APPENDIX E
COST ENGINEERING AND RISK ANALYSIS

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ACRONYMS AND ABBREVIATIONS

C&SF	Central and Southern Florida
O&M	operations and maintenance
ROM	rough order of magnitude
SFWMD	South Florida Water Management District
Section 203 Study	Central and Southern Florida Flood Resiliency (Section 203) Study for Broward Basins
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers

E COST ESTIMATES

E.1 Cost Estimating Standards

U.S. Army Corps of Engineers (USACE) cost estimates for planning purposes are prepared in accordance with the following guidance:

- ER 1110-1-1300, Cost Engineering Policy and General Requirements (March 26, 1993);
- ER 1110-2-1302, Civil Works Cost Engineering (June 30, 2016);
- ER 1110-2-1150, Engineering and Design for Civil Works Projects (August 31, 1999);
- ER 1105-2-100, Planning Guidance Notebook (April 22, 2000, as amended);
- EM 1110-2-1304 (Tables revised September 30, 2018), *Civil Works Construction Cost Index System* (September 30, 2018);
- CECW-CP Memorandum for Distribution, Subject: Initiatives to Improve the Accuracy of Total Project Costs in Civil Works Feasibility Studies Requiring Congressional Authorization (September 19, 2007);
- CECW-CE Memorandum for Distribution, Subject: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs (July 3, 2007); and
- Cost and Schedule Risk Analysis Process (March 2008).

Cost estimates completed for the Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (Section 203 Study) Integrated Feasibility Study report, described in **Appendix E**, are in accordance with the above listed standards.

E.2 Class 4 Cost Estimates to Support Plan Formulation

The plan formulation process for the Study, leading to the identification of the Tentatively Selected Plan (TSP), which was later referred to as the Recommended Plan, is described in the main report, **Appendix C** and **Appendix D**. The TSP/Recommended Plan is described in **Section 6** of the main report and in **Section A.1** of **Appendix A**.

As part of the plan formulation process, Class 4 cost estimates, as defined in ER 1110-2-1302, were prepared for the purpose of comparing alternatives. These cost estimates included Class 4 construction cost estimates and Class 4 annual operations and maintenance (O&M) cost estimates prepared for the final array of alternatives and the TSP, as described in **Sections E.2.1** and **E.2.2**. These cost estimates are also referred to as rough order of magnitude (ROM) cost estimates in the main report and **Appendix A**.

E.2.1 Class 4 Construction Cost Estimates for Plan Formulation

The Class 4/ROM construction cost estimates for the final array of alternatives and the TSP were developed using the following considerations.

Existing structures were evaluated using available information taken from as-built drawings. From these drawings, we were able to establish the items of work that would be required to deconstruct the existing facilities and estimate quantities of materials that would need to be demolished and removed

from the site. These items included (but were not limited to) upland vegetation removal, excavation of dredged material, and demolishing/removal of rip rap, sheet pile and concrete caps, tie-rods, walers, base slabs, needle beams, abutments, service bridges, liquid propane tanks, fuel tanks, control buildings, control panels, pumps, motors/power units, antennas, stilling wells, staff gauges, fencing, walkways, paving and signage.

For the ROM construction cost estimates, it was assumed that all excavated or demolished miscellaneous materials would be hauled off site and disposed of at the nearest local landfill.

Proposed structures were evaluated based on their proposed footprint and how the construction would need to be sequenced to maintain full functionality of the flood control system. In most cases, this meant that portions of existing structures would need to be partially demolished and false work constructed to provide workarounds that would allow for continuous operation during construction.

For the ROM construction cost estimates, it was necessary to estimate the size of the cofferdams and excavations that would be required; temporary and permanent sheet pile needed; tie-back systems; reinforced concrete base slabs; abutments; piers; service bridges; operating platforms; retaining walls; access; and grading, paving, and drainage of the parking areas. The ROM construction cost estimates also include assumptions for the control buildings, antenna poles, pumping systems, instrumentation and controls, mechanical systems, structurally connected upland systems, rip rap scour protection, water safety devices, weed and debris barriers, and fencing and signage.

For the development of these ROM cost estimates, the base cost was assumed to be based on the project developed site plans, which were reviewed for the purpose of approximating the quantities to be constructed. The steps below were taken to develop the ROM construction cost estimates:

1. Prepare general construction sequence plan.
2. Take off quantities from the site plans for each phase of the sequence plan.
3. Estimate quantities for structures using historical information for most likely structural configurations. At the time the ROM was developed, no quantitative information was available for the structures themselves, so assumptions were made for these features.
4. Determine the unit rate cost of each activity on the sequence plan phases.
5. Sum up the total cost.
6. Estimate the midpoint cost.
7. Estimate contingency cost percentage.
8. Sum up the total ROM cost.

E.2.1.1 Prepare General Construction Sequence Plan

Proposed structures were evaluated based on their site plan footprint and the construction sequencing required to maintain full flood control system functionality. This approach involves phased construction, with the following steps outlining the process for typical projects:

For a new spillway:

- Two or more bays of the new structure are built while the canal flow is temporarily diverted.
- Once the new bays are complete and operational, the old spillway is demolished.
- Flow is then rerouted through the newly constructed bays, allowing for the completion of the remaining features.

For combined spillway and pump station sites:

- The same phased strategy is used as for the new spillway.
- One new structure (e.g., the pump station) is constructed first.
- The existing structure is then demolished.
- Construction then proceeds on the remaining new structure (e.g., the spillway).

This phased approach provides a continuous workaround, ensuring the flood control system remains fully operational during construction.

E.2.1.2 Take Off Quantities for Each Phase of the Sequence Plan

The new drawings were used to perform a detailed quantity takeoff for each construction phase. The activities were broken down into individual tasks, including mobilization and laydown area preparation, cofferdam installation, bypass channel construction, and the building of the new spillway and pump station. Other components accounted for were asphalt pavement; various types of fences, riprap, sod; the new control building; a fuel tank; a generator room; an antenna pole; a staff gauge; stilling wells; etc.

E.2.1.3 Estimation of Unit Rates Cost of Each Activity on the Sequence Plan Phases

The proposed unit rates for the project's structures were estimated using historical data from the South Florida Water Management District's (SFWMD) current and past projects. This includes an analysis of actual costs for similar or equivalently sized project activities.

Pump Stations:

Unit rates for pump stations were determined by incorporating SFWMD’s cost-curve assumptions that compare pump station total project cost to its design flow rate (cost per cubic foot per second). After the total pump station costs were estimated using this chart, the pricing for internal items of work was estimated based on percentages of total cost seen for similar items of work on other SFWMD pump stations.

Spillways:

The same strategy was used to estimate the cost of the spillways, which involved consideration of cost based on the size of the bays and gates. Historical cost data based on these gate sizes was then interpolated and used to estimate the total overall cost.

E.2.1.4 Total Structure Cost

The total project cost is derived from a comprehensive analysis of all unit costs, which includes a rough estimate and breakdown of materials, labor, and equipment.

E.2.1.5 Estimate the Midpoint Cost

Estimate the midpoint cost using the current Inflation rate and forecast the future inflation rates. The future midpoint costs were estimated to be 20 percent. This was an across-the-board estimate that will be refined from structure to structure in future revisions of this cost model.

E.2.1.6 Estimate Contingency Cost Percentage

The contingency cost was estimated to be between 30 percent and 50 percent, depending on the complexity of the project. For example, a minor construction without phasing would use a 30 percent contingency, a gated spillway would use 40 percent, and a combination spillway/pump station structure that requires a complex phasing plan, access management issues, and real estate availability issues would use 50 percent.

E.2.1.7 Sum Up the Total ROM Cost

Sum up the total unit cost, midpoint cost, and contingency cost to determine the total ROM cost for the proposed project site.

E.2.2 Class 4 O&M Cost Estimates for Plan Formulation

The Class 4/ROM annual O&M cost estimates for the Final Array of Alternatives and the TSP were prepared using the Microsoft Access-based SFWMD O&M Cost Estimating Tool software (September 28, 2010 version), developed by Stanley Consultants, Inc. and RADISE International, LC. for SFWMD. This cost estimating tool software, released in 2010, estimates O&M costs in 2010 U.S. dollars, for typical SFWMD infrastructure, such as pump stations, gated spillways, gated culverts, canals, stormwater treatment areas, flow ways and levees, based on historical records of SFWMD annual field operations O&M costs.

Since the SFWMD O&M Cost Estimating Tool provides estimated annual O&M costs in 2010 U.S. dollars, these costs were converted into estimated annual O&M costs for each year of the 50-year period of analysis (from 2035 to 2085) for the cost-benefit analysis of the Final Array and the TSP, as described in the main report, using the annual escalation rates shown in **Table E.2-1**.

Table E.2-1. Annual Escalation Rates Applied to Estimated Annual O&M Costs.

Year	Annual Escalation Rate
2010	No Escalation Rate (Base Year)
2011	1.90%
2012	1.98%
2013	1.87%
2014	1.62%
2015	1.02%

Year	Annual Escalation Rate
2016	0.75%
2017	1.94%
2018	2.04%
2019	1.88%
2020	1.62%
2021	2.47%
2022	7.00%
2023	5.33%
2024	2.40%
2025	2.63%
2026 - 2085	2.70%

E.3 Class 3 Cost Estimate for The Recommended Plan (PLACEHOLDER FOR PRE-FINAL REPORT)