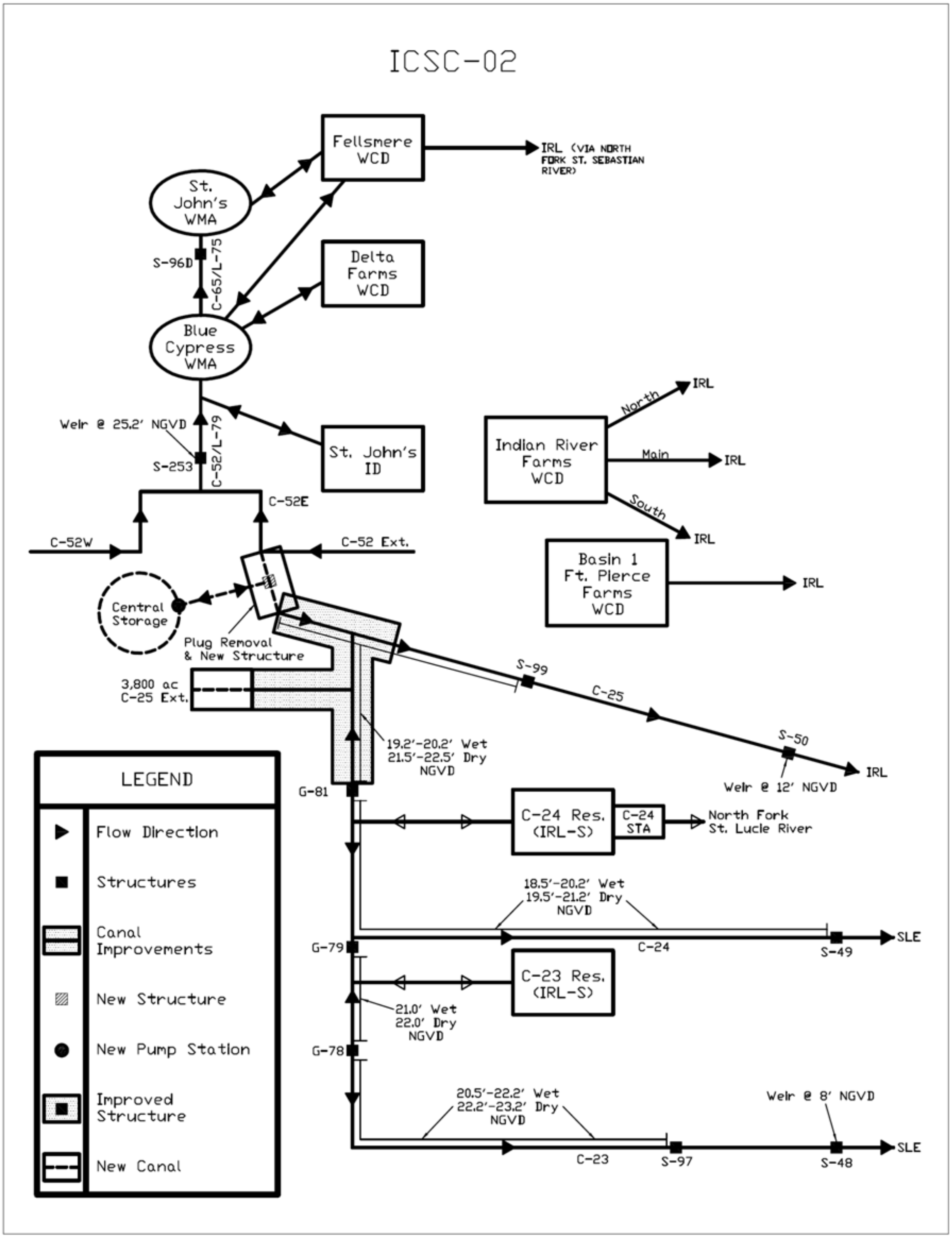


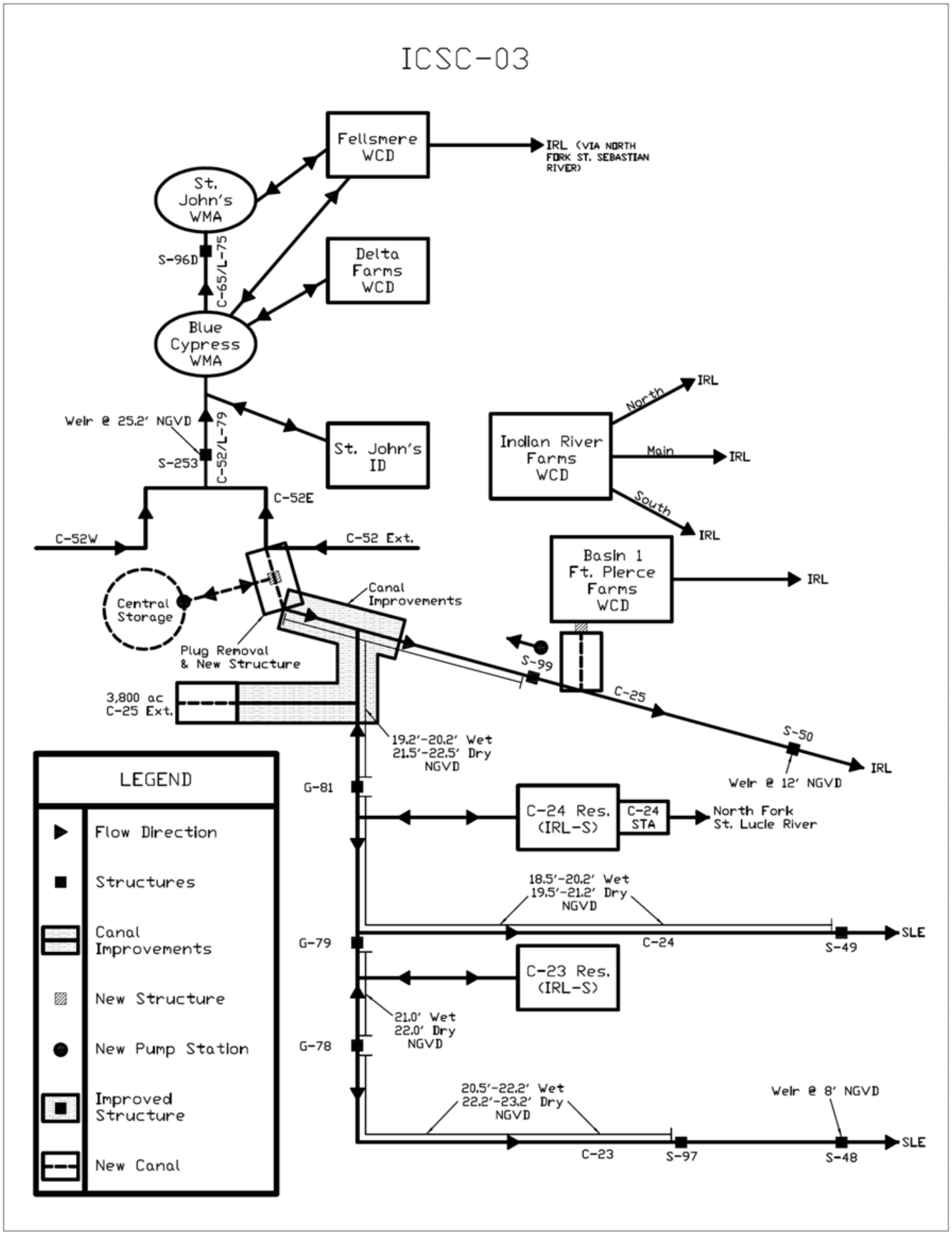
ICS-02
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
IRL
Main
IRL
South
IRL
Basin 1 Ft. Pierce Farms WCD
IRL
C-52E
C-52W
C-52 Ext.
Central Storage
S-99
C-25
S-50
IRL
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE

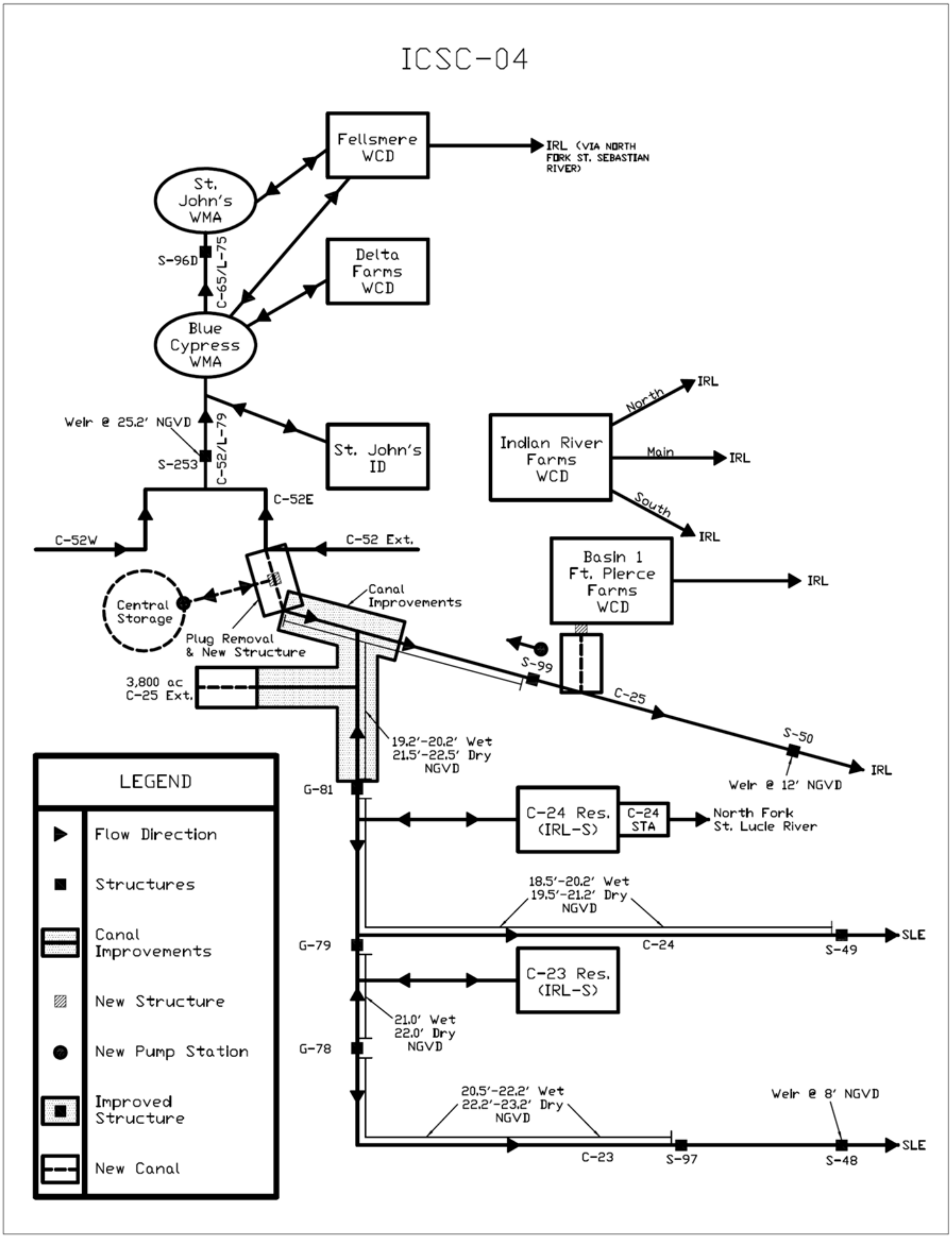

ICSB-01
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
IRL
Main
IRL
South
IRL
C-52E
C-52W
C-52 Ext.
Basin 1 Ft. Pierce Farms WCD
IRL
Central Storage
S-99
C-25
S-50
IRL
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal


ICSB-02
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
C-52E
C-52W
C-52 Ext.
Central Storage
Basin 1 Ft. Pierce Farms WCD
S-99
C-25
S-50
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48

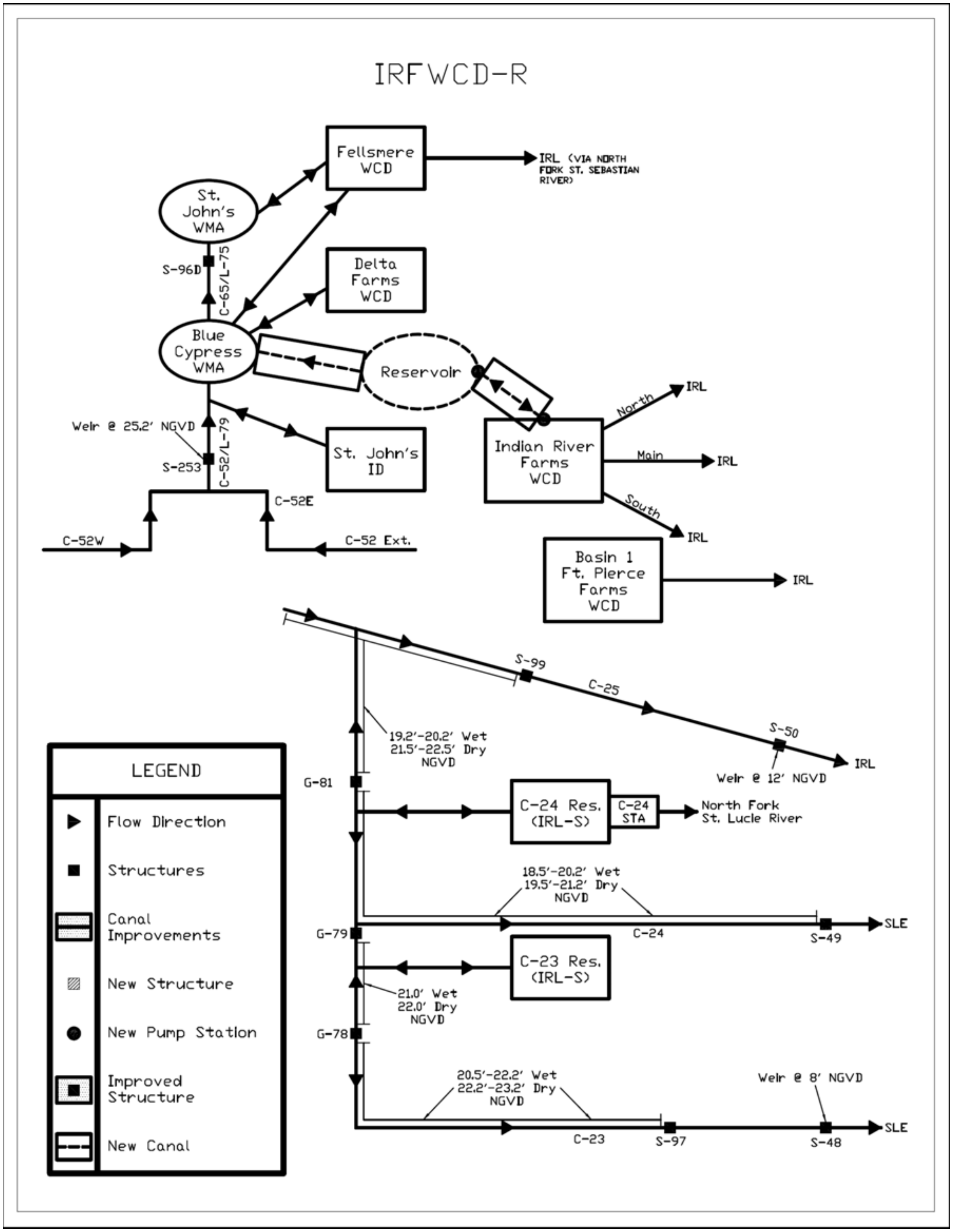

ICSC-01
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
IRL
IRL
Basin 1 Ft. Pierce Farms WCD
IRL
C-52E
C-52W
C-52 Ext.
Central Storage
3,800 ac C-25 Ext.
S-99
C-25
S-50
IRL
Weir @ 12' NGVD
19.2'-20.2' Wet 21.5'-22.5' Dry NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet 19.5'-21.2' Dry NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet 22.0' Dry NGVD
G-78
20.5'-22.2' Wet 22.2'-23.2' Dry NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal


ICSC-02
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
IRL
IRL
Basin 1 Ft. Pierce Farms WCD
IRL
C-52E
C-52W
C-52 Ext.
Central Storage
Plug Removal & New Structure
3,800 ac C-25 Ext.
S-99
C-25
S-50
IRL
Weir @ 12' NGVD
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal


ICSC-03
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
IRL
Main
IRL
South
IRL
C-52W
C-52E
C-52 Ext.
Basin 1 Ft. Pierce Farms WCD
IRL
Central Storage
Canal Improvements
Plug Removal & New Structure
S-99
3,800 ac C-25 Ext.
C-25
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
S-50
IRL
Weir @ 12' NGVD
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE



ICSC-04
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
Indian River Farms WCD
North
Main
South
IRL
C-52E
C-52W
C-52 Ext.
Basin 1 Ft. Pierce Farms WCD
Central Storage
Canal Improvements
Plug Removal & New Structure
S-99
3,800 ac C-25 Ext.
C-25
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
S-50
Weir @ 12' NGVD
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48


IRFWCD-R
Fellsmere WCD
IRL (VIA NORTH FORK ST. SEBASTIAN RIVER)
St. John's WMA
S-96D
C-65/L-75
Delta Farms WCD
Blue Cypress WMA
Reservoir
IRL
North
Indian River Farms WCD
Main
IRL
South
IRL
Weir @ 25.2' NGVD
S-253
C-52/L-79
St. John's ID
C-52E
C-52W
C-52 Ext.
Basin 1 Ft. Pierce Farms WCD
IRL
S-99
C-25
S-50
19.2'-20.2' Wet
21.5'-22.5' Dry
NGVD
Weir @ 12' NGVD
IRL
LEGEND
Flow Direction
Structures
Canal Improvements
New Structure
New Pump Station
Improved Structure
New Canal
G-81
C-24 Res. (IRL-S)
C-24 STA
North Fork St. Lucie River
18.5'-20.2' Wet
19.5'-21.2' Dry
NGVD
G-79
C-24
S-49
SLE
C-23 Res. (IRL-S)
21.0' Wet
22.0' Dry
NGVD
G-78
20.5'-22.2' Wet
22.2'-23.2' Dry
NGVD
Weir @ 8' NGVD
C-23
S-97
S-48
SLE

# Appendix B – WaSh Model Setup, Calibration and Validation

This report is provided as a separate document.

# Appendix C - RESOPT Results for the Final Alternatives

C-25 Central Storage Reservoir
ICS-01

**10,800 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 60 | 43,220 | 99 | 54,189 | 1 |
| 100 | 65,430 | 90 | 65563 | 14 |
| 110 | 67620 | 85 | 66458 | 17 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 101 |
| Ave Ann Vol (ac-ft) = | 65,554 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 65,614 |

**6000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 90 | 59,784 | 92 | 62,019 | 13 |
| 100 | 63,074 | 87 | 64,069 | 19 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 94 |
| Ave Ann Vol (ac-ft) = | 61,000 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 62,777 |

**3000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52414 | 90 | 55420 | 20 |
| 90 | 56484 | 87 | 59308 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 81 |
| Ave Ann Vol (ac-ft) = | 52,842 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 55,829 |

**6000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 100 | 62000 | 95 | 69539 | 6 |
| 110 | 72277 | 91 | 75984 | 15 |
| 40 | 75863 | 87 | 78670 | 19 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 96 |
| Ave Ann Vol (ac-ft) = | 73,015 |
| # yrs w/ < Del | 16 |
| Ave Withdrawal (acre -ft) = | 76,537 |

C-25 Central Storage Reservoir
ICS-01

**10,800 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 150 | 99365 | 91 | 107533 | 10 |
| 160 | 103,079 | 89 | 109,606 | 17 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 156 |
| Ave Ann Vol (ac-ft) = | 101,445 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 108,694 |

**2,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 60 | 40071 | 92 | 47882 | 19 |
| 70 | 44907 | 89 | 50313 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 66 |
| Ave Ann Vol (ac-ft) = | 43,026 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 49,368 |

**1,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 40 | 26164 | 90 | 41110 | 20 |
| 30 | 31235 | 86 | 43025 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 39 |
| Ave Ann Vol (ac-ft) = | 26,535 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 41,250 |

**500 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 20 | 13576 | 94 | 36712 | 18 |
| 30 | 18937 | 87 | 38370 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 26 |
| Ave Ann Vol (ac-ft) = | 16,581 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 37,641 |

C-25 Central Storage Reservoir
ICS-01

**6,000 acre reservoir and 400 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 120 | 79051 | 91 | 86081 | 15 |
| 130 | 82940 | 88 | 88280 | 20 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 123 |
| Ave Ann Vol (ac-ft) = | 80,301 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 86,788 |

**6,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 120 | 80061 | 92 | 91525 | 13 |
| 130 | 84575 | 90 | 94100 | 19 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 129 |
| Ave Ann Vol (ac-ft) = | 84,182 |
| # yrs w/ < Del | 18 |
| Ave Withdrawal (acre -ft) = | 93,876 |

**6,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 130 | 85386 | 91 | 98459 | 18 |
| 140 | 89435 | 88 | 100718 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 133 |
| Ave Ann Vol (ac-ft) = | 86,520 |
| # yrs w/ < Del | 19 |
| Ave Withdrawal (acre -ft) = | 99,092 |

**6,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 130 | 85908 | 91 | 102093 | 18 |
| 140 | 90099 | 89 | 104264 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 135 |
| Ave Ann Vol (ac-ft) = | 88,004 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 103,179 |

C-25 Central Storage Reservoir
ICS-01

**10,800 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 160 | 104,549 | 90 | 113,583 | 12 |
| 170 | 108180 | 88 | 115703 | 17 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 161 |
| Ave Ann Vol (ac-ft) = | 104,852 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 113,760 |

**10,800 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 120 | 79381 | 91 | 81887 | 13 |
| 130 | 82619 | 88 | 83767 | 16 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 124 |
| Ave Ann Vol (ac-ft) = | 80,550 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 82,566 |

**3,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 90 | 58657 | 90 | 87070 | 22 |
| 100 | 63244 | 87 | 89188 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 90 |
| Ave Ann Vol (ac-ft) = | 58,657 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 87,070 |

**3,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 53718 | 93 | 80833 | 17 |
| 90 | 58648 | 90 | 83429 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 90 |
| Ave Ann Vol (ac-ft) = | 58,472 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 83,336 |

C-25 Central Storage Reservoir
ICS-01

**2,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 60 | 40097 | 92 | 74723 | 19 |
| 70 | 45219 | 89 | 76873 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 67 |
| Ave Ann Vol (ac-ft) = | 43,853 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 76,300 |

**10,800 acre reservoir and 400 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 130 | 87399 | 93 | 91967 | 9 |
| 140 | 90891 | 90 | 94168 | 14 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 139 |
| Ave Ann Vol (ac-ft) = | 90,455 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 93,893 |

**3,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 53703 | 93 | 76321 | 17 |
| 90 | 58617 | 90 | 78992 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 90 |
| Ave Ann Vol (ac-ft) = | 58,442 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 78,897 |

**4,500 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 110 | 72724 | 91 | 86920 | 20 |
| 120 | 77001 | 89 | 89091 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 115 |
| Ave Ann Vol (ac-ft) = | 74,783 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 87,965 |

C-25 Central Storage Reservoir
ICS-01

**4,500 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 110 | 72921 | 92 | 91259 | 19 |
| 120 | 77454 | 89 | 93526 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 116 |
| Ave Ann Vol (ac-ft) = | 75,754 |
| # yrs w/ < Del | 22 |

**4,500 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 100 | 66287 | 92 | 71789 | 16 |
| 110 | 70521 | 89 | 74501 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 105 |
| Ave Ann Vol (ac-ft) = | 68,404 |
| # yrs w/ < Del | 19 |
| Ave Withdrawal (acre -ft) = | 73,145 |

**2,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 60 | 40097 | 92 | 56904 | 19 |
| 70 | 45188 | 89 | 59241 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 67 |
| Ave Ann Vol (ac-ft) = | 43,710 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 58,563 |

**2,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 60 | 40097 | 92 | 78424 | 19 |
| 70 | 45215 | 89 | 80691 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 67 |
| Ave Ann Vol (ac-ft) = | 43,850 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 80,086 |

**1,000 acre reservoir and 400 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 40 | 26170 | 90 | 58352 | 20 |
| 50 | 31278 | 86 | 60216 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 41 |
| Ave Ann Vol (ac-ft) = | 26,563 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 58,495 |

C-25 Central Storage Reservoir
ICS-01

**500 acre reservoir and 400 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 20 | 13575 | 94 | 54241 | 18 |
| 30 | 18943 | 87 | 56174 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 26 |
| Ave Ann Vol (ac-ft) = | 16,631 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 55,341 |

**1,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 40 | 26172 | 90 | 69138 | 20 |
| 50 | 31276 | 86 | 71044 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 41 |
| Ave Ann Vol (ac-ft) = | 26,555 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 69,281 |

**7,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 140 | 91928 | 91 | 105686 | 16 |
| 150 | 96070 | 88 | 108106 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 143 |
| Ave Ann Vol (ac-ft) = | 93,058 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 106,346 |

**7,000 acre reservoir and 900 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 140 | 92666 | 91 | 111028 | 15 |
| 150 | 96984 | 89 | 113396 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 146 |
| Ave Ann Vol (ac-ft) = | 95,414 |
| # yrs w/ < Del | 19 |
| Ave Withdrawal (acre -ft) = | 112,535 |

C-25 Central Storage Reservoir
ICS-01

**7,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 130 | 86003 | 91 | 95285 | 11 |
| 140 | 90065 | 89 | 97675 | 18 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 135 |
| Ave Ann Vol (ac-ft) = | 88,115 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 96,528 |

**10,800 acre reservoir and 800 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 160 | 105,377 | 91 | 116,709 | 10 |
| 170 | 109258 | 89 | 118889 | 17 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 164 |
| Ave Ann Vol (ac-ft) = | 106,965 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 117,601 |

**16,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 150 | 100,816 | 93 | 105,124 | 9 |
| 160 | 104224 | 90 | 107134 | 12 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 160 |
| Ave Ann Vol (ac-ft) = | 104,106 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 107,065 |

**16,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 160 | 106,995 | 92 | 112,550 | 10 |
| 170 | 110352 | 90 | 114464 | 13 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 169 |
| Ave Ann Vol (ac-ft) = | 109,855 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 114,180 |

C-25 Central Storage Reservoir
ICS-01

**16,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 170 | 112,416 | 91 | 118,747 | 10 |
| 180 | 115754 | 89 | 120457 | 14 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 175 |
| Ave Ann Vol (ac-ft) = | 114,152 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 119,636 |

**16,000 acre reservoir and 800 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 170 | 113,567 | 92 | 122,117 | 10 |
| 180 | 117200 | 90 | 123958 | 13 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 180 |
| Ave Ann Vol (ac-ft) = | 117,042 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 123,878 |

**16,000 acre reservoir and 900 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 180 | 118,149 | 91 | 126,503 | 11 |
| 190 | 121588 | 88 | 128472 | 14 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 183 |
| Ave Ann Vol (ac-ft) = | 119,046 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 127,017 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**16000 acre reservoir and 700 cfs pump (Max)**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 70 | | | | |
| 260 | 170962 | 90.8 | 176494 | 12 |
| 270 | 174598 | 89.3 | 179337 | 16 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 265 |
| Ave Ann Vol (ac-ft) = | 172,901 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 178,010 |

**16000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 230 | 152871 | 91.7 | 156484 | 12 |
| 240 | 155605 | 89.5 | 158137 | 16 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 238 |
| Ave Ann Vol (ac-ft) = | 154,984 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 157,761 |

**16000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 54318 | 93.7 | 54140 | 8 |
| 90 | 57533 | 88.2 | 54415 | 15 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 87 |
| Ave Ann Vol (ac-ft) = | 56,481 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 54,325 |

**1,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52491 | 90.6 | 109203 | 22 |
| 90 | 57903 | 88.8 | 111026 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 83 |
| Ave Ann Vol (ac-ft) = | 54,295 |
| # yrs w/ < Del | 23 |
| Ave Withdrawal (acre -ft) = | 109,811 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**1,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52491 | 90.6 | 95623 | 22 |
| 90 | 57899 | 88.8 | 97496 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 83 |
| Ave Ann Vol (ac-ft) = | 54,294 |
| # yrs w/ < Del | 23 |
| Ave Withdrawal (acre -ft) = | 96,247 |

**1,000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 70 | 46546 | 91.8 | 47756 | 20 |
| 80 | 51148 | 88.3 | 51575 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 75 |
| Ave Ann Vol (ac-ft) = | 48,913 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 49,720 |

**10,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 240 | 157172 | 90.4 | 166090 | 18 |
| 250 | 161266 | 89.0 | 168729 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 243 |
| Ave Ann Vol (ac-ft) = | 158,342 |
| # yrs w/ < Del | 19 |

**10,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 220 | 144873 | 90.9 | 150588 | 14 |
| 230 | 148520 | 89.1 | 153045 | 18 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 225 |
| Ave Ann Vol (ac-ft) = | 146,697 |
| # yrs w/ < Del | 16 |
| Ave Withdrawal (acre -ft) = | 151,817 |

**10,000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 53881 | 93.0 | 53932 | 10 |
| 90 | 56924 | 87.3 | 54406 | 18 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 85 |
| Ave Ann Vol (ac-ft) = | 55,483 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 54,181 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**5,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 180 | 118201 | 90.6 | 140935 | 20 |
| 190 | 122921 | 89.3 | 143751 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 185 |
| Ave Ann Vol (ac-ft) = | 120,379 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 142,235 |

**5,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 180 | 117635 | 90.2 | 128904 | 21 |
| 190 | 122250 | 88.8 | 131703 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 181 |
| Ave Ann Vol (ac-ft) = | 118,294 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 129,304 |

**5,000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 53482 | 92.3 | 53589 | 11 |
| 90 | 55578 | 85.2 | 54367 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 83 |
| Ave Ann Vol (ac-ft) = | 54,161 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 53,841 |

**8,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 220 | 144905 | 90.9 | 157826 | 21 |
| 230 | 149188 | 89.5 | 160463 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 226 |
| Ave Ann Vol (ac-ft) = | 147,658 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 159,521 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**8,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 210 | 138288 | 90.9 | 144874 | 18 |
| 220 | 142414 | 89.4 | 148412 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 216 |
| Ave Ann Vol (ac-ft) = | 140,764 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 146,997 |

**8,000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 53722 | 92.7 | 53840 | 10 |
| 90 | 56527 | 86.7 | 54406 | 21 |
| 100 | | | | |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 85 |
| Ave Ann Vol (ac-ft) = | 54,984 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 54,095 |

**3,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 140 | 91318 | 90.0 | 125914 | 21 |
| 150 | 96324 | 88.6 | 128131 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 140 |
| Ave Ann Vol (ac-ft) = | 91,318 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 125,914 |

**3,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 140 | 91318 | 90.0 | 113139 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 140 |
| Ave Ann Vol (ac-ft) = | 91,318 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 113,139 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**3,000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52813 | 91.1 | 53146 | 15 |
| 90 | 54886 | 84.2 | 54270 | 26 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 82 |
| Ave Ann Vol (ac-ft) = | 53,143 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 53,325 |

**2000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 110 | 72309 | 90.7 | 117366 | 21 |
| 120 | 77419 | 89.1 | 119353 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 114 |
| Ave Ann Vol (ac-ft) = | 74,545 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 118,235 |

**2000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 110 | 72309 | 90.7 | 104006 | 21 |
| 120 | 77425 | 89.1 | 106101 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 114 |
| Ave Ann Vol (ac-ft) = | 74,547 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 104,923 |

**2000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52186 | 90.0 | 52571 | 18 |
| 90 | 54538 | 83.6 | 54188 | 26 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 80 |
| Ave Ann Vol (ac-ft) = | 52,186 |
| # yrs w/ < Del | 18 |
| Ave Withdrawal (acre -ft) = | 52,571 |

**5,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 160 | 105695 | 91.2 | 109661 | 20 |
| 170 | 109792 | 89.1 | 112389 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 166 |
| Ave Ann Vol (ac-ft) = | 108,036 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 111,220 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**8,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 170 | 113033 | 91.8 | 115633 | 16 |
| 180 | 116468 | 89.3 | 117918 | 17 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 177 |
| Ave Ann Vol (ac-ft) = | 115,506 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 117,278 |

**10,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 180 | 117383 | 90.0 | 118637 | 16 |
| 190 | 119979 | 87.2 | 119998 | 20 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 180 |
| Ave Ann Vol (ac-ft) = | 117,383 |
| # yrs w/ < Del | 16 |
| Ave Withdrawal (acre -ft) = | 118,637 |

**24100 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 240 | 158867 | 91.4 | 160251 | 11 |
| 250 | 161665 | 89.3 | 161489 | 13 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 247 |
| Ave Ann Vol (ac-ft) = | 160,732 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 161,076 |

**24100 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 260 | 175289 | 93.1 | 181152 | 9 |
| 270 | 178047 | 91.0 | 182685 | 11 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 275 |
| Ave Ann Vol (ac-ft) = | 179,360 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 183,415 |

**24100 acre reservoir and 900 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 290 | 190421 | 90.6 | 196002 | 10 |
| 300 | 193229 | 88.9 | 197393 | 14 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 294 |
| Ave Ann Vol (ac-ft) = | 191,412 |
| # yrs w/ < Del | 11 |
| Ave Withdrawal (acre -ft) = | 196,493 |

C-23, 24, and 25 Central Storage Reservoir
ICS-02

**24100 acre reservoir and 1000 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 300 | 195551 | 90.0 | 201455 | 12 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 300 |
| Ave Ann Vol (ac-ft) = | 195,551 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 201,455 |

**16000 acre reservoir and 900 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 270 | 178151 | 91.1 | 187593 | 11 |
| 280 | 181932 | 89.7 | 189863 | 15 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 278 |
| Ave Ann Vol (ac-ft) = | 181,122 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 189,377 |

**10000 acre reservoir and 900 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 240 | 158391 | 91.1 | 173760 | 18 |
| 250 | 162850 | 89.9 | 176393 | 20 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 249 |
| Ave Ann Vol (ac-ft) = | 162,478 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 176,174 |

C-25/Basin 1 Central Storage Reservoir
ICS-03

**15,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 110 | 74129 | 93 | 74274 | 10 |
| 120 | 76769 | 88 | 74996 | 16 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 116 |
| Ave Ann Vol (ac-ft) = | 75,814 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 74,735 |

**6,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 100 | 67,709 | 94 | 69,989 | 12 |
| 110 | 71,063 | 89 | 72,187 | 18 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 108 |
| Ave Ann Vol (ac-ft) = | 70,439 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 71,778 |

**3,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 90 | 60237 | 92 | 64325 | 19 |
| 100 | 64560 | 89 | 67373 | 23 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 97 |
| Ave Ann Vol (ac-ft) = | 63,381 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 66,542 |

**2,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52,936 | 91 | 67,223 | 23 |
| 90 | 57,786 | 89 | 69,430 | 23 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 85 |
| Ave Ann Vol (ac-ft) = | 55,271 |
| # yrs w/ < Del | 23 |
| Ave Withdrawal (acre -ft) = | 68,286 |

C-25/Basin 1 Central Storage Reservoir
ICS-03

**For 2,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 80 | 52,693 | 91 | 57,067 | 23 |
| 90 | 57,242 | 88 | 60,862 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 83 |
| Ave Ann Vol (ac-ft) = | 54,014 |
| # yrs w/ < Del | 23 |
| Ave Withdrawal (acre -ft) = | 58,169 |

**15,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 190 | 124934 | 91 | 130528 | 12 |
| 200 | 128229 | 89 | 132526 | 15 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 193 |
| Ave Ann Vol (ac-ft) = | 126,080 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 131,223 |

**1000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 33656 | 93 | 47455 | 20 |
| 60 | 38808 | 89 | 49354 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 58 |
| Ave Ann Vol (ac-ft) = | 37,806 |
| # yrs w/ < Del | 23 |
| Ave Withdrawal (acre -ft) = | 48,985 |

**500 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 40 | 26385 | 91 | 44546 | 24 |
| 50 | 31496 | 87 | 45989 | 28 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 43 |
| Ave Ann Vol (ac-ft) = | 27,756 |
| # yrs w/ < Del | 25 |
| Ave Withdrawal (acre -ft) = | 44,933 |

**6,000 acre reservoir and 400 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 140 | 92,307 | 91 | 98,497 | 17 |
| 150 | 96,244 | 89 | 100,947 | 21 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 144 |
| Ave Ann Vol (ac-ft) = | 93,947 |
| # yrs w/ < Del | 19 |
| Ave Withdrawal (acre -ft) = | 99,518 |

C-25/Basin 1 Central Storage Reservoir
ICS-03

**6,000 acre reservoir and 600 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 150 | 98,915 | 91 | 113,112 | 20 |
| 160 | 103,071 | 89 | 115,522 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 155 |
| Ave Ann Vol (ac-ft) = | 100,894 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 114,260 |

**6,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 150 | 99,401 | 92 | 117,920 | 19 |
| 160 | 103,706 | 90 | 120,065 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 158 |
| Ave Ann Vol (ac-ft) = | 102,630 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 119,529 |

**15,000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 200 | 130803 | 90 | 138111 | 12 |
| 210 | 134183 | 88 | 139894 | 16 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 201 |
| Ave Ann Vol (ac-ft) = | 131,286 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 138,366 |

**3,000 acre reservoir and 400 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 100 | 66475 | 92 | 82618 | 20 |
| 110 | 71207 | 89 | 85076 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 108 |
| Ave Ann Vol (ac-ft) = | 70,024 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 84,462 |

C-25/Basin 1 Central Storage Reservoir
ICS-03

**3,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 100 | 66524 | 92 | 89531 | 20 |
| 110 | 71335 | 90 | 91967 | 22 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 108 |
| Ave Ann Vol (ac-ft) = | 70,289 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 91,437 |

**10000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 160 | 106887 | 92 | 114240 | 9 |
| 170 | 110771 | 90 | 116468 | 15 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 170 |
| Ave Ann Vol (ac-ft) = | 110,602 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 116,371 |

**10000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 180 | 118611 | 91 | 130196 | 13 |
| 190 | 122507 | 89 | 132560 | 18 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 185 |
| Ave Ann Vol (ac-ft) = | 120,559 |
| # yrs w/ < Del | 16 |
| Ave Withdrawal (acre -ft) = | 131,378 |

**1000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 33675 | 93 | 75288 | 20 |
| 60 | 38846 | 89 | 77022 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 58 |
| Ave Ann Vol (ac-ft) = | 37,984 |
| # yrs w/ < Del | 23 |
| Ave Withdrawal (acre -ft) = | 76,733 |

C-25/Basin 1 Central Storage Reservoir
ICS-03

**4500 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 130 | 85751 | 91 | 100084 | 20 |
| 140 | 90024 | 89 | 102476 | 24 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 135 |
| Ave Ann Vol (ac-ft) = | 87,795 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 101,228 |

**4500 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 130 | 86,173 | 92 | 110,262 | 20 |
| 140 | 90,627 | 89 | 112,715 | 23 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 137 |
| Ave Ann Vol (ac-ft) = | 89,354 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 112,014 |

**19800 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Annual Discharge Vol (acre-ft) | Reliability (%) | Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 210 | 137,353 | 90 | 142,331 | 12 |
| 220 | 140,530 | 88 | 144,186 | 15 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 211 |
| Ave Ann Vol (ac-ft) = | 137,807 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 142,596 |

**19800 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Annual Discharge Vol (acre-ft) | Reliability (%) | Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 190 | 124,005 | 90 | 126,402 | 13 |
| 200 | 126,758 | 88 | 127,654 | 16 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 190 |
| Ave Ann Vol (ac-ft) = | 124,111 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 126,450 |

**19800 acre reservoir and 800 cfs pump**

| Delivery Discharge Rate (cfs) | Annual Discharge Vol (acre-ft) | Reliability (%) | Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 210 | 139,791 | 92 | 147,399 | 10 |
| 220 | 143,138 | 90 | 149,078 | 12 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 219 |
| Ave Ann Vol (ac-ft) = | 142,819 |
| # yrs w/ < Del | 12 |
| Ave Withdrawal (acre -ft) = | 148,918 |

Indian River Farms Water Control District Reservoir
IRFWCD-R

**5,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 30 | 21734 | 100.0 | 32548 | 0 |
| 50 | 35569 | 98.2 | 40608 | 2 |
| 60 | 40434 | 93.0 | 43357 | 11 |
| 70 | 42875 | 84.5 | 44621 | 23 |
| 100 | 44657 | 61.6 | 45332 | 38 |
| 300 | 45513 | 20.9 | 45332 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 64 |
| Ave Ann Vol (ac-ft) = | 41,304 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 43,808 |

**5,000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 30 | 21734 | 100.0 | 30452 | 0 |
| 50 | 34280 | 94.6 | 37425 | 8 |
| 60 | 37107 | 85.4 | 38924 | 22 |
| 70 | 38294 | 75.5 | 39531 | 32 |
| 100 | 39374 | 54.4 | 39632 | 40 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 55 |
| Ave Ann Vol (ac-ft) = | 35,695 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 38,175 |

**For 4,000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 35470 | 97.9 | 40197 | 2 |
| 60 | 40216 | 92.5 | 42941 | 11 |
| 70 | 42801 | 84.4 | 44353 | 25 |
| 100 | 44720 | 61.7 | 45332 | 38 |
| 200 | 45455 | 31.4 | 45332 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 63 |
| Ave Ann Vol (ac-ft) = | 41,019 |
| # yrs w/ < Del | 15 |
| Ave Withdrawal (acre -ft) = | 43,379 |

**For 4,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 35780 | 98.8 | 41667 | 2 |
| 60 | 41212 | 94.8 | 44932 | 9 |
| 70 | 44982 | 88.7 | 47046 | 18 |
| 100 | 47724 | 65.9 | 48675 | 38 |
| 200 | 48851 | 33.7 | 48748 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 68 |
| Ave Ann Vol (ac-ft) = | 44,180 |
| # yrs w/ < Del | 16 |
| Ave Withdrawal (acre -ft) = | 46,596 |

Indian River Farms Water Control District Reservoir
IRFWCD-R

**For 2,000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 35028 | 96.7 | 40547 | 8 |
| 60 | 40231 | 92.6 | 43682 | 16 |
| 70 | 43112 | 85.0 | 45489 | 32 |
| 100 | 47211 | 65.2 | 48007 | 40 |
| 200 | 48793 | 33.7 | 48748 | 41 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 63 |
| Ave Ann Vol (ac-ft) = | 41,207 |
| # yrs w/ < Del | 21 |
| Ave Withdrawal (acre -ft) = | 44,295 |

**2,000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 20 | 14489 | 100.0 | 20384 | 0 |
| 30 | 21503 | 98.9 | 24517 | 2 |
| 40 | 26048 | 89.9 | 27354 | 17 |
| 50 | 27677 | 76.4 | 28368 | 34 |
| 60 | 28417 | 65.4 | 28808 | 37 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 40 |
| Ave Ann Vol (ac-ft) = | 25,993 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 27,320 |

**5000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 30 | 21734 | 100.0 | 33750 | 0 |
| 50 | 35969 | 99.3 | 42369 | 2 |
| 60 | 41540 | 95.6 | 45566 | 7 |
| 70 | 45547 | 89.8 | 47900 | 13 |
| 100 | 48242 | 66.6 | 49345 | 38 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 75 |
| Ave Ann Vol (ac-ft) = | 49,847 |
| # yrs w/ < Del | 14 |
| Ave Withdrawal (acre -ft) = | 50,332 |

**1000 acre reservoir and 200 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 20 | 14489 | 100.0 | 24691 | 0 |
| 30 | 21615 | 99.5 | 28783 | 5 |
| 50 | 32437 | 89.5 | 35071 | 29 |
| 60 | 35105 | 80.8 | 36630 | 36 |
| 70 | 36925 | 72.8 | 37802 | 38 |

| Values @ 90% Reliability | |
|---|---|
| Delivery (cfs) = | 49 |
| Ave Ann Vol (ac-ft) = | 31,944 |
| # yrs w/ < Del | 28 |
| Ave Withdrawal (acre -ft) = | 34,785 |

Indian River Farms Water Control District Reservoir
IRFWCD-R

**1000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 30 | 21689 | 99.8 | 32765 | 1 |
| 50 | 33417 | 92.3 | 39583 | 27 |
| 60 | 37084 | 85.3 | 41525 | 34 |
| 70 | 39845 | 78.6 | 43098 | 37 |
| 100 | 45097 | 62.3 | 46349 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 53 |
| Ave Ann Vol (ac-ft) = | 34,608 |
| # yrs w/ < Del | 29 |
| Ave Withdrawal (acre -ft) = | 40,214 |

**For 500 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 20 | 14405 | 99.4 | 19747 | 4 |
| 30 | 20574 | 94.7 | 23169 | 17 |
| 50 | 26934 | 74.4 | 27479 | 38 |
| 60 | 28045 | 64.5 | 28264 | 40 |
| 70 | 28581 | 56.4 | 28678 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 35 |
| Ave Ann Vol (ac-ft) = | 22,035 |
| # yrs w/ < Del | 22 |
| Ave Withdrawal (acre -ft) = | 24,159 |

**500 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 30 | 21086 | 97.0 | 32607 | 9 |
| 40 | 26586 | 91.7 | 35633 | 27 |
| 50 | 30623 | 84.5 | 37723 | 34 |
| 60 | 33877 | 77.9 | 39406 | 38 |
| 70 | 36675 | 72.3 | 40955 | 40 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 42 |
| Ave Ann Vol (ac-ft) = | 27,565 |
| # yrs w/ < Del | 29 |
| Ave Withdrawal (acre -ft) = | 36,139 |

**100 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 10 | 7181 | 99.1 | 26615 | 5 |
| 20 | 13556 | 93.6 | 29134 | 31 |
| 30 | 18606 | 85.6 | 31260 | 37 |
| 50 | 25792 | 71.2 | 34682 | 41 |
| 60 | 28507 | 65.6 | 35937 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 24 |
| Ave Ann Vol (ac-ft) = | 15,818 |
| # yrs w/ < Del | 34 |
| Ave Withdrawal (acre -ft) = | 30,086 |

Indian River Farms Water Control District Reservoir
IRFWCD-R

**3000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 35565 | 98.2 | 41276 | 4 |
| 60 | 40982 | 94.3 | 44639 | 9 |
| 70 | 44528 | 87.8 | 46819 | 24 |
| 100 | 48102 | 66.4 | 48972 | 38 |
| 200 | 49461 | 34.1 | 49378 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 67 |
| Ave Ann Vol (ac-ft) = | 43,327 |
| # yrs w/ < Del | 19 |
| Ave Withdrawal (acre -ft) = | 46,080 |

**3000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 30 | 21607 | 99.4 | 25181 | 2 |
| 40 | 26089 | 90.0 | 27680 | 16 |
| 50 | 27715 | 76.5 | 28564 | 32 |
| 60 | 28344 | 65.2 | 28808 | 37 |
| 70 | 28636 | 56.5 | 28808 | 40 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 40 |
| Ave Ann Vol (ac-ft) = | 26,093 |
| # yrs w/ < Del | 16 |
| Ave Withdrawal (acre -ft) = | 27,682 |

**5000 acre reservoir and 1000 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 60 | 41566 | 95.6 | 45666 | 7 |
| 70 | 45618 | 90.0 | 48025 | 13 |
| 100 | 48363 | 66.8 | 49540 | 38 |
| 200 | 49722 | 34.3 | 49581 | 41 |
| 300 | 49751 | 22.9 | 49581 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 70 |
| Ave Ann Vol (ac-ft) = | 45,613 |
| # yrs w/ < Del | 13 |
| Ave Withdrawal (acre -ft) = | 48,022 |

**4000 acre reservoir and 700 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 35782 | 98.8 | 41869 | 2 |
| 60 | 41313 | 95.0 | 45211 | 9 |
| 70 | 45198 | 89.1 | 47442 | 18 |
| 100 | 48174 | 66.5 | 49201 | 38 |
| 200 | 49490 | 34.2 | 49378 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 69 |
| Ave Ann Vol (ac-ft) = | 44,626 |
| # yrs w/ < Del | 17 |
| Ave Withdrawal (acre -ft) = | 47,113 |

Indian River Farms Water Control District Reservoir
IRFWCD-R

**3000 acre reservoir and 500 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 35548 | 98.1 | 41102 | 4 |
| 60 | 40884 | 94.1 | 44363 | 10 |
| 70 | 44332 | 87.4 | 46443 | 24 |
| 100 | 47657 | 65.8 | 48469 | 38 |
| 200 | 48822 | 33.7 | 48748 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 66 |
| Ave Ann Vol (ac-ft) = | 42,991 |
| # yrs w/ < Del | 19 |
| Ave Withdrawal (acre -ft) = | 45,634 |

**1000 acre reservoir and 100 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 20 | 14489 | 100.0 | 19970 | 0 |
| 30 | 21215 | 97.6 | 23867 | 6 |
| 40 | 25692 | 88.7 | 26681 | 22 |
| 50 | 27476 | 75.9 | 28011 | 37 |
| 60 | 28307 | 65.1 | 28573 | 38 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 39 |
| Ave Ann Vol (ac-ft) = | 25,023 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 26,261 |

**2000 acre reservoir and 300 cfs pump**

| Delivery Discharge Rate (cfs) | Average Annual Discharge Vol (acre-ft) | Reliability (%) | Average Annual Withdrawal (acre-ft) | # yrs w/ < delivery |
|---|---|---|---|---|
| 50 | 34868 | 96.3 | 39124 | 8 |
| 60 | 39427 | 90.7 | 41859 | 19 |
| 70 | 41619 | 82.1 | 43240 | 35 |
| 100 | 44672 | 61.7 | 45123 | 40 |
| 200 | 45397 | 31.3 | 45332 | 41 |

**Values @ 90% Reliability**

| | |
|---|---|
| Delivery (cfs) = | 61 |
| Ave Ann Vol (ac-ft) = | 39,605 |
| # yrs w/ < Del | 20 |
| Ave Withdrawal (acre -ft) = | 41,972 |