



US Army Corps of Engineers

**Jacksonville District** 

South Florida Water Management District

# **CERP Standard Design Manual**

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### CERP Standard Design Manual

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# SECTION 1 GENERAL

### 1.1 General

### Introduction

The Comprehensive Everglades Restoration Plan (CERP) Standard Design Manual describes activities, level of effort, and design products associated with the engineering and design of civil works features for the CERP. The following information is intended to be used as guidance by the U.S. Army Corps of Engineers (USACE), the South Florida Water Management District (SFWMD), and all agencies or entities responsible for the engineering and design of CERP features. Responsible agencies or representatives include:

- 1. Federal sponsor (Jacksonville District Corps of Engineers) or their representatives
- 2. SFWMD
- 3. State of Florida
- 4. Other non-federal sponsors or their representatives
- 5. Architect-Engineer designers

Because of the diversity of government and private sector engineering support that shall be involved in the design of CERP projects, it is recognized that different business practices shall be employed in the accomplishment of engineering activities. The intent of this document is to provide guidance that will ensure consistency among these various governmental and private sector engineering organizations in the preparation of engineering appendices, design analyses, design plates, and construction contract plans and specifications.

### References

Corps of Engineers ER 1110-2-1150, Engineering and Design for Civil Works Projects

Corps of Engineers ER 1110-2-1200, Plans and Specifications for Civil Works Projects

Corps of Engineers ER 1110-1-8159, Engineering and Design, DrChecks

CERP Master Program Management Plan, Appendix D, Description of Format and Content for Project Implementation Reports, http://www.evergladesplan.org/pm/mpmp.cfm

*CERP Master Program Management Plan, Appendix E, Description of Format and Content for Design Documentation Reports,* http://www.evergladesplan.org/pm/mpmp.cfm

Standards for Construction of Water Resources Facilities, Design Details, South Florida Water Management District, June 2003

Standards for Construction of Water Facilities, Design Guidelines, South Florida Water Management District, June 2003

### **Plates and Drawings**

Examples of report plates showing presentation of typical design results, as well as design details approved for use in CERP construction contract documents can be found at <u>www.website address</u> to be filled in later!!!.com.

### **Design Quality**

Quality of design is achieved through sufficient planning of design activities prior to the commencement of design work. A Quality Control Plan (QCP) documents this pre-design planning and must be prepared for each CERP project phase (i.e., Project Implementation Report [PIR], and Plans & Specifications [P&S]) prior to the commencement of design work. The QCP serves as a roadmap for subsequent design and contains the following elements:

- 1. A detailed project schedule that focuses on the engineering activities involved.
- 2. An engineering cost estimate.
- 3. A list of engineering team members.
- 4. A description of project features.
- 5. A scope of plan describing the analyses, design activities, and investigations to be performed to accomplish the design.
- 6. A list of design criteria to be followed.
- 7. A discussion of how review is to be performed with a list of names of the reviewers.
- 8. A list of plates, drawings to be prepared.
- 9. A list of major concerns and design considerations such as seepage, uplift, corrosion, utility conflicts, adjacent properties, and constructability.

The QCP must be updated to reflect any changes in project scope, schedule, budget, or personnel.

### 1.2 **Project Phases**

Engineering and design occurs during the PIR and P&S phases of project development as indicated in **Figure 1**. The level of engineering and design effort during these phases is described below:

- 1. Project Implementation Report: The PIR is composed of two prime components, the Alternatives Evaluation phase and the Design of Tentatively Selected Plan (TSP) phase. Brief descriptions of these phases are as follows:
  - Alternatives Evaluation: During this phase of the PIR a low level of design shall be required during the development of feasible alternatives. The level of design required must be adequate for development of a base line cost estimate.

# GENERAL

- Design of Tentatively Selected Plan: During this phase of the PIR a higher level of design is required in the TSP in order to satisfy programmatic requirements for cost estimate development. The level of design required shall be suitable for moving directly into preparation of contract documents (P&S), upon approval of the PIR.
- 2. Plans & Specifications: During this phase of work the TSP design documents shall be utilized to develop biddable contract documents. The P&S phase will include compliance with all local building codes, connection detailing, detailed site development, and other activities necessary to develop a complete set of contract documents.

ER 1110-2-1150 describes five separate project phases – Reconnaissance, Feasibility, Pre-Construction Engineering and Design (PED), Construction, and Operation - associated with Corps of Engineers civil works projects. CERP project phases are unique in that they include only four phases – PIR, P&S, Construction, and Operation. The primary difference, in regards to engineering and design, between CERP projects and the traditional USACE civil works process is that the reconnaissance and Feasibility phases are replaced by the PIR phase under CERP. Otherwise, all provisions of ER 1110-2-1150 shall be complied with.

The following sections provide additional detail regarding each phase of engineering design.

### **1.2.1 Project Implementation Report**

During this phase, arrays of alternatives that accomplish project objectives are generated. Each alternative may contain a number of separate features, such as levees, canals, spillways, or pumping stations. Screening of these alternatives is performed by the Project Delivery Team (PDT) to eliminate those alternatives that are deemed non-feasible due to cost, environmental impact, or other reasons. A low level of engineering is then conducted for the features of the remaining (feasible) alternatives in order to determine construction costs. Although the scope of engineering and associated cost estimates for each alternative generated during the alternatives evaluation is gross in magnitude, it is consistent for all alternatives and provides an equitable basis for cost comparison.

After selection of the TSP, detailed design is performed to a level sufficient enough to proceed directly to plans and specifications upon approval of the PIR without the need for additional studies or investigations. A Micro Computer-Aided Cost Engineering System (MCACES) cost estimate is prepared based upon this detailed design and is presented in the PIR for appropriation of project funding for the PED and construction phases.

### **Alternatives Evaluation**

Engineering and design activities during the alternatives evaluation phase include those tasks associated with the following:

- 1. Surveying of study area –To support hydrologic and economic modeling and provide a low level of topographic/hydrographic detail for alternative feature siting.
- 2. Geotechnical investigations of study area -To support hydrogeologic modeling.
- 3. Hydrologic modeling and analysis of baseline conditions –To determine existing, without, and with project conditions.

- 4. Development of array of conceptual alternatives Feasible alternatives considered with possible screening out of unfeasible alternatives.
- 5. Conceptual design of alternatives Low level of feature definition required to support conceptual construction cost estimates.

### **Design of the Tentatively Selected Plan**

Engineering and design activities during the detailed design of the TSP involves performing adequate design/analysis to support the preparation of the MCACES cost estimate and to proceed directly to P&S. The MCACES cost estimate serves as the basis for funding appropriation for the plans and specifications phase and construction phase, and therefore, must be determined to a high degree of confidence. Cost estimates for the TSP phase shall be developed in accordance with the provisions of Public Law 99-662, Section 902 and, as such shall be developed with enough detail to ensure that cost estimates are developed to within 20% of the total project cost. This requires that engineering of the TSP be sufficient enough to thoroughly investigate all items of uncertainty, such as source of borrow material, method of dewatering, and foundation types.

Engineering and design activities during the TSP phase include those tasks associated with the following design efforts:

- 1. Surveying Full topographic/hydrographic/utility surveys to support site development, diversion and care of water during construction, and utility relocations.
- 2. Geotechnical investigations Core borings and analysis to support foundation investigations; hazardous, toxic, radioactive, waste (HTRW) remediation.
- 3. Hydraulic analysis Canal cross-sections and conveyance, and spillway and pumping station requirements.
- 4. Civil/Structural/Mechanical/Electrical design Construction of rights-of-way, defining of construction and project access, and spacing allowance for feature components.

### 1.2.2 Plans & Specifications

During this phase, data and design concepts finalized during the PIR phase are collected to produce plans and specifications required for contract bid estimation and construction of the project. During this phase, previously undefined or otherwise ambiguous details which may alter the quality or presentation of the end product, or that may introduce conflict during the execution of construction, shall be finalized.

### **1.3** Technical Documentation

Preparation of technical appendices, plates, drawings, and specifications shall be appropriate to the level of engineering for the various decision and implementation documents. Engineering products are typically submitted at 30%, 60%, and 100% intervals to provide for interim review of progress. For P&S, an additional review is performed after receipt of the 100% submittal prior to advertisement. This requirement may be waived or adjusted based upon project complexity, experience, or other factors determined by the project engineer. Submittal schedules shall be addressed in the QCP.

### GENERAL

The following supporting documentation shall be provided during the project phases. For information regarding the documentation requirements and the expected level of completion for each phase of engineering design, refer to ER 1110-2-1150.

- 1. Design Analysis
- 2. Design Documentation Report (DDR)
- 3. Engineering Documentation Report (EDR)

### **1.3.1 Project Implementation Report**

Engineering appendices shall contain sufficient technical write-up to describe general physical quantities for the features of the various alternatives. Plates and figures, showing conceptual layouts and aerial features, shall be used to fully describe the extent of alternative features. Emphasis of presented data shall be on the feature requirements (e.g., conveyance). Features of the recommended plan (TSP) shall be fully described and supplemented with structure data sheets and tables for levees and canals showing template geometry and length.

Presentation of data for the detailed design of the TSP shall include design criteria; stability analyses; cut/fill quantities; detailed site layouts; and such plates, figures, tables, and technical write up necessary to describe the types and quantities of materials required, methods of construction, special requirements (e.g., blasting, dewatering, construction phasing, and traffic diversion) and construction contract strategy. Design data included in the DDR in lieu of the PIR shall be in accordance with ER 1110-2-1150.

### 1.3.2 Plans & Specifications

Upon approval of the PIR, contract documents in the form of project plans and specifications shall be produced. Engineering efforts shall be focused on detailing the various civil, structural, architectural, mechanical, and electrical feature components. Detail shall be sufficient enough to provide a biddable set of documents. During this phase, previously obtained surveys shall be checked to determine if site conditions have changed to a point where the changes would adversely impact the approved design. Changes to the approved design shall be documented in an EDR in accordance with ER 1110-2-1150.

Plans and specifications shall be prepared in accordance with ER 1110-2-1200 and ER 1110-1-8155. Review of P&S shall be accomplished with the web-based project review system DrChecks and shall be in accordance with ER 1110-1-8159.



# SECTION 2 GRAPHIC PRESENTATION

### 2.1 General

Graphic presentation guidance is presented in this section to provide detailed specifications in the preparation of graphics used to describe the projects and reports for the Comprehensive Everglades Restoration Plan (CERP) projects.

### 2.2 References

Tri-Service AEC CADD Standard Manual, Release 2.0

### CERP CADD Manual

Florida Department of Transportation (FDOT) Standard Font/Symbol Library

### 2.3 **Project Implementation Report**

#### **General Requirements**

Graphic design shall be prepared using the specified CADD platform that is proprietary to the agency performing the design task. Microstation Version 8.0 or later, by Bentley Systems Inc., shall be used when preparing CADD designs for the U.S. Army Corps of Engineers (USACE), and AutoCAD Release 2000i or later, by Autodesk Inc., when preparing CADD design for the South Florida Water Management District (SFWMD). Guidance for application of the Tri-Service AEC CADD Standards is found in the companion CERP CADD Manual. Civil design, utilizing the specialized site design software incorporating earthwork, roadway, channel, and/or survey criteria, shall be accomplished using InRoads or one of its modules produced by Bentley Systems Inc. These software modules are compatible with either Microstation or AutoCAD as a base platform.

Graphic design presentation is described in the following elements:

- 1. Sheet Size Format
  - a. Sheet dimensions shall be determined by measuring the overall size of the surrounding border, identified by a graphic shape, which distinguishes the trim line for the sheet. Dimensions are determined by the extent of the border file trim element and sized in order to scale and plot to the required full-size plot of 34"x44" (ANSI E) or alternate full-size plot of 22"x 34" (ANSI D). Reduced sheet sizes are plotted productions of the full-size created designs. All ANSI sheet sizes except the ANSI F are available for use in project sets as deemed appropriate by the project engineer, considering the type of design work to be accomplished.

Sheet sizes shall be determined based on the scale required, area to be depicted, and text readability at reduced sizes. One size shall be used throughout a design project. Refer to the CERP CADD Manual for details.

The element attributes of the graphic trim line shape are:

- Color Table = Default
- Element type = Shape
- Level = "G-----TTP-"
- Color = Lt. Gray #9
- Line code = 1 Dotted
- Weight = 0 (.18mm)
- b. Scales, text sizes, dimensions, and leaders shall be determined based on their clarity of presentation on both full and reduced size sheets. Initial creation of the graphic presentation shall be formatted, sized, and scaled so that the presentation does not become illegible at reduced size plots.
- c. The title block template shall be used as a reference file without changing the element attributes within the file. The shape found at the trim line location around the border sheets is to be used for batch plotting processes in which the element attributes are critical for plotting.
- 2. Fonts

Font symbology shall be created using the Bentley System's default font file provided, "*font.rsc*" (in AutoCAD use the standard supplied font library). Font #1, known as "working," is a proportional font (in AutoCAD use Roman simplex with a width factor of .8) and shall be used for all leader type notes and dimension text. Font 3, known as "engineering," is a monotext font (in AutoCAD use Monotext) and shall be used for all stacked or column formatted text. Font #23, slanted font, is used for hydrographic feature identification, such as water flow information (in AutoCAD use Roman Simplex with an oblique angle of 21.8 degrees). Other fonts may be used in special circumstances, such as font #43, the filled font, for titles, subtitles, and cover sheet text (in AutoCAD use the Swiss True Type font and set the textfill system variable to 1). Designs containing graphic presentations for roadways specifying compliance to FDOT standards shall incorporate the FDOT font/symbol libraries where appropriate.

3. Graphic Attribution and Drafting Tools

Adherence to the CERP CADD Manual Graphic workflow procedures shall be strictly maintained. The CERP CADD Manual will define the required portions of the Tri-Service AEC CADD Standards to follow. The CERP CADD Manual will have precedence over any other document referencing graphic presentations or formatting. The Scope of Work, CERP CADD Manual, standard prototype design files, resource files, and/or any supplemental information shall be provided as required for the design tasks specified.

InRoads configurations specifying appropriate graphic attribution and level assignments are also developed for the user to assist in compliance with the AEC graphic standards.

4. Border File/Title Blocks

Border/Title Blocks are to be referenced to each sheet file in the drawing set when using Microstation. The use of Layouts (Paper Space) shall be used in AutoCAD.

### 5. File Naming Convention

File naming conventions shall be as specified in the Statement of Work.

6. Reference Files

Reference files shall be fully utilized in all practical applications. Sheet files shall contain only information that pertains to the specific drawing sheet. All other design and drawing information shall be included through the use of referenced model design files and raster files. Refer to AEC CADD Standard Manual, Chapter 2, page 8, figure 4, for additional information.

7. Design File Coordinate System

All designs depicting geographic locations shall be located according to the State Plane Grid System (Florida Coordinate System). Refer to Surveying & Mapping, Section 4 of this manual, for additional information.

8. Civil Design Tools

Graphic presentations for civil-site, navigation, flood control, and hydrographic designs shall be created using InRoads, by Bentley Systems Inc., used in conjunction with either a Microstation or AutoCAD platform.

### 2.4 **Required Documentation/Products**

1. Project Implementation Report

The Alternatives Evaluation and Design of Tentative Selected Plan phase plates and drawings shall be 8-1/2" x 11", which is one-fourth of the full-size ANSI E, or 17" x 11", which is one-half size of the ANSI D sheet size.

2. Plans and Specifications

The Plans and Specifications phase shall be created using either the ANSI E, for larger civil site or alignment projects, or ANSI D for most structural, mechanical, or electrical projects. Full-size plotted plan sets should always be considered when planning the project. Only one full size border can be utilized in each project (ANSI E or ANSI D). Review sheets are typically plotted at half-size dimensions of the full-size original.

### 3.1 General

The Hydrology and Hydraulics (H&H) engineer shall perform analyses, interpret results of the analyses, and execute hydraulic structure designs and operations. It is assumed that most H&H tasks are completed within the Project Implementation Report (PIR) phase.

ER 1110-2-1150 shall be used as a guideline for H&H procedures and methods to complete a PIR (ER applies to a Feasibility Study Report) for the Engineering Appendix.

All models used shall be screened for validity to meet project objectives, performance measures, and project conditions/constraints. Calibrations shall be performed when appropriate to validate usage and ensure accuracy of data inputs.

All surveys used for design and model effort and evaluations are required to be tied to survey monuments for standardization and documentation.

### 3.2 References

EM 1110-2-1601, Engineering and Design - Hydraulic Design of Flood Control Channels

EM 1110-2-1414, Water Levels and Wave Heights

ER 1110-8-2(FR), Engineering and Design - Inflow Design Floods for Dams and Reservoirs

ER 1110-2-1150, Engineering and Design -Engineering and Design for Civil Works Projects

ETL 1110-2-299, Engineering and Design - Overtopping of Flood Control Levees and Floodwalls

US Dept of Interior, Bureau of Reclamation's Downstream Hazard Classification Guidelines for hazard probability concerning public safety

U.S. Army Waterways Experimental Station Shore Protection Manual (1984)

National Dam Safety Act of 1972

Open-Channel Hydraulics, Ven T. Chow, McGraw-Hill, latest edition

Handbook of Hydraulics, Brater, E.F. and King, H.W., McGraw-Hill, 1976

Central and Southern Florida (C&SF) Project, Part VI, Section 5

SFWMD's Basis of Review for Environmental Resource Permit Applications, Appendix 6

"mod-T", presented in the H&H Portland Conference, 2003 (Design of Levee Heights for Shallow Reservoirs)

### **3.3 Project Implementation Report (PIR)**

### 3.3.1 Alternatives Evaluation

### General

The following detailed list of hydraulic considerations shall be addressed to some degree, dependent on existing information and modeling detail orientation, during the alternative evaluation phase. It is important to ascertain enough hydraulic characteristics to enable a fair cost estimate across all alternatives (e.g., enable excavation quantities to be estimated, determination of structure type and rough sizing, and real estate requirements).

The H&H engineer shall evaluate by analytical or numerical means wave analysis, water level analysis, wave and structure interaction, and cross-shore or long-shore sediment transport. Hydrodynamic modeling of tidal currents within estuaries as it relates to water quality and system flushing shall also be considered.

### 3.3.1.1 Canals

A general description of the canal and overall project area shall be provided. The description shall include the overall purpose of the project, which may include: flood control, transfer of non-flood flow for environmental reasons, connector to other canals, and structure approach improvements.

The Alternatives Evaluation phase shall take into account the following elements:

- People and property at risk
- Freeboard
- Maximum permissible velocities
- Side slopes
- Flow regime
- Hydraulic design data
- Disposal areas

Descriptions of the elements are described in the following:

### People and Property at Risk

The existing and forecast type of area and land use to be protected (e.g., agricultural, residential, commercial property, and/or hospitals) shall be evaluated using the inventory of data available (local comprehensive plans, FEMA flood maps). Potential damages at all locations along the entire length of the canal shall be considered when setting flood inundation lines and the canal alignment. The canal design shall be capable of conveying the design flood or deliveries; whichever is larger, within canal cross-section plus freeboard necessary at design stages for providing adequate head to allow lateral drainage into the canal. Consideration of the local residential population shall also be carefully reviewed.

### Freeboard

The hydraulic design shall take into consideration runoff from adjacent areas. Design canal stages along each reach shall afford the local flood control and drainage system adequate tailwater

elevation to function at existing flood damage reduction capabilities. Zero freeboard (natural grade) seldom provides an adequate benchmark for design. However, bank overflow may be entirely appropriate if serving environmental needs (hydroperiod enhancement and littoral shelves for wildlife). Therefore, the design of channel/levee freeboard is site specific. The design shall consider the following elements:

- The potential for roughness values exceeding the design roughness (potential for aquatic plant growth, falling trees through bank erosion, and trash).
- The maintenance of a channel.
- A roughness coefficient sensitivity analyses.
- A sensitivity analyses to determine areas where overtopping could occur (identify area to overtop first).

### Maximum Permissible Velocities

Allowable canal velocities shall be determined from the soil type within the design reach and existing structures not modified (i.e., bridges not replaced). Velocities and stages within a design canal shall be checked by using a high roughness value for a "seasoned" or older canal and a lower roughness value that would denote velocities for "new" canals or canals recently constructed (relative values can be swapped given soil conditions). Allowable design velocities for a riprap or gabion lined channel shall be limited to manufacturers criteria. A geotechical engineer shall review the final determination of allowable velocities for soil and riprap. A concrete lined channel shall be designed to meet velocity requirements as recommended by the structural engineer.

#### Side Slopes

Geotechnical investigations and reports shall determine the maximum side slopes that would be used for a trapezoidal section channel. With limitations noted by the geotechnical engineer, side slopes shall be designed to create the most hydraulically efficient conveyance channel.

### Flow Regime

The flow regime in Florida and for the Comprehensive Everglades Restoration Plan (CERP) projects shall be almost entirely sub-critical in nature. A description of the flow conditions information is as follows:

- 1. Subcritical flow: Subcritical channel conveyances shall have a Manning's roughness coefficient "n" value evaluation analysis—factors contributing include channel lining material (earth, concrete, riprap), relative straightness or alignment, and channel depth. Guidance is available in many references, including, but not limited to: Central and Southern Florida (C&SF) Project, Part VI, Sections 5 and 7, EM 1110-2-1601, Brater and King, *Handbook of Hydraulics* (any edition), and Chow, *Open Channel Hydraulics* (1959). Calibrating a hydraulic model to given discharge events is an acceptable method of determining Manning's "n" roughness values. Channel sensitivity to the roughness coefficient shall be analyzed as well. The logic relating to how the Manning's "n" values were derived shall be clearly stated in the project design report.
- 2. Supercritical flow: The design procedure shown in EM-1110-2-1601 section 8. b., shall be utilized to determine the k-Factors for "seasoned" and "new" channel performance. High velocity concrete channels shall be designed with a roughness value computed from k=0.007 for

discharge capacity and maximum water surface elevations. The design channel shall be checked for maximum velocities and lowest stages that would occur with roughness values set k=0.002. The "K" coefficient shall provide a lower limit of Manning's "n" value. The difference in super elevation shall be computed and heights of channel walls shall be set at the most conservative height. The report shall include a statement if the difference between velocities at k=0.007 and k=0.002 is small.

### Hydraulic Design Data

Hydraulic design data for a canal shall show the entire length of the canal with appropriate stationing intervals. Appropriate intervals include stationing of: water control structures, channel geometric transitions, channel flow rate transitions, bridges, confluences with other channels, and other points of interest. Each station point shall have the following data:

- Station, ft.
- Natural grade elevation, ft. NGVD.
- Bottom width, ft.
- Bottom elevation, ft. NGVD.
- Side slope ratio, in ft. Horizontal to vertical (i.e., H:V).
- Design stage, with maximum and minimum stages expected, in ft, NGVD.
- Design and maximum expected velocities if velocity is critical for station point.

### **Disposal Areas**

Spoil disposal sites shall be adjacent to but outside the floodway so that they will not cause increased flooding under discharge conditions. If a disposal site is required to be located within a floodway, adequate measures to protect it from erosion shall be designed. Maps shall be provided that show the locations of the proposed disposal sites.

### 3.3.1.2 Levees

### General

The rational for the proposed alignment shall be discussed in the project design report and include the following:

- Land use and real estate considerations
- Environmental considerations
- Geotechnical limitation(s)
- Locations where the levee ties into higher ground
- The encroachment of the floodway
- The residual flooding for runoff of upland areas
- Maintenance buffer for operation and maintenance work

The minimum levee side slope shall be based on geotechnical stability analyses. However, consideration shall also be given to operations and maintenance requirements (e.g., 3 on 1 minimum slope for mowing) and design considerations. Reference shall be made to SFWMD standards for levee design.

### Levee Design

Describe the levee design profile referencing ETL 1110-2-299. The levee design shall include the following:

- 1. Levee Freeboard: Levee freeboard is assumed to be the same for all alternatives (e.g., three feet) but ultimately must be designed for site environment and public safety considerations.
- 2. Computer Modeling for Levee Design: Designing means establishing a levee crest by sensitivity analyses of channel or floodway roughness and risk analyses. Levee crest must be designed by compiling a HEC-RAS or UNET model of the floodway with proposed levee features. Typically a calibrated existing conditions model of the floodway would be modified to reflect the addition of levees to the floodway. The model would be compiled to determine the effects of the loss of conveyance and the subsequent stages in the floodway resulting from construction of the levees.
- 3. Design Criteria: Previous design criteria called for compiling stages in the floodway with the highest expected "Manning's n" roughness coefficient values for flood conveyance. The procedure would result in the highest stages for a "worst possible condition" with respect to vegetation, sedimentation, reduced conveyance at bridges and other similar features. The design level of protection provided shall be stated. A table showing stages at various stations along the design reach shall be compiled for use by other disciplines (Geotechnical, and Levees and Waterways sections). The table shall also show stationing versus water surface elevation profile, top of levee elevation profile, natural ground surface elevation, road crossings, and inlet structures. Mapping of residual flooding for post project discharges shall be plotted for use by the Planning Economist.
- 4. Levee Superiority Features: Levee "superiority" (formerly known as freeboard) would be called for at critical reaches along the alignment. Additional levee height would be provided at selected sites to insure against overtopping at locations which would potentially suffer loss of life, or high cost damages (i.e., levee sections adjacent to a hospital as opposed to improved pasture). Some sections of levees can be designed lower than others to insure the "point of failure." Freeboard could be tied directly to a roughness coefficient sensitivity analyses to determine areas where overtopping could occur. Design of "low sections" in the height of the levee to give warning of flood stages that are exceeding the design capacity of the leveed floodway. Levees adjacent to high benefit areas would be correspondingly higher.
- 5. Levee Tieback: Where levee placement in a potential floodway is required to prevent flood damages from occurring, a levee tieback design feature shall be implemented to inhibit flow behind the levee system that may add risk for an increase in flood damage.
- 6. Levee Superiority when Levees can be classified as Dams: This case is presented in Section 3.3.1.3 in the design of impoundments or shallow reservoirs.
- 7. Levee Failure Analysis: On a project dependent basis, a dam break scenario may be required for emergency planning purposes to meet FEMA guidelines. The risk associated with a possible dam break occurrence may cause a more conservative levee design to be considered.

### 3.3.1.3 Impoundments/Shallow Reservoirs

#### General

Note: the following design processes are for impoundments that can be legally defined as dams under the National Dam Safety Act of 1972. Dam safety standards are specified in ER 1110-8-2(FR). Regulations provide Safety Dam Standards (categories) that require addressing through the design process.

In addition to federal requirements in the design of dams/reservoirs, *SFWMD's Basis of Review for Environmental Resource Permit Applications*, Appendix 6 shall also be followed. Where federal and state guidelines are different, the more stringent criterion may be followed dependent on project specifics.

A general description of the function of the reservoir shall be provided with objectives (e.g., flood control and water supply) and constraints of operation (storage volume and allowed seepage).

### Impoundment Design

The following steps are required when designing impoundments:

- 1. The conceptual plan-storage volume shall be identified. The design storage-volume shall be balanced with the following factors that require study:
  - a. Real estate availability (Planning responsibility).
  - b. Design storage-stage versus seepage-out through impoundment bottom. Seepage is a function of sub-surface permeability and head differential between stored water stage and surrounding water table elevation.

In South Florida, a seepage collection system will most likely be required for all impoundments. The seepage collection system shall consist of, but not be limited to: a seepage collection canal, return pump station, and gate/weir control for discharge into a receiving canal (secondary seepage control).

Liners can be cost-effective, but a cost analysis must be performed to demonstrate the feasibility of use.

Aquifer Storage and Recovery (ASR) is another design alternative in control of seepage. However, a secondary seepage collection system will still be required as ASR only provides stage reduction versus time advantage and not seepage control.

c. Water availability

A hydrologic analysis may be required to identify amount of runoff that may be made available for storage via event and/or period-of-record flood routing. The design storage volume shall be efficiently used to meet the impoundment's primary objective.

Canal size to inflow pumps must provide sufficient conveyance capacity, during times when runoff is available, to meet assumptions used for pumps in the hydrologic analysis.

Ability to discharge releases through delivery canals is important. If the impoundment is not allowed to draw down for the next successive storm event, availability for water storage is limited to the surplus storage volume.

- 2. Dam-levee freeboard design criteria have the objective to contain water in a design storm and protect levee integrity where failure would be considered catastrophic to public safety. The analysis for this section is based on ER 1110-8-2(FR). Paragraph 9 of this reference provides design requirements regarding freeboards of dams and levees. The following analyses must be performed with respect to risk associated if a dam-levee failure (breach) was to occur:
  - a. To address Paragraphs 9.a, 9.b, and 9.c, an Inflow Design Flow (IDF) routing must be performed to determine the most critical pool elevation or surcharge above the full pool. Paragraph 8 provides a procedure to meet regulation requirements for this step.

An analysis shall be performed for 6-hour and 72-hour Probable Maximum Precipitation (PMP) storm events if Standard 1 applies (Paragraph 7.b), with results scrutinized for applicability and associated risks.

An analysis shall be performed for a range of floods (e.g., 10-, 25-, 50-, and 100-year return storms and Standard Project Flood [SPF] storm), including PMP event, with a cost versus risk analysis performed on the resulting levee height requirements for the other Dam Safety standards as described in Paragraph 7.

As recommended in Paragraph 8.e, use of gates during storm events in routing the inflow design flow (IDF) is limited to those that do not require power or human operation. An emergency overflow spillway or an alternative non-operating structure shall be used in the IDF. This recommendation shall also be followed when addressing Paragraph 9.c as this pertains to the probability of high winds occurring when the pool remains surcharged or above full pool (36-hour rule).

b. To address Paragraphs 9.a and 9.b, a series of analyses must be performed to determine probability of wave overtopping dam-levees and evaluating if the rate of overtopping will exceed recommended values where levee integrity may be at risk.

The following wind velocities shall be used for all analyses: 90 mph (Category I Hurricane), 100 mph (Category II), and 120 mph (Category III). The 120 mph wind speed analysis is also required under the South Florida Building Code and ASCE 7-98 requirements.

Based on the results of the following analyses, a cost-design optimization shall be performed regarding placement of wind breaks and interior levees strategically oriented to reduce levee height requirements. Alignment of levees adjacent to risk-associated (public or private) property may also incorporate a design setback to reduce risks with respect to flood wave velocities and depth that result from a levee breach.

A wind set-up analysis shall be performed with the critical fetch length direction toward the levee adjacent to risk prone (public or private) property. The determination of fetch distance shall be performed with the procedure provided in EM 1110-2-1414. A model selected for wind set up shall be one that is applicable to the impoundment design parameters (i.e., depth). The model proposed in the paper, "mod-T", presented at the H&H Portland Conference, 2003 (Design of Levee Heights for Shallow Reservoirs), may be considered as appropriate for CERP-type impoundments.

A wave generation analysis shall be performed with the critical fetch length direction toward the levee adjacent to risk associated (public or property) should failure occur. A model with a robust wind wave growth capability, including variable bathymetric input (i.e., topographic data), wave-bottom interactions, depth induced wave breaking, and non-linear wave-wave interactions shall be employed. SWAN, a third-generation numerical wave model for the realistic estimation of wave parameters, or an equivalent model is required to adequately capture each set of site-specific characteristics.

A wave run up analysis shall be performed on the levee adjacent to risk associated (public or property) should failure occur. A model(s) shall be selected based on the ability to perform the three following requirements: (1) quantifying wave run up heights for levees with different planar or varying slopes (levee bench) and slopes with different surface friction values employed in a sensitivity analysis, (2) calculating wave run up on probability basis extending from the theoretical approach of irregular wind waves generation, and (3) quantify overtopping as a volume rate for a levee height with a specific wave height assigned. *U.S. Army Waterways Experimental Station Shore Protection Manual* (1984) provides method and graphic solutions for the previous requirements.

Coordination with the geotechnical engineer is required to establish acceptable overtopping rates (for a specified duration based on probability) that do not place dam-levees at risk of losing integrity.

- 3. Impoundments and shallow reservoirs that are federally classified as dams may require a FEMA Emergency Action Plan. An acceptable model to perform this calculation is U.S. National Weather Service's FLDWAV computer program (incorporates the classic DAMBRK model). Since CERP impoundments are not considered classic dams in that they do not form an obstruction to a channel (control inflow only, no gravity inflow) and do not discharge into a historic river channel (e.g., no gorges, valleys, or v-shape floodplains), assumptions must be made with a view toward protecting public safety. The following are assumptions and tasks assigned to fulfill this requirement:
  - a. A catastrophic dam break shall be modeled with the largest possible head differential that may occur between the pool stage and the surrounding ground elevation. A sensitivity analysis shall be performed on the breach width and time to complete failure. Additionally, an analysis shall be performed on the Manning's n roughness coefficient used for the flood wave conveyance channel/floodplain.

If the critical dam-levee has a canal running parallel with it, the canal shall be assumed blocked, for design purposes, at both ends to represent the settlement of eroded levee material. The resulting plunge jet formed by the escaping water during a breach of the dam-levee shall be assumed to flow into this closed-end canal.

b. Results from the dam break analysis shall include graphs and tables of model results illustrating maximum water velocities and water depths versus distance from breach. The results from this analysis shall be compared to figures provided in U.S. Dept of Interior, Bureau of Reclamation's *Downstream Hazard Classification Guidelines* for hazard probability concerning public safety.

- c. Time of flood recession shall be documented. Recession shall be considered complete when water depth falls to one-foot above natural grade. This takes into consideration the numerous internal (to the modeled floodplain) secondary drainage canals and retention ponds that are found throughout the CERP project area.
- d. Assist the U.S. Army Cops of Engineers (USACE) and/or the sponsor's Dam Safety Officers, if required, with the completion of the required FEMA Emergency Action Plan.

### **3.3.1.4 Pumping Systems**

### General

A general description of the function of the pumping station shall be provided and include its purpose (e.g., flood control and transfer of non-flood flow [water supply and environmental]). All hydraulic design work shall be coordinated with structure design engineers using standard guidelines and drawings acceptable with the sponsor and compliant with USACE regulations.

Applicable engineering manuals, such as EM 1110-2-1601, Hydraulic Design of Flood Control Channels, shall be used for the design process. A hydraulic data table that shows all hydraulic design criteria shall be provided. Hydraulic design data tables shall be provided to show structure type, length, width, number of water control gates. The table shall show the following data:

### **Design Conditions**

- 1. Design discharge: Maximum design discharge in cubic feet per second (cfs) with design headwater, tailwater and total dynamic head and frequency of discharge.
- 2. Pump operational headwater and tailwater discharge ranges, including:
  - a. Intake Water Surface Elevations (Headwater):
    - Maximum Non-Pumping stage
    - Maximum Pumping stage
    - Design Pumping stage
    - Minimum Pumping stage
    - Minimum Non-Pumping stage
  - b. Discharge Water Surface Elevations (Tailwater):
    - Maximum Non-Pumping stage
    - Maximum Pumping stage
    - Design Pumping stage
    - Minimum Pumping stage
    - Minimum Non-Pumping stage
- 3. Pump data shall include:
  - a. Pump mix with the discharge capacity of each pump
  - b. Pump type, diesel or electric

- c. Emergency equipment if necessary (e.g., generators and fuel tanks)
- d. Estimated bay width and apron elevation with intake elevation for each pump
- e. Energy dissipation methods such as: rows of baffle blocks, increased apron length, and discharge elevation
- f. Scour protection criteria such as: rip rap length and typical rock size
- g. Protection elevation: elevation of no overtopping (Standard Project Flood [SPF] + 1 foot)
- 4. Site conditions shall include:
  - a. Natural grade elevations
  - b. Intake side approach canal bottom width, elevation and bank side slopes
  - c. Discharge side approach canal bottom width, elevation and bank side slopes
  - d. Tieback levee crest elevation and side slopes
  - e. Estimation of debris, trash, and vegetation build-up
- 5. If applicable, the pumping rate of excess water from the basin shall also be included.

### 3.3.1.5 Bridges

### General

The data contained in this section pertains to hydraulic characteristics only. Bridge widths and structural low chord data must be assumed unless information can be obtained by other sources. Design criteria for bridge modifications or new bridges shall be addressed. These criteria include:

- If the bridge will convey floating debris, then a velocity analysis with appropriate debris buildup on piers shall be performed.
- The reason for bridge replacement. Examples are; low chord elevation too low, bridge too narrow, velocities through existing section too high, and inability to transition to proposed channel. A sensitivity analyses will be preformed on existing bridges that are not to be replaced to determine if debris build-up would cause excessive stages upstream of the bridge.
- Recommendations for remedies for debris build-up such as: leading edge debris deflectors befitted to new piers or retrofitted to existing bridges piers.
- Potential and quantify scouring of bridge piers and embankments.
- Compliance with SFWMD permitting requirements, as well as Florida Department of Transportation (FDOT) requirements if a state road.

### **Bridge Data**

Bridge requirements shall include the following information:

- Road number and name of bridge.
- Length and width of bridge, in feet, critical distance being that that is parallel to channel flow. If channel flow runs obliquely to bridge, that distance shall also be noted in the analysis and documentation.
- Low chord elevation, in feet (as determined from clearance criteria for navigation or debris passage).
- Design and maximum discharge water surface elevation, in feet, with duration and frequency of maximum discharge expected.
- Required net cross-section area under the design water surface elevation, in feet.
- Average and maximum velocities, in feet per second.
- Analysis of possible scouring with recommendation of bottom erosion protection if required (e.g., rip rap, gabions, and grouted rock).

### 3.3.1.6 Spillways/Water Control Structures (Non-Impoundments)

### General

All hydraulic design work shall be coordinated with the structural engineer using standard guidelines and drawings acceptable with the sponsor and complying with USACE regulations. A general description of the function and use of the water control structure shall be provided for each structure (e.g., flood damage reduction, water supply, and environmental releases). Types, descriptions, and design information of the structures are shown below:

### Water Control Structures

Use applicable engineering manuals, such as EM-1110-2-1601 for general design parameters. All hydraulic design data tables shall be shown in a hydraulic data table that shall be provided with the project feature design. Hydraulic design data tables shall contain structure type, length, width, number of water control gates, and design heads. Coordination shall be made with water managers concerning the collected and derived data and recommendation for input into the Operating Manual.

### **Spillway Structures**

Provide a general description and purpose of the project (e.g., flood control and transfer of nonflood flow for environmental reasons). The description shall include the following items:

- Design and maximum discharge, rates of flow in cfs, and the frequency of that discharge.
- Maximum headwater elevation with corresponding minimum tailwater conditions.
- Crest type: ogee, sharp crest sheetpile, and wide berm overflow.
- Gates; the number, width, and height of gates and type (e.g., vertical lift and obermeyer).
- Apron; upstream and downstream length, elevation, width.
- Energy dissipation method: rows of baffle blocks and increased apron length.
- Scour protection: rip rap length and rock size.
- Protection elevation: elevation of no overtopping (SPF +1 foot).
- Approach and discharge channel geometry and characteristics.

### Culverts

Provide a general description and purpose of the project (e.g., flood control and transfer of nonflood flow for environmental reasons). The description shall include the following items:

- Design and maximum discharge: rates of flow in cfs and the frequency of that discharge.
- Maximum headwater elevation with corresponding minimum tailwater conditions.
- Type of culvert: corrugated metal pipe (CMP), reinforced concrete pipe (RCP), box culverts, three-sided.
- Crest height and width of embankment over the culvert.
- Diameter or box dimensions: elevation of upstream and downstream inverts.
- Inlet and outlet structure: Headwall type (e.g., winged or straight) and top of wall elevation.
- Inlet control: stoplog riser, slide gate, and flap gates (manual or automatic with telemetry).
- Erosion control length: upstream and downstream length, elevation, width (e.g., rip rap and gabion blankets).
- Energy dissipation method: rip rap length, rock size, and concrete grout bag.
- Protection elevation; elevation of no overtopping (SPF +1 foot).
- Approach and discharge channel geometry and characteristics.

### **Tributary Inlet Spillways**

Local runoff into a channel or floodway through a levee can influence the costs of an alternative. An inlet structure is a minor item with respect to the overall project cost; however, the project may require a number of structures, therefore having an impact on the total project cost that is typically unaccounted for in the planning process. Hydraulic design data shall be completed to a level of sizing the spillway for costs estimating. The hydraulic design data shall be provided in a table and list the following parameters:

- Location and stationing
- Size
- Length
- Invert elevation
- Design and maximum discharge
- Number of barrels
- Type of controls
- Riprap requirements

### **Required Documentation/Products**

- Hydraulic data sheets on all proposed structures.
- Channel cross-section geometry and reach length tables.
- Levee cross-section geometry and length tables.
- CADD plates showing proposed alignments of all channels, levees, and structure locations.

### 3.3.2 Design of Tentatively Selected Plan

All of the previous listed detail hydraulic considerations from the Alternatives Evaluation phase shall be designed to completion. Additional hydraulic features and characteristics may require

analyses, dependent on specific project and objectives (e.g., water quality as major objective with hydraulic requirements).

Prepare all final designs that include coastal type structures such as jetties, groins, revetments, seawall, bulkheads, protective beaches, dune systems, and navigation and estuarine flow channels.

### **Required Documentation**

- Hydraulic data sheets on all proposed structures.
- Channel cross-section geometry and reach length tables.
- Levee cross-section geometry and length tables.
- CADD plates showing proposed alignments of all channels, levees, and structure locations.
- Flood inundation mapping (Flood and dam break [the latter if required]).

# SECTION 4 SURVEYING AND MAPPING

### 4.1 General

This section is intended to serve as a guide for the U.S. Army Corps of Engineers (USACE), Jacksonville District, South Florida Water Management District (SWFMD), and AEC personnel performing field surveys in support of Comprehensive Everglades Restoration Plan (CERP) projects. It provides guidelines which foster uniformity of field methods, note keeping, and the complete and accurate collection of survey data. It is to be used as a supplemental resource to the various technical publications referenced herein, with an emphasis on acceptable practice with USACE, Jacksonville District, and SFWMD. Compliance with these technical requirements is mandatory for all CERP projects. The following information shall instruct survey personnel in the acceptable procedures of acquiring and recording such data.

### 4.2 References

"Technical Requirements for Surveying, Mapping, and Geospatial Services," USACE Jacksonville District Survey Section, 2004 or most recent version.

Central and South Florida Project, Comprehensive Everglades Restoration Plan, Program.

Management Plan, Data Management, USACE Jacksonville District & South Florida Water Management District, February 26, 2002 (CERP Data Management) or most recent version.

### 4.3 Data Collection and Types

The CERP Data Management provide for a program-wide phased approach to management and acquisition of data. Included in this scope are activities to identify, standardize, organize, document, serve, and preserve program data. Compliance is mandatory for all CERP related projects.

The following provides information on data collection categories and the type of information collected under each category. The actual survey method used shall be based on the phase of the project and project specific requirements.

- 1. Conventional Topographic Data
  - a. Features and Contours
    - Break lines
    - Levees
    - Ditches
    - Roads
    - Surface water lines
    - Vegetation
  - b. Boring Locations

When boring locations are not performed as part of the survey, raw survey data and survey documentation shall be provided to the party overseeing the survey such that the surveys are properly tied together and all data is on a common spatial framework.

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### c. Structures

Survey information required for the design of structures is oftentimes field-collected during the Alternatives Evaluation phase or incorporated from as-built documents. Subsequently, during the Design of Tentatively Selected Plan (TSP) survey, these data shall be field verified to ensure accuracy in reporting. Additional information is available from annual Operations and Maintenance Structural Deformation Surveys for select structures. The following structures are included in the Conventional Topographic Data:

- Bridges
- Plants/pump stations
- Culverts/weirs
- Locks/dams
- d. Cadastral

The Cadastral information is typically incorporated from records research during the Alternatives Evaluation phase. Subsequently, during the TSP survey, these data shall be field verified to ensure accuracy in reporting.

e. Utilities

Utilities, especially those below ground, are typically incorporated from as-built documents during the Alternatives Evaluation phase. Utility details and locations are to be provided by the respective utility owner(s). Subsequently, during the TSP survey, the locations of these utilities shall be verified to confirm accuracy in reporting. Typical utilities include the following:

- Telephone
- Cable
- Fiber optic
- Gas
- Water
- Sanitary sewer
- Storm drainage
- Electric
- Manholes
- Catch basins
- f. Property Surveys

This information is typically incorporated from legal documents during the Alternatives Evaluation phase. Subsequently, during the TSP survey, the applicable property lines shall be field verified to confirm accuracy in reporting.

g. Laser Scanning

Ground-based Laser Scan surveys can be incorporated indiscriminately during the Alternatives Evaluation phase; however, during the TSP survey, only ground-based Laser Scan surveys of "hard" features (e.g., manmade structures and non-vegetated features) shall be included.

- 2. Hydrographic
  - a. Single beam cross-sections and profiles
    - Single frequency (locates apparent or "soft" bottom)
    - Dual frequency (locates "soft" bottom and "firm" bottom)
    - Mudflow (identifies thickness of "firm" layer above "hard" bottom)
  - b. Multi-beam swath bathymetry
  - c. Side scan sonar bathymetric imagery
  - d. Hard-bottom (exposed reef) mapping
  - e. Vegetation mapping/seabed classification
  - f. Magnetometer
  - g. Sub-bottom linearly swept, frequency modulated pulse (CHIRP) profiling
  - h. Acoustic Doppler Current Profiling (ADCP)
  - i. Jet probes
- 3. Aerial Remote Sensing
  - a. Light Detection and Ranging (LiDAR) topographic
    - Bare earth with levees
    - Bare earth without levees (Region Hydrologic Model)
    - Bare earth with structures
    - Vegetated with structures
    - Feature coded points (via intensity return or additional sensor)
  - b. Submerged Hydrographic Operational Airborne LiDAR Survey (SHOALS)
  - c. Photogrammetry
    - Stereo compilation
    - Ortho-rectified scanned imagery
    - Digital imagery

- d. Multi- or hyper-spectral digital imagery
  - Feature codes
- 4. Geographic Informational System (GIS)
  - a. Parcel mapping
  - b. Land use
  - c. First floor elevations
- 5. Property Records Information
  - a. Legal descriptions
  - b. As-built documents
  - c. Historic data sets

### 4.4 **Project Implementation Report**

### 4.4.1 Alternatives Evaluation

### **General Requirements**

In the Alternatives Evaluation phase, data is collected with the intent of comparing alternative sites with regard to various disciplines and considerations. These data sets are usually generated from the following: existing as-built drawings (e.g., utilities and structures), remote sensing instruments (e.g., light detection and ranging [LiDAR], SHOALS, aerial photogrammetry, satellite imagery, and multi/hyperspectral imagery), historic data sets, and minimal topographic/hydrographic site surveys. The data shall be sufficient to identify typical elevations and cross-sections for numerical hydrologic & hydraulic modeling, economic impact determination, and gross quantities estimation.

Detailed data collections can result in higher than necessary costs and have a negative impact on the project schedule. It is important to strike a balance between cost, schedule (critical path), and the minimum needs of each discipline involved in order to determine the relative adequacy of each alternative. If the study area is small or homogenous it may be cost effective and schedule efficient to perform a more detailed survey suitable to satisfy the requirements for the TSP.

1. Historic Data Sets

Historic data sets shall be field verified and subsequently connected to the new survey. Detailed or extensive field verification is not necessary for Alternatives Evaluation surveys. The surveys are to be used as a quality check on remote sensing surveys.

### SURVEYING AND MAPPING

### 2. Data Density

Land or water based surveys shall be kept to a minimum during this phase. Estimates or generalizations shall be made from a minimum of "typical sections." Mass data points can be collected with less cost using remote sensing instruments.

### Survey Request

The requestor of the survey shall provide the following information to the surveyor:

- 1. Study area location and boundaries
- 2. End use of data to be collected
- 3. Specific features to be field captured and/or researched (as-built survey documents, legal records, GIS data, boring locations, and historic survey data sets)
- 4. Minimum required horizontal and vertical accuracy

Typically, the cost of the survey is proportional to the accuracy requested. Therefore, unless a cost benefit analysis indicates future savings that outweigh current costs, the Alternatives Evaluation survey shall not be performed to Plans & Specifications standards (i.e., suitable for design and publishing in contract bid document as specified by the controlling documents). The level of accuracy for the survey data shall be determined by the requestor.

5. Datum

All CERP projects shall originate from the CERP Geodetic Vertical Control network. The CERP datum shall be NAD83/02 and NAVD88. In addition to the datum, all control surveys shall be tied to previous monuments in the vicinity of the project. These monuments may include National Geological Survey (NGS) control monuments with second order or above NAD27, and NGVD29 published values unless this data acquisition is deemed cost prohibitive for the project.

Prior to 2003, CERP projects were tied to NAD83/90 and NAVD88 in addition to the CERP network, as final results of the network were not complete. Care shall be taken to verify that all data is properly transferred to the CERP network. Despite the name, the CERP Geodetic Vertical Control network is a horizontal and vertical control network. Although not available to the public, one requirement of the network was that NGS would provide USACE with "superceded" NGVD29 elevations for the network to facilitate migration from NGVD29 to NAVD88. The surveyor for the CERP project must be made aware of this data, as it not available outside of the USACE, Jacksonville District, and the SFWMD.

- 6. Historic data sets to be field verified for incorporation into design plans
- 7. Data density

### **Required Documentation/Products**

The following is a listing of documentation and products that shall be provided to the survey requestor in the Alternatives Evaluation phase.

1. Standard Products

Standard products are defined as those that are required as appropriate and include the following:

- a. MicroStation files
- b. AutoCAD files
- c. InRoads files
- d. Raw data files compatible with InRoads Survey, HYPACK, or GeoDAS as applicable
- e. ASCII files
- f. Paper plots (including check and final plots)
- g. Survey report, field books, and log sheets (MS-Word, MS-Excel, or Adobe PDF as specified)
- 2. Typical Products

Typical products are defined as those that are frequently stipulated for various reasons (Contractual requirements, construction, local sponsor, and/or presentations) and include the following:=

- a. 3D Models/Fly-throughs inclusive of all survey data, imagery, and alternative design model
- b. Environmental Systems Research Institute (ESRI) compatible files
- c. Quantities/volumes

#### 4.4.2 Design of Tentatively Selected Plan

#### **General Requirements**

In the TSP phase, a detailed survey and comprehensive data collection shall be conducted. Data presented to the user shall be of adequate quality and detail to facilitate the creation of final project design and the subsequent production of plans and specifications.

All other aspects of data collection and survey requests are the same as the Alternatives Evaluation phase.

### **Required Documentation/Products**

Deliverables shall be the same as those for the Alternatives Evaluation phase and shall include all the imagery (hard and softcopy) for the project.

### 4.5 Plans & Specifications

#### **General Requirements**

The purpose of a survey in the Plans & Specifications (P&S) phase is to identify and record any changes to the project site that may have occurred since the original TSP survey. Initial effort shall involve both an aerial and ground visual inspection/verification of the project site with the intent to identify possible changes of the site conditions. Any observed changes shall be researched and incorporated into the P&S survey. The scope of work for the ground verification or P&S survey shall be developed from the visual inspection.

All other aspects of data collection and survey request are the same as the Project Implementation Report (PIR) phase.

### **Required Documentation/Products**

For the P&S phase, the deliverables shall be the same as those for the TSP phase and shall include metadata and the Survey Report.

# SECTION 5 GEOTECHNICAL

### 5.1 General

The Geotechnical engineer shall plan field explorations, evaluate sites, perform analyses, interpret results of the analyses, and execute geotechnical and foundation designs. It is assumed that most geotechnical tasks are completed within the Project Implementation Report (PIR) phase. However, when canal and/or levee alignments or structure locations are changed after the PIR, additional field exploration work may be necessary at that time.

### 5.1.1 Design Elements

The following geotechnical design elements are applicable to all project phases and features.

1. Shallow Foundations

Shallow foundation analysis is applicable to the evaluation of existing sub-grade materials in regards to the safety of the foundation considering both bearing capacity and allowable settlement. Shallow foundations are suitable for relatively lightweight structures founded on competent subgrade materials.

Settlement and bearing computations are based on existing subsurface investigation data from the site. Bearing capacity is typically determined using closed form solutions based on the shear strength parameters provided from geotechnical investigations and empirical bearing capacity factors. Settlement computation methods are also based on site-specific strength parameters with closed form solutions used on simple projects and numeric solutions for complex project features. Settlement computations shall be completed for total and differential settlement.

Computational methods for determining the allowable settlement and bearing capacity on soils are given in EM 1110-1-1904 and EM 1110-1-1905 respectively. Methods for determining bearing capacity on rock foundations are given in EM 1110-1-2908. For building foundations, TM 5-818-1 shall be used for settlement and bearing capacity procedures.

Settlement computations must include the evaluation of immediate and consolidation settlement. Immediate settlement can be estimated through the use of Standard Penetration Test or Cone Penetration logs. In areas where consolidation settlements may be deemed significant, undisturbed samples of compressible cohesive strata shall be taken and tested in accordance with standard consolidation procedures under the loading conditions expected for the projected life of the structure. Procedures and reporting of consolidation tests shall be in accordance with the Jacksonville Exploration Manual and EM 1110- 2-1906.

For structures to be constructed in areas where highly plastic or expansive clays are encountered, the soils must be evaluated for swell potential in accordance with TM 5-818-7. Typically, consolidation tests with rebound curves, swell tests or soil suction tests are required for undisturbed samples taken at representative depths within the zone of influence of the foundation. Further provisions for embankment foundations are given in EM 1110-2-1913 and EM 1110-2-2300.

Typically, structures such as spillways, locks, pump structures and other concrete structures cannot tolerate excessive settlement. The limits of settlement for various structures are

detailed in the U.S. Army Corps of Engineers (USACE) engineering and Technical Manuals (TMs) with general guidance given in EM 1110-1-1904. The design shall follow the guidelines contained in these manuals for the planned structure and the site specific ground conditions. However, in some cases, founding of earth and rock fill embankments on soft sub-grade materials such as peat and other exceptionally soft or loose materials may be the only cost-effective approach to construction. In such cases, instrumentation to record settlement during construction is required.

Prior to construction, prediction of settlement shall be made based on core borings to establish the lithology and consolidation testing on undisturbed samples. This is typically accomplished through the installation of settlement plates or post-construction borings through the embankment at selected intervals along the crest and at the heel and toe of the embankment. The geotechnical engineer shall report the settlement, bearing capacity and foundation recommendations in the Geotechnical Report for the project features. This report shall include all laboratory and field logs, as well as test results.

2. Deep Foundations

Deep foundations shall be considered for project elements that are founded on subsurface materials of insufficient bearing capacity or that yield excessive settlement. Deep foundations are required to transfer the load to an adequate bearing subsurface layer or improve the underlying soils by reducing the bearing stresses or strengthening the existing soils.

Typically, deep foundations consisting of piles are used in areas where bearing capacity cannot be achieved in shallow layers. Piles used in practice include pressure treated timber piles for light structures and steel or pre-stressed concrete piles for heavier structures. Piles are designed for both tension and compressive loads depending on the structure and its anticipated reaction to applied forces. Piles are also designed for horizontal loading or a combination of vertical and horizontal loading as individual piles and groups.

Geotechnical guidance for pile foundation design is contained in EM 1110-2-2906. Standard software used for pile design includes SPT97 v1.5 for vertical loading and L-Pile, FLPIER, or COM624 for lateral loads. Pile design can be performed by closed form solution or by use of wave equation programs such as GRLWEAP.

Specifics on pile foundation design procedures can be obtained in the Jacksonville Exploration Manual. Geotechnical field explorations for deep foundations must be of sufficient depth to characterize the shear strength parameters and define the subsurface materials in the zone of influence of single piles as well as pile groups. Continuous Standard Penetration Tests (SPT) and Cone Penetration Tests (CPT) shall be conducted for the anticipated full depth of the pile influence zone. The contracting officer (USACE, South Florida Water Management District [SFWMD], or other cost-sharing agency as applicable) and Geotechnical Branch must approve the CPT prior to use on any project. The initial pile design is typically made using static analysis based on SPT and CPT results. If the CPT procedure is used, it must be used in conjunction with companion borings to retrieve samples and develop a profile to characterize the subsurface materials. The designer shall determine the frequency of companion borings. For some projects one companion boring may be necessary per CPT, while for other projects one companion boring may suffice for several CPTs. An example of such a project would be a bridge where one CPT and one SPT would be drilled per pier. The SPT would provide the geologic lithology directly by obtaining samples, while the CPT would obtain direct measurements of side friction and end bearing

with depth. When the CPT is performed, the geotechnical engineer shall include a plot of pile load capacity with depth, the recommended depth of penetration, and the final pile tip elevations of single and group piles in the Geotechnical Report. These data shall be used by the structural engineer for design purposes.

If applicable for the project, Static Load Tests can be performed during construction to either prove the load carrying capacity of the pile or to reduce costs. Proving the load carrying capacity is necessary for critical life-safety projects such as large bridges. Reduction of costs can be accomplished by the performance of Static Load Tests by two means. The first, as described in EM 1110-2-2906, allows the designer to use a lower factor of safety when a Static Load Test is performed. The second means is by providing data that may allow the designer to shorten the indicated production pile length by analysis based on SPT or CPT test data. The Statnamic test can be used as an economical alternative to a Static Load Test in granular materials where current industry experience indicates that the two tests show similar results. However, the Statnamic test is not recommended for pile foundations in clayey soils. The use of Static Load Tests (via reaction loading or Osterberg cell), Statnamic tests, dynamic load tests using a Pile Driving Analyzer (PDA), and other commercial load test methods shall be addressed in the specifications and included as a submittal requirement when used. All pile testing shall be subject to approval by the contracting officer (USACE, SFWMD, and other cost-sharing agency as applicable) and Geotechnical Branch.

During construction and prior to production pile installation, dynamic pile load tests using a PDA, or equivalent shall be used to calibrate the pile driving hammer and test the integrity of the pile during driving.

Excavation during construction for the placement of structures on deep foundations may require cofferdams or extensive shoring. Design provisions for dewatering during construction in deep excavations requires analysis of dewatering and design of tremie plugs to prohibit blowout from foundation heaving. Dewatering procedures and requirements are detailed in TM 5-818-5.

3. Retaining Walls

Retaining walls shall be installed as determined by the project requirements. Based on the project conditions, the structural engineer shall determine whether a flexible or rigid wall system is required. Flexible and rigid wall system design guidance is provided in EM 1110-2-2504 and EM 1110-2-2502 respectively.

Required geotechnical investigations include continuous split sampling and rock core boring to a minimum length of 10% of the penetration depth below the design pile tip elevation. For rigid walls, continuous split spoon sampling and rock core boring shall be taken until one of the following is true:

- A depth is reached below the footing base of two times the unsupported wall height.
- The boring penetrates 10 feet into firm or sound rock.
- The material takes more than 50 blows to penetrate six inches or less or 100 blows to penetrate one foot in an SPT.

Backfill with cohesive materials is typically not allowed. Additionally, rigid walls usually require cohesionless backfill and a drainage system behind the wall to reduce lateral pore pressure. The geotechnical engineer shall provide recommended soil and rock shear strength,

dry and saturated unit weight, index values, wall friction, sub-grade reaction values, coefficient of passive, active and at-rest earth pressure values, excavation and backfill requirements, and tieback and anchor pullout resistance values in the Geotechnical Report.

4. Seepage Control

Seepage is anticipated from reservoirs that impound water. Seepage must either be controlled or cutoff to prevent the migration of fine-grained foundation and embankment material (commonly referred to as piping), prevent or counter large uplift pressures, limit internal pore pressures, prevent flooding of adjacent lands, and handle potentially erosive seepage exit flows. Design methods for controlling or cutting off seepage are described in EM 1110-2-1901. In general, control measures consist of: toe drains, filters, chimney drains, blanket drains, zoning of fill materials, or pressure relief systems. Cutoffs can be partial or full systems and are typically considered impermeable or semi-permeable. The selection of the best seepage control device is typically evaluated during the Alternatives Evaluation phase. Detailed analyses are performed in the Design of Tentatively Selected Plan (TSP) phase using either flownet or 2D finite element method. The computer program SEEP2D shall be used for performing two-dimensional seepage analyses. Three-dimensional seepage analyses are rarely performed. If three-dimensional seepage analyses are required, they shall be performed with FEMWATER, MODFLOW, or another approved numeric modeling computer program. FEMWATER is to be used where sloping model features cannot be discretized adequately by the finite difference method of MODFLOW.

The selection of the design seepage control feature is dependant on the allowable seepage quantity, the cost effectiveness of the control system and the value of the retained water. General seepage control requirements must assure that exit gradients are kept to a minimum value as described in EM 1110-2-1901 and ETL 1110-2-555. The phreatic surface shall not exit on the downstream slope. A seepage collection trench at the downstream toe of all embankments is a minimum requirement. Caution shall be used to ensure that the seepage collection trench does not cut through a surficial formation and into very permeable strata. An example of this would be the cap rock over the Biscayne Aquifer in Dade County where all seepage would be lost into the Biscayne Aquifer if the cap rock were breached. Granular filters are required when pipeable materials such as fine sands, silts, and clays are in contact with soil of higher permeability or to an exposed face in the flow direction. The use of synthetic filter and liner materials is allowed per the scope of work for each project. Special seepage control features are required when porous foundation rock underlies a granular embankment or where there is a caprock foundation or other impermeable geological feature underlain by unconsolidated sediments.

Geotechnical investigations for seepage control shall include water pressure tests in fractured rock, borehole flowmeter tests, pump tests, slug tests, constant head recharge tests, specific capacity tests, and laboratory permeability tests on undisturbed and remolded soil and rock samples. Field double ring infiltrometer and percolation tests have been used in the past to determine vertical permeability along with laboratory tests. The appropriate field test will depend on the subsurface geology. For example, aquifer pump tests are recommended in highly permeable rock formations such as the Biscayne Aquifer in the Miami area. Permeabilities can also be estimated from grain size distribution on granular materials such as the Kozeny-Carman or Hazen equations; however, there are constraints associated with these relationships that shall be followed.

The geotechnical deliverables contained in the Geotechnical Report shall be the coefficient of horizontal and vertical permeability, transmissivity of aquifers, the identification of aquifers and aquicludes, leakage through an aquiclude, seepage quantities from the seepage analysis, recommendations for seepage control, drain materials, and filter materials. These values and coefficients shall be provided to the hydraulic and civil-site engineers. Contamination transport soil parameter may also be required in the Geotechnical Report. The need for contaminant transport parameter determination shall be determined by the project design team and shall be specified in accordance with the Geoenvironmental Section of the Geotechnical Branch.

Pilot projects are sometimes specified for large projects where their costs are justifiable. This may include modeling the effectiveness of seepage barriers through different methodologies to optimize the design and aid in selection of a final design alternative.

### 5. Slope Stability

Slope stability analysis is important for the design of dams and levees. General guidance for embankment design for earth and rock fill dams is provided in EM 1110-2-2300. EM 1110-2-1913 provides guidance for the design of levees. Formal slope stability analyses shall be performed for all permanent cuts deeper than six feet. Temporary cuts for utilities shall be sloped or shored in accordance with EM 385-1-1. Analysis of slope stability in soils shall be conducted in accordance with EM 1110-2-1913 for levees and EM 1110-2-1902 (Draft SEP 1993) for earth and rock fill dams. Interim USACE guidance for projects in Florida, which delineates the definitions of dams and levees, is contained in the Comprehensive Everglades Restoration Plan (CERP) Dam vs. Levee white paper (13 DEC 2000), which is included in the appendix. The slope stability manual for dams (EM 1110-2-1902) is currently under revision and the provisions of the current draft version of EM 1110-2-1902 (SEP 1993) is to be used, featuring Spencer's method of slices as the preferred slope stability method for all banks and cuts. Slopes are evaluated under different pool and tailwater elevations for loading cases anticipated to be experienced throughout the history of the slope. These loading cases, as specified in applicable engineer manuals (Ems), include end of construction placement, steady-state seepage with maximum storage pool, sudden drawdown and earthquake loading. However, the earthquake loading case is not evaluated in Florida.

Embankment materials shall be composed of suitable soil and rock materials. Suitable soils would consist of soils classified by the Unified Soils Classification System (USCS) as GW, GW-GM, GM, SW, SP, SW-SC, SW-SM, and SM. In general, crushed limerock is also suitable for embankment fill. Organic materials, trash, and fine-grained soil materials too wet for field compaction are considered unsuitable as embankment fill material. Embankment materials are typically obtained from the adjacent canal excavation or from material contained within the reservoir. However, these materials may be obtained off site if sufficient quantities of embankment materials are available in close proximity to the site. The most economical source of materials for the project is usually the source that is selected.

Earthen embankments may be homogeneous or zoned to account for seepage and strength characteristics of individual material types or limitations in available quantities. In areas where water retention is critical, impervious or semi-impervious material (CH, CL, ML, CL-ML, SC, GC, SM, and GM as defined by the USCS) may be required for the embankment core and cutoff trench. In some areas, rock shells may be more economical to use and more readily available. Rock slope protection may be required on slopes subject to wave action and erosive channel water velocities. In cases where embankments are zoned into more than one
material, the design must apply filters as required in EM 1111-1-1902, EM 1110-2-1901, EM 1110-2-1902, EM 1110-2-1913, and EM 1110-2-2300 to prevent piping or migration of materials from one zone to another. Transition areas lying between zones with a large difference in particle sizes may require more than one graded layer. For example, an embankment with a clay core and a gravel surface may require more than one graded layer to act as filters to prevent the piping of the clay. Zones within an embankment must be materially homogenous to the greatest extent possible.

Construction methods for embankments are detailed in EM 1110-2-1911, EM 1110-2-1913, and EM 1110-2-2300. Limit equilibrium analysis methods are sufficient for most slope stability analyses. However, deformation type analyses using numerical methods may be used in cases where estimation of stresses and pore pressures are required. Such cases may include, but are not limited to, the prediction of failure mechanism and location of failure surface. Additional information can be referenced in EM 1110-1-1902. Instrumentation of slopes may be required depending on the size of the project and site conditions. Instrumentation guidance is provided in EM 1110-2-1908. The computer program UTEXAS4 shall be used for all slope stability analyses. Pore pressure and seepage forces may be imported from the seepage program SEEP2D. Alternative software packages such as Slope/W, FLAC, or Plaxis may be used as a check to UTEXAS4 output.

Geotechnical investigations shall include continuous split spoon sampling and rock core drilling to a minimum depth of twice the unsupported height of the slope or to ten feet below the interface of firm/sound rock or material with SPT values exceeding 50 blows in six inches or less penetration or 100 blows in one foot of penetration, whichever occurs first. Borings in soft strata shall not be terminated in zero blow count material, but shall be advanced until a more competent stratum, as determined by the geotechnical engineer, is encountered. The defining of the depth at which a competent stratum is encountered is an essential part of the slope stability analysis. The requirements for drilling ten feet into cemented soil or rock may be relaxed if sufficient geological exploration data exists in the site area to ascertain, within reasonable certainty, the presence of bedrock within the depth of influence. Unconfined compression tests on undisturbed Shelby tube samples are typically required for stiff cohesive layers encountered within the depth of drilling. Piston or Osterberg samplers are typically used for obtaining undisturbed samples in soft or sensitive cohesive materials. The unconfined compression test is less expensive than triaxial compression testing; however, there may be conditions where triaxial tests may be required. Soil and rock index test parameters of the various layers encountered shall also be determined from laboratory tests. The geotechnical engineer shall provide the following to the civil-site and hydrology/hydraulic engineers:

- The results of the slope stability analyses for the project slope features the minimum factor of safety for all loading conditions as per EM 1111-1-1902 and EM 1110-2-1913.
- The soil/rock strength parameters.
- Recommendations for slope angles, filters, and drainage.
- Slope protection features.
- Control, drain materials, and filter materials.
- Contamination transport soil parameters (as required by the project scope of work).

Contamination transport soil parameters may also be required in the Geotechnical Report. The need for contaminant transport parameter determination shall be determined by the

Project Delivery Team (PDT) and shall be specified in accordance with the Geoenvironmental Section of the Geotechnical Branch.

6. Wells

Well design includes the design of observation wells, water quality monitoring-wells, relief wells, Aquifer Storage & Recovery (ASR) wells and piezometers. Design of observation, relief wells, and piezometers is described in EM 1110-2-1901 and the Jacksonville Exploration Manual. Water quality monitoring-well guidance and ASR well design guidance can be obtained from the Geoenvironmental Section of the Geotechnical Branch of the USACE. Well requirements are defined during the Alternatives Evaluation phase. Monitoring wells and piezometers may be installed during the Alternatives Evaluation phase as required. Wells designed for injection must be licensed by the state in which they are to implemented. For this reason injection tests to determine groundwater flow properties are discouraged. Furthermore, installation of long-term wells usually requires a lease agreement with private property owners.

Geotechnical investigations for wells include continuous split spoon sampling and rock core boring to the minimum depth of the well. Continuous borehole geophysical tests are typically required in a companion boring within ten feet of the split spoon boring. Required geophysical tools for borehole logging shall be as specified by the Geology Section of the Geotechnical Branch of the USACE. Field pumping tests and other field tests for determining the hydraulic flow characteristics of the subsurface materials shall be conducted as required. Laboratory index tests and permeability tests are also routinely performed to estimate hydraulic conductivity.

7. Earthwork

Earthwork design includes the testing, evaluation, and specification of excavation, handling, and placement of in-situ and imported soil and rock materials. Ground improvement techniques are also included here because these aspects are not unique to any other single geotechnical task. Excavation is typically accomplished in soil and weathered rock with standard mechanical construction equipment; such material is considered to be rippable. Insitu material that cannot be excavated economically by mechanical means shall be reduced to workable particle sizes through blasting techniques. Whether a material is rippable or not can be determined by evaluating historical subsurface information about the in-situ formations, core-boring data coupled with rock mass classification techniques, or by evaluation of empirical relationships between seismic p-wave velocities and rock types. Excavation requirements and blast design parameters for project features need to be provided, as soon as they are available, to the civil-site and structural engineers to assist in finalization of the site location. Additionally, these data shall be included in the Geotechnical Report. Blasting design and excavation methods are described in EM 1110-2-3800, ETL 1110-2-282, and FHWA-HI-92-001.

Material handling and processing involves field scalping, screening, mixing, stockpiling, and hauling of material prior to placement during construction. Specific requirements are contained in the applicable technical references for the particular feature of work. For embankments, material handling details are described in EM 1110-2-1913, EM 1110-2-1911, and EM 1110-2-2300. For projects requiring riprap, material handling is described in EM 1110-2-5025 and EM 1110-2-5027. Geologic profiles and bulking factors for soil and rock excavation and

fill shall be provided to the civil-site engineer for computation of quantities for completion of the cost estimate for each phase of design.

Design of fill material involves evaluation of the suitability and placement characteristics of the desired material. Suitable fill is typically described as per the USCS designation. It is standard practice to include granular USCS soil types as suitable, including sands (SW, SP, SW-SC, and SW-SM) and gravels (GW, GP, GW-GC, and GW-GM). The exceptions are OH, OL and peat (Pt). Rubbish and trash, though not USCS material classifications, are also not suitable for fill. Additionally, clays (CH and CL), clayey sands (SC), clayey gravels (GC), and plastic silts (MH) are typically considered to be unsuitable due to their high moisture content In-Situ and subsequent difficulty in achieving the required compaction. However, there are cases where these materials can be processed or treated to make them suitable as fill material. Non-plastic silts (ML), silty sands (SM), and silty gravels (GM) may be suitable if compaction can be achieved under the worst case at the in-situ moisture content.

Unsuitable material within the limits of excavation is either relocated to a designated disposal area or becomes the property of the contractor who will in-turn coordinate the removal of the material from the site. Fill material containing oversized particles are also considered unsuitable. Maximum particle size requirements for buildings, open areas, and subsurface structures are described in TM-5-818-1 and TM 5-818-4. Maximum particle size requirements for embankments are described in EM 1110-2-2300, EM 1110-2-1911, and EM 1110-2-1913. Except in open areas not subject to loading, fill materials are compacted per project specific/feature requirements. For embankment construction, placement by hydraulic methods is not allowed. Compaction limits, lift thickness, and quality control requirements are described for cohesive and non-cohesive materials in TM 5-818-1, EM 1110-2-2300, EM 1110-2-1911, and EM 1110-2-1911, and EM 1110-2-1911, and EM 1110-2-1913. The degree of compaction is measured as a percentage of the maximum dry density as determined by the modified Proctor procedure (ASTM D 1557-91).

8. Ground Improvement

There are numerous ground improvement techniques available to improve the subsurface materials to meet design requirements for strength, bearing, permissible deformation, and seepage control. These include techniques to improve properties by mechanical means, synthetic reinforcement, chemical additives, or by altering the material chemistry, which must be done in accordance with Florida Department of Environmental Protection (FDEP) requirements. Commonly accepted ground improvement techniques include the following:

- Compaction
- Vibrocompaction
- Vibrofloatation
- Preloading and wick drains
- Dynamic compaction
- Slurry walls
- Liners
- Geotextiles

Geotextiles are the most common synthetic improvement medium. Design methods for their use are contained in TM 5-818-8. Geotextiles include filter fabric and reinforcing

membranes. Filter fabric is designed strictly for filtration and material separation purposes. Reinforcing membranes are used for strengthening of the soil material. The use of filter fabrics for utility trench drains, prevention of soil pumping in subgrades during construction, and separation for wall backfill is encouraged. Filter fabric is typically not used in the place of granular filters in embankment construction. Composite filter fabric synthetic drainage material may be useful in some applications. Chemical additives include grouting and lime stabilization of clays. Each of these techniques has optimal effectiveness for specific site conditions and for specific soil and rock types.

Any ground improvement technique may be proposed as a cost-effective alternative to conventional treatment such as replacement or standard compaction. The geotechnical engineer must provide the alternative method in a written proposal to the Geotechnical Branch of the USACE for review and approval. The proposal must provide commercially accepted design standards for the approach along with case histories of the technique success on various projects with similar site conditions found at the feature site.

9. Scour/Erosion Protection

Scour protection is required for design of channels when water velocities exceed the provisions of EM 1110-2-301. Design guidance for channel slope stabilization is given in EM 1110-2-301. Erosion protection for levee and dam earth slopes in Florida is accomplished by hydroseeding or installation of sod. However, in a high wave or high flow environment, riprap or synthetic slope protection may be required. Design details for typical practice on CERP may be obtained from the Levees and Waterways section of the USACE. Interior slopes of dams and levees in reservoir areas subject to wave action may require slope protection. Design guidance is found in EM 1110-2-2302, EM 1110-2-2300, EM 1110-2-1414, and the USACE Shore Protection Manual (1984) – *Impoundments Subject to Wave Action*.

10. Hazardous and Toxic Waste

Guidance for geotechnical design requirements for sites that contain hazardous and toxic waste is available from the USACE Geoenvironmental Section of the Geotechnical Branch. Applicable references shall be provided by the Geoenvironmental section. Typically, any hazardous or toxic waste material found during the Alternatives Evaluation or Design of Tentatively Selected Plan phase shall be reported and assessed in accordance with U.S. Environmental Protection Agency (EPA), FDEP, and local environmental regulations. The presence of contaminants shall be reported to the PDT when discovered.

11. Ground Anchors

Ground anchors refer to tension members such as rock bolts, tendons, or strap and anchor block tiebacks. Applications typically include tie down of tremie plugs for deep excavations, rock-bolting anchors for securing of submerged tanks, and tieback anchors for retaining walls in earth and rock. Rock anchors may also be used for stability of walls in some applications. Design provisions for ground anchors are contained in EM 1110-2-2907, EM 1110-2-2504, EM 1110-2-2502, and FHWA-DP-68-1R. Geotechnical investigations conducted in support of the anchor design shall include sufficient subsurface data to provide shear strength parameters of the material in the anchor bond area. This data shall include field interpretation of SPT data, laboratory soil and shear strength tests, and unconfined compression strength

tests on rocks and clays. Pullout tests or proof tests are specified at the beginning of construction and prior to production anchor installation.

### 5.2 References

#### **Engineering Manuals**

EM 385-1-1, Safety and Health Requirements, 03 September 1996

EM 1110-1-1003, NAVSTAR Global Positioning System Survey, 01August 1996

EM 1110-1-1801, Geotechnical Investigations, 01January 2001

EM 1110-1-1802, Geophysical Exploration for Engineering & Environment, 31August 1995

EM 1110-1-1804, Geotechnical Investigations, ENG 1836, ENG 1836A, 29 February 1984

*EM 1111-1-1902, Slope Stability Manual*, 10 September 1993 (DRAFT)

*EM 1110-1-1904, Settlement Analysis*, 30 September 1990

EM 1110-1-1905, Bearing Capacity of Soils, 30 October 1992

EM 1110-1-1906, Soil Sampling, 30 September 1996

EM 1110-1-2907, Rock Reinforcement, 15 February 1980

EM 1110-1-2908, Rock Foundations, 30 November 1994

EM 1110-1-3500, Chemical Grouting, 31 January 1995

*EM 1110-1-4000, Monitoring Well Design, Installation, & Documentation, CEMP-RT at HTRW Sites,* 01 November 1998

*EM 1110-2-301, Guidelines for Landscape Planting at Floodwalls, Levees & Embankment Dams,* 01 January 2000

*EM 1110-2-1601, Hydraulic Design of Flood Control Channels*, 30 June 1994 Change 1, ENG 4794-R

EM 1110-2-1614, Design of Coastal Revetments, Seawalls & Bulkheads, 30 June 1995

EM 1110-2-1810, Coastal Geology, 31 January 1995

*EM 1110-2-1901, Seepage Analysis & Control for Dams*, CH 1, 30 September '86/30 April '93, Chg 1

EM 1110-2-1902, Stability of Earth & Rock Fill Dams, CH 1, 01 April 1970

EM 1110-2-1906, Laboratory Soils Testing, CH 1-2, 30 November '70/20 August '86

# GEOTECHNICAL

EM 1110-2-1908, Instrumentation of Embankment Dams & Levees, 30 June 1995

*EM 1110-2-1909, Calibration of Laboratory Soils Testing Equipment*, 01 December '70/10 March '86, Chg 1

EM 1110-2-1911, Construction Control for Earth & Rock-Fill Dams, 30 September 1995

EM 1110-2-1913, Design & Construction of Levees, 30 April 2000

EM 1110-2-2006, Roller-Compacted Concrete, 15 January 2000

EM 1110-2-2200, Gravity Dam Design, 30 June 1995

*EM 1110-2-2300, Earth & Rock-Fill Dams General Design & Construction, Considerations*, 31 July 1994

EM 1110-2-2302, Construction With Large Stone, 24 October 1990

EM1110-2-2502, Retaining Walls, 25 September 1992

*EM 1110-2-2504, Design of Sheet Piles*, 31 March 1994

*EM 1110-2-2901, Tunnels & Shafts in Rock, 30 May 1997* 

EM 1110-2-2904, Design of Breakwaters & Jetties, 08 August 1986

EM 1110-2-2906, Design of Pile Foundations, 15 January 1991

EM 1110-2-3506, Grouting Technology, 20 January 1984

EM 1110-2-3800, Systematic Drilling & Blasting for Surface Excavations, 01 March 1972

EM 1110-2-5025, Dredging & Dredged Material Disposal, 25 March 1983

EM 1110-2-5027, Confined Disposal of Dredged Material, September 1987

#### **Engineering Regulations**

*ER* 1105-2-101, Risk-Based Analysis for Evaluation of, Hydrology/Hydraulics, Geotechnical Stability, & Economics in Flood Damage Studies, 01 March 1996

ER 1110-1-261, Quality Assurance of Laboratory Testing Procedures, 28 April 1999/15 June '99

ER 1110-1-1807, Procedures for Drilling in Earth Embankments, 30 September 1997

ER 1110-1-1901, Project Geotechnical & Concrete Materials Completion, Report for Major USACE Projects, 22 February 1999

ER 1110-1-2005, Compilation of Concrete Aggregate & Stone Riprap Test Data, 01 January 1999

ER 1110-1-8100, Laboratory Investigations & Testing, 31 December 1997

ER 1110-1-8155, Specifications, 24 December 1998/CECW-E

ER 1110-2-100, Periodic Inspection & Continuing Evaluation of Completed, 15 February 1995

ER 1110-2-101, Reporting of Evidence of Distress of Civil Works Structures, 15 March 1996

ER 1110-2-103, Strong Motion Instrument for Recording Earthquake, Motions on Dams, 10 December 1981

ER 1110-2-112, Required Visits to the Construction Sites by Design Personnel, 15 April 1992

ER 1110-2-1150, Engineering & Design for Civil Works Projects, 31 August 1999

ER 1110-2-1155, Dam Safety Assurance Program, 12 September 1997

ER 1110-2-1156, Dam Safety -Organization, Responsibilities, & Activities, 31 July 1992

ER 1110-2-1200, Plans & Specifications for Civil Works Projects, 30 October 1993

ER 1110-2-1806, Earthquake Design & Evaluation of Civil Works Projects 31July 1995/EG

*ER 1110-2-1925, Field Control Data for Earth & Rockfill Dams*, 03 July 1969 (RCS: ENG CW-E-11(R1), Chg 1-2

ER 1110-2-1942, Inspection, Monitoring & Maintenance of Relief Wells, 25 September 1998

*ER 1110-2-2902, Prescribed Procedures for the Maintenance Protection Works & Operation of Shore,* 30 June 1989

### **Engineer Technical Letters**

ETL 1110-1-138, Standard Penetration Test, 31 March 1988

ETL 1110-1-162, Checklist for Hazardous Waste Landfill Cover Design, 30 September 2001

ETL 1110-1-183, Using differential GPS Positioning for Elevation Determination, 01 April 1998

ETL 1110-1-184, Use of the U.S. Coast Guard Differential Global Positioning System and the Continuously Operating Reference Station System, 01 October 1998

ETL 1110-1-185, Guidelines on Ground Improvement for Structures and Facilities, 01 February 1999

ETL 1110-2-231, Initial Reservoir Filling Plan, 30 March 1979

ETL 1110-2-256, Sliding Stability for Concrete Structures, 24 June 1981

ETL 1110-2-281, Reservoir Contaminants, 17 June 1983

# **GEOTECHNICAL**

ETL 1110-2-282, Rock Mass Classification Data Requirements for Rippability, 30 June 1983

ETL 1110-2-286, Use of Geotextiles under Riprap, 25 July 1984

ETL 1110-2-299, Overtopping of Flood Control Levees and Floodwalls, 22 August 1986

ETL 1110-2-309, Water and Wastewater Laboratory Inspections, 05 February 1988

*ETL 1110-2-334, Design and Construction of Grouted Riprap*, 21 August 1992

ETL 1110-2-343, Structural Design Using the Roller-Compacted Concrete (RCC) Construction Process, 31 May 1993

ETL 1110-2-362, Environmental Engineering Initiatives for Water Management, 31 July 1995

ETL 1110-2-544, Geotechnical Analysis By The Finite Element Method, 31 July 1995

ETL 1110-2-547, Introduction to Probability and Reliability Methods for Using Geotechnical Engineering, 30 September 1995

ETL 1110-2-555, Design Guidance on Levees, 30 November 1997

ETL 1110-2-556, Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies, 28 May 99

ETL 1110-8-11, Underwater Blast Monitoring, 15 July 1991

*ETL 1110-8-14, Selected USACE References Relating to Hazardous and Toxic Waste Activities,* 08 Feb 1991

#### **Technical Manuals**

*TM* 5-818-1, Soils and Geology Procedures for Foundation Design of Buildings and Other Structures (Except Hydraulic Structures), 21 October 1983

TM 5-818-4, Backfill for Subsurface Structures, 01 June 1983

TM 5-818-5, Dewatering and Groundwater Control (Incl. C1), 01 June 1981

TM 5-818-6, Grouting Methods and Equipment (Incl. C1), 27 February 1970

TM 5-818-7, Foundations in Expansive Soils (Incl. C1), 01 September 1983

TM 5-818-8, Engineering Use of Geotextiles, 20 July 1975

#### **Other Government Publications**

CERL Rock Testing Handbook, 1993

FHWA-HI-92-001, Rock Blasting and Overbreak Control, 1991

FHWA-DP-68-1R, Permanent Ground Anchors, 1988

USBR Drainage Manual, 1984

Jacksonville Exploration Manual - DRAFT, 2002

CERP Dam vs. Levee white paper (13 DEC 2000)

#### American Society of Testing and Materials (ASTM) Standards

C 117-90, Test Method for Material Finer Than 75 –um (n 0.200) Sieve in Material Aggregates for Washing

C 136-84, Method for Sieve Analysis of Fine and Coarse Aggregates

D 420-87, Recommended Practice for Investigating and Sampling Soil and Rock for Engineering Purposes

D 421-85, Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants

D 422-63, Method for Particle-Size Analysis of Soils

D 653-90a, Terminology relating to Soil, Rock and Contained Fluids

D 698-91, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3) (600kN-m-m/3)

D 1140-54, Test Method for Amount of Material in Soils Finer than the No.200 (75-um) Sieve

D 1241, Specification for Materials for Soil-Aggregate Sub-base, Base, and Surface Courses

D 1452-80, Practice for Soil Investigation and Sampling by Auger Borings (1990)

D 1556-90, Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

D 1557-91, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

D 1586-84, Method For Penetration Test and Split-Barrel Sampling of Soils

D 1587-83, Method For Thin-Walled Tube Sampling of Soils

D 2113-83, Method for Diamond Core Drilling for Site Investigation (1987)

D 2167-84, Test Method for Density and Unit Weight of Soil In-Place by the Rubber Balloon Method (1990)

D 2216-90, Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock

D 2487-90, Classification of Soils for Engineering Purposes

D 2488-90, Practice for Description and Identification of Soils (Visual- Manual Procedure)

D 2922-91, Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

D 2937-83, Test Method for Density of Soil in Place by the Drive-Cylinder. 6-2

D 2938-95, Standard Test Method for Unconfined Compressive Strength of Intact Rock Core Specimens

D2974-00, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

D 3017-78, Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

D 3740-88, Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design

D3967-95a(2001), Standard Test Method for Splitting Tensile Strength of Intact Rock Core Specimens

D 4043-91, Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques

D 4044-91, Test Method (Field Procedure) for Instantaneous Change in Head (Slug Test) for Determining Hydraulic Properties of Aquifers.

D4318-00, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

D 4428/4428M-91, Test Method for Cross-hole Seismic Testing

D 4718-87, Practice for the Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

D 4829-88, Test Method for Expansion Index of Soils

G 57-78, Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

G 57-78, Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method (1984)

### 5.3 **Project Implementation Report (PIR)**

#### 5.3.1 Alternatives Evaluation

#### **General Requirements**

The Alternatives Evaluation phase of the geotechnical design process shall consist of limited geotechnical investigations and analyses to screen alternative design features. However, the geotechnical investigations shall be of sufficient scope to permit selection of the most favorable site within the physical region, determine the general type of structure or system best suited to the site conditions, evaluate the influence of hydrogeology on site design and construction, assess the geotechnical aspects of environmental impact, and to ascertain the costs of developing the various project plans in sufficient detail to allow comparative cost estimates to be developed. The decision on when to or when not to do an Alternatives Evaluation shall be at the discretion of the PDT in accordance with the provisions of the Project Management Plans for a particular project.

A literature search shall be performed prior to any geotechnical field exploration. All geotechnical field exploration is typically performed by government exploration staff or by inhouse geotechnical specialty contracts administered by the Geotechnical Branch of the USACE. Geotechnical exploration investigations can be performed by A/E design contracts only by exception and with consent of the Geotechnical Branch. Investigations consist of subsurface drilling to determine material characteristics (soil and/or rock materials), field sampling, field borehole tests, field surficial testing, geophysical testing, earth materials, water physical, and chemical testing.

General guidance for conducting field geotechnical investigations, and the applicable surveying, drilling, sampling, testing, and reporting standards are found in the Jacksonville Exploration Manual. Other applicable references for the drilling, logging, sampling, geophysical investigations, field testing, and laboratory testing are contained in DM 1110-1-1, EM 1110-1-1804, EM 1110-1-1802, EM 1110-1-1906, EM 1110-1-4000, EM 1110-2-3800, ER 1110-1-1807, and ER 1110-1-8100. Computer-generated boring log procedures for producing digital boring logs are available from the Geotechnical Branch and are required on all CERP projects. Additional exploration requirements can be obtained from the Geotechnical Branch.

Exploration efforts during the Alternatives Evaluation phase typically consist of limited perimeter shallow borings supplemented by deep borings with geophysical logging, geophysical surface survey and associated field-testing, sampling, and laboratory testing. Drilling is typically accomplished by continuous split-spoon sampling testing techniques and core drilling through rock. Hazardous and toxic waste investigations may also be required.

Geotechnical design efforts during this phase consist primarily of reduction and interpretation of field investigation data, and engineering analysis of subsurface conditions sufficient to screen alternatives, identify adverse site conditions and identify cost-effective alternatives. Such analyses are minimal in scope and data gaps are supplemented by historical data from the site area and from similar previous design parameters. Geotechnical analyses that may be required include subsurface material classification, seepage analyses, bearing capacity analyses, borrow investigations, settlement analysis, detailing of the area hydrogeologic framework and slope stability analysis. Geotechnical analysis and design shall follow the provisions of CESAJ-EN-G Jacksonville Exploration manual. Current design references include EM 1110-1-1904, EM 1110-1-1905, EM 1110-2-1901, EM 1110-2-1902, EM 1110-2-1913, ER 1105-2-101, and ER 1110-2-

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1150. Work under this phase may also be supplemented by references TM 5-818-1, TM-5-818-4, and TM-5-818-8.

1. Embankments (Levees, Dams), Canals, and Floodwall

Geotechnical investigations for these features include shallow perimeter core borings to a depth up to 60 feet at perimeter corners and interior perimeter borings spaced between half a mile and one mile. At least one deep boring (>60 feet) for regional hydrogeologic groundwater modeling may be required in each reservoir. Typically, this shall be accompanied by geophysical logging in the completed core boring after over-reaming or in a companion boring. The depth shall be dependent on the site geology and depth of the level of influence sought by the groundwater modelers. Core boring data shall be supplemented by perimeter surface geophysical surveys using the most cost-effective method best suited to the site. Laboratory testing shall be performed on disturbed samples unless there is a specific requirement for undisturbed sampling. Field tests shall consist of methods required to provide hydrologic groundwater flow parameters for modeling purposes and general assessment of deformation and strength of foundation and fill materials. Wash core borings or push tube borings may be required for widening and deepening of channels to ascertain presence of shallow rock and/or the thickness of muck deposits in existing canals. Prospective new canal alignments shall be drilled with enshallow core borings at a spacing of one mile, supplemented by surficial geophysical surveys along the proposed alignment. Typically, these borings are no deeper than 10 feet below the channel bottom.

Geotechnical analyses and design performed during the Alternatives Evaluation phase will typically consist of two-dimensional seepage analysis to screen alternatives at different impoundment levels. Assessment of magnitude of settlement on soft foundations, presence of contaminated soils, and simplified slope stability computations are appropriate during this phase of design.

2. Waterways

Wash core borings in existing waterways or push tube borings may be required for widening and deepening of existing waterways to ascertain presence of shallow rock and/or the thickness of muck deposits in existing canals. Prospective new waterway alignments shall be drilled with shallow core borings at a spacing of one mile, supplemented by surficial geophysical surveys along the proposed alignment. Typically, these core borings are no deeper than ten feet below the channel bottom.

Boring data shall be supplemented by perimeter surface geophysical surveys using the most cost-effective method best suited to the site. Laboratory testing shall be performed on disturbed samples unless there is a specific requirement for undisturbed sampling. Field tests shall consist of field methods required to provide hydrologic groundwater flow parameters for modeling purposes and for general assessment of deformation and strength of foundation and fill materials.

Typically, geotechnical analyses performed during the Alternatives Evaluation phase will consist of two-dimensional seepage analysis to screen alternatives at different impoundment levels. Assessment of magnitude of settlement on soft embankment foundations, presence of contaminated soils, and simplified slope stability computations are also appropriate.

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#### 3. Pumping Stations

Geotechnical investigations for pumping stations include evaluation of historical geotechnical subsurface data from the area. However, the investigations are typically not performed until the TSP.

Geotechnical analysis to be performed includes the examination of existing subsurface data for assessment of potential adverse foundation conditions, potential footing seat location, and foundation typing (i.e., spread footing, mat, or deep).

4. Utility Relocations

Geotechnical investigation includes the evaluation of historic geotechnical subsurface data from the area. Field geotechnical investigations for utility relocations are typically not performed until a definite utility alignment has been decided. For final alignments, probes shall be performed at each turning point in the utility alignment. Probes for use in investigation can be push tube or auger type. Auger probes shall be run to a depth of at least two pipe diameters below the design pipe invert elevation.

Geotechnical analysis performed for this feature is the examination of existing subsurface data for assessment of potential for adverse pipe seat conditions, and the shoring requirements for excavations.

5. Bridges & Roadways

Geotechnical investigations for bridges and roadways include evaluation of historical geotechnical subsurface data from the area. However, the investigations are typically not performed until the TSP.

Geotechnical analyses to be performed include the examination of existing subsurface data for assessment of potential adverse foundation conditions, and evaluation and availability of suitable borrow materials for road construction.

6. Administrative Facilities

Geotechnical investigations for administrative facilities include evaluation of historical geotechnical subsurface data from the area. Site requirements for water, power, and real estate acquisition are coordinated through the Levee and Waterways Section of the Design Branch. However, the investigations are typically not performed until the TSP.

Geotechnical analyses to be performed include the examination of existing subsurface data for assessment of potential adverse foundation conditions.

7. Wastewater Treatment Plants

Geotechnical investigations for wastewater treatment plants include evaluation of historical geotechnical subsurface data from the area. However, the investigations are typically not performed until the TSP.

Geotechnical analyses to be performed include the examination of existing subsurface data for assessment of potential adverse foundation conditions and potential footing seat location.

Preliminary evaluations can be conducted with existing subsurface data for assessment of hydrogeology flow and contaminant transport parameters.

8. Spillways

Geotechnical investigations for spillways include evaluation of historical geotechnical subsurface data from the area. However, the investigations are typically not performed until the TSP.

Geotechnical analyses to be performed include the examination of existing subsurface data for assessment of potential adverse foundation conditions and potential footing seat location.

#### **Required Documentation/Products**

A Geotechnical Report shall be compiled during the Alternatives Evaluation phase that shall be included in the appendix to the Alternatives Evaluation document. The geotechnical portion of the appendix shall contain a write-up of the existing subsurface conditions based on historical and field data retrieved during this phase of the design. It shall also contain any geotechnical analyses or assessments conducted during this phase or from prior studies done at the project site. All core boring and geophysical logs, geophysical survey results, geomaterial laboratory results, and field-testing data shall be included in the Geotechnical Report.

#### 5.3.2 Design of Tentatively Selected Plan

#### **General Requirements**

The level of detail in the TSP phase is 100 percent of the geotechnical exploration and design effort for the PIR. The geotechnical design for the TSP phase shall provide information to support the cost estimate decisions regarding the functional and technical design of structures necessary to achieve project objectives and development of construction plans and specifications. Upon the commencement of this phase, all final project feature locations are fixed and final geotechnical field investigations shall be completed along with all geotechnical analyses and design details.

The final product is the Geotechnical Report that is an integral part of the final PIR document. The Geotechnical Report shall be completed by the end of this phase using the results of the all field investigations up to that point in the design. Supplemental field investigation results and analyses shall be appended to the Geotechnical Report. The Geotechnical Report and preliminary design geotechnical data are to be provided as required by other disciplines specified in this manual. All geotechnical investigations shall be complete by the concept design level of the TSP phase. At that time, a concept Geotechnical Report shall be submitted for review to the Geotechnical Branch of the USACE. This document shall contain all field data and logs collected during the Alternatives Evaluation and TSP phases, as well as all geotechnical design parameters, analyses, and designs completed to that point. The concept and final Geotechnical Report is subject to review by USACE technical staff members.

Procedures, standards, and references for geotechnical explorations during the TSP phase include those described during the Alternatives Evaluation phase. The scope, however, is much more definitive and detailed and is focused on the selected alternative generated through the Alternatives Evaluation phase. Core borings for fixed structures such as pumping stations, spillways, outlet works, and buildings are performed to depths required within the zone of influence of the design loads to the foundation. Additionally, these borings are used to define the

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footing seat conditions, identify a suitable foundation type for bearing or anchoring, and the subsurface profile for the preliminary required depth of deep foundations. Embankment core borings are performed at fixed intervals to depths that define the zone of influence of the loads and adequately delineate the flow characteristics of the underlying subsurface materials.

Shallow core borings shall be conducted in new channels or canals to ascertain excavation conditions, the presence and quantity of rock, quality of rock, and the nature of the material to be side cast for use as fill. Wash borings and barge mounted push tube sampling shall be performed in existing channels to determine the depth to rock, quality of the material to be excavated, and thickness of organic sediments. Final core borings may be supplemented by geophysical surveys to define layers between systematic core borings. Boring spacing and depths are dependent upon site conditions, type of structure, and the phase of the project. Boring locations and depths, and geophysical survey depths require professional judgment.

General guidance for CERP projects is provided in the CERP Geotechnical investigations committee paper on subsurface investigations, which is in draft form in the CERP guidance manual. Individual drilling and testing program spacing needs to be coordinated with the USACE, Geotechnical Branch prior to field exploration. Each exploration program shall be adapted to the project conditions on a case-by-case basis. Detailed laboratory and field tests shall be conducted in this phase, which will include index and physical property tests on all differing materials in order to determine the subsurface material adequacy for bearing, flow, and use as fill material. Final groundwater pumping and other flow tests shall be performed as required during this stage to determine hydraulic conductivity and other groundwater flow parameters necessary for final design of seepage control features.

Analysis and design during this phase includes detailed evaluation of:

- Seepage control
- Settlement
- Slope stability
- Wells
- Erosion protection
- Erosion control
- Geo-material design
- Excavation and filling
- Hazardous and toxic waste design
- Ground improvement
- Bearing capacity of shallow foundations
- Capacity of deep foundations
- Loading to retaining walls
- Embankments (levees, dams), canals, and floodwalls

Wash core borings in existing canals or push tube borings may be required for widening and deepening existing channels to ascertain presence of shallow rock and/or the thickness of muck deposits in existing canals. Prospective new canal alignments shall be drilled with shallow core borings. Typically, these core borings are no deeper than ten feet below the channel bottom. For existing and new canals, wash probes, push tube sampling, and core boring spacing shall not be less than 500 feet nor greater than 1,000 feet.

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Historical core boring data may be used in lieu of new core borings provided they are within the footprint of the structure and are to the same prospective design depths. Embankment and retaining wall core borings shall be drilled to a depth prescribed in design elements Slope Stability and Retaining Walls at a spacing of not less than 500 feet nor greater than 1,000 feet. For embankments, these core borings shall be systematically staggered along the entire alignment of the embankment toe, heel, and centerline. For retaining walls, these borings may be staggered for rigid walls (at the geotechnical engineer's discretion), or along the wall centerline for sheetpiles. The spacing requirements may also be relaxed with permission from the Geotechnical Branch of the USACE where ground subsurface conditions are uniform and reliable geophysical surveys along the alignment have been performed.

Boring data may be supplemented by perimeter surface geophysical surveys using the most cost effective method best suited to the site. Laboratory testing shall be performed on disturbed samples unless there is a specific requirement for undisturbed sampling. Field tests will consist of field methods required to provide hydrologic groundwater flow parameters for modeling purposes and for general assessment of deformation and strength of foundation and fill materials.

Geotechnical analyses performed during this phase shall consist of performing the geotechnical tasks detailed in design elements Slope Stability, Retaining Walls, Seepage Control, Earthwork, Shallow Foundations, and Deep Foundations. Assessment of magnitude of settlement on soft embankment foundations, presence of contaminated soils, and simplified slope stability computations shall be performed.

#### 1. Waterways

Wash core borings in existing waterways or push tube borings may be required for widening and deepening of existing channels to ascertain the presence of shallow rock and/or the thickness of muck deposits in existing canals. Prospective new waterway alignments shall be drilled with shallow core borings. Typically, these core borings are no deeper than ten feet below the channel bottom. For existing and new waterway wash probes, push tube sampling and core boring spacing shall not be less than 500 feet nor greater than 1,000 feet.

Historical core boring data may be used in lieu of new core borings provided they are in proximity to the alignment and are to the same prospective design depths. Embankment and retaining wall core borings shall be drilled to a depth as prescribed in design elements Slope Stability and Retaining Walls at a spacing of not less than 500 feet nor greater than 1000 feet. For embankments, these core borings shall be systematically staggered along the entire alignment of the embankment toe, heel, and centerline. For retaining walls, these borings may be staggered for rigid walls (at the geotechnical engineer's discretion), or along the wall centerline for sheetpiles. The spacing requirements may also be relaxed with permission from the Geotechnical Branch of the USACE where ground subsurface conditions are reliably uniform and reliable geophysical surveys along the alignment have been performed.

Boring data may be supplemented by perimeter surface geophysical surveys using the most cost-effective method best suited to the site. Laboratory testing shall be performed on disturbed samples unless there is a specific requirement for undisturbed sampling. Field tests shall consist of field methods required to provide hydrologic groundwater flow parameters for modeling purposes and for general assessment of deformation and strength of foundation and fill materials.

Geotechnical analyses performed during this phase will consist of performing the geotechnical tasks detailed in design elements Slope Stability, Retaining Walls, Seepage Control, Earthwork, Shallow Foundations, and Deep Foundations. Assessment of magnitude of settlement on soft embankment foundations, presence of contaminated soils, and simplified slope stability computations shall be performed.

2. Pumping Stations

Geotechnical investigations for this feature include shallow or deep borings dependant on site conditions from previous investigations and evaluation of historical geotechnical subsurface data for the area. Investigations are fixed location boring directly under the proposed footing location with a minimum of one center boring and one corner boring to evaluate total and differential settlement. Projected boring depths are contained in design elements Ground Anchors, Retaining Walls, Shallow Foundations, and Deep Foundations. Field and laboratory tests shall be of sufficient detail to identify subsurface strata of adequate bearing capacity, minimal settlement potential, and adequate tremie plug anchor capacity.

Geotechnical analyses performed for pump stations are detailed analysis of the bearing capacity, settlement, and anchor strength of subsurface materials as described in design elements Ground Anchors, Earthwork, Retaining Walls, Shallow Foundations, and Deep Foundations.

3. Utility Relocations

Field geotechnical investigations for utility relocations are typically along the selected realignment. Final exploration requirements shall be dependent on the site conditions. Push tube, auger, split spoon sampling, and test pits shall be specified as required depending on the site conditions. The exploration plan for these investigations is subject to approval by the USACE, Geotechnical Branch. Probes can be of the push tube variety or auger type. Augered explorations shall be taken to a depth at least two diameters below the design pipe invert elevation. Vertical structures requiring relocation shall have a comprehensive foundation investigation.

Geotechnical analyses performed for utility relocations are an examination of existing subsurface data for assessment of potential adverse pipe seat conditions and excavation conditions for shoring. Foundations for vertical structures shall have performed a detailed analysis of the bearing capacity, settlement, and anchor strength of subsurface materials as described in design elements Ground Anchors, Earthwork, Retaining Walls, Shallow Foundations, and Deep Foundations.

4. Bridges & Roadways

Geotechnical investigations for bridges and roadways include shallow or deep borings, dependant on site conditions from previous investigations, and evaluation of historical geotechnical subsurface data for the area. Geotechnical investigations are fixed location boring directly under the proposed footing location with a minimum of one center boring and one corner boring to evaluate total and differential settlement. Projected boring depths are contained in design elements Ground Anchors, Retaining Walls, Shallow Foundations, and Deep Foundations. Field and laboratory tests shall be of sufficient detail to identify subsurface strata of adequate bearing capacity, minimal settlement potential, and adequate anchor capacity.

Geotechnical analyses performed for bridges and roadways are detailed analysis of the bearing capacity, settlement, and anchor strength of subsurface materials as described in design elements Ground Anchors, Earthwork, Retaining Walls, Shallow Foundations, and Deep Foundations.

5. Administrative Facilities

Geotechnical investigations include shallow or deep borings, dependant on site conditions from previous investigations and evaluation of historical geotechnical subsurface data for the area. Geotechnical investigations are fixed location boring directly under the proposed footing location with a minimum of one center boring and one corner boring to evaluate total and differential settlement. Projected boring depths are contained in design elements Shallow Foundations and Deep Foundations. Field and laboratory tests shall be of sufficient detail to identify subsurface strata of adequate bearing capacity and minimal settlement potential.

Geotechnical analyses performed for administrative facilities are detailed analysis of the bearing capacity, settlement, and anchor strength of subsurface materials as described in design elements Shallow Foundations and Deep Foundations.

6. Wastewater Treatment Plants

Geotechnical investigations for wastewater treatment plants include evaluation of historical geotechnical subsurface data for the area.

Geotechnical analyses performed for wastewater treatment plants are examination of existing subsurface data for assessment of potential adverse foundation conditions and potential footing seat location. Preliminary evaluations can be conducted with existing subsurface data for assessment of hydrogeology flow and contaminant transport parameters.

7. Spillways

Geotechnical investigations for spillways include shallow or deep borings dependant on site conditions from previous investigations and evaluation of historical geotechnical subsurface data for the area. Geotechnical investigations are fixed location boring directly under the proposed footing location with a minimum of one center boring and one corner boring to evaluate total and differential settlement. Projected boring depths are contained in design elements Ground Anchors, Retaining Walls, Earthwork, Shallow Foundations, and Deep Foundations. Field and laboratory tests shall be of sufficient detail to identify subsurface strata of adequate bearing capacity, minimal settlement potential, and adequate anchor capacity.

Geotechnical analyses performed is detailed analysis of the bearing capacity, settlement, and anchor strength of subsurface materials as described in design elements Ground Anchors, Retaining Walls, Shallow Foundations, and Deep Foundations.

#### **Required Documentation/Products**

A Geotechnical Report shall be compiled during the TSP phase, and shall be included in the appendix to the TSP document. The geotechnical portion of the appendix shall contain a write-up of the existing subsurface conditions based on historical and field data retrieved during this phase of the design. It shall also contain any geotechnical analyses or assessments conducted during this

phase or from prior studies done at the project site. All core boring and geophysical logs, geophysical survey results, geomaterial laboratory results, and field-testing data shall be included in the Geotechnical Report.

#### 5.4 Plans & Specifications

#### **General Requirements**

Geotechnical investigations during the Plans and Specifications (P&S) phase are limited to unforeseen conditions that institute substantial changes to the selected alternative. These changes may have been instituted due to legal or environment considerations that generate an Engineering Document Report (EDR). Core borings, field-testing, and laboratory testing shall meet the requirements as listed in the TSP phase and follow the exploration guidelines, standards, and references contained in both the Alternatives Evaluation and TSP.

Any additional core boring logs, field and laboratory test data, geophysical logs, and survey data generated shall be incorporated into an amended version of the TSP phase Geotechnical Report. Geotechnical field data shall be provided in draft form to the PDT as required, and as expeditiously as possible to limit project delays during the design modification process. A copy of the appended draft Geotechnical Report shall also be provided to the Geotechnical Branch of the USACE for review.

Design effort during this phase shall also include the development of geotechnical specification sections, drawings, and provision of geotechnical parameters and paragraphs for incorporation to other structural and civil-site sections. This will include sections such as earthwork, wells, dewatering, slope protection, geotextiles, ground improvement, blasting, character of materials paragraphs, pile tip elevations, slope and cut angles, bulking factors, shear strength, and sub-grade reaction parameters. Core boring logs shall be provided to the specification coordinator for incorporation into the specifications.

Core boring location coordinates and geotechnical products such as wells are provided to the civil-site engineer for incorporation in the site drawings. Core boring logs shall not be shown in the contract drawings. In addition, design analyses and recommendations contained in the Geotechnical Report are not included in the specifications. Typical design standard details may be provided in the specifications. Geotechnical standard contract document details may be obtained from the Geotechnical Branch of the USACE. Non-standard and oversized details shall be presented in the drawings. Since the specifications legally govern over wording on the drawings, repetition of design requirements in both contract documents shall be avoided.

Geotechnical exploration for P&S is mainly limited to the final location of vertical structures and borings and soundings for plans and specifications. References regarding geotechnical explorations are the same as indicated in the Alternatives Evaluation and TSP phases.

Design procedures pertinent to this phase include all analyses and design required in the TSP with the addition of formulation of contract plans and specifications. Additional references for this phase of work include EM-1110-1-2907, EM-1110-1-3500, EM 1110-1-3500, EM 1110-2-1601, EM 1110-2-1911, EM 1110-2-2006, EM 1110-2-2302, EM 1110-2-2504, EM 1110-2-2906, EM 1110-2-3506, EM 1110-2-5025, EM 1110-2-5027, ER 1110-1-8155, and ER 1110-2-112.

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### **Project Features**

Project features to be described in the P&S include the following:

1. Embankments (levees, dams) canals, and floodwalls

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.1.

2. Waterways

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

3. Pumping Stations

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

4. Utility Relocations

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

5. Bridges & Roadways

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

6. Administrative Facilities

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

7. Wastewater Treatment Plants

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

8. Spillways

Geotechnical investigations and geotechnical design procedures and requirements are described in Section 5.3.2.

#### **Required Documentation/Products**

The final Geotechnical report shall be contained in the project design notebook or technical report. It is considered to be a portion of the design analysis. The test pit and core boring logs are contained as an appendix to the specifications. Specific technical requirements pertinent to the project features, such as grain size distributions, compactive effort, tip elevations, equipment requirements, and levels of effort are contained within the body of the particular specification

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section with which they are associated. Laboratory and field test data are contained within the design analysis and in the appendix to the specifications. Standard penetration test values, field permeability, and pump test results are found on the boring logs. Digital boring logs are to be provided to the Geotechnical Branch Explorations Manager. Geologic cross sections are typically contained within the design analysis. Geologic descriptions and notes along with the character of materials paragraph are contained in the geotechnical appendix to the specifications.

# SECTION 6 CIVIL – SITE

### 6.1 General

This section prescribes the requirements and procedures for the preparation of the civil site design during each phase of a Comprehensive Everglades Restoration Plan (CERP) project. The level of detail, cross section frequency, graphical depiction scale, and other layout and drawing concerns shall be considered on a case-by-case basis. For detailed guidelines of acceptable procedures for the rendering and file management of drawings refer to Graphic Presentation, Section 2 of this manual. In general, levee and channel cross section are depicted on 200' to 500' intervals and site plans are prepared at scales of 1"=40' to 1"=100'. Florida Department of Transportation (FDOT) guidelines shall be followed for the design of roadways.

### 6.2 References

### Site Design

EM 1110-2-1601, Hydraulic Design of Flood Control Channels

EM 1110-2-1913, Design and Construction of Levees

ER 415-1-11, Bidability, Constructibility, and Operability

ER 1110-1-12, Quality Management

ER 1110-1-1300, Cost Engineering Policy and General Requirements

ER 1110-1-8155, Specifications

ER 1110-2-112, Required Visits to Construction Sites By Design Personnel

ER 1110-2-1150, Engineering and Design for Civil Works Projects

ER 1110-2-1200, Plans and Specifications for Civil Works Projects

ER 1110-345-700, Design Analysis, Drawings and Specifications

#### **General Roadway Design**

American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures, 1993

AASHTO Supplement to the Guide for Design of Pavement Structures

AASHTO Guide for Design of Pavement Structures, Vol. 2

AASHTO A Policy on Geometric Design of Highways and Streets, 2001

AASHTO Model Drainage Manual, 2000

AASHTO Roadside Design Guide, 3rd Edition (2002)

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AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT<400) (2001)

United States Department of Transportation - Federal Highway Administration Manual on Uniform Traffic Control Devices (MUTCD), Millennium Edition

Florida Department of Transportation (FDOT) Design Standards, 2002

FDOT Flexible Pavement Design Manual, 2002

FDOT Rigid Pavement Design, 1996

FDOT Standard Specifications Road & Bridge Construction, 2000

FDOT Uniform Minimum Standards (Greenbook), 2002

### 6.3 **Project Implementation Report (PIR)**

#### 6.3.1 Alternatives Evaluation

#### **General Requirements**

The Alternatives Evaluation phase of the project is for the collection of information and data necessary to evaluate alternative solutions and develop appropriate level cost estimates for comparing these alternatives.

The following guidelines shall be utilized when preparing civil-site input for all types of CERP projects during the Alternatives Evaluation phase.

- 1. Use of a terrain modeling software package to aide in the generation and development of the design information is highly recommended. It can be used to facilitate and document the design process, to provide accurate quantities, to transfer and share information, and to refine or revise the design. Prior to the civil-site engineer performing the work, the following information is needed in digital files.
  - a. Horizontal and vertical alignments and the dimensions of flood control/environmental features as provided by the hydrology/hydraulics, geotechnical, and/or other discipline(s).
  - b. Typical sections of flood control/environmental features with slope and slope protection requirements as provided by the hydrology/hydraulics and/or the geotechnical engineer(s).
  - c. Topographic surveys of the project area. Evaluate if existing surveys can be used. Existing surveys may be used if it is determined that the data is in the correct datum (or can be translated to the correct datum), has not changed significantly since the survey was taken, and is accurate enough to be used for earthwork quantity calculations for this phase of work. If existing surveys are not available or cannot be used for this phase of work then the civil-site engineer shall request new surveys of scope appropriate for this phase to evaluate each alternative.
- 2. The civil-site engineer is responsible for the production of a general footprint for each alternative by preparing a preliminary plan view and typical section files. Guidelines for

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acceptable procedures for file compilation can be found in Graphic Presentation, Section 2 of this manual. Depending upon the project, the civil-site engineer shall either produce this footprint or direct the coordination of the footprint through other disciplines. Appropriate buffer zones, set backs, and aesthetic requirements shall be considered when determining the project footprint. The files will require refinement as a particular alternative progresses through successive review screenings. The following information shall be developed for each alternative:

- a. Horizontal and vertical alignments.
- b. Typical sections.
- c. Surface models.
- d. Digital graphics and terrain models. These files shall be used in conjunction with topographic survey files to layout the preliminary footprints for each alternative and to compute preliminary volumes. The civil-site engineer shall use the preliminary volumes to size the project disposal and borrow areas. Quantities shall be developed based on typical templates. Include quantities for: earthwork cut, fill, backfill, clearing and grubbing, slope protection including revetment, geotextiles, bedding, and roadway features.
- 3. The preliminary footprints and volumes shall be shared with the rest of the Project Delivery Team (PDT). The civil-site engineer shall provide draft plan view files depicting the proposed footprints overlaying the topographic survey files. On-site, plan-in-hand field investigations are strongly recommended for all project team members. Input and comments relating to the following items shall be solicited by the civil-site engineer from the PDT:
  - a. Preliminary footprints of proposed improvements
  - b. Interior drainage features and requirements
  - c. Roadways, utilities, and facilities proposed
  - d. Staging areas
  - e. Disposal areas
  - f. Borrow areas and haul routes
  - g. Hazardous Toxic Radioactive Waste (HTRW) concerns
  - h. Environmental concerns/mitigation
  - i. Construction easements and access requirements for the construction, operation, and maintenance of the project, including relocations
  - j. Extent of geotechnical investigation

- k. Permitting issues
- 1. Property ownership issues
- 4. The hydrology/hydraulic (H&H) engineer shall provide preliminary interior drainage requirements including approximate location and size of culverts, ditches, and retention areas. The civil-site engineer shall incorporate these features and quantities into the digital graphics and terrain model files.
- 5. Roadway relocation alternative corridors, alignments, pavement structures, bridges, other structural features, detour requirements, and maintenance of traffic (MOT), shall be coordinated with the FDOT and/or the appropriate government agency and shall meet their requirements. Identify any special roadway embankment treatments and/or construction requirements. Coordinate relocations in writing with the appropriate owner/operator. The civil-site engineer shall incorporate these features and quantities into the digital graphics and terrain model files.
- 6. Determine if vegetative burning shall be allowed.
- 7. Design spoil areas, pipeline corridors, and return flow requirements if the anticipated mode of construction entails hydraulic excavation.
- 8. Describe the anticipated mode of construction and water control plan. The description shall address erosion, turbidity, sedimentation control measures, and any flow bypass requirements if applicable.
- 9. The civil-site engineer shall revise the digital graphics and terrain model files based on the information gathered above, and derive refined quantities, footprints, and right of way (ROW) requirements for each alternative. The civil-site engineer shall provide the revised plan view drawings, showing the project footprint with construction easements and access requirements, to the Project Manager of the PDT for coordination with appropriate offices and agencies.

#### **Utility Relocations**

Utility relocations may require support from the mechanical and electrical engineers. The project corridors shall be investigated to coordinate and resolve potential conflicts with the following utilities as appropriate:

- Power
- Telephone
- Cable
- Fiber optic
- Gas
- Water
- Sanitary sewer

### **Required Documentation/Products**

The civil-site engineer shall provide any refined quantities along with dimensioned typical sections and plan views to the cost estimator. A footprint of the site as well as any applicable design files shall be provided to the PDT for use in the Design of Tentatively Selected Plan (TSP) phase.

#### 6.3.2 Design of Tentatively Selected Plan

#### **General Requirements**

- 1. The purpose of the TSP is to perform sufficient design, coordination, and engineering details to:
  - a. Obtain state permits and water quality certification.
  - b. Initiate preparation of the Design Documentation Report (DDR).
  - c. Resolve all long-lead design issues such that after completion of the TSP, the preparation of the contract Plans & Specifications can proceed unencumbered, without the need for further field investigations or changes in the project scope or design.

The following instructions shall be utilized when preparing civil-site input for all types of CERP projects during the TSP phase. Prior to the civil-site engineer beginning work on the TSP, the following information is needed:

- a. All civil-site information relating to the TSP generated during the Alternatives Evaluation phase
- b. Plans & Specifications level surveys of the TSP
- c. Final hydrologic and hydraulic analyses of the TSP
- d. Final geotechnical analysis of the TSP
- 2. The civil-site engineer shall have the lead for the preparation of the scope for the TSP level surveys, with written input from the PDT. The civil-site engineer shall provide a final TSP survey scope to the PDT for review prior to submitting the actual survey request. At a minimum, the survey scope shall encompass the entire TSP area shown for construction easements and access as determined during the Alternatives Evaluation phase. The scope shall include all areas required for the following:
  - a. Construction
  - b. Operation
  - c. Maintenance of the project (with relocation areas defined)
  - d. Temporary construction easements
  - e. Disposal

- f. Borrow
- g. Haul routes

Additionally, the scope shall include a location map, vicinity map, and an overall plan view of the immediate project area showing the local roads/streets, structures, and other planimetric features of interest. The aerial extent of the survey shall be sufficient to allow for planning of construction activities.

- 3. At a minimum, the final hydrologic and hydraulic analysis of the TSP, performed by the H&H engineer, shall contain all pertinent design data necessary for the layout of all project features including:
  - a. Information developed during the Alternatives Evaluation phase along with any refinements to this information
  - b. Change in alignments
  - c. Invert and crest elevations
  - d. Top and bottom widths
  - e. Curve/radius details for hydraulic features
  - f. Culvert data including locations, type, number of barrels, inverts, diameters, lengths, and inlet/outlet treatments
  - g. Pumping station, gates, weir or other structure locations, dimensions, and inverts
  - h. Locations requiring revetment protection
  - i. Rough sketch of the layout of the project features
- 4. At a minimum, the following geotechnical information of the TSP shall be provided to the civil-site engineer for layout of all project features:
  - a. Information developed during the Alternatives Evaluation phase along with any refinements to this information
  - b. Typical sections with side slope and dimensioned slope protection requirements
  - c. Calculated settlement values
  - d. Character of excavated materials with bulking factors and blasting requirements
  - e. Borrow sources for fill, backfill, bedding, and stone, with percent of usable/unusable and character of material
- 5. The civil-site engineer shall refine the project footprint and prepare plan, profile, and cross sections in digital graphics and terrain model files. Files from the Alternatives Evaluation

phase shall not be overwritten. New project digital graphics and terrain model files for the TSP shall be prepared.

- 6. The civil-site engineer shall compute refined quantities for earthwork cut, fill, backfill, clearing, clearing and grubbing, slope protection including revetment, geotextiles, bedding, and roadway features.
- 7. Design final roadway relocation alignments (horizontal and vertical), pavement structures, detour requirements, and MOT. Design of bridges and other structural features shall be performed as described in the Structural section of the Standard Design Manual. If special roadway embankment treatments and/or construction methods are required, the PDT shall complete the design in this phase. Any relocation shall be coordinated in writing with the FDOT and/or the appropriate owner/operator. The civil-site engineer shall incorporate features into the digital graphics and terrain model files and include in the quantities package.
- 8. Refine the description of the anticipated mode of construction and water control plan. In particular, orders of work, blasting, hydraulic excavation, and environmental issues shall be thoroughly addressed if needed. Additional on-site, plan-in-hand field investigations are strongly recommended for all PDT members.

#### **Required Documentation/Products**

The refined plan view drawings shall depict the proposed work overlaying the existing topography including the following:

- a. Proposed project feature footprints with environmental mitigation areas and interior drainage features.
- b. Location of the disposal and borrow areas.
- c. Access and haul routes.
- d. Schematic depiction of utility relocations.
- e. Roadway and facility relocations.
- f. Schematic depiction of items to be removed, relocated, replaced, or demolished.
- g. The ROW requirements shall encompass sufficient lands to allow for not only the construction, but also the operation and maintenance of the project including utility relocations.

### 6.4 Plans & Specifications

#### **General Requirements**

The purpose of the Plans & Specifications (P&S) phase is to prepare a complete set of technical contract plans and specifications. The design efforts shall follow the design guidelines set forth in this manual.

The following information shall be utilized when preparing civil-site input for all types of CERP projects during the P&S phase.

- 1. Prior to the civil-site engineer completing work on the P&S, the following information is needed:
  - a. All civil-site information relating to the TSP generated during the Alternatives Evaluation and TSP phases.
  - b. Updated P&S level surveys.
  - c. Adverse weather conditions and water stages specifications paragraphs from the hydraulics/hydrology engineer.
  - d. Borrow sources, character of materials, blasting, geotextiles, and earthwork specifications paragraphs and sections from the geotechnical engineer.
  - e. Revetment details and typical revetment sections from the geotechnical engineer.
  - f. Environmental and turbidity monitoring specifications sections from the environmental section of the PDT.
  - g. Bid schedule, measurement and payment, field office requirements, and quality control specifications paragraphs and sections from construction quality assurance.
  - h. Order of work, schedule, or special instructions specifications paragraphs and sections from the PDT.
  - i. Final footprint of structures and utility relocations.
- 2. The civil-site engineer shall have the lead for the preparation of the scope of the P&S level check surveys, with written input from the PDT. The civil-site engineer shall incorporate comments from the PDT and deliver the final scope to the PDT. Upon receipt of the check surveys the civil-site engineer shall incorporate them into the drawings and revise the quantities accordingly.
- 3. The civil-site engineer shall coordinate and incorporate hydrologic, hydraulic, geotechnical, environmental, construction quality assurance and other PDT input into the plans and specifications.

The civil-site engineer shall refine the project footprint and prepare plan, profile, and cross sections in digital graphics and terrain model files. Much of the work completed in the TSP phase may be utilized in the P&S phase and shall not be duplicated. New or more detailed information that revises a feature's dimensions, template, profile, alignment, or new topographic information warrants revisions in the feature's terrain model and/or revisions in the quantity computations. Files from the PIR phases shall not be overwritten. Prepare new, or copy and rename, digital graphics and terrain model files for the P&S effort and maintain in a separate directory from earlier phases. Compute refined quantities for earthwork cut, fill, backfill, clearing and grubbing, slope protection including revetment, geotextiles, bedding, and roadway features as needed. The new drawings shall accurately portray the proposed work overlaying the existing topography in sufficient detail for construction of the project

feature. This also includes plans and specifications for miscellaneous details and maintenance of traffic.

4. In general, the civil-site engineer shall have the lead to assemble the data necessary and coordinate the preparation of specifications concerning clearing and grubbing, disposal, and roadway work. The civil-site engineer shall collaborate with the geotechnical engineer on specifications concerning earthwork. The civil-site engineer shall also incorporate all necessary language needed in the specifications concerning modes of construction, control of water, and orders of work, if appropriate. The engineer shall avoid the means and methods unless involvement is justified.

#### **Required Documentation/Products**

The civil-site drawings shall include but are not limited to:

- 1. Cover sheet and index (if not already developed by other).
- 2. Location and vicinity maps.
- 3. ROW and control maps and tables.
- 4. A complete set of the topographic survey drawings. Substantive changes to the topographic survey drawings shall only be made by the survey contractor so as not to violate any warranty of the survey. Minor changes to the title block, border, and scale are permitted. Details of the planned work such as right-of-way and outlines of project features may be shown provided that the survey data is not obscured. The location and description of permanent horizontal and vertical control points shall be provided.
- 5. Site plan drawings of the project features, environmental mitigation areas, disposal and borrow areas, access and haul routes, interior drainage features, schematic depiction of utility relocations, roadway and facility relocations, schematic depiction of items to be removed, relocated, replaced, or demolished, HTRW areas, and ROW requirements.
- 6. Profiles.
- 7. Cross-sections.
- 8. Typical revetment sections and details.
- 9. Detailed roadway drawings as required by the FDOT.

# SECTION 7 STRUCTURAL

### 7.1 General

This section provides information applicable to the structural design of the Comprehensive Everglades Restoration Plan (CERP) projects. It outlines the acceptable design guidelines to be used, as well as provides considerations and requirements that are specific to these projects. This section is not intended to provide the structural engineer with all data required for design; rather, it is to define the expected level of effort and presentation for these projects.

### 7.2 References

ER 1110-2-1150, Engineering and Design for Civil Works Projects

ER 1110-2-1200, Plans and Specifications for Civil Works Projects

#### **Stability Design**

EM 1110-2-2100, Stability Analysis of Concrete Structures (draft)

EM 1110-2-2504, Design of Sheet Pile Walls

EM 1110-2-2503, Design of Sheet Pile Cellular Structures

ETL 1110-2-352, Stability of Gravity Walls, Vertical Shear

U.S. Department of the Interior, Bureau of Reclamation, ACER Technical Memorandum No. 11, Downstream Hazard Classification Guidelines

#### Wind Design

ASCE 7, Minimum Design Loads for Buildings and Other Structures

Florida Building Code

FEMA 361, Design and Construction Guidance for Community Shelters

#### Seismic Design

TI 809-04, Seismic Design for Buildings

FEMA 302, NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures

International Building Code (IBC) 2000

EM 1110-2-6050, Response Spectra and Seismic Analysis for Concrete Hydraulic Structures

FEMA 350, Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings

AISC, Seismic Provisions for Structural Steel Buildings

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### **Concrete Structures Design**

EM 1110-2-2000, Standard Practice for Concrete for Civil Works Structures

EM 1110-2-2102, Waterstops and Other Preformed Joint Materials for Civil Works Structures

EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures

EM 1110-2-2005, Standard Practice for Shotcrete

EM 1110-1-2009, Architectural Concrete

ACI 315, Details and Detailing of Concrete Reinforcement

ACI 318, Building Code Requirements for Structural Concrete

ACI Manual of Concrete Practice

Concrete Reinforcing Steel Institute Handbook

PCI Design Handbook, Pre-cast and Pre-stressed Concrete

#### **Steel Structures Design**

EM 1110-1-2101, Working Stresses for Structural Design

EM 1110-2-2105, Design of Hydraulic Steel Structures

AISC, Manual of Steel Construction, Allowable Stress Design

AISC, Manual of Steel Construction, Load & Resistance Factor Design

Steel Deck Institute, Design Manual for Composite Decks, Form Decks and Roof Decks

Steel Joist Institute, Standard Specifications and Load Tables For Steel Joists and Joist Girders

American Welding Society, Structural Welding Code-Steel

American Welding Society, Structural Welding Code-Stainless Steel

#### **Aluminum Structures Design**

The Aluminum Association, Aluminum Design Manual

American Welding Society, Structural Welding Code-Aluminum

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#### **Masonry Structures Design**

TM 5-809-3, Masonry Structural Design for Buildings

ACI 530, Building Code Requirements for Masonry Structures

ACI 530.1, Specification for Masonry Structures

#### Wood Structures Design

American Forest & Paper Association, National Design Specification for Wood Construction

American Forest & Paper Association, National Design Specification Supplement

American Forest & Paper Association, Manual For Engineered Wood Construction and Supplement

#### **Composite Material Design**

ETL 1110-2-548, Composite Materials for Civil Engineering Structures

#### **Bridge Design**

American Association of State Highway Traffic Officials (AASHTO), Standard Specification of Highway Bridges

Florida Department of Transportation (FDOT), Standard Specifications for Road and Bridge Construction

#### **Culvert Design**

EM 1110-2-2902, Conduits, Culverts and Pipes

FDOT, Standard Specifications for Road and Bridge Construction

#### **Concrete Channel Design**

EM 1110-2-2007, Structural Design of Concrete Lined Flood Control Channels

#### **Pumping Station Design**

EM 1110-2-3102, General Principles of Pumping Station Design and Layout

EM 1110-2-3104, Structural and Architectural Design of Pumping Stations

TI 809-02, Structural Design Criteria for Buildings

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### **Spillway Design**

EM 1110-2-2400, Structural Design of Spillways and Outlet Works

EM 1110-2-2701, Vertical Lift Gates

#### **Retaining Wall Design**

EM 1110-2-2502, Retaining and Flood Walls

EM 1110-2-2504, Design of Sheet Pile Walls

TR-01-1, State of the Practice in the Design of Tall, Stiff, and Flexible Tieback Retaining Walls

#### **Closure Structure Design**

EM 1110-2-2705, Structural Design of Closure Structures for Local Flood Protection Projects

Standard Details and Guideline Drawings

### 7.3 **Project Implementation Report (PIR)**

#### 7.3.1 Alternatives Evaluation

#### **General Requirements**

The Alternatives Evaluation phase of the project is for the collection of information and data necessary to develop conceptual plans and costs for an evaluation and comparison of design alternatives. The evaluation of alternatives will identify those that are constructible and the degree that the respective design meets the safety, reliability, technical, functional, operational, and maintenance requirements and objectives.

The following guidelines shall be utilized for preparing structural input during the Alternative Evaluation phase.

The structural engineer shall:

- 1. Collect, from the Project Delivery Team (PDT), the following information:
  - a. A description of the structural feature(s) for each alternative with pertinent hydraulic/hydrologic data for each structure.
  - b. A description of the geology at each structure, preliminary soil parameters, and guidance on soil characteristics such as approximate bearing capacities and groundwater levels.
  - c. Topographic survey data for each project site.
  - d. Use of the structure (e.g., flood control, water supply, and environmental restoration).

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- 2. Be responsible for identifying all functional design requirements and technical design criteria for the structural elements of the project. These include all design data obtained through coordination with other disciplines (e.g., machinery loads and layout).
- 3. Be responsible for the production of a preliminary conceptual plan and a typical section of each structure included in the alternatives evaluated.
- 4. Coordinate conceptual designs with the civil-site engineer and cost estimator for preparation of site plans and cost estimates respectively.
- 5. Prepare a written description of the technical basis for selection of type and configuration of main and major appurtenant structures included in the alternatives studied.
- 6. Prepare a written description of the probable construction techniques and sequencing, plans for dewatering and care of water (e.g., cofferdams and diversion walls), and possible site restrictions for the structures included in the alternatives studied.
- 7. Participate in appropriate PDT activities, including site visits.
- 8. Solicit input on the conceptual designs and incorporate these comments through revisions as appropriate.
- 9. Refer to Standard Guideline Drawings and Details in the formulation of alternative plans as appropriate.

#### **Required Documentation/Products**

The report plates and structural descriptions shall be presented in the engineering appendix to the PIR. All views presented in the report plates shall be prepared as electronic CADD files in accordance with the requirements of Graphic Presentation, Section 2 of this manual.

#### 7.3.2 Design of Tentatively Selected Plan

#### **General Requirements**

During this phase of the project, all significant structural design issues shall be resolved in accordance with ER 1110-2-1150. The design of the structural features in the Design of Tentatively Selected Plan (TSP) shall be developed to a level required to ensure that they can be presented in contract plans and specifications without the need for major revisions. The design performed must also be sufficient to ensure that reasonable costs can be developed for preparation of a detailed baseline cost estimate.

Information presented in this section is organized within four subcategories: Design Guidelines/Considerations, Design Criteria, Special Requirements, and Required Documentation. The Design Guidelines/Considerations section outlines the expected design efforts that shall be performed by the structural engineer. Additionally, this section describes some of the considerations, arranged according to feature type, which shall be examined during the TSP phase. The Design Criteria section provides a detailed listing of typical structural analysis methods, design values, bolted connections, and coatings used for CERP projects. Within the Special Requirements section are design considerations that are applicable to projects located

near waterways. The Required Documentation section provides direction for the presentation of data acquired during the TSP phase.

#### **Design Guidelines/Considerations**

The following guidelines shall be utilized for preparing structural input during the TSP phase. The structural engineer must exercise judgment with these guidelines and determine the appropriate level of effort necessary to satisfy the objectives stated previously for this design phase.

The structural engineer shall:

- 1. Provide results of stability analyses to show application of stability criteria, methods of analysis, and assumptions for each type of structural monolith. Flotation analysis may be necessary for gated culvert structures and other water control structures.
- 2. Provide results of initial stress analysis to show application of strength criteria, methods of analysis, assumptions, and key dimensions of components of each major structural system.
- 3. Provide results of initial seismic analysis to show application of seismic criteria, methods of analysis, assumptions, and key dimensions of components of each major structural system required to meet seismic requirements (refer to the Design Criteria section for further information regarding seismic design criteria).
- 4. Describe the results of any analyses, laboratory tests, or field tests, which were necessary to evaluate unusual site conditions, operating environments, material availability, or load levels (e.g., a concrete materials report).
- 5. Identify any significant unresolved design issues and make recommendations to address them. For example, a type, size, and location engineering study may be required to identify a cost-effective conveyance structure located underneath a highway. An evaluation of structural alternatives such as this shall be initiated upon commencement of the TSP.
- 6. Be responsible for the production of a detailed plan view, elevation view, and longitudinal and transverse section views of each structure. Additional views may include cofferdam details and a foundation plan if they are required. The structural engineer shall work with the civil-site engineer to develop a construction site plan and a final site plan for each structure.

The following considerations are typical for use in the design of structural features for CERP projects:

1. Retaining Wall Structures

The structural engineer is responsible for determining whether a rigid or flexible wall system is utilized for the retaining structure and for providing justification of this selection in the design documentation.

Sheet pile walls shall be designed in accordance with EM 1110-2-2504. For concrete retaining walls, the design shall be in accordance with the requirements of EM 1110-2-2502.
### 2. Pumping Stations

Pump stations shall be designed in accordance with EM 1110-2-3104. Depending upon the size of the station, components to be analyzed may include the foundation design, substructure, intake structure, upstream and downstream wingwalls, service bridges, operating floor, and superstructure. South Florida Water Management District (SFWMD) Guideline Drawings shall be followed as applicable.

The following considerations are employed in the a typical design process:

- a. Classification Refer to Mechanical, Section 8 of this manual, for a description of small, medium, and large-sized pump stations.
- b. Superstructure Pump station superstructures are not considered hydraulic control structures and shall be designed in accordance with ACI 318. Large and medium-sized pump stations shall be fully enclosed and include both an office and a restroom. Concrete or steel framing systems shall be considered for the enclosure. Avoid use of masonry block construction for the superstructure except on small-sized stations. Temporary pump stations (service life ten years or less) shall be covered with a roof system. Consideration for pump and equipment vibration and isolation shall be made for the design of pump station structures.
- c. Roof Large and medium-sized pump stations, primarily used for flood control, generally will not require roof hatches for servicing and removal of pump equipment. Small, unmanned flood control or water supply stations may require roof hatches. Where roof hatches are used, the facility shall be designed with respect to the type of crane that shall be used for the pump extraction. For stations with engine exhaust stacks, a 3-ply modified bitumen roofing system shall be used to resist damage from hot particles.
- d. Substructure Concrete substructures are considered hydraulic control structures and shall be designed in accordance with EM 1110-2-2104. Configurations for intake (rectangular versus formed suction intake) and discharge depend on the pumping capacity per bay. Refer to Mechanical, Section 8 of this manual, for selection of configurations. Concrete investigations, to identify mix designs and placement methods, shall be performed for all designs that include mass concrete.
- e. Intake and Discharge Structures Large and medium-sized pumping stations will generally be separate monoliths upstream and downstream of the substructure designed in accordance with EM 1110-2-2104. These structures allow each bay to be dewatered using a system of aluminum dewatering needles resting against a dewatering beam that is installed in wall recesses. In general, the stability analysis considers only one bay dewatered at any time. For access, a service bridge (minimum width of 14 feet) will generally be constructed across the intake structure. The service bridge shall be designed for an American Association of State Highway and Transportation Officials (AASHTO) HS-20 service load, or other loads as defined by the end user. The design shall be checked for Florida legal SU-3 and SU-4 truck loads which may be anticipated during construction. Trash racks shall be designed for five feet of differential head.

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#### 3. Bridges

The design of bridges for public use shall satisfy AASHTO and Florida Department of Transportation (FDOT) standards, including maintenance of traffic criteria. Design progression should agree with FDOT standards, including a concept study, bridge development report, and design phase milestones. Vertical alignment alternatives will satisfy drainage/exposure vertical clearance requirements. For conventional bridges, arrangements of superstructure depth, span arrangements, and bridge sections shall be considered. For culvert bridges, arrangements of pre-cast concrete bridge systems shall be considered. Selected designs should include the combination of maintenance of traffic, roadway modifications, structure requirements, and impacts to existing structures that produce the least total construction costs based on acceptable levels of safety and disruption to the motoring public. Selected designs should also include a utility relocation plan, indicating the type and ownership of all existing utilities. Components to be analyzed may include the foundation, piers, abutments, and superstructure.

#### 4. Spillways

Spillways shall be designed in accordance with EM 1110-2-2400. For hydraulic control structures, the concrete shall be designed in accordance with EM 1110-2-2402. These structures allow each bay to be dewatered using a system of aluminum needles resting against a dewatering beam that is installed in wall recesses. In general, the stability analysis considers only one bay dewatered at a time. For access, a service bridge (minimum width of 14 feet) will generally be constructed across the structure just downstream of the vertical lift gate. The service bridge shall be designed for an AASHTO HS-20 service load or other loads as defined by the end user. The design shall be checked for Florida legal SU-3 and SU-4 truck loads that may be anticipated during construction. Components to be analyzed may include the foundation design, gate monolith, stilling basin, service bridge, vertical lift gate, operating platform, and upstream and downstream wingwalls.

5. Buildings

Pre-engineered concrete buildings shall be utilized where practical. The overturning stability of these structures for high wind conditions shall be reviewed. For architectural requirements, see Architectural, Section 10 of this manual.

6. Culverts

Culverts shall be designed in accordance with EM 1110-2-2902. Components to be analyzed may include the foundation, culvert structure, headwalls, wingwalls, discharge basins, walkways, and gates.

a. Pipe Type - For construction in-the-dry, culverts shall be reinforced concrete pipe. For construction in-the-wet, culverts shall be corrugated aluminum pipe. Operating platforms, when required, shall be aluminum railing, decking, and framing mounted to steel H-piles. The H-piles shall be coated with coal tar epoxy to provide a level of corrosion resistance. Dewatering requirements for maintenance of gates are typically not required. Dewatering requirements for maintenance of gates are typically not required. Where possible, the use of a precast gate enclosure should be utilized to provide secure access to the gates. For culverts passing through levees, the enclosure can be located near the levee crest to provide personnel access.

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b. Box Type - Pre-fabricated concrete box culvert systems shall be utilized where practical. The ends of the box culvert will typically consist of a headwall with straight wingwalls and slots on each side so the structure can be de-watered for maintenance.

### 7. Cofferdams

Cofferdams, where required for temporary construction dewatering, shall be designed using steel sheet piles in accordance with EM-1110-2-2504. In general, a detailed cofferdam design shall be prepared and presented in the contract documents when it is required for dewatering. This design will consider load cases that can occur during excavation and dewatering and will clearly specify when cross bracing is required to be installed or can be safely removed after construction is complete. When tremie concrete is placed to seal the bottom of the cofferdam, consideration shall be given to reducing the tremie thickness required by utilizing anchors to resist uplift forces. When cofferdams are required for the dewatering plan, components to be analyzed include the steel sheet pile walls, wales, and struts.

### Design Criteria

The criteria described below are considered typical for application in the design of structural features for CERP projects. Exceptions to criteria may be required for certain design situations.

1. Load Combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in ASCE 7. If load combinations are prescribed in an applicable engineering manual, then the load combinations shown in the engineering manual takes precedence over ASCE 7.

2. Stability

For the purpose of establishing safety factors for use in stability analyses, structures are designated as either critical or normal. Structures are designated as critical if their failure will result in loss of life. If the effects of a structural failure are unknown, then an inundation study may be required to classify the downstream hazard. Additional guidance on the classification of downstream hazards is provided in ACER Technical Memorandum No. 11.

3. Wind Design

Wind loads for the design of the main wind-force resisting system and for components and cladding shall be determined using the provisions of the most recent edition of ASCE 7.

- a. Wind Speed (V) Basic sustained wind speed determined from Figure 6.1 of ASCE 7.
- b. Level of Importance (I) For critical structures that are occupied during or are required to operate in a hurricane condition, a category III importance factor of 1.15 shall be used. For all other structures, the importance factor is 1.0 (category II) shall be used.
- c. Mean Recurrence Interval (MRI) For the control room of a pumping station or other facility that is manned during a hurricane, a MRI of 500 years shall be applied. All structural elements shall be evaluated for effects of hazards, from elements within

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proximity of the control room, and should adopt the more stringent design criteria. For structures that are designated flood control structures and are required to operate during a hurricane, a MRI of 200 years shall be applied. This includes the flood control structure's control building. For water control structures that are not required to operate during a hurricane, which may include but not limited to seepage control and water supply structures, a MRI of 50 years shall be applied.

- d. Wall openings For structures that have been designed for a MRI of 200 years or greater, rolling doors, fans, windows, ducts, and louvers shall be designed to meet the building envelope protection requirements of the Florida Building Code, Test Protocols for High Velocity Hurricane Zones. Additionally, all items shall meet this requirement for components and cladding. Single or double doors shall meet the requirements of FEMA 361. For structures that have been designed for a MRI of 50 years, fans, ducts, and louvers shall be designed to meet the requirements of the Florida Building Code. All exterior doors shall be steel.
- 4. Seismic Design

The Department of Defense will adopt the provisions of IBC 2000 to calculate seismic loadings for pumping station superstructures and other structures. Normally, seismic loads will not be significant for CERP projects in Florida.

5. Concrete Design

General criteria for concrete shall be in accordance with EM 1110-2-2000 and ACI 318.

- a. Load Factors Load combinations and strength design factors for hydraulic concrete structures shall be in accordance with EM 1110-2-2104. Load combinations and strength design factors for all other concrete structures shall be in accordance with the most recent edition of ASCE 7.
- b. Design Values Typical design values are as follows:
  - Mass Concrete  $f_c^* = 2500 \text{ psi}$  (a) 28 days.
  - Structural Concrete  $f'_c = 3000$  to 4000 psi @ 28 days.
  - Prestressed Concrete  $f'_c = 5000 \text{ psi}$  @ 28 days.
  - Steel Reinforcement  $f_v = 60$  ksi.
- 6. Steel Design

General criteria for steel shall be in accordance with EM 1110-2-2105 and AISC.

a. Load Factors – Load combinations and strength design factors for hydraulic steel structures shall be in accordance with EM 1110-2-2105. Load combinations and strength design factors for all other steel structures shall be in accordance with the most recent edition of ASCE 7.

- b. Design Values Typical design values are as follows:
  - Structural Steel A 572, Grade 50.
  - Corrosion Resisting Steel Type 304 (freshwater) and 316 or 317L (saltwater).
  - Sheet Piles Normally type A 328 or A 572 (grade 50), hot rolled for permanent structures. Cold rolled sections (A 328 or A572) may be used for temporary structures including bypass walls.
- c. Bolted Connections Structural steel connections normally type A325 Type I, or A490 Type I. Submerged connections (i.e., gate seals) normally CRES bolts with Armco Nitronic 60 nuts.
- d. Coatings Normally, components that shall be exposed to the elements are either hotdipped galvanized or painted with coal tar epoxy. Vertical lift gates and steel sheet pile structures may be painted with a vinyl paint system.

### **Special Requirements**

The following design considerations may be identified as necessary at some sites:

- 1. Manatee Barriers Designed to prevent entrance of manatees into culverts or spillways. Barrier designs will vary depending on specific site conditions. The design should include provisions for removal of the barrier(s) to allow for cleaning and routine maintenance.
- 2. Debris/Safety Barriers Designed to prevent boaters, floating vegetation, and debris from entering structures. Barriers are normally floating type installed with galvanized wire cable and pressure treated timber piles. Other barrier designs may include mechanized trash cleaning racks installed upstream of structures on a steel frame with H-pile supports.

#### **Required Documentation**

The report plates and structural descriptions shall be presented in the Engineering Appendix to the PIR. All views presented in the report plates shall be prepared as electronic CADD files in accordance with the requirements of Graphic Presentation, Section 2 of this manual.

### 7.4 Plans & Specifications

### **General Requirements**

Plans & Specifications (P&S) shall be prepared in accordance with ER 1110-2-1200 and applicable CADD standards presented in Graphic Presentation, Section 2 of this manual.

As outlined in ER 1110-2-1200,, the Pre-construction Engineering and Design phase (PED) is the phase during which the design is finalized, the P&S are prepared, and the construction contract is prepared for advertising. Structural products produced during the PED phase are subject to an Independent Technical Review (ITR) to ensure the designs conform to proper criteria, that any deviations to criteria or scope are properly justified, and that appropriate design methods have been followed.

The following guidelines shall be utilized for preparing structural input during the P&S phase.

The structural engineer shall:

- 1. Collect the following information from the PDT:
  - a. Final hydraulic/hydrologic data for each structure, including pool surfaces and hydraulic jump profiles if applicable.
  - b. Final soil design parameters and copies of the core boring logs.
  - c. Final topographic surveys of project sites including contours and spot elevations.
- 2. Identify and/or verify all sponsor requirements, functional design requirements, and technical design criteria to be used for this work.
- 3. Complete all design analysis of components not performed during the TSP phase. The analysis shall be checked by another structural engineer in the design office to verify that all design assumptions and calculations are correct.
- 4. Prepare contract drawings utilizing designs developed for the PIR.
- 5. Prepare all contract specifications as related to the structural features for the identification of all structural submittal requirements in the submittal register.
- 6. Coordinate all work related to the structural design and participate in all PDT activities to ensure design continuity.
- 7. Prepare input for the Engineering Considerations and Instructions (ECI) for field personnel, as discussed in ER 1110-2-1150. This document will provide field personnel with insight on unique aspects of the work as well as background information about the design intent.
- 8. Address all review and bidder comments and incorporate them into the contract documents as applicable.

# SECTION 8 MECHANICAL

### 8.1 General

This section provides guidance for the preparation and development of the mechanical portion of various design products associated with the engineering and design of civil works features for the Comprehensive Everglades Restoration Plan (CERP). These civil works features include pumping stations, spillways, gated culverts, Aquifer Storage and Recovery (ASR) systems, utility relocations, and administrative facilities. The information in this section is to be used as guidance by all agencies as well as the U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD) representatives responsible for the engineering and design of these CERP features.

#### 8.2 **References**

#### **Pump and Ancillary Equipment**

EM 1110-2-3102, General Principles of Pumping Station Design and Layout

EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

*ETL 1110-2-313, Hydraulic Design Guidance for Rectangular Sumps of Small Pumping Stations with Vertical Pumps and Ponded Approaches* 

Hydraulic Institute (HI) 2.1-2.5, Vertical Pumps

*Hydraulic Institute (HI) 2.6, Vertical Pump Test* 

Hydraulic Institute (HI) 9.1-9.5, Pumps – General Guidelines

UFGS 15131A, Vertical Pumps, Axial-Flow and Mixed-Flow Impeller-Type

#### **Reduction Gears**

American Gear Manufacturers Association (AGMA) 6010, (1997: Rev. F) Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives

American Gear Manufacturers Association (AGMA) 6023, (1988: Rev. A) Design Manual for Enclosed Metric Module Gear Drives

UFGS 15005A, Speed Reducers for Storm Water Pumps

#### Engines

UFGS 15133A, Diesel/Natural Gas Fueled Engine Pump Drives

NFPA 37, Installation and Use of Stationary Combustion Engines and Gas Turbines

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### **Fuel Systems**

Florida Administrative Code (FAC) 62-762 for Aboveground Storage Tanks

MIL-HDBK-1022, Petroleum Fuel Facilities

NFPA 30, Flammable and Combustible Liquids

OSHA 1910.106, Flammable and Combustible Liquids

UFGS 13202A, Fuel Storage Systems

UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids

UL 2085, Insulated Aboveground Tanks for Flammable and Combustible Liquids

#### **Emergency Generator**

NFPA 110, Emergency and Standby Power Systems

UFGS 16263A, Diesel Generator Set Stationary 100-2500kW, with Auxiliaries

UFGS 16264A, Diesel Generator Set, Stationary 15-300kW, Standby Operation

#### **Spillways**

*EM 1110-2-2701, Vertical Lift Gates* 

EM 1110-2-3200, Wire Rope Selection Criteria for Operating Mechanism

#### 8.3 **Project Implementation Report (PIR)**

#### 8.3.1 Alternatives Evaluation

#### **8.3.1.1** Pumping Stations

#### **General Requirements**

Specific pumping requirements for each pumping station shall be obtained from the hydrology and hydraulic (H&H) engineer. The requirements include the total flow and head requirements for the station, the required number of pumps and their capacity, and the anticipated use for the station (e.g., whether it shall be used for flood control or water supply). Generally, pumps used for flood control shall be driven by diesel engines through right angle reduction gears. Pumps for water supply or seepage pumps may be driven by either electric motors or diesel engines. For the Alternatives Evaluation phase, assume that when electric motor pump drives are used they shall be directly coupled to the pumps with no speed reducer used.

Plates M-1 through M-6 show sections and plan views of typical small-, medium-, and large-sized pumping stations. Plate M-7 shows a complex fuel system for a typical large-sized pumping station.

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During the Alternatives Evaluation phase a number of pumping station alternatives may be proposed. The designer must define the project requirements and constraints. Additionally, the general pumping system arrangements, along with an order of magnitude of major equipment sizes and pump bay width requirements will need to be estimated. The pumping equipment information (i.e., pumps, pump drives, and reduction gears) shall be provided to the cost estimator. The equipment sizes and proposed arrangements shall be coordinated with the electrical engineer and provided to the structural engineer so that the required mechanical and electrical spaces can be determined. Any large fuel system requirements (i.e., tanks and tank farms) shall also be provided to the cost estimator and structural engineer.

Pumping stations can be broken into three categories: small-sized, medium-sized, and large-sized. For the purpose of this manual, small-sized pumping stations are assumed to have a total pumping capacity of less than 250 cubic feet per second (CFS), medium-sized pumping stations are assumed to have a total pumping capacity from 250 CFS to 1,000 CFS, and large-sized pumping stations are assumed to have a total pumping capacity of over 1,000 CFS.

Pumping stations shall be sized and arranged in accordance with Hydraulic Institute (HI) standards, EM 1110-2-3102, and EM 1110-2-3105. The intake bays for small and medium-sized pumping stations will follow the guidance of ETL 1110-2-313. The requirements for any formed suction intakes (FSI) shall be evaluated for each pumping station, and based upon the size of the pump(s) and the channel intake design.

Pumping stations will use axial flow or, for systems with large heads, mixed flow pumps. All pumps shall be water lubricated with either product water or treated/filtered canal or well water.

#### Small-Sized Pumping Stations

The small-sized pumping stations will typically have one to three pumping systems. The pumps shall be axial-flow-type vertical-shaft pumps and will generally be lubricated with product water. For the purpose of the Alternatives Evaluation phase, assume that the power to the pumps shall be provided by diesel engines through right-angle reduction gears (for flood control pumps) or direct-drive electric motors (for water supply pumps). Note that during the Design of Tentatively Selected Plan (TSP) phase, the pump drives and reduction gears will need to be readdressed.

Small-sized pumping stations shall be configured in the same way as the three-bay pump station shown on Plates M-1 and M-2. This layout is similar to a medium-sized pumping station except it does not have an office or toilet room. The engine-driven pumps typically run at less than 500 rpm with an efficiency that ranges from 70-80 percent. The motor-driven pumps typically run at no less than 600 rpm with an efficiency that ranges from 70-80 percent. Diesel engine pump drives shall be in a range of 150 to 250 horsepower each. The electric motor pump drives should generally be limited in size to no more than 200 horsepower each. The electric motor pump drive requirements shall be coordinated with the electrical engineer.

Each of the small-sized pumping stations shall include, but not be limited to, the following various support items:

- 1. An emergency generator sized to provide power to run pump station auxiliaries.
- 2. A diesel fuel system, including vaulted, double-wall, aboveground fuel storage tanks capable of holding enough fuel to operate the diesel engine pump drives and/or emergency generator

for 14 continuous days. A floor-mounted, packaged system day tank shall also be provided for each engine pump drive and generator.

- 3. Hoisting system for maintenance or repair of the pumping equipment.
- 4. Ventilation system to provide outside air for the operating floor and generator area. The ventilation requirements shall be coordinated with the designer responsible for the louvers.
- 5. An engine and/or motor controller for each pump drive.
- 6. A flexible trash rake for cleaning the trash rack.
- 7. Stilling wells with water level indicators and/or shut-off switches for monitoring and/or operating the pump station.
- 8. A keel cooler and shaft-driven cooling water pump and expansion tank to cool each main engine.

### Medium-Sized Pumping Stations

The medium-sized pumping stations will typically have three to five pumping systems. These pumps may have a suction bell or FSI, and based upon discharge water elevation requirements, may be conventional discharge or siphon-discharge type. At times, a small, electric motor driven pump is included for seepage control and its flow rate is not included in the total flow capacity of the station. The pumps in these stations shall be axial-flow-type vertical-shaft pumps and will generally be lubricated with product water. Power to the pumps shall be provided by either diesel engines through right angle reduction gear drives or by direct-drive electric motors. Right-angle gears shall be equipped with a backstop clutch.

Medium-sized pumping stations shall be configured similarly to that shown on Plates M-3 and M-4. Pumps with a siphon discharge arrangement shall be configured similar to the arrangement shown on Plate M-6. The engine-driven pumps typically run at less than 500 rpm with an efficiency that ranges from 70-80 percent. Motor-driven pumps typically run at no less than 600 rpm with an efficiency that ranges from 70-80 percent. The diesel engine pump drives shall be in a range of from about 300 to 1,000 horsepower each. The electric motor pump drives shall generally be limited in size to no more than 300 horsepower each. The electric motor pump drive requirements shall be coordinated with the electrical engineer.

Each of the medium-sized pumping stations will include, but not be limited to, the following various support items:

- 1. An emergency generator sized to provide power to run pump station auxiliaries.
- 2. A diesel fuel system, including vaulted, double-wall, aboveground fuel storage tanks capable of holding enough fuel to operate all engine driven pumps and the emergency generator for seven continuous days. A floor-mounted, packaged system day tank shall also be provided for each engine pump drive and generator.
- 3. Manual or electric bridge crane hoisting system for maintenance or repair of the pumping equipment.

- 4. Toilet facility with a water closet and lavatory.
- 5. Potable water system and a septic system for the plumbing fixtures.
- 6. Ventilation system to provide outside air for the operating floor, generator area, and toilet room. The ventilation requirements shall be coordinated with the designer responsible for the louvers.
- 7. A Programmable Logic Controller (PLC)-based engine and/or motor control system for each pump drive.
- 8. A flexible trash rake for cleaning the trash rack.
- 9. Stilling wells with water level indicators and/or shut-off switches for monitoring and/or operating the pump station.
- 10. Cooling of each main engine shall be by way of a keel cooler and shaft-driven cooling water pump and expansion tank, or by a motor-driven raw water pump supplying raw water to the engine expansion tank.

#### **Large-Sized Pumping Stations**

The large-sized pumping stations will typically have three to five pumping systems, and shall be configured similarly to that shown on Plates M-5, M-6, and M-7. When analyzing alternatives that include large-sized pumping stations, the long lead-time needed for the delivery of the pumping equipment needs to be addressed early. A long delivery time for the large pumps, engines, and gears may require two separate contracts, one for machinery and another for building construction, which add significant time to the project schedule

Features commonly found in large-sized pumping stations are listed below. Most of these features are also found in the medium and small-sized pumping stations.

The large-sized pumping stations will have the following features:

1. Pumps: A large-sized pumping station may have several large pumps over 75" in diameter. These large pumps may be designed with FSIs, and may include rectangular pipe for the intake and discharge. FSIs have been shown to be more efficient than suction bell intakes.

Large-sized pumping stations may also incorporate smaller electric motor-driven or diesel engine-driven pumps. These shall be similar to those described previously for small and medium-sized pumping stations.

In order to reduce the engine size needed to overcome the start-up head for large pumps, siphoning systems are used to fill the entire chamber of the pump above its summit. For normal operations, priming is accomplished by means of the station vacuum system; however, with the impeller submerged and depending on the characteristics of the equipment offered, the pumps may be self-priming (in an emergency). Each pump shall be equipped with an automatic water lubrication system for its bearings.

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- 2. Power Required to Drive Pumps: The main engines shall be standard model full-diesel types, 2 or 4-cycle, with heat exchanger cooling. Diesel engine horsepower will generally range from about 750 to 2,500 hp. The fuel system for each main engine will consist of a floor mounted, packaged system day tank sized to hold from four to eight hours of fuel (typically up to 660 gal capacity) to supply the diesel engine (note that NFPA 37 limits the total amount of day tank fuel storage within a facility). Cooling of each main engine shall be by means of a closed system consisting of a heat exchanger, expansion tank, and engine-driven jacket water-circulating pump. Water for cooling the heat exchanger shall be provided by the raw water system described below. Engines of the sizes used for large pumping stations typically will use compressed air for starting. Starting air system for the main engines and for the engine generator sets will consist of a combination engine-motor-driven compressor with air receiver tanks located on the auxiliary equipment platform at the intake side of the station. A PLC-based engine instrument panel shall be provided to each engine for monitoring and controlling the engines. The engine instrument panel shall be coordinated with the electrical engineer.
- 3. Speed Reducers: Power shall be transmitted from the engines to the pumps by means of right-angle type gear reducer units with built-in backstop clutches to prevent reverse rotation.
- 4. Backflow Gates: Siphon-discharge-type pumps have their discharge pipe below water. Backflow control shall be provided at the discharge outlet to prevent water from backing up into the pump. Each pump discharge tube shall be equipped with twin vertical-lift type gates with relief flaps located at the siphon discharge terminus as shown on Plate M-6. Primary functions of the gates are to protect against backflow during pump shut-down and non-pumping periods when the discharge pool is above the invert, and to prevent the possibility of reverse siphoning due to incomplete breaking of the prime during pump shut-down. Each gate shall be raised and lowered by a screw-stem with a Limitorque-type electric motor operator controlled from within the station.

A means to allow application of compressed air to the invert of the discharge of the pump shall be provided as a secondary (emergency) means of preventing backflow.

- 5. Raw Water System: The raw water for the main engine heat-exchanger and engine-generator sets, as well as for station service and domestic use, shall be provided by a system of deep-well turbine type pumps installed in a common raw water intake structure.
- 6. Vacuum System: A vacuum system shall be provided to ensure adequate priming of the main pumps. If required, the system may also be used to produce a low-pressure air lock within the main pump discharge tubes to assist in preventing backflow during periods of high discharge stages.
- 7. Fuel Oil Storage System: Aboveground storage tanks (ASTs) shall be located at a safe distance from the station. ASTs shall be concrete-vaulted and have a dual containment feature. Fuel capacity may be as much as 50,000 gallons and contained in multiple tanks. Fuel capacity shall be for seven days, 24-hours/day with all engines and generators continuously operating at the maximum fuel consumption rate.
- 8. Station Crane/Hoist: For a large pumping station, a double-girder, and overhead bridge-type electric crane will typically be used. The crane/hoist shall be capable of handling the maximum load anticipated to be lifted in the station, up to 30-ton loads. The crane/hoist will

handle pumping station equipment such as engines, reduction gears, or pump components during initial installation, as well as for general service thereafter.

- 9. Diesel Engine-Generator Sets: Large pumping stations may use several diesel engine-driven generator sets (gen-sets) up to 500 kW each. These generators must provide sufficient power to operate the station at full capacity, including running all auxiliary equipment, for as long as seven continuous days.
- 10. Trash Rake: Trash rake systems may be one of two types; 1) an automatic, continuously rolling, flex rake and trash rack system, or 2) an electrically, hydraulically, and/or pneumatically powered rail-mounted traveling trash rake and hoist car assembly. In the latter case, raking operations and car travel shall be either automatic or push-button-controlled by an operator.

### 8.3.1.2 Wastewater Treatment Systems

The design of wastewater treatment systems greatly depends on the required discharge water quality and flow rate of the discharge. These variables depend upon the receiving point and/or area of discharge, soil type, flora and fauna, ecology, and topography. The mechanical and environmental engineers need to determine the desired discharge water quality and flow rate to prepare a design of the wastewater treatment system. From a design standpoint, the desired discharge water quality and the flow rate would depend on the source of the influent wastewater, influent wastewater pollutants/contaminants, influent flow rate, applicable treatment technology, and levels of treatment such as primary, secondary and/or tertiary.

Other factors to be considered in the design of the wastewater treatment systems are the topography of the terrain, which would determine gravity flow, use of pumps, or combination of both; piping systems, which would include pipe lengths and sizes, valves, manholes, siphons; and auxiliary units such as electrical power sources and diesel engines, fuel tanks, and generators. For a successful design of a wastewater treatment system, it is necessary to coordinate with all engineering disciplines involved in the project.

The mechanical engineer shall provide a description and the approximate capacity of each of the major pump systems to the cost estimator.

The treatment portion of the wastewater shall be described by an environmental engineer or related discipline.

#### 8.3.1.3 Spillways

The following items shall be addressed:

1. The number of gates, their size, the gateway opening dimensions, and the head and tailwater elevations shall be obtained from the H&H engineer. Coordinate this information with the structural engineer, who shall provide the weights of the gates. The operating mechanism for each gate shall be the electric motor-driven/double stage reduction gear type, hydraulic cylinder with wire rope type, or a hinged gate with inflatable bladder type.

The electric, motor-driven double stage reduction gear, if used, shall be centered on the operating platform above each gate and shall be of the double-input, double-output shaft type

as shown on Plate M-8. In addition, a cable slack limit switch, a rotary limit switch, and gate travel readout or gate position indicator system shall be provided.

The hydraulic cylinder with wire rope type of operating mechanism, if used, is made up of a hydraulic cylinder that is connected, via its piston rod, to the spillway gate with wire ropes routed through an arrangement of sheaves. The system allows a short stroke to raise the gate a longer distance. A centralized hydraulic power unit shall be used for multiple gates and hoisting units.

The operating platform for the double stage reduction gear and hydraulic cylinder with wire rope types of systems shall be designed to support the weight of the gate, the operating mechanism, and any thrust loads developed by the system. The operating platform shall also be large enough to accommodate the layout of the complete hoist system, including sufficient room for maintenance. The design shall be coordinated with the structural engineer.

The bottom-hinged spillway gate utilizes a row of steel gate panels supported on their downstream side by inflatable air bladders. The downstream elevation maintained by the gates can be variably adjusted within the system control range (full inflation to full deflation) by controlling the pressure in the bladders. As the pressure is increased or lowered, the gate rises or lowers and accurately maintains the downstream water elevation at user-selected set points. This type of gated spillway requires a compressed air system, with the compressor located in a control house. Air supply lines shall run to the gate bladders from the control house.

- 2. Each spillway shall have a Liquefied Petroleum Gas (LPG) fueled generator for backup power. The generator shall be located in a control room. A LPG fuel system shall also be provided.
- 3. Stilling wells with water level monitoring equipment upstream and downstream of the spillway shall be provided.
- 4. The cost estimator shall be provided the number of gate operators and the approximate size of the generator and LPG fuel tank.

### 8.3.1.4 Gated Culverts

This section covers not only structures listed specifically as gated culverts, it also covers control, drawdown, and equalizer structures, which essentially operate as gated culverts. Flow through each structure will depend on the area of opening per barrel, the number of barrels in the culvert, and the height of water impounded behind the gate.

The following items shall be addressed:

- 1. The gated culvert(s) shall have a commercially available self-contained aluminum or steel gate unit. A rising stem, suitable for attaching to a concrete bulkhead or corrugated metal pipe, shall be used to raise and lower the gate via an electric actuator/operator. The electric operator shall include, but is not limited to, the motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, stem nut, declutch lever, and handwheel as a self-contained unit.
- 2. The cost estimator shall be provided the number of gate operators.

#### 8.3.1.5 Aquifer Storage and Recovery (ASR) Well Facilities

- 1. Pumps/Wellhead: The water supply rate and estimated aquifer head range needs to be defined by the geotechnical engineer for each alternative site location. Depending on conditions, a vertical turbine, submersible, or horizontal pump may be suited for the well. Pump selection will determine piping and valves needed for each wellhead configuration.
- 2. Raw Water Treatment Facilities: Water stored or injected by the ASR well is required to be treated to meet all primary and secondary drinking water standards. Source water quality shall be evaluated at each intended location so that the relative difficulty and cost of filtration and treatment is included for each alternative.
- 3. Utility and Site Issues: The relative difficulty of providing commercial electric power to the ASR well alternative site locations shall be determined. Electricity shall be needed to power the ASR pump motors, as well as the treatment equipment and telemetry-related sensors and controls. Remoteness will increase periodic maintenance costs including filter cleaning and the delivery of disinfectant chemicals.
- 4. The cost estimator shall be provided the number of ASR pump systems required and a brief description of the pump and engine/motor pump drive requirements.

#### 8.3.1.6 Utility Relocations

If gas, sewer, or other non-electrical utilities have to be relocated, the extent of these shall be addressed in the narrative. The points of contact for the various utilities shall be provided. All utility relocation work shall be coordinated with the electrical engineer.

#### 8.3.1.7 Required Documentation/Products

The following shall be provided for all structures or items being considered during the Alternatives Evaluation phase:

- 1. Narrative
  - a. References used in the analysis, including government design documents, industry standards, and information gathered from the end user shall be listed.
  - b. Proposed type of pumping systems, spillway hoist, utility relocations, and associated fuel system requirements shall be explained.
  - c. Any environmental concerns and actions taken to address them shall be listed.
- 2. Drawings
  - a. A minimal, basic floor plan indicating, as applicable, bay widths, space for major items of mechanical and electrical equipment, and hoisting equipment to provide a general arrangement of what is being analyzed shall be provided.

- b. For pump stations, section(s) indicating pump arrangement, elevation and discharge type shall be provided.
- c. A plan indicating any substantial fuel system items shall be provided.

### 8.3.2 Design of Tentatively Selected Plan

The mechanical engineer shall perform sufficient Design of TSP to provide input to the cost estimator and the design shall be at such a point that allows the engineer to proceed directly to the production of plans and specifications.

### 8.3.2.1 Pumping Stations

The selected pumping station(s) shall be sized and arranged in accordance with HI standards, EM 1110-2-3102, EM 1110-2-3105, and other applicable publications. The intake bays for pumps with suction bells will also follow the guidance of ETL 1110-2-313. The requirements for any formed suction intakes at pumps shall be evaluated as needed for each pumping station, and shall be based upon the size of the pump(s) and the channel intake design.

The pumping station features shall be as indicated in the Alternatives Evaluation section.

### Coordination

The final pumping requirements for the pumping stations shall be analyzed in conjunction with the H&H engineer to determine the final pump mix (i.e., the number of pumps, the size of each of the pumps, and which pumps are for flood control and which are for water supply). The mechanical engineer shall use judgment and cost benefit life cycle analysis and coordinate with the H&H engineer to determine the appropriate pump mix that addresses, for example, whether several small pumps may be more advantageous (in terms of cost and/or ease of construction) for the pumping station than two large ones. Once finalized, the pump sizes can be determined and the width of the pump bays can be sized.

The engineer must also coordinate with the end user and further define the end user's requirements and requests. The engineer shall then incorporate the applicable items into the design.

#### **Design Requirements**

The pumping system arrangements shall be finalized at this point. Pumping system items to be determined include those described in the Alternatives Evaluation phase and the following:

- 1. Whether the pumps will have suction bell intakes or Formed Suction Intakes (FSI).
- 2. Dimensions of the FSI, if applicable.
- 3. The type of pump discharge system (i.e., a standard horizontal discharge above the high water elevation or a siphon discharge). Note that a siphon discharge will likely require backflow gates that can be raised during pumping.

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- 4. Electric motor and/or diesel engine and reduction gear space requirements, along with requirements for spacing day tanks and the emergency generator(s). Use a minimum of three manufacturers for sizing purposes so that the space allocated for equipment is adequate.
- 5. Final pump bay widths.
- 6. The required minimum height of the crane hook based upon the sizes of the pumping equipment being removed. This height shall be coordinated with the structural and electrical engineers to set the height of the pumping station.
- 7. Whether the station will incorporate roof hatches for maintenance purposes. Coordinate this with the end user and the structural engineer.
- 8. Determine the type of overhead crane to be used and its capacity.
- 9. Determine the sizes of any required major components for the accessories to the pumping equipment. This includes the compressed air systems, the vacuum systems, the engine cooling systems, and the external pump lubrication systems.
- 10. Determine the type of trash rake system to be used.
- 11. Finalize the size of the required fuel tanks along with the general layout for the fuel system.
- 12. Size the ventilation system for the pumping station to determine intake and exhaust air requirements. Coordinate the ventilation requirements with the designer responsible for the louvers.
- 13. Determine the size of the domestic water and sewer systems (fixture units), and the water heater.
- 14. Coordinate with the electrical engineer regarding the engine and/or motor control system for each pump drive.
- 15. Locate stilling wells with water level indicators and/or shut-off switches for monitoring and/or operating the pump station. A stilling well with a low-water cut-off switch shall be located in each pump bay to ensure that they do not operate below a safe level for the pump. Stilling wells for water level indication shall be provided upstream and downstream of the pumping station, as well as in each pump bay.

### **Design Considerations**

- 1. The ventilation system shall be designed in a manner to optimize the airflow across the engines/motors. It shall avoid intake or exhaust openings over electrical equipment. Intake or exhaust openings shall not be installed on the roof.
- 2. Engine pump drives are to be rated for continuous duty. That is, the engines shall be capable of driving the pumps at rated speed and at full load for 24 hours a day, seven days a week, continuously (except for routine maintenance), for several months at a time. No ratings that are specific to particular manufacturers (e.g., WMR ratings) shall be acceptable.

- 3. Separate day tanks for each engine and generator shall be used. A siphon priming system for top-suction fuel storage tanks shall be provided.
- 4. The overhead crane travel shall be coordinated with the equipment to be lifted, loaded, and unloaded. The building design shall include room for a vehicle to enter the facility for loading and unloading pumping equipment. This shall be coordinated with the electrical and structural engineers.
- 5. Electrical requirements shall be coordinated with the electrical engineer for primary and emergency power (generator).
- 6. In accordance with paragraph 7-4a of EM 1110-2-3102, the basic requirement for pump discharge lines in which backflow can occur without siphon action is to provide two means of preventing backflow, one means for normal use and the other for emergency use in the event of failure of the normal method. In siphon discharge systems, flap gates shall not be considered a positive means of backflow prevention.

### 8.3.2.2 Wastewater Treatment Systems

The selected wastewater treatment system shall be finalized at this time. A conceptual layout of the system, to include treatment facilities, pump stations, piping, valves, manholes, motors, engines, and fuel tanks shall be finalized and coordinated.

#### Coordination

Prior to finalizing the wastewater treatment systems, the system shall be coordinated with all engineering disciplines for review and approval. The mechanical engineer shall determine the proper selection and arrangements of units and systems applicable to the system, such as pumps, pipes, valves, manholes, engines, fuel tanks, and auxiliary mechanical systems. The environmental engineer shall design the treatment facilities. The engineering disciplines must then integrate their various designs to provide a unified design capable of providing the final output requirements of the system. The design shall be in compliance with all applicable local, state, and federal agencies.

#### **Design Requirements**

- 1. Whether the system will obtain influent from a wastewater treatment plant, from the surface water, groundwater, or a combination thereof shall be determined.
- 2. Whether pumps shall be required, and/or if the system shall be gravity fed shall be determined.
- 3. Piping requirements, both internal and external of the treatment facilities, shall be determined. Pipe types, sizes, and arrangements shall be provided.
- 4. Whether the treatment facility shall be constructed, prefabricated, or a combination of both shall be determined.

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- 5. Use of electric motors, diesel engines, and auxiliary units such as generators or combination depending upon sizes of pumps used shall be determined.
- 6. Use of valves and manholes shall be determined.

#### **Design Considerations**

- 1. The wastewater treatment system shall be designed to optimize gravity flow. This will result in the use of smaller pumps utilizing less power from electricity or diesel fuel, resulting in a reduction in operational, fuel, and equipment costs.
- 2. Coordination with the structural engineer to design appropriate housing for equipment protection from vandalism and the elements shall occur.

### 8.3.2.3 Spillways

#### **Operating Mechanisms**

Finalize the number of gates, their size, the gateway opening dimensions, and the head- and tailwater elevations with the hydraulic engineer. Coordinate this information with the structural engineer, who shall provide the weights of the gates. Select the operating mechanism for each gate from either the electric motor-driven/double stage reduction gear type, hydraulic cylinder with wire rope type, or a hinged gate with inflatable bladder type.

The double stage reduction gear, if used, shall be centered on the operating platform above each gate and shall be of the double-input, double-output shaft type. A double reduction gear consisting of two separate gearboxes joined together is not acceptable. In addition, a slack cable limit switch, a rotary limit switch, and gate travel readout or gate position indicator system shall be provided. The rotative limit switch shall be provided to delimit the upper and lower position of the gate. The complete hoist assembly, including hoist frame, drum, shaft(s), reduction gear, motor, bearings, supports, cables, sheaves, covers, and all hardware shall be designed to handle all loads encountered, and shall be configured to eliminate any interferences of moving parts or systems.

The hydraulic cylinder with wire rope type of operating mechanism, if used, is made up of a hydraulic cylinder that is connected, via its piston rod, to the spillway gate with wire ropes routed through an arrangement of sheaves. Select the type of wire rope and sheave arrangement that shall be used to lift the gates. Also, size and locate the centralized hydraulic power unit. Coordinate this with the structural engineer.

The operating platform shall be designed in coordination with the structural engineer to support the weight of the gate, the operating mechanism and any thrust loads developed by the system. The operating platform shall also be large enough to accommodate the layout of the complete hoist system, including sufficient room for maintenance and adequate clearance between the operating mechanism and the fence.

The gate lift system design shall include the following features:

1. All mechanical components shall be installed on a common frame to facilitate the removal of the operating mechanism from the platform as a unit, allowing minimum disturbance of alignments between components.

- 2. The systems shall be capable of lifting the gate at a speed of six inches per minute  $\pm$  0.6 inches per minute.
- 3. The electric motor and brake, if used, shall be interlocked for a fail-safe operation.
- 4. A removable wire rope shall link between the gate and each wire rope connection at the gate.
- 5. After opening the gate to the maximum allowed by the system, a set of dogging slings shall be provided to support the gate at an intermediate open position.
- 6. The LPG-driven generator shall be sized for backup power. The capacity of the generator shall be coordinated with the electrical engineer. The capacity of the LPG fuel system shall also be provided.
- 7. The location of the stilling wells shall be indicated with water level monitoring equipment upstream and downstream of the spillway.

### 8.3.2.4 Gated Culverts

Size the electric operator in coordination with the structural and electrical engineers. The electric operator shall include, but is not limited to, the motor, actuator unit gearing, limit switch gearing, position limit switches, torque switches, stem nut, declutch lever, and hand wheel as a self-contained unit. The actuator shall have sufficient capacity to raise or lower the gate at a speed of six inches per minute against the operating heads. The hand wheel shall operate in the clockwise direction to close. The external declutch lever shall be padlockable in either the manual (hand wheel) or motor mode. Indicate the location of the stilling wells with water level monitoring equipment upstream and downstream of the gated culvert.

#### 8.3.2.5 Aquifer Storage and Recovery (ASR) Well Facilities

Pumps/Wellheads: Choose whether to use a vertical turbine, submersible, or horizontal pump. Pump/drive selection needs to operate under a wide range of head conditions. If a vertical turbine pump is chosen, it may be used both for water injection and recovery by changing the flow with piping and valves, while submersible pumps require separate pumps for each flow direction. Piping and valves are arranged to suit the pump selection. Develop a site plan, including mechanical and electrical equipment layout, control building size requirements, and intake/discharge connections with source and treatment facilities.

Raw Water Treatment Facilities: Evaluate source water quality with regard to all applicable contaminants, so that the cost estimate includes all necessary filtration and treatment equipment. Choose the most cost-effective, suitable method that uses disinfectant in conjunction with in-bank horizontal wells, slow sand filters, direct filtration, or conventional coagulation. Develop the design for the method chosen for providing dissolved oxygen to the returned surface water, so that its cost can be included in the project estimate. Overall costs are a combination of the infrastructure, chemicals, energy and manpower needed to set up and operate the treatment facilities. Consider all of these components in order to select the most cost-effective equipment package.

Utility and Site Issues: Coordinate with the electrical engineer to help determine the cost of providing commercial electric power to the selected ASR well location. Decide whether to recommend telephone service, which is normally provided if the facility is to be occupied.

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Coordinate location of new poles and lines with utility companies. Determine the telemetryrelated sensor, relay and control equipment instrumentation required. Ensure that the site accessibility and maintenance difficulties are included as a factor in pump, wellhead, and water treatment equipment selection.

#### 8.3.2.6 Utility Relocations

Contact the non-electrical utility owner(s) to determine the best procedure in which to have the utilities relocated. If the utility owner is responsible for relocating the utilities, determine what cost shall be required to compensate the utility owner for the work. Coordinate any utility work with the electrical engineer.

### 8.3.2.7 Required Documentation/Products

The following documentation and products shall be provided:

- 1. Technical Write-Up A technical write-up shall be developed, which shall include, but not be limited to, the following items as applicable:
  - a. List all references used in the analysis including government design documents, industry standards, and information gathered from the end user.
  - b. Provide pump total head, engine sizing, fuel system, ventilation, water and sewer system, and any other calculations needed to demonstrate that the mechanical systems have been properly sized.
  - c. Describe the type of pumping systems and fuel system requirements. List all assumptions made.
  - d. Provide representative pump curves, equipment catalog cuts, and other manufacturer's information to support the sizes of the equipment indicated on the drawings. Also, indicate the weights of major pieces of equipment that are to be lifted by the overhead crane.
  - e. Provide hoisting load calculations.
- 2. Drawings
  - a. Pumping Stations
    - Provide a floor plan indicating bay widths and showing the locations for major items of mechanical and electrical equipment.
    - Provide section(s) indicating pump intake and discharge arrangements, elevations, and dimensions of the FSI (if applicable).
    - Coordinate with the structural and electrical engineers on the size and location of the exhaust fans and intake louvers. These sizes and locations are typically indicated on the structural elevations and sections.
    - Provide a site plan indicating any substantial fuel system items and the number and size of fuel tanks. Also, provide for a fuel delivery area that includes room for delivery trucks to drive through and turn around for departure. Provide sufficient room for inspection of the fuel system.

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- Locate the water level indicators and the low-water pump shutdown switches in the intake pump bays and indicate the locations on the floor plan and section(s).
- Locate, on a site plan, the water level indicating stilling wells in the intake and discharge channels.
- Indicate on a site plan the source of the domestic water and sewer utilities, and/or where the water well and/or septic system and drain field shall be located.
- b. Spillways
  - Provide a plan view indicating the general hoist type and showing the locations for major items of mechanical equipment.
  - Provide a section indicating the general hoist type.
  - Provide a plan view of the control house indicating the approximate size of the genset and showing that it will fit. Also, show the location of the fuel tank and provide for a fuel delivery area that includes room for delivery trucks to drive through and turn around for departure.
  - Locate, on a site plan, the water level indicating stilling wells in the intake and discharge channels.
- c. Gated Culverts
  - Indicate any required trash rake that may be required on a trash rack for any gated culverts.

### 8.4 Plans & Specifications

The Plans & Specifications (P&S) phase includes the final design documents. These include the preparation of contract plans and specifications, along with the preparation of a Design Documentation Report (DDR) and a design analysis. The preparation of the P&S may be broken into multiple phases (e.g., 30%, 60%, and final submittals). For 60% submittals, specifications shall be provided that shall describe the systems up to the actual specifying of the products.

#### 8.4.1 **Pumping Stations**

The pumping station(s) shall be sized and arranged in accordance with HI standards, EM 1110-2-3102, EM 1110-2-3105, and other applicable publications as indicated following.

#### **Design Requirements**

The pumping station design shall be finalized at this point. This includes refinement and completion of the information that was prepared in the PIR phase. The work shall include, but is not limited to, the following:

- 1. The complete design of the fuel, compressed air, vacuum, exhaust, and lubricating oil systems.
- 2. The design of the station's plumbing system (potable water and sanitary sewer). The design of the HVAC system that will support office spaces.
- 3. The design of the trash rake.

- 4. The design of the stilling well system.
- 5. The design of the overhead crane.

#### **Design Considerations**

- 1. Design the ventilation system in a manner to optimize the airflow across the engines/motors. Avoid intake or exhaust openings over electrical equipment. Do not install intake or exhaust openings on the roof.
- 2. Engine pump drives are to be rated for continuous duty. That is, the engines shall be capable of driving the pumps at rated speed and at full load for 24 hours a day, seven days a week, continuously (except for routine maintenance), for several months at a time. No ratings that are specific to particular manufacturers (e.g., WMR ratings) shall be acceptable.
- 3. Use separate day tanks for each engine and generator.
- 4. Coordinate the overhead crane travel with the equipment to be lifted so that the walls or other equipment will not keep large items (such as pumps) from being lifted.
- 5. In accordance with Paragraph 7-4.a. of EM 1110-2-3102, the basic requirement for pump discharge lines in which backflow can occur without siphon action is to provide two means of preventing backflow: one means for normal use and the other for emergency use in the event of failure of the normal method. In siphon discharge systems, flap gates shall not be considered a positive means of backflow prevention.
- 6. The designer shall check the HVAC design calculations and ensure that all loads, including the heat coming through the wall from the pump bays, are considered. A sufficiently large air-conditioning unit shall be provided that is not excessively over-sized. Consider using a split system room unit, thereby minimizing the size of the penetration through the wall of the office. Note that over-sizing the air-conditioning unit can lead to moisture problems.
- 7. For flood control pumping stations, provide a water heater for hot water service to the shower, lavatory, and sink.
- 8. Require that engine sizing and reduction gear selection be the responsibility of the pump supplier.
- 9. Assume "severe" operating conditions when assigning an application factor to reduction gears. According to Unified Facilities Guide specification 15005A, the reducer application factors are stated as follows: "where reducer operating conditions are considered severe, the application factors of 1.75 (electric motor) and 2.0 (diesel engine) may be used to increase reliability."
- 10. Provide a mechanical means to hold up the flap gates when the pumps shall be operated for long periods of time.
- 11. Provide grease lines for lubricating the flap valves up to the service walkway on the discharge side of the pumping station.

- 12. The clear opening between bars in a trash rack should not exceed three inches. Bar spacing shall be coordinated with the pump manufacturer via information in the contract specifications for the pump.
- 13. Coordinate the cooling of the generators either air or water-cooling with the cooling of the other major items in the station.
- 14. All major mechanical items of pumping equipment shall be provided with a minimum twoyear warranty.

#### 8.4.2 Administrative Facilities

Provide the complete design for the mechanical systems for administrative facilities including all HVAC, plumbing, and, if required, fire protection.

#### 8.4.3 Wastewater Treatment Systems

All mechanical units and systems applicable to the final design of the wastewater treatment system shall conform and/or be designed according to applicable standards. The integration of the units and systems to provide the complete design of the wastewater system shall also conform to all applicable standards.

#### **Design Requirements**

The wastewater treatment system design shall be finalized at this point. This includes refinement and completion of the information that was prepared in the PIR phase. The work shall include, but not be limited to, the following:

- 1. Design of system to provide influent from a wastewater treatment plant, from surface water, groundwater, or a combination thereof.
- 2. Design of pumps and pump stations, if necessary.
- 3. Design of piping requirements both internal and external of the treatment facilities and that include pipe types, arrangements, and sizes.
- 4. Design to include electric motors, diesel engines, and auxiliary units such as generators or a combination depending upon sizes of pumps used.
- 5. Design of valves and manholes.
- 6. Design connections of mechanical requirements to the wastewater treatment facilities.

#### **Design Considerations**

- 1. Design the wastewater treatment system to optimize gravity flow. This will result in the use of smaller pumps utilizing less power from electricity or diesel fuel and resulting in a reduction in operational, fuel, and equipment costs.
- 2. Coordinate with the structural engineer to design appropriate housing for equipment protection from vandalism and the elements.

#### 8.4.4 Spillways

The spillway gate hoist design shall be finalized at this point. This includes refinement and completion of the information that was prepared in the PIR phase. The work shall include, but is not limited to, the following:

- 1. The complete design of the LPG fuel system for the generator set.
- 2. The complete design of the ventilation system for the control house.
- 3. The complete design of the gate hoist system, including the hoist frame if applicable.
- 4. Finalize the location of the stilling wells upstream and downstream of the spillway with the hydraulics and hydrology engineer and the civil-site engineer. These stilling wells shall come complete with water level monitoring equipment in accordance with SFWMD standards.

#### 8.4.5 Gated Culverts

The following items need to be addressed:

- 1. Complete the design for the hoist for the culvert gate. The gate, having the frame attached to a bulkhead over the culvert pipe or having a spigot or flanged connection to the culvert pipe, shall be lifted by an electric actuator/operator through the gate's stem.
- 2. Finalize the location of the stilling wells upstream and downstream of the gated culvert with the hydraulics and hydrology engineer and the civil-site engineer. These stilling wells shall come complete with water level monitoring equipment in accordance with SFWMD standards.

#### 8.4.6 Aquifer Storage and Recovery (ASR) Well Facilities

Specify pump/drive wellhead system criteria after coordinating complete pump/drive system selection with the pump manufacturer. Water treatment facility equipment functions and capabilities need to be detailed. The manufacturer of the equipment needs to be coordinated. Verify that water treatment facility flow and function are compatible with the selected pump and wellhead. Pertinent technical standards for the equipment shall be researched and listed.

#### **Design Requirements and Considerations**

1. Vertical turbine pump system is preferred, since bypass valves and piping allow use of a single pump for both well intake and discharge.

- 2. Solenoid valves, with manual override, shall be specified to allow the option of telemetry control.
- 3. Develop a detailed site plan for the complete water intake and discharge system.
- 4. Finalize the number of stages of the selected pump. Select a system that allows stages to be added or removed in the field to meet possible changing future head conditions.
- 5. To avoid stagnation problems when the pump is not operating, it may be necessary to maintain a trickle flow of chlorinated water. Include the necessary piping, valves, equipment, and operation schedule to provide this flow in the design.
- 6. Select open line shaft construction for the pump bowl assembly, so that water instead of oil is used to lubricate both the pump and the column bearings.
- 7. Proper pump column size selection is important to minimize friction head loss.
- 8. Coordinate flow between the pump and water treatment facility, so that automatic shutdown of both occurs if either one malfunctions.

#### 8.4.7 Utility Relocations

Provide a complete design of the gas, water, sewer, or other non-electrical utility relocations. If the utility owner is performing the relocations at the construction contractor's expense, provide a point of contact with the utility and the cost that the utility owner indicates that it will charge. Coordinate any utility relocation work with the electrical engineer.

#### 8.4.8 Required Documentation / Products

- 1. Drawing Requirements
  - a. Provide a fully coordinated final plan indicating all of the mechanical equipment.
  - b. Provide a fully coordinated final section(s) indicating all of the mechanical equipment.
  - c. Provide a site plan for the complete fuel system. Provide a larger scale site plan if any mechanical utilities are relocated.
  - d. Provide all necessary details, sections, and schematics to clearly define what is to be constructed.
- 2. Narrative The narrative shall include, but is not limited to, the following applicable items:
  - a. List all references used in the analysis including government design documents, industry standards, and any information gathered from the end user.
  - b. Provide final calculations for all mechanical systems.

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- c. Provide equipment catalog cuts and other manufacturer's information to show representative equipment that can meet the requirements of the plans and specifications. Use a minimum of three manufacturers to help establish that the specified equipment is not proprietary.
- 3. Specifications

Finalize all specifications necessary to complete the mechanical portion of the construction documents.

4. Guidance for the Cost Estimate

The cost estimate shall be based on the contract plans and specifications. As an aid to the cost estimator, provide any manufacturer's supplied costs for major items of mechanical equipment.

# SECTION 9 ELECTRICAL

### 9.1 General

This section provides general guidelines for the preparation of the electrical input to the design documents required for the Project Implementation Report (PIR) and Plans & Specifications (P&S). Typical design documents include: drawings, specifications, and design analysis as related to power, lighting, grounding, and electronic systems. This section includes specific design requirements that supplement the requirements of General, Section 1 of this manual. All required documents, including drawings and design analysis, shall be in accordance with Graphic Presentation, Section 2 of this manual.

#### 9.1.1 **Pumping Stations**

Pumping stations are categorized as small-, medium-, and large-sized. For the purpose of this manual, small-sized pumping stations are assumed to have a total pumping capacity of less than 250 cubic feet per second (cfs), medium-sized pumping stations are assumed to have a total pumping capacity from 250 cfs to 1,000 cfs, and large-sized pumping stations are assumed to have a total pumping capacity of over 1,000 cfs. For further information regarding the design of pumping stations for use with Comprehensive Everglades Restoration Plan (CERP) projects, refer to Mechanical, Section 8 of this manual.

Large- and medium-sized pumping stations are usually staffed with operation personnel. Smallsized stations, which are usually seepage stations, are not normally staffed. Unstaffed stations require closed-circuit television (CCTV), intrusion detection, fire alarms, and other systems that relay an adequate presentation of the existing conditions at the station to a remote site. Staffed stations are equipped with similar systems to give the station operator, as well as personnel at the remote site, a real-time picture of the station activities.

All structures shall have the ability for manual operation regardless of the intended mode of operation. The manual controls shall be placed in close proximity to the equipment and give the operator the ability to control the equipment even when automatic or remote operation is off-line.

#### **Small-Sized Pumping Stations**

Small-sized pumping stations will typically have one to three pumping systems with a pumping capacity of less than 250 cfs. The prime mover for small-sized pumping stations are electric motors usually coupled directly to the pump. The pumps are expected to run at no less than 600 rpm with an efficiency of 70-80 percent. The electric motor pump drives shall be sized to operate within the medium voltage range (less than 600 volts).

Features of the small-sized pumping station include local-remote-automatic operation, trash rake/rack system, water level sensing, motor control center, telemetry operation via Motorola Supervisory Control and Data Acquisition (MOSCAD) system, and backup generator.

A typical one-line diagram for small-sized pumping stations is shown on Plate E-1. A typical Supervisory Control And Data Acquisition (SCADA) block diagram for small-sized pumping stations is shown on Plate E-2.

### **Medium-Sized Pumping Stations**

Medium-sized pumping stations will typically have three to five pumping systems. The pumps in these stations shall be axial-flow-type vertical-shaft pumps. Power to the pumps shall be provided by a diesel engine through right angle reduction gear drives. Medium-sized pumping stations usually contain an electric motor driven pump for seepage control. The electric motor pump drives shall be sized to operate within the medium voltage range (less than 600 volts).

Features of the medium-sized pumping station include local-remote-telemetry operation, trash rake/rack system, control station/panel with programmable logic controllers (PLCs), fuel transfer system with leak detection, fire alarm, intrusion detection, exhaust fans, cooling water pumps, water level sensing, motor control center, telemetry operation via MOSCAD system, and backup generator.

A typical one-line diagram for medium-sized pumping stations is shown on Plate E-3. A typical SCADA block diagram for medium-sized pumping stations is shown on Plate E-4.

#### Large-Sized Pumping Stations

Large-sized pumping stations will typically have three to five large capacity pumping systems. Power to the pumps shall be provided exclusively by diesel engines. Large-sized pumping stations usually contain one or more electric motor driven pump(s) for seepage control. The electric motor pump drives shall be sized to operate within the medium voltage range (less than 600 volts).

Features of the large-sized pumping station include local-remote-telemetry operation, trash rake/rack system, control station/panel with PLCs, fuel transfer system with leak detection, fire alarm, intrusion detection, exhaust fans, cooling water pumps, water level sensing, motor control center, telemetry operation via MOSCAD system, and backup generator. Additionally, large-sized pumping stations have a ventilation controlled control room. Operation of the station is characteristically achieved via a SCADA system.

A typical one-line diagram for large-sized pumping stations is shown on Plate E-5. A typical SCADA block diagram for large-sized pumping stations is shown on Plate E-6.

#### 9.2 References

In addition to the following list of codes and standards, all electrical work shall comply with the applicable requirements of the latest edition of the National Electrical Manufacturer's Association (NEMA); Insulated Power Cable Engineer's Association (IPCEA); and all applicable federal, state, city, and local requirements. All newly manufactured equipment shall be listed by the Underwriter's Laboratory (UL) or comparable testing laboratory acceptable to the U.S. Army Corps of Engineers (USACE). When codes conflict, the more stringent standard shall govern.

#### **Civil Works Engineer Manuals (EM)**

*EM 385-1-1, Safety and Health Requirements Manual* 

EM 1110-2-2701, Vertical Lift Gates

EM 1110-2-2702, Design of Spillway Tainter Gates

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EM 1110-2-2703, Lock Gates and Operating Equipment

EM 1110-2-2704, Cathodic Protection on Systems for Civil Works Structures

EM 1110-2-3102, General Principles of Pumping Station Design and Layout

EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

EM 1110-2-2430, Instrumentation for Concrete Structures

Institute of Electrical and Electronic Engineers (IEEE) {tc \l2 "17.2.2 Institute of Electrical and Electronic Engineers.}

IEEE 141, *Recommended Practice for Electrical Power Distribution for Industrial Plants* (Red Book)

IEEE 142, *Recommended Practice for Grounding of Industrial and Commercial Power* Systems (Green Book).

IEEE 241, *Recommendation Practice for Electric Power Systems in Commercial Building* (Gray Book)

IEEE 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)

IEEE 399, Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book)

IEEE 446, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (Orange Book)

IEEE 493, Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (Gold Book)

IEEE 739, Recommended Practice for Energy Conservation and Cost-Effective Planning in Industrial Facilities (Bronze Book)

IEEE 1100, *Recommended Practice for Powering and Grounding Sensitive Electronic Equipment* (Emerald Book)

Instrument Society of America (ISA) {tc \12 "17.2.3 Instrument Society of America (ISA).}

ISA 55.1, Instrumentation Symbols and Identification

ISA 55.2, Binary Logic Diagrams for Process Operations

**National Fire Protection Association (NFPA)**{tc \l2 "17.2.4 <u>National Fire Protection</u> <u>Association (NFPA)</u>.}

NFPA 70, National Electrical Code (Latest Issue)

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- NFPA 70E, Occupational Safety Hazard Agency (OSHA) Electrical Safety Requirements for Employee Workplaces
- NFPA 72, National Fire Alarm Code
- NFPA 90A, Installation of Air Conditioning and Ventilating Systems
- NFPA 101, Safety to Life from Fire in Buildings and Structures
- NFPA 170, Fire Safety Symbols

Technical Manuals{tc \l2 "17.2.8 Technical Manuals.}

TM 5-809-11, Design Criteria for Facilities in Areas Subject to Typhoons and Hurricanes

TM 5-811-l, Electric Power Supply and Distribution

TM 5-811-2, Electrical Design: Interior Electrical Systems

TM 5-811-3, Electrical Design: Lightning and Static Electricity Protection

TM 5-811-7, Cathodic Protection

TM 5-811-14, Coordinated Power System Protection

#### **Unified Facilities Guide Specifications (UFGS)**

- 13100A, Lightning Protection System
- 13110A, Cathodic Protection System (sacrificial anode)
- 13112A, Cathodic Protection System (impressed current)
- 13720A, Electronic Security System
- 13721A, Small Intrusion Detection System
- 13850A, Fire Detection and Alarm System, Direct Current Loop
- 13851A, Fire Detection and Alarm System, Addressable
- 16221A, Electric Motors, 3-Phase Vertical Induction Type
- 16222A, Electric Motors, 3-Phase Vertical Synchronous Type
- 16263A, Diesel-Generator Set Stationary 100-2500 KW with Auxiliaries
- 16403A, Motor Control Centers, Switchboards and Panelboards
- 16404A, 480-Volt Station Service Switchgear and Transformers

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16410A, Automatic Transfer Switch and By-Pass/Isolation Switch

16415A, Electrical Work, Interior

16528A, Exterior Lighting including Security and CCTV Applications

16710A, Premises Distribution System

16751A, Closed Circuit Television Systems

16905A, Electrical Equipment for Gate Hoist

#### **Engineering Technical Letters**

- ETL 1110-3-403, Electrical Power Systems for Non-Linear Loads
- ETL 87-9, Prewiring
- ETL 91-6, Cathodic Protection

#### **Miscellaneous References**

AEI, Architectural and Engineering Instructions, Design Criteria

ANSI-C2, National Electrical Safety Code

IESNA 00 (Illuminating Engineering Society of North America), Lighting Handbook Reference and Application

NEMA E1 13 (National Electrical Manufacturers Association), *Pulse Initiators for Watt-hour and Other Integrating Meters* 

STD 40-06-04, *Lighting Fixtures, Standard Detail No. 40-06-04* (http://www.hnd.usace.army.mil/techinfo/index.htm)

TIA/EIA-606-A (Telecommunications Industry Association / Electronics Industry Alliance), *Administration Standard for the Telecommunications Infrastructure* 

CFR 28 Part 36, Nondiscrimination on the Basis of Disability of by Public Accommodation and in Commercial Facilities, Final Edition (ADA)

FED-STD-795, Uniform Federal Accessibility Standards AFM 85-5, Maintenance and Operation of Cathodic Protection Systems.

AFM 91-24, Energy Management and Control Systems (UMCS [EMCS])

#### 9.3 **Project Implementation Report**

The information gathered in each phase of the PIR shall be submitted to the appropriate Project Development Team (PDT) member(s) for incorporation into the Engineering Appendix. The electrical engineer is ultimately responsible for the validity of the information and the correctness

of the design. Prior to final submission, all data used for the design shall be checked thoroughly for errors and conflicts within and between disciplines and proprietary call outs.

### 9.3.1 Alternatives Evaluation

#### **General Requirements**

The Alternatives Evaluation phase is for the collection of information and data necessary to evaluate alternative designs and develop appropriate level cost estimates for comparing these designs. The alternatives are usually driven by hydraulic/hydrology considerations or pump mix determinations; however, the electrical engineer may be asked to participate in a diesel engine versus electric motor comparison.

The following information shall be utilized when preparing the electrical input for the Alternatives Evaluation phase for all types of CERP projects. The Alternatives Evaluation shall include the following requirements as well as all data and calculations made to support design decisions and estimates. The analysis shall also incorporate specific criteria furnished at conference discussions of project features.

#### Utility Relocations

Utilities include, but are not limited to: electrical, telephone, and cable television lines. During the Alternatives Evaluation phase, coordination with the respective utility owner(s) shall be initiated. The utility owner shall be advised of the project and the proposed period of construction. The utility owner shall be solicited for as-built information for all utilities affected by the project. The focus during the Alternatives Evaluation phase is to identify the utilities that will require relocation due to interference with project features.

The following requirements are be applicable for all project types and are intended to provide guidance for evaluating utilities that may potentially interfere with project features:

- Obtain as-built information on all known existing aerial, underground, and/or supported utilities entering, exiting, and within the project area.
- Request assistance from the respective utility owner to obtain as-built information for any utilities in the project area.

#### **Instrumentation and Controls**

The electrical engineer shall evaluate each alternative to determine the instrumentation and controls requirements.

The following items shall be performed:

- Coordinate the following project features with the local project sponsor: local, remote, and/or telemetry operation of equipment; intrusion detection; CCTV; SCADA;, and water level sensor needs.
- MOSCAD, SCADA, PLC are used by South Florida Water Management District (SFWMD) for remote operations. The pump stations and spillways shall have two modes of operation: local and remote. The local operation shall not be dependent upon the MOSCAD or SCADA, but instead shall be totally functional in the event of a MOSCAD or SCADA failure.

- At locations where CCTV is required, the design shall incorporate adequate bandwidth using microwave communications.
- Pumping stations shall contain a Station Control Center (SCC) with a PLC to provide for monitoring and control of common station functions such as backup generators, fire alarms, fuel system leak detection and level monitoring, security alarms, trash rakes, and ventilation fans. In pumping stations with an office there shall be a computer to allow for interface with the pumping station control system for monitoring and control.
- The electrical engineer shall coordinate with the local sponsor the requirements for automatic or manual operation as well as manned and unmanned pumping station or spillway.
- Develop a plan view with typical controls layout.
- Provide the cost estimator with an estimation of costs for instrumentation and control components.

#### **Pumping Stations**

The electrical engineer shall evaluate each alternative to determine the electrical requirements. Information for the electrical design of pumping stations can be found in EM 1110-2-3102 and EM 1110-2-3105. Items to consider for the electrical design include: establishing main service to the structure, identifying special loads within or around the structure, identifying needs of the local sponsor regarding local-remote-telemetry operation, and providing power to all electrically-operated equipment and devices.

The electrical engineer shall perform the following for each plan:

- Determine the route of electrical service from the nearest or most feasible distribution line to the project site. Coordinate the route with the local utility owner and other PDT members.
- Coordinate, with the local utility owner, the cost of bringing the required level of electrical service to the site.
- Develop electrical load requirements from pump mix, ancillary equipment, and lighting loads. Provide a brief description of the electrical characteristics (i.e., phase and voltage) for the electrical system(s).
- Develop requirements for a backup generator. Limit the size of the generator to only power equipment directly involved in the flood control mission.
- Determine the estimated cost for supplying electrical service and generator to the cost estimator. Provide the cost estimator with any known cost of electrical components or systems derived through discussions with manufacturers.
- Develop vertical and horizontal working clearance requirements to the structural engineer for station geometry (i.e., height and width) considerations.
- Develop a list of sole source items with justification for approval. Sole source items may include: Onan generators, Onan transfer switch, Bindicator and Balluff water level sensors, fire alarm systems, MOSCAD and CCTV systems or components.

#### **Spillways or Gated Culverts**

The electrical engineer shall evaluate each alternative to determine electrical requirements. Information regarding the design of spillways and gated culverts can be found in EM 1110-2-2701 and EM 1110-2-2702.

The following items shall be performed if the project contains a spillway or gated culvert(s).

- Determine the route of electrical service from the nearest or most feasible distribution line to the project site. Coordinate the route with the local utility owner and other PDT members.
- Develop requirements for a backup generator. Limit the size of the generator to only power equipment directly involved in the flood control mission.
- Determine if an electronic Manatee Protection System (MPS) is required for the structure. If a MPS is required, the electrical engineer shall specify the bumper type system for spillways.
- Determine the estimated cost for supplying electrical service and generator, and furnish these data to the cost estimator. Provide the cost estimator with any known cost of electrical components or systems derived through discussions with manufacturers.

The electrical engineer shall coordinate equipment utilization with the mechanical engineer. Care shall be taken to provide adequate power and control for all equipment at the spillway or gated culvert.

#### **Required Documentation/Products**

1. Narrative

The electrical engineer shall provide a descriptive narrative describing the electrical features of each of the alternatives considered. The narrative shall discuss utility relocation, plans for providing new service or upgrading the existing service, interior electrical requirements, and other electrical requirements that are unique to the respective design. The level of coordination with local utility owners shall be defined, as well as the suggested method for resolution of problematic issues.

The narrative shall also include a discussion of the following items:

- a. Physical characteristics of overhead and/or underground utilities within the project area, as well as those entering and exiting the project area.
- b. Control scheme for major equipment. Discussions on local-remote-telemetry operations and manual-automatic starting shall also be included.
- c. Backup generator and the items within the structure that shall be powered by the generator.
- d. Trash cleaning system and mode of operation.
- e. Water level sensors.
- f. Requirements relating to station and engine PLC(s), SCADA, MOSCAD, and telemetry. The physical components as well as the mode of operation shall be discussed.
- 2. Drawings

The Alternatives Evaluation phase electrical drawings shall be limited to an existing utility site plan and a plan view of temporary and permanent routes for any affected utilities.

### 9.3.2 Design of Tentatively Selected Plan

#### **General Requirements**

Work accomplished during the Design of Tentatively Selected Plan (TSP) phase shall include the requirements stated within the following paragraphs, all data collected, calculations performed to support any design decisions, and the cost estimate for this phase of design. It shall also incorporate specific criteria furnished at conference discussions of project features.

#### **Utility Relocations**

The following items shall be performed for electrical utility relocations, and shall include telephone and cable television lines:

- Coordinate/establish, with utility owner(s), the local sponsor, and the civil-site engineer, temporary and/or permanent relocation of utilities that interfere with project features.
- Obtain a written, estimated cost to relocate a utility and the intentions that the utility owner(s) to perform the relocation. If the utility owner does not assume the responsibility of relocating the utility, provide workmanship, safety, and equipment standards to the contractor performing the work. Economic feasibility and the reliability of various power factor correction schemes shall be considered by the electrical engineer designing the relocation scheme.
- Request a life-cycle analysis of the existing utility from the utility owner.
- Coordinate and clearly detail the level of work required by the utility owner and the project's construction contractor for any utility relocation.

#### Instrumentation and Control

The electrical engineer shall match the instrumentation and controls with the project requirements and specify the equipment most likely to be used during the TSP phase.

The following items shall be performed:

- Identify the equipment starter type.
- Develop an initial telemetry plan.
- Develop typical control schematic(s) and operating sequence(s).
- Determine water level sensor needs.
- Prepare tentative control panel layouts for motor control centers and/or engine control panels.

#### **Exterior Electric and Other Utilities**

The following guidelines have been developed for the most common projects such as locks and/or spillways and minor exterior electrical design. The requirements shall be defined, developed, and agreed to during this phase. Projects, which require extensive exterior electrical work, and projects with complicated or highly technical interior electrical work shall have special requirements developed for the respective project. The design shall be complete and accurate and checked by the electrical engineer to ensure compliance with project criteria. It shall be thoroughly checked for errors and conflicts within and between disciplines and proprietary requirements. No proprietary equipment shall be included in the design unless specifically authorized. The electrical engineer's focus shall be directed toward identifying, sizing, and
quantifying the major pieces of equipment that shall be included in the pumping station.

The electrical engineer shall:

- Coordinate with the local utility owners to arrange for electric power and telephone service if needed.
- Obtain from the utility owner any available information regarding existing utility lines within the project area and any necessary work needed to bring the required utility to the project.
- Determine with the utility owner whether the existing utility requires upgrades (i.e., single phase to three phase and/or 120 volts to 480 volts).
- Provide main service to the structure and provide necessary distribution devices to all equipment and electronics requiring power.

The following is a list of design requirements for elements relevant to the electrical design:

1. Transformer

Although the local utility owner provides the transformer, the electrical engineer shall specify a delta-wye transformer to block transit frequency.

Additionally, the electrical engineer shall obtain information about the transformer from the utility owner, including:

- Type
- Number
- Capacity (kVA)
- Impedance
- Statement of the method of sizing
- 2. Lightning Protection System

Describe the lightning protection system; if protection is not required, an explanation shall be provided. Design requirements shall be based on TM 5-811-3 and EM 385-1-1.

3. Site and Station Grounding

The electrical engineer shall evaluate the grounding plan and discuss real estate requirements with other disciplines as necessary. The grounding system to be installed shall be described. If a counter poise, a grid, or EMI shielding requirements are to be used, state the standards in design calculations.

4. Backup Generator

Spillways shall have a backup generator to provide power for essential flood control equipment and station lighting. The electrical engineer shall coordinate with the local sponsor, hydraulic/hydrology and mechanical engineers for other items that require backup power.

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5. Telecommunications/Data System

Provide a descriptive narrative of all electronic systems that are required for the project.

6. One-Line Diagram

Prepare a one-line diagram from the service drop to secondary panels including major equipment.

7. Control Centers Suggested Layouts

Prepare tentative control panel layouts for motor control centers and/or engine control panels.

8. Intrusion Detection System

Pump stations shall be equipped with electronic intrusion detection. The system shall operate such that, upon intrusion, an alarm shall be sounded in the station and registered at a remote location.

9. Cathodic Protection System

Clearly define areas of structures or components in soil or water to be protected. Indicate the type of system recommended, comparison of systems, and a cost estimate.

10. Fire Detection and Alarm System

The pump station shall be equipped with a fire detection/alarm system in accordance with NFPA 72 National Fire Alarm Code.

11. Manatee Protection System

For spillways located in areas that are frequently visited by manatees, the designer shall specify a bumper type manatee protection system. The manatee protection system control shall be integral to the spillway controls.

12. Gate Position Indicator with Display

Spillways shall have an installed gate position indicator with display. The indicator shall be capable of providing an electrical signal to the PLC.

13. Pushbutton Control Station

The spillway shall have a pushbutton control station on the walkway and in the control building for local and remote control, respectively.

### **Required Documentation**

1. Narrative

The narrative shall describe the features of the TSP and include, but not be limited to, the following:

- a. An explanation of any utility relocation divided into: the work to be performed by the local utility owner and the work that will need to be performed by the project contractor.
- b. Electrical characteristics of new power supply from the service point to the main service equipment (i.e., voltage and phase).
- c. Description of operation, which shall include requirements for local-remote-telemetry operation.
- d. Description/characteristics of auxiliary equipment and/or systems. A brief discussion on each auxiliary system shall be provided.
- e. All sole source items and a brief discussion justifying the need for sole sourcing.
- f. A discussion of the physical characteristics of overhead and/or underground utilities within the project area, as well as those entering and exiting the project area.
- g. Provide a discussion of the control scheme for major equipment. Discussions on localremote-telemetry operations and manual or automatic starters shall also be included.
- h. A discussion of backup power generation and the items within the structure that shall be powered by the generator.
- i. A discussion of trash cleaning systems and mode of operation.
- j. A discussion of water level sensors. If sensors are to be provided as sole source, then a narrative shall be provided for the justification for the sole source item.
- k. A discussion of requirements relating to station and engine PLC(s), SCADA, MOSCAD, and telemetry. The physical components, as well as the mode of operation, shall be discussed.
- 2. Drawings and Plates

Drawings and plates shall graphically present the design as finalized in the TSP phase.

The information presented shall be specific to the TSP and include, but not be limited to, the following:

a. An electrical site plan that includes existing utilities and illustrates the proposed routes for temporary or permanent utility relocation.

- b. A typical one-line diagram showing power distribution from the service pole to the load panels.
- c. A typical control schematic for the main drive unit and a separate control schematic for each major auxiliary equipment type (i.e., fuel oil pump, raw water supply pump, and vacuum pump).
- 3. Sample Drawings

The typical drawings are provided to serve as a guide to the level of information that shall be conveyed. The drawings are representations and shall be revised as necessary to adequately reflect the features of the TSP. Examples of these drawings are as follows:

- Panel Schedule (E-15)
- Lighting Fixture Schedule (E-18)
- Conduit and Cable Schedule (E-16/17)

#### **General Requirements**

The following requirements apply to the development of plans and specifications for the design of electrical systems. These requirements are applicable to all CERP projects.

#### **Power Supply**

Coordinate with the local power owner to bring in a new service or convert a single-phase service into a three-phase service. Conductors shall be copper except for overhead high voltage and distribution voltage (i.e., 12470Y/7280V), which are generally aluminum.

The electrical engineer shall coordinate the location of all major pieces of electric equipment, including panel boards, with the structural and mechanical engineers.

#### Plans

{tc \l2 "17.4.1 Interior Electrical System Design Analysis Narrative.} Plans shall graphically present the design and include the following:

1. General

An electrical symbols and legend drawing shall be prepared.

2. Utility Relocation

A demolition plan for any existing utility requiring removal and/or demolition shall be prepared.

3. Electrical Site Plan

An electrical site drawing indicating the locations of the following items shall be prepared:

- Service into the site
- Transformer pad(s)

- Exterior lighting
- Conduit runs for primary and secondary power

Existing and new electrical primary lines both overhead and underground shall be properly identified. Any removals and/or relocations of electrical components shall be shown. If work to be completed is so extensive that the clarity on the plan is diminished, additional drawings shall be provided. The secondary service to the facility and whether it is to be routed overhead or underground shall be indicated.

4. Lightning Protection and Grounding Plan

A lightning protection plan and grounding plan shall be prepared. The lightning protection plan shall show the location and detail of air terminal, down conductor location, and grounding grid or counter poise system.

5. One-Line Diagram

A one-line diagram that shows the main electrical service and secondary transformers, metering equipment, major electrical components, power panels, and lighting panels shall be prepared. The type, number, capacity (kVA), and impedance of the proposed transformer installation and state the method of sizing shall be indicated.

6. Conduit Plan

A conduit plan that shows location of switchgear, control centers, panel boards, motors, and disconnects shall be prepared. The conduit and cable plan shall include all power, control, communications, and alarm cables.

7. Intrusion/Fire Detection Plan

An electrical floor plan that includes fire alarm and security devices shall be prepared. A riser diagram for fire alarm, telecommunications/data systems, security alarms with all devices shown, zones, and wiring shall be prepared.

8. Lighting Plan

A lighting layout, receptacles, and telephone jack location plan shall be prepared. The lighting system(s) shall include in tabulation form, the lighting intensity, type of fixture, number of lights, and wattage.

9. Control Schematic and Plan

Control schematics for each component shall be prepared. A control plan indicating the conduit and cable size for all control circuits shall be prepared.

10. Conduit and Cable Schedule

Conduit and cable schedules that include source and designation of conduit, conduit size, number of conductors, and purpose of the circuit shall be prepared.

11. Suggested Control Center Layout

Suggested layouts for Motor Control Center (MCC), Engine Control Center (ECC), Spillway Control Center (SCC), and gate control panels shall be prepared. The layouts shall include all controls, meters, alarms, and PLC displays. Gate control panels shall also include an interior layout. Panel board schedules shall include Amperes Interrupting Capacity (AIC) ratings, voltage, breaker size, and voltamp requirements of each circuit.

12. Hazardous Areas at Fuel Farms

Any and all hazardous areas shall be defined with the applicable class, group, division, and suitable operating temperature as defined by the National Electrical Code. Do not attempt to "design around" the hazardous areas in lieu of designating the areas. Source of criteria, such as Safety Officer or some other recognized official shall be provided, and documentation of the source shall be included.

13. Equipment Grounding Plan

An equipment grounding plan showing the location of major equipment with grounding conductor, building grounding conductor, and grounding loop shall be prepared.

14. SCADA Logic Diagram

A SCADA Logic Diagram that shows the operating logic, inputs and outputs, computer location, and other components of the SCADA system shall be prepared.

15. MOSCAD Plan

A MOSCAD plan that identifies the system components and location within the structure shall be prepared.

### Specifications

The current guide specifications utilized by the USACE are known as the Unified Facilities Guide Specifications (UFGS). The electrical specifications are numbered within sections 16000 to 16999. However, numbers are not consecutive and not all numbers are used. The electrical engineer shall be aware that specifications covering special items such as cathodic protection are contained in section 13000. The electrical engineer will need input from the mechanical engineer to complete the generator specifications.

The electrical engineer shall edit the guide specifications to reflect the equipment that is being selected for the project. Care shall be exercised to ensure that conflicts between specifications sections are eliminated.

#### **Required Documentation/Products**

The electrical engineer shall furnish supporting documentation consisting of Design Analysis (DA), Design Documentation Report (DDR), and Engineering Documentation Report (EDR) to adequately document the approach, assumptions, decisions, and equipment selection criteria that yielded the final design.

### Design Analysis

The DA shall document all alternatives considered for a project feature and the reasoning for selection or rejection. The electrical engineer shall evaluate at least three different supplier's equipment and design to the most conservative (i.e., the largest when space is a factor, or the slowest when speed is a factor). The DA shall include the following:

- A documented statement that the primary supply is adequate to support the added load. If the primary source is inadequate, stated measures proposed to correct the deficiency in the design shall be included. Reference photographs of existing substations, pole line structures, and/or other exterior components shall be included. The photographs shall be included in the design analysis of all affected equipment and structures.
- Where additions or alterations to existing systems are to be made, systems that are expandable and can accommodate these changes shall be verified. A description of all proposed additions and alterations to each system shall be provided.
- Any additional criteria, deviations concerning criteria, questions or problems shall be listed.

#### **Design Documentation Report**

The DDR shall document the final design. The electrical engineer shall include in the DDR, pertinent and relevant information about the equipment contained in the design. Documentation shall be included in the DDR that clearly indicates that the selected equipment matches the project feature. Manufacturer's catalog cut, specification sheets, installation instruction, and cautions, may be included in this report. Engineering considerations and instructions to construction personnel or equipment operators may also be included. As a minimum, the DDR shall include the following:

- A statement describing standards of design, such as primary and secondary voltage drop, and physical characteristics of overhead or underground circuits. If underground, state the basis for the selection and reference applicable conclusions and/or calculations. State short circuit current available at project site and the source of this data.
- A statement describing all exterior lighting, with handicapped features if required. IES pointto-point calculations shall be submitted to support the selection for the aforementioned lighting system.
- A statement describing the extent of any exterior work, such as telephone lines and duct banks, outside of five feet from the building line.
- A descriptive narrative of all electronic systems, which are required for the project. A list of possible electronic components and/or systems that may be required on a given project are as follows: Telecommunication/Data Systems, Fire Detection and Alarm System Fire Suppression System Controls, Cathodic Protection, Special Grounding Systems, Public Address Systems, and Security Systems.
- Any additional criteria, deviations concerning criteria, questions or problems.

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# SECTION 10 ARCHITECTURAL

### 10.1 General

This section provides general guidelines of the preparation and coordination of the architectural input to the Project Implementation Report (PIR) and plans and specifications. The architect shall direct, guide, and coordinate the efforts of the various design disciplines for all vertical construction. The architect shall ensure that proper building systems are selected and their function, in accordance with the desired intent, are properly interfaced.

The architect shall ensure that high quality, cost effective buildings are designed using sound technical knowledge, and that they are constructed using recognized commercial building industry practices. The design shall incorporate the above characteristics, which will provide buildings with present and continuing utility, durability, and desirability, and provide a safe and healthy environment that is economical to maintain for the life of the building.

One of the important underlying goals is to standardize the building systems for repetitive building types such as pump stations.

### 10.2 References

ER 1110-345-700, Design Analysis, Drawings and Specifications

EM 1110-2-3-3104, Structural and Architectural Design of Pumping Stations

Unified Facilities Criteria (UFC)

Florida Building Code, latest edition

Florida Fire Prevention Code

International Building Code

National Fire Protection Association (NFPA), latest edition, applicable portions

Life Safety Code, NFPA 101, latest edition.

Architectural and Engineering Instructions (AEI), latest edition (published by the Corps of Engineers)

Requirements established by the St. Johns Water Management District, Department of Public Works, or using agency

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### **10.3 Project Implementation Report (PIR)**

#### **10.3.1** Alternatives Evaluation

#### **General Requirements**

The architect will provide general costs data for architectural and building systems, as described in the Cost Estimating Section, for the Alternatives Evaluation Phase of the project. A more detailed analysis shall be performed during the Design of the Tentatively Selected Plan Phase, as described in the following sections. The Alternatives Evaluation Phase is for the collection of information and data necessary to develop conceptual plans and costs for an evaluation and comparison of alternatives.

#### **10.3.2** Design of the Tentatively Selected Plan

#### **General Requirements**

The Detailed Design Phase of the project is for the collection of information and data necessary to develop conceptual plans and costs for an evaluation and comparison of alternatives. The architect will perform an evaluation of alternatives for the selected plan, identifying those that are constructible, and the degree that safety, reliability, technical, environmental considerations, functional requirements and objectives are met in light of operations and maintenance considerations.

Architectural Programming is a function of the Project Design Team (PDT) and an integral part of the planning of a project by encompassing a wide range of issues that influence the project in varying degrees. The following guidelines shall be utilized in preparation of Architectural Programming input during this phase. The architect must exercise judgment with these guidelines and determine the appropriate level of effort necessary to satisfy the objectives of the project. These issues include, but are not limited to:

- Organizing the decision making process.
- Establishing operational requirements and their relationships.
- Creating a value system for the hierarchical arrangement of functions and ensuing spaces.
- Establishing models that meet user expectations.
- Defining design constraints such as building code issues, site constraints, funding limitations, and environmental issues.
- Determining the orientation to views, the sun, wind, and water (when applicable).
- Evaluating the relationship to any surrounding natural or manmade environment.
- Evaluating the interface with any contiguous traffic circulation.
- Developing a description of the architectural feature(s) for each alternative with pertinent data for each structure.
- Developing a summary type description of the civil, structural, geotechnical, mechanical, and electrical engineering at each structure, preliminary parameters, and guidance on general characteristics.

In order for the architectural programming to be successful, a continuous loop of feedback from all members of the design team must be performed. Bubble diagrams and/or other graphic methods of organizing the functional requirements shall be used, followed by functional matrices of all tangible and intangible project influences. These shall be developed for each functional area

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of the proposed facility and for the overall project. These studies will result in graphic and written documentation of all facility aspects for the proper planning, design, and construction. Depending on the complexity of the project, the Architectural Programming of a facility can be best accomplished by a meeting of all interested parties, in a design charette format. This may require one to four days to finalize the process depending on project complexity.

### Architectural Input and Coordination

The following guidelines shall be utilized for architectural input and overall coordination during this phase:

- 1. The architect shall participate in all PDT activities, including site visits.
- 2. The architect shall determine if the facility is in view of a public right-of way. This shall be the driving force in how influential the following factors are in the design process:
  - Exterior appearance
  - Acoustical containment and equipment selection
  - Landscaping
  - Building orientation
  - Building access
- 3. The architect is responsible for identifying and/or coordinating all functional design requirements and technical design criteria for the project. This includes all design data obtained through coordinating with other disciplines (e.g., machinery loads and layout).

#### **Design Considerations**

The design considerations described below are considered typical for application in the design of structural features for CERP projects.

1. Pumping Stations and Other Building Types

Pumping stations shall be designed in accordance with *EM 1110-2-3104, Structural and Architectural Design of Pumping Stations*. The following considerations are employed in the normal design process:

- a. Classification Refer to Mechanical, Section 8 of this manual, for a description of small-, medium-, and large-sized pumping stations.
- b. Superstructure Pumping station superstructures are not considered hydraulic control structures and shall be designed in accordance with ACI 318. Medium- and large-sized pump stations shall be fully enclosed and include both an office and a restroom. Concrete or steel framing systems must be carefully considered. Avoid use of masonry block construction for the superstructure except on small stations. Temporary pump stations (service life ten years or less) shall be covered with a roof system.
- c. Roof Medium- and large-sized pumping stations primarily used for flood control will not generally require roof hatches for servicing and removal of pump equipment. Small-unmanned flood control or water supply stations may require roof hatches. Where roof

hatches are used, the facility shall be designed with respect to the type of crane that shall be used for the pump extraction. For stations with engine exhaust stacks, a three-ply modified bitumen roofing system with a ceramic granular faced cap sheet shall be used to resist damage from hot particles.

d. Wall Openings - For structures that have been designed for a mean recurrence interval (MRI) of 200 years or greater, rolling doors, fans, windows, ducts, and louvers shall be designed to meet the building envelope protection requirements of the Florida Building Code, Test Protocols for High Velocity Hurricane Zones. Single or double doors shall meet the requirements of FEMA 361. For structures that have been designed for a MRI of 50 years, fans, ducts, and louvers shall be designed to meet the requirements of the Florida Building Code. Doors and frames shall be hot-dipped galvanized steel.

### **Design Analysis**

The architect shall prepare a written description of the technical basis for selecting the type and configuration of buildings included in the alternatives studied and the selected plan. The architect shall solicit input on the conceptual designs and incorporate these comments through revisions as needed.

General description of the project includes stating the purpose, function, and capacities in sufficient detail to delineate and characterize functional features and the desired image or visual appearance of the project. The narrative shall reflect the regional architecture as well as the visual characteristics of the existing facilities around the site.

Basis of Design Summary - the architect shall provide a summary of the Basis of Design, which will include all major elements of the Architectural Programming and, but not limited to, the following:

- 1. Building Systems Analysis Include any information or documentation to support the selection of architectural materials. Selection shall be based on a comparison of several alternate systems, which shall be presented. Indicate the economic decision process (comparative cost analysis method, life-cycle analysis method, or other techniques used) and any other rationale utilized in the selection of the various systems. It must be evident that the designer has adequately conceived the project as a whole and that the systems selected represent the maximum value that can be obtained for the intended result. The following are some, but not necessarily all, of the systems that shall be investigated:
  - Exterior wall systems
  - Passive solar systems
  - Fenestration
  - Roof systems
  - Interior partition systems
  - Openings in interior partitions (doors, windows, etc.)
  - Ceiling systems
  - Floor systems
  - Integrated building systems
  - Noise and/or acoustics control measures
  - Special equipment
  - Vertical transportation systems (elevators)

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- 2. Design Calculations Submit complete calculations for the following:
  - Gross building areas in accordance with the AEI, Design Criteria
  - "U" values for each exterior construction assembly (walls and roofs)
  - Calculations for toilet fixture count
- 3. Provide the building construction type and occupancy classification appropriate to the model code(s) in use.
- 4. Provide the design wind speed and velocity pressure used in the design.
- 5. State the functional areas and their relationships.
- 6. List the space allocations.
- 7. Provide the energy conservation measures used in the design.
- 8. Provide the noise control criteria established for the design.
- 9. Provide any requirements for exterior finish materials and color selection. Indicate that consultation has occurred with the South Florida Water Management District (SFWMD) to review the architectural compatibility and insure that the finish materials and colors selected are in accordance with the approved standards.
- 10. List special requirements such as security requirements and raised flooring.

#### **Technical Criteria**

The designer shall state the assumptions and rationale behind all major facility design decisions including, but not limited to, discussions that address the following elements:

- 1. Orientations to the sun, wind, and water (when applicable).
- 2. The relationship to any surrounding natural or manmade environment.
- 3. The interface with any contiguous traffic circulation.
- 4. The visual impact of the facility with regard to the overall area.

Occupancy type and all other code requirements shall be determined and documented per the Florida Building Code, The Florida Fire Prevention Code, and the various NFPA publications. These code requirements, include:

- 1. If a fire/smoke detection system is required.
- 2. How the system shall be alarmed (locally or notification of the local fire department via modem).
- 3. How the alarm system is interlocked with the HVAC and/or ventilation system(s).

### **Design Review Submittal**

The design shall include three review phases, which are at 30%, 60%, and 100% completion. Additional level of design detail shall continue through each of the 60% and 100% design phases. The 30% submittal is based on the building systems analysis, which shall include any substantiating material to support the selection of architectural materials systems. Selection shall be based on a comparison of several alternate systems, which shall be presented. The architect shall determine Indicate the economic decision process (comparative cost analysis method, life-cycle analysis method, or other techniques used) and any other rationale utilized in the selection of the various systems. It must be evident that the designer has adequately conceived the project as a whole and that the systems selected represents the maximum value that can be obtained for the intended result.

#### **Technical Requirements**

The architectural design shall comply with AEI, Design Criteria, as supplemented by the TI-800-01 and detailed on the architectural drawings. Materials and construction methods shall comply with the instructional notes inserted in the applicable guide specifications.

The following guidelines and criteria shall be followed for the plans and specifications:

1. Site Work

Floor Relation to Grade - The finish floor of concrete floor slabs on fill shall be a minimum of 6 inches above the finished grade. All stoops, steps, or similar required access to entrances that will normally be built by a building contractor as differentiated from sidewalks and driveways, which are normally constructed by a paving contractor, shall be shown required to allow access by the physically impaired.

- 2. Masonry
  - Interior Walls and Partitions Concrete masonry units (CMU) for interior masonry walls and partitions shall be not less than 6 inches in nominal thickness. Where split face units are used, provide smooth face units where concrete paving or flashing occurs and where items are attached to wall surfaces.
  - Coursing Concrete masonry unit coursing shall be coordinated with door heights to eliminate the need for cutting block.
- 3. Miscellaneous Metals

All access panels required to service mechanical items normally furnished and installed by the non-mechanical trades shall be shown on the architectural drawings. Insure that access panels, when required, are specified and detailed.

4. Thermal and Moisture Protection

Roof and Wall Insulation - Except when required for refrigerated spaces, roof and wall insulation shall be drawn at a nominal thickness consistent with the insulation requirements of the particular building or project. The thickness of roof or wall insulation shall not be dimensional nor the thickness indicated on the drawings. General standards for insulation, as indicated in the applicable guide specification, require insulation thickness as determined by

the established "U" value for total roof or wall thickness, and the type of material utilized. Unless specifically directed, "U" values shall be provided as indicated in the AEI, Design Criteria. Details shall allow for possible differences in insulation thickness.

5. Standing Seam Metal Roofs

All standing seam metal roofs shall be installed over a slip-sheet over a 40-mil self-sealing secondary water barrier over rigid insulation board (if attic is to be used as a return air plenum) or over a structural metal deck (for diaphragm action). Roof panels shall be a minimum thickness of 24-gauge steel or 0.040 aluminum. Vented ridge caps are not desirable due to potential leaks. Use locking type seams (as opposed to snap lock type) for hurricane and high wind areas. Roof specifications shall require that an independent registered roofing consultant be present to monitor the entire roof application.

6. Roof Slope

The minimum roof slope for built-up roofs shall be 1/4-inch per foot; however, the use of a "flat" built-up roof is discouraged except for facilities of unusual building configuration or extremely large areas. In no case shall a built-up roof slope exceed 2 inches per foot. Roof slope for standing seam metal roofs shall be 1:12 minimum; however, individual Installation/Command policy will dictate required slope for a particular base.

7. Sheet Metal

In all cases sheet metal for various elements used throughout a building shall be of the same basic metal. Atmospheric conditions shall be considered in the selection of exposed sheet metal. Different types of sheet metal that can cause accelerated corrosion (galvanic action) of either one shall not be placed in direct contact. Sheet metal used on roofs with concrete roof tiles shall not react with nor corrode excessively due to the concrete.

8. Gutters and Downspouts

When downspouts are required they shall not drain directly onto a walk or platform. When downspouts must occur at walks or platforms they shall pass through or under into underground drains or toward open ground beyond. Downspouts draining onto open ground shall be diverted using precast concrete splash blocks to prevent erosion. Use of interior downspouts shall be avoided. The use of scuppers shall be maximized. Avoid built-in gutters behind fascia or parapet due to expansion/contraction of metal and surrounding material. All gutters shall have leaf screens.

- 9. Doors
  - Pedestrian Doors All pedestrian doors shall be 7 feet 0 inches or 7 feet 2 inches high. Door openings shall, in general, be 3 feet 0 inches wide, except for special purpose doors, toilet rooms (except for handicap) for instance.
  - Doors to Rooms Doors to rooms shall be of adequate size to accommodate the installation and removal of furniture and equipment installed therein.
  - Exterior Doors Except in underground structures and floors above the first story of multistory structures, doors to boiler or mechanical rooms, doors from power rooms, generator rooms, and doors from similar areas shall be to the outside of the building only. Electrical closet and air handling room doors may open to the building interior.

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- Special-Purpose Doors Special-purpose doors such as rolling and coiling doors shall be adequately designed to safely resist the design wind pressure. Rolling and coiling steel or aluminum doors shall be designed so as to permit operation of the doors at maximum wind velocities defined in the area where used.
- 10. Finish Hardware
  - When selecting finish hardware carefully read the "Notes to Specifier" for the hardware specification Section 08700, Builder's Hardware. Hardware shall then be selected from BHMA and ANSI standards. Except for items not listed by BHMA or ANSI manufacturer names and catalog numbers shall not be used in hardware schedules. All cylinders shall have seven pins.
  - Hardware Set Designations Hardware set designations shall be listed in the Door Schedule in preference to locating on the floor plans. Specification Section 08700, Builder's Hardware, shall provide the necessary hardware set designation numbers, plus description and function of each hardware item included in the Hardware Set.
- 11. Return Air Louvers

Overall size of return air louvers located in doors shall be included in the Door Schedule. Minimum bottom rail dimension shall be 10 inches and the minimum stile dimension shall be 5 inches.

#### **Required Documentation/Products**

The report drawings descriptions shall be presented in the engineering appendix to the PIR. All views presented in the report drawings shall be prepared as CADD files in accordance with the requirements of Graphic Presentation, Section 2 of this manual.

The Design of the Tentatively Selected Plan shall include documentation of the different design alternatives investigated during the PIR. At minimum, the architect, in close coordination with the structural engineer, is responsible for the production of a preliminary conceptual plan and a typical section, elevation, and site plan of each building included in the alternatives evaluated. The architect shall coordinate these conceptual designs with the civil-site and cost engineers for preparation of site plans and cost estimates. The minimum requirements for this submittal consist of floor plan(s) drawn to appropriate scale, fire protection information as required by the paragraph titled Life Safety Analysis Plan, exterior building elevations, typical wall sections to indicate material usage and structure, a site plan, and a design analysis. Additional drawings may be required at this submittal due to the complexity of the project to adequately describe the proposed design.

During this phase of the project, all significant design issues shall be resolved. The design of the facility features in the tentatively selected plan shall be developed to a level required to ensure that they can eventually be presented in contract plans and specifications without the need for major revisions. The design must also be sufficient to ensure that reasonable costs can be developed for the preparation of a detailed baseline cost estimate.

The architect shall identify any significant unresolved design issues and make recommendations to address them. For example, a type, size, and location engineering study may be required to identify a cost effective conveyance structure constructed under a highway. An evaluation of

architectural alternatives such as this shall be initiated upon identification of a tentatively selected plan.

The architect is responsible for the production of a detailed plan view, elevation view, and longitudinal and transverse section views of each structure. Additional views may include other details and a foundation plan if they are required. The architect will work with the landscape architect, structural engineer, and the civil-site engineer to develop a construction site plan and a final site plan for each structure.

### Drawings

This submittal consists of one or more single line schematic floor plans, which effectively indicate the agency that the function, circulation, and life safety issues have been assessed and can be met by the proposed design. At least one major elevation (preferable the front elevation) for each submitted building is required. A site plan is required to indicate the building orientation and circulation to the building entrances.

The Building Organization Analysis shall include any graphic design aids such as affinity drawings, spatial organization and relationship matrices, and space layout sketches in a sequential order, with sufficient narrative to indicate the reasoning and justification for major design decisions. Any provisions for future expansion shall be indicated, including schedules for phasing.

### **10.4 Plans & Specifications**

Upon approval of the PIR, the architect shall finalize the design and begin preparing plans and specifications for the construction contract. The Pre-construction Engineering and Design Phase (PED), as described on the ER1150, is the phase for finalizing the design, preparing the plans and specifications (P&S), and the preparation of advertising the construction contract. P&S shall be prepared in accordance with ER 1110-2-1200, and applicable CADD standards presented in Graphic Presentation, Section 2 of this manual.

The plans and specifications shall be prepared and submitted for review during three phases; 30%, 60%, and 100% completion. Though much of the design in completed during the Design of the Tentatively Selected Plan phase, additional design will continue during the plans and specifications phase. A description of the required drawings during the three review phases are shown in the following:

### 10.5 30% Concept Design Submittal

#### **Composite Floor Plans**

When the main floor plans must be drawn in segments in order to comply with the requirements for the proper scales, provide a composite floor plan for each floor level. These plans shall show the following:

The general building layout showing exterior walls, interior partitions, and circulation elements (stairs, elevators, and corridors) drawn to scale.

1. The identification of major areas and their functional relationships

- 2. Overall building dimensions, out to out
- 3. Planning grid or column lines where applicable
- 4. Match lines indicating larger scale floor plan segments
- 5. Cross-references for enlarged floor plans and building sections
- 6. Gross area tabulations

#### **Floor Plans**

The architect shall provide a floor plan or floor plan segments, 1/8-inch scale minimum, 1/4-inch scale for health care facilities, for each floor showing functional arrangement and circulation elements, drawn to scale. In addition, the following shall be shown:

- 1. Planning grid and/or column lines
- 2. All major overall dimensions
- 3. Type of occupancy in each area
- 4. Finish floor elevations for each floor or change in floor level
- 5. Openings in walls (doors and windows)
- 6. All major equipment
- 7. Furnishings layouts or typical rooms where required
- 8. Gross floor area tabulations on the first floor plan sheet
- 9. Cross-references for sections and details
- 10. Provisions for the handicapped where required
- 11. Reflected ceiling plans

### **Roof Plan**

Provide a roof plan showing the following:

- 1. Planning grid and/or column lines
- 2. Overall dimensions
- 3. Indication of roof slope and drainage

- 4. Roof accessories (skylights and roof scuttles)
- 5. Major roof-mounted equipment

### **Demolition Plans (if required)**

- 1. Floor plans showing demolition work in sufficient detail to indicate all existing building materials and finish conditions are required for renovation and modification projects. Drawings shall be of sufficient detail to indicate "existing to remain," "existing to be removed," and new work and materials.
- 2. Contractors are not required to site verify correctness or completeness of renovation and modification contract drawings and specifications; therefore, the drawings shall be complete with adequate detail and descriptions of existing materials, assemblies, and systems (type, thickness, quantity spacing, length, width, height, ) to enable the contractor to bid on the project.
- 3. Building Elevations

The architect shall provide building elevations showing the exterior design of all major elevations. Each elevation shall show the following:

- Planning grid and/or column lines
- Building masses and fenestration
- Identification of all major building materials
- Roof accessories, when visible in elevations
- Major roof-mounted equipment
- Indication and elevation of all floor lines
- 4. Building Sections

The architect shall provide building sections as necessary to demonstrate the coordination of the structural, mechanical, and electrical systems. In addition, the following shall be shown:

- Planning grid and/or column lines
- Structural system
- Changes in floor levels
- Finish ceilings
- Floor-to-ceiling and floor-to-floor heights
- Floor elevations
- Spaces to be used by the lighting and HVAC systems
- Adjacent grades

### 5. Typical Wall Sections

The architect shall provide at least one unbroken, typical wall section (3/4-inch scale preferred). All sections shall be fully noted. These sections shall show the following:

- Structural system
- Exterior wall and roof assemblies
- Ceiling systems
- Floor-to-ceiling and floor-to-floor heights
- Floor elevations
- Spaces to be used by the lighting and HVAC systems
- "U" values through walls and floors
- 6. Finish Schedules
- 7. Details

In addition to the above requirements, show details of any design significant features and any sections necessary to demonstrate the required coordination of the various building systems.

8. Life Safety Analysis Plan

A Life Safety Analysis Plan shall be submitted for each floor at the Project Definition Phase and the Concept Design phase. Life Safety Analysis Plan sheets shall be referenced as LSA-1, LSA-2, and placed after the architectural drawing sheets in the contract drawing submittal set. The plan shall include the following data and provide a legend for symbols used on the drawings:

- Type of occupancy
- Type of construction
- Fire/smoke compartments
- Exit width calculations and number of exits
- Location and rating of walls (1 hr and 2 hr)
- Door labels
- Door hold open devices
- Fire extinguisher and/or fire hose cabinet locations and details
- Egress distances form most distant point to exit
- Smoke proof doors
- Exit lights
- Signage
- Egress travel distances
- Portable fire extinguisher locations, size and type
- Hazard signage
- Emergency lighting
- Paths of egress
- Common paths of travel
- Dead-end corridors

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- Fuel containment
- Appropriate egress door hardware
- Post construction life safety training for the occupants
- 9. Coordination

Final coordination with work of other technical disciplines shall be implemented.

10. Design Analysis – Submit updated Design Analysis

#### 10.6 60% Preliminary Design Submittal

#### **Interim Design Drawings**

These drawings shall include, but are not limited to, the following items:

1. Concept Design Review Comments

Implement concept design review comments into the drawings and provide annotated comments (responses) describing the action taken for each comment (changes or additions to the design, reasons for the design, directions received from the user).

2. Building Plans

Provide plans for each floor, roof, and ceiling showing dimensions, functional arrangement, and equipment for all areas, including corridors, exits, stairs, and utility spaces. The relationship of the building to exterior access, vehicle parking, service areas, etc., shall be indicated on site plans. Individual treatment shall be given to special design or items involving deviation from normally accepted standards. All column lines shall be designated to aid in locating project components and all fire rated construction shall be indicated. Show indications of phased construction if required. Thoroughly cross-reference section cut symbols on plans and elevations to detail sheets. Identify firewalls and smoke partitions. Include door and window numbers, space names, section cuts, and complete door and window details to minimum of 60%.

3. Schedules

The drawings shall include door, window, and equipment schedules. Schedules need not be complete at this point; however, they shall be sufficient to indicate the door and window sizes and major equipment items.

- 4. Specifications
- 5. Design Analysis Submit updated Design Analysis

### 10.3.1 100% Final Design Submittal

#### **Final Design Analysis Narrative**

The Final Design analysis narrative shall include all items in the Interim - Design analysis narrative and any revisions necessitated by comments about the Interim Design submittal and/or previous submittals.

#### **Final Drawings**

- 1. Complete to the extent required for the Ready To Advertise Submittal. Drawings are to be complete, except for incorporation of comments about this submittal.
- 2. Implement Interim Design review comments into the drawings and provide annotated comments describing the action taken for each comment (changes or additions to the design, reasons for the design, and directions from user).
- 3. Insure that all details and sections necessary for the final documents have been added to the drawings and are complete and thoroughly cross-referenced.
- 4. Complete all schedules. Insure that hardware sets have been added to the door schedule and coordinated with the specifications.
- 5. Complete all title blocks including drawing and file numbers, specification numbers, dates, and drawing titles. Information required from the Corps of Engineers shall be requested from the Project Coordination and Specification Section.
- 6. Insure that the drawing index is complete, accurate, and coordinated with the drawings and all other disciplines.
- 7. Coordination All architectural work shall be coordinated with work of other technical disciplines.
  - Insure adequate above-ceiling space for ductwork, piping, lighting, and structural members.
  - Coordinate reflected ceiling plans with lighting and HVAC plans.
  - Coordinate light switches with door swings.
  - Coordinate electrical and mechanical drawings with architectural plans to assure proper power, gas, water for drinking fountains and kitchen equipment.
  - Coordinate with other disciplines to insure no there are no conflicts in roof drain, exhaust fan, louvers, and other similar item locations.
  - Insure that all door louvers are coordinated with mechanical drawings and that no louvers are located in fire or smoke doors.
  - Insure complete coordination between site work, walks and landscaping, water supply, sewerage, architectural, and electrical.
  - Coordinate structural with architectural to insure framing at all roof openings.

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### Final Submittal (100% Ready for Bid Advertise)

- 1. Implement Final Design review comments into the drawings.
- 2. Verify consistency between plans and specifications.
- 3. Verify that all drawings are finalized.

#### General

The architect shall prepare input for the Engineering Considerations and Instructions for Field Personnel (ECI). This document will provide field personnel with insight on unique aspects of the work, as well as background information about the design intent. The architect shall address all review and bidder comments and incorporate them in the contract documents as applicable.

Architectural products produced during the PED phase are subject to an Independent Technical Review (ITR) to ensure the designs conform to proper criteria, that any deviations to criteria or scope are properly justified, and that appropriate design methods have been followed.

# SECTION 11 COST ESTIMATES

### 11.1 General

The purpose of this section is to provide guidance for the preparation of cost estimates for Comprehensive Everglades Restoration Plan (CERP) projects. Estimates are made for programming, cost control during design, evaluation of bids, control of negotiations, and to serve as a guide in establishing a schedule of payments. Often these estimates are also used to evaluate the reasonableness of the contractor's proposal for negotiated procurement contracts. Therefore, the estimates must be consistent with the best estimating practice of the construction industry and be current, accurate, and complete. They must reflect the anticipated cost to a governmental entity to perform the work by contract and include all reasonable costs, which a prudent, experienced, and well-equipped contractor might encounter.

### 11.2 References

All cost estimates for CERP projects shall conform to the provisions of the following publications:

ER 1110-1-1300, Engineering and Design Cost Engineering Policy and Requirements

ER 1110-2-1302, Engineering and Design Civil Works Cost Engineering

EI01D010, Engineering Instructions - Construction Cost Estimates

*EP 1110-1-8, Volume 3, Current Edition - Construction Equipment Ownership and Operating Expense Schedule - Region III* 

EM 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS)

MCACES User Manual, Volume I - Function and Capabilities & Volume II - Advanced Options

CERP Guidance Memorandum 005.00 "Total Project Cost Estimate Management"

### **11.3 General Requirements**

The cost estimator shall obtain the current version of all software and applicable user manuals. Additionally, the cost estimator shall obtain the latest copy of aided cost engineering system (MCACES) along with the most current databases. MCACES software, unit price book and users manuals can be downloaded from: http://www.hnd.usace.army.mil/traces/.

### 11.4 Reviews

Whenever the cost estimator delegates, contracts, or assigns cost estimating responsibilities to another entity, a formalized submission and review process shall be established. The requirements for cost estimating thoroughness shall be no less than this document requires.

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#### 11.5 Cost Engineer Qualifications

The cost estimating staff shall consist of full-time cost estimating specialists. It is imperative that estimates be prepared by, and reviewed under the supervision of, personnel who are competent in construction cost estimating. The cost estimator must possess a working knowledge of construction and be capable of making professional determinations based on experience. If the responsible estimating entity determines the staff does not possess all these qualifications, a qualified firm shall be obtained for assistance whose specialty is cost estimating. In making this determination, the lead cost estimator shall consider the complexity of the project and the number and qualifications of his full-time cost estimating staff. In consideration and selection of a consulting firm, the lead cost estimator shall consider the firm's specialties, its ability to coordinate the estimates with the designers, and its previous experience in preparing cost estimates for a governmental entity. Estimates prepared by a consultant must be reviewed by the responsible estimating entity.

### 11.6 Cost Quality Management

The lead cost estimator(s) shall provide cost estimates in a timely manner. The quality or integrity of cost estimates shall not be compromised in order to meet completion deadlines or agency imposed budget requirements.

### **11.7** Methods Of Estimating

#### 11.7.1 General

Except for preliminary screening, the method used to prepare estimates shall be the Micro-Computer Aided Cost Engineering System (MCACES). The following is a description of the required procedures for preparing cost estimates, as well as a listing of required information to be included in the estimate.

### **11.7.2 MCACES Estimation**

Under the MCACES procedure, the estimate shall be prepared as explained in the MCACES User Manual. A MCACES prepared cost estimate is required for all but the preliminary screening cost estimates.

#### Labor

Labor costs in the MCACES estimate must be based on rates that include basic wages, overtime and holiday premium payments, and contractor's contributions for fringe benefits such as health and welfare, holiday and vacation pay, pension fund, and apprentice training. Estimated rates shall be those that the contractor shall be expected to pay. Estimation of wage rates shall consider prevailing rates actually being paid in the project area, as well as minimum rates that are in accordance with the requirements of the Davis-Bacon Act. The cost estimator must copy a MCACES labor rates database and adjust the rates for the local project area. Ultimately, the cost estimator is responsible for all wage rates used in the cost estimate.

# **COST ESTIMATES**

### Equipment

The cost estimator preparing the MCACES cost estimate must be familiar with applicable construction equipment and job-site conditions. The equipment selected shall conform to job conditions and be suitable for use with the materials that will exist on the project. The Equipment Ownership Schedule in EP1110-1-8 determines the hourly rates for equipment ownership and operating expenses. MCACES estimates shall utilize the EP1110-1-8 equipment database adjusted to region III (southeast United States).

#### Material

Materials are those items that are incorporated into and become part of the permanent structure. Supplies are those items which are used in construction but do not become physically incorporated into the project (i.e., concrete forms). Materials and supplies for the purpose of estimating can commonly be considered materials unless they need to be separated because of different tax rates. Costs may be obtained from the MCACES Unit Price Book (UPB), reference manuals, manufacturers' catalogs, quotes, or historical data. Quotes from manufacturers and suppliers shall be obtained for all specialty or not readily available materials and equipment to be furnished and installed by the contractor. When an item is relatively minor or not yet fully defined, it may be satisfactory to base pricing on data in estimating handbooks or the MCACES Database. In these cases, appropriate adjustments must be made to account for project conditions. For later stages or for significant items, material costs shall be based on verbal or written quotes obtained from manufacturers and suppliers, price lists, or recently acquired quotes. Specific current price quotes, from at least two sources if feasible shall be obtained for major items of permanent equipment and for significant, unusual, or nonstandard material items. Where quantities or unit costs will have only moderate impact, recently acquired quotes such as comparable items from other projects for are considered acceptable. Freight costs to the project site must be covered. Sales and other applicable taxes must be included in the estimate.

### 11.8 Estimate Requirements

#### 11.8.1 General

The lead cost estimator shall prepare a professional quality construction cost estimate at each of the various stages of project development/design. Estimates must accurately reflect the scope and features of work shown in the design documents. The degree of detail must be commensurate with that represented by the plans, specifications, and design analyses. Where the design is not sufficiently complete to enable accurate definition of any portion of the work, appropriate allowances, assumptions, or contingency based on estimating experience and judgment, shall be made to cover work not yet fully defined. Costs must be broken down into priceable elements. All costs and quantities in the estimate must be supported. Unsupported lump sum pricing is not acceptable at any stage of design. The level of breakdown must be commensurate with detail available from the design information provided.

### 11.8.2 Cost Control

CERP features and projects may be subject to cost constraints based on the **Central And Southern Florida Project Comprehensive Review Study**. The cost estimator must be aware of cost constraints and provide the Project Delivery Team (PDT) information regarding the cost of current design compared with the baseline cost estimate. Throughout the development/design

process, close coordination between the designer and cost estimator must be exercised to achieve accurate cost control.

#### 11.8.3 Indirect Cost

Cost estimates made at any point in the project cycle must include indirect costs. Indirect costs are those associated with a contractor, and usually included as overhead, profit, and bond. Indirect costs are those that cannot be attributed to a single task of construction work. Costs that can be applied to a particular item of work shall be considered a direct cost and are not to be included in indirect cost estimates. The overhead costs are usually divided into job office overhead (general conditions or field office overhead) and home office overhead (general and administrative). Home office overhead is typically based on a percentage. However, estimates of field office overhead shall be made with the same rigor and detail as the balance of the estimate. Other indirect costs that must be included in the estimate are profit and bond. All indirect costs are necessary for inclusion in all estimates. The one exception to the foregoing is the requirement that profit not be included in the cost estimate made for contract award.

#### 11.8.4 Construction Contingency Cost

Contingency cost is the measure of project uncertainties on the estimated total project cost. The goal in contingency development is to identify the uncertainty associated with an item of work or a task, forecast the risk/cost relationship, and assign a value to this task that will limit the cost risk to an acceptable degree of confidence. This cost shall be most properly determined by a cost risk analysis. The cost risk analysis shall be accomplished as a joint analysis between the cost estimator, designer(s), and/or appropriate PDT` member. Contingencies may vary throughout the cost estimate and could have a significant impact on overall cost being high when lack of investigation data or design detail is associated with critical/high cost elements. The reasons for final contingency development and assignment that describe the potential for cost growth must be included in the cost estimate as part of the project narrative. Contingency allocations are specifically related to the project uncertainties and shall not be reduced without appropriate supporting justification. Normally, contingency costs are not part of the estimate for contract award.

#### 11.8.5 Quantity Survey

Accuracy and completeness of the quantity survey (takeoff) is essential as it directly and critically affects the accuracy of the estimate. The takeoff shall be comprehensive and accurate to cover all work for the project. It shall be based on all facts that can be gathered from the available engineering and design data. Assumptions as to details that are beyond the level available at the current stage of design are often necessary to insure that total cost of the overall project work is covered. In such cases, statements and explanations of necessary assumptions shall be included so that, when design details become available, quantities can be reconciled. Quantity surveys must be planned to fit the pricing for the work involved. Surveys must be clearly documented in such manner that computations can be followed and verified by others. Relevant sketches shall be included. Quantity survey documentation must be preserved as backup data for the estimate.

#### 11.8.6 Subcontract

The cost estimator must first determine those parts of the work that most likely shall be subcontracted. When work to be subcontracted has been determined, those items shall be

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identified in the estimate. The appropriate subcontractor overhead and profit cost shall be applied to the subcontractor direct cost items in addition to the appropriate prime contractor overhead and profit. The cost estimator may utilize quotes for the expected subcontracted work when reviewed and verified as reasonable. In lieu of a quote, each task of the subcontract shall be priced as a direct cost with an appropriate rate of subcontractor's overhead and profit added. The total subcontract cost is considered a direct cost to the prime contractor.

#### 11.8.7 Format

The MCACES software shall be employed in the production of all but preliminary screening estimates. The cost estimates shall be prepared in the Civil Works Breakdown Structure (CWBS). The MCACES is a multi-user software program used for the preparation of detailed construction cost estimates for civil works. The system includes a project database and supporting databases. The supporting databases include the Unit Price Book (UPB), crews, assemblies, labor rates, equipment ownership schedule cost, and models. The databases, which are described in the MCACES users manual, work in conjunction with each other to produce a detailed cost estimate.

### **Preliminary Screening Estimates**

Prior to the evaluation of viable alternatives, a screening process may be used to review all the initial alternatives. The basis of costs may be historical, unit-based, parametric, published data, or developed. This estimate shall reflect the level of detail of the design provided. An effort must be made to ensure that the general magnitude of expected cost is reflected in the estimates and that the estimates are comparable. The estimate must be organized, legible and contain documentation that includes all the relevant cost information and assumptions. The screening process may become iterative and different levels of cost estimating detail may be appropriate at different levels of screening. The MCACES method is not a requirement of the preliminary screening estimates.

#### **Estimates for Alternatives**

The screening process will lead to a final list of typically two to five viable alternatives. A MCACES cost estimate is required for each alternative. Each estimate shall be made in the CWBS. The basis of costs may be historical, unit-based, parametric, published data, or developed. This estimate shall reflect the level of detail of the design provided. The MCACES estimate shall incorporate appropriate comments reflecting the methods of construction, assumptions, data available, and if applicable, derivation of production rates. These cost estimates will rely on incomplete project data. An estimate of cost risk or construction contingency must be incorporated into the estimate as a separate cost item. The non-construction cost and related contingency cost must be included in the alternative estimates. The cost estimator must make known the requirements for an estimate of real estate, pre-construction engineering and design, and construction management costs to be incorporated into the alternative estimate.

#### **Tentatively Selected Plan and Selected Plan Estimates**

After a review, comment and revision process, the tentatively selected plan will become the selected plan. The requirements for the cost estimate are the same for both plans. The engineering and design are generally refined to a sufficient level to allow for the estimating of equipment, labor, material, and production rates suitable for the project. This estimate shall be made in the CWBS to the sub feature level. This estimate includes construction contingencies of real estate

# **COST ESTIMATES**

costs, pre-construction engineering and design, and construction supervision. The estimate is developed for a specific price date. The cost estimate shall reflect the level of design and shall contain appropriate comments and clear documentation reflecting the methods of construction, assumptions, data available, and if applicable, derivation of production rates. It is generally anticipated that this cost estimate will become the Baseline Cost Estimate (BCE).

### **Estimates During Pre-construction Engineering and Design**

This phase consists of completing all detailed technical studies and designs needed to initiate construction. Cost estimates during this phase consist of revisions and refinements to previous estimates. The cost estimator must ensure that the BCE is used as a guide in managing the engineering and design process. The cost estimates are refined by use of more accurate cost data (specific supplier and material information), incorporation of site-specific data, and detailed quantities. As design progresses, the construction contingencies contained in the BCE are replaced by construction cost estimates of designed elements in the Current Working Estimate (CWE). Estimates of construction costs at the 100 percent design stage do not contain construction contingencies. This MCACES estimate shall include appropriate comments and clearly documented backup data shall be maintained.

#### **Estimate for Contract Award**

This estimate shall be a refinement of the CWE and shall be organized by bid item. This estimate represents the cost of performing the work within the time allocated by determining the necessary labor, equipment, and materials. The cost estimate shall be prepared as though the governmental entity were competing for the award. This estimate is the fair and reasonable cost to a governmental entity of a qualified and well-equipped contractor to perform the work described in the plans and specifications. This estimate does not include the prime contractor's profit. This estimate must be supported by material and quantity takeoff backup data and development computations. The estimate shall be comprised entirely of work tasks for which basic costs are detailed. The cost estimator is responsible for the complete cost estimate including amendments that might occur during the advertising period. This estimate shall not contain construction contingency cost. If bids are received where the closest responsive bid is out of the awardable range, the cost estimator shall promptly evaluate the cost estimate prepared for contract award. This includes a detailed review to determine if the cost estimate contains any omissions. discrepancies (i.e., errors in calculations), quantity takeoff errors, or errors in cost and pricing data. In addition, the reviewer shall further analyze any unusual conditions or circumstances that may affect or complicate the work.

### **11.9 Safeguarding Cost Estimates**

The cost estimator shall manage the estimates in a discretionary manner. Access to each estimate and its contents shall be limited to those persons whose duties require knowledge of the estimate. Any request by the public for information and pricing in the estimate shall not be provided until coordination, verification of data, and the designated authority has given approvals. Access to the cost estimate made for contract award shall be limited to approved personnel. A list of the names of the individuals who have had access to the total amount of the cost estimate made for contract award shall be maintained. Typically, after the contract award, only the title page, signature page, and bid schedule are disclosed outside the governmental entity. The estimate for contract award backup data shall not be released since it contains sensitive cost data that are proprietary or might compromise cost estimates for future similar procurement.

AA	Alternatives Analysis
AASHTO	American Association of State Highway and
	Transportation Officials
ADA	American Disabilities Act
ADCP	Acoustic Doppler Current Profiling
AFC	Architect Engineer Contractor
AGMA	American Gear Manufacturers Association
AIC	Amperes Interrupting Capacity
AISC	American Institute of Steel Construction
	American National Standards Institute
ASCE	American Society of Civil Engineers
ROOL	American objecty of only Engineers
ASR	Aquifer Storage and Recovery
AST	Aboveground Storage Tanks
ASTM	American Society of Testing and Materials
CADD	Computer Aided Drafting and Design
CCTV	Closed-Circuit Television
CERP	Comprehensive Everalades Restoration Plan
CES	Cubit Feet Per Second
CMP	Corrugated Metal Pipe
CMU	Concrete Masonny Units
	Concerence Masoning Onlits
	Cone Fenetionneler Test
	Design Desumentation Depart
	Design Monucl
ECC	
ECI	
EDR	Engineering Document Report
EIA	Electronics industry Alliance
EM	Engineer Manuals
EMCS	Emergency Management and Control Systems
EPA	Environmental Protection Agency
ER	Engineering Report
ESRI	Environmental Systems Research Institute
EIL	Engineering Technical Letter
FDEP	Florida Department of Environmental Protection
грот	Florida Donortmont of Transportation
	Fionua Department of Transportation
	Federal Emergency Management Agency
F51	Formed Suction Intakes
GIS LINU	
H&H	Hydrology and Hydraulics
HI	Hydraulic Institute
HIRW	Hazardous Toxic Radioactive Waste
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IDF	Inflow Design Flow

IEEE IESNA	Institute of Electrical and Electronic Engineers Illuminating Engineering Society of North
	America Insulated Power Cable Engineer's Association
	Independent Technical Review
	Light Detection and Panging
	Liquefied Petroleum Cas
	Life Safety Analysis
LOA	Motor Control Contor
MOSCAD	Motorola Supervisory Centrol and Data
MOSCAD	Acquisition
МОТ	Maintenance of Traffic
MPS	Manatee Protection system
MRI	Mean Recurrence Interval
MUTCD	Manual on Uniform Traffic Control Devices
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
NGS	National Geological Survey
NGVD	National Geodetic Vert. Datum
OSHA	Occupational Safety Hazard Agency
P&S	Plans and Specifications
PDA	Pile Driving Analyzer
PDF	Portable Document Files
PDT	Project Delivery Team
PED	Pre-construction Engineering and Design
PIR	Project Implementation report
PLC	Programmable Logic Controllers
PMP	Probable Maximum Precipitation
RCC	Roller-Compacted Concrete
RCP	Reinforced Concrete Pipe
ROW	Right of Way
SCADA	Supervisory Control and Data Acquisition
SCC	Station Control Center
SFWMD	South Florida Water Management District
SHOALS	Submerged Hydrographic Operational Airborne
	LiDAR Survey
SPF	Standard Project Flood
SPT	Standard Penetration Test
TIA	Telecommunications Industry Association
ТМ	Technical Manuals
TSP	Design of Tentatively Selected Plan
UFGS	Unified Facilities Guide Specification
UL	Underwriter's Laboratory
USACE	United States Army Corps of Engineers
USCS	Unified Soils Classification System