ENGINEERING GUIDELINES FOR THE EVALUATION OF HYDROPOWER PROJECTS

CHAPTER 15 – SUPPORTING TECHNICAL INFORMATION DOCUMENT AND DIGITAL PROJECT ARCHIVE

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FEDERAL ENERGY REGULATORY COMMISSION
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Revision Log		
No.	**Date**	**Description**

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ABBREVIATIONS

CA	Comprehensive Assessment
CAR	Comprehensive Assessment Report
CFR	Code of Federal Regulations
Commission	Federal Energy Regulatory Commission
D2SI	Division of Dam Safety and Inspections
DPA	Digital Project Archive
DSPMP	Dam Safety Performance Monitoring Program
DSSMP	Dam Safety Surveillance and Monitoring Plan
DSSMR	Dam Safety Surveillance and Monitoring Report
EAP	Emergency Action Plan
FAAP	FERC After Action Panel
FERC	Federal Energy Regulatory Commission
FERC-RO	Regional Office (of the FERC, D2SI)
FERC-WO	Washington Office (of the FERC, D2SI)
FPC	Federal Power Commission
Guidelines	FERC Engineering Guidelines for the Evaluation of Hydropower Projects
IC	Independent Consultant
IC Team	Independent Consultant Team
IDF	Inflow Design Flood
IFT	Independent Forensic Team
Part 12D	18 CFR Part 12, Subpart D
PFM	Potential Failure Mode
PFMA	Potential Failure Modes Analysis
PI	Periodic Inspection
PIR	Periodic Inspection Report
PIPR	Pre-Inspection Preparation Report
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
Project Works	Features defined as Project Works in the Project License
RA	Risk Analysis
RAR	Risk Analysis Report
SSPMP	Site-Specific Probable Maximum Precipitation
STID	Supporting Technical Information Document

Note: all references to "Licensee" in this chapter are also applicable to Exemptees.

PREFACE

The information in this chapter was previously contained in Chapter 14, Appendix I of the Commission's Engineering Guidelines. In a significant departure from that guidance, this chapter does not contain any examples of the level of detail expected in the STID. Instead, this new guidance provides a more thorough discussion of the information that should be provided in each section of the STID.

This chapter substantially increases the guidance provided to licensees for the development of an STID, and changes the terminology associated with the companion reference material to refer to a Digital Project Archive (DPA). Several of the enhancements were suggested, or resulted from a discussion of shortcomings, by the Oroville Spillway Independent Forensic Team (Oroville IFT) and/or the FERC After-Action Panel (FAAP). Several pertinent passages from the Oroville IFT Report are shown below (emphasis added):

<u>IFT Report, Page 66:</u>

> In support of its Part 12 process, FERC does have specific and detailed requirements for information management. One of those requirements is development of a Supporting Technical Information Document (STID), which is intended to be a 'living document,' updated at an interval of not more than five years, which captures all of the key information needed to properly evaluate a dam and its appurtenances.
>
> The IFT notes that **the STID for Oroville Dam which was updated in 2014 did not include much of the information which would have helped identify the risks at the two spillways, and was therefore incomplete**. Drawings with service spillway chute slab details, as well as numerical flood routings and water surface profile calculations, were among the information which was not included in this STID. Drawings with slab details were included in the 2014 Ninth Part 12D report, however the IFT found no evidence that those details were reviewed.

<u>IFT Report, Page F3-13:</u>

> It is significant to note that **neither the 2014 PFMA report nor the 2014 STID include any service spillway chute drawings, either design or as-built**. Further, during interviews, participants in the PFMA did not recall reviewing these drawings.

<u>IFT Report, Page K2-4:</u>

> **There does not appear to have been a process to check whether the STID actually contained all information required to properly undertake a design review**. Rather, in the case of the Oroville STID, it contained a limited selection of

drawings and documents, none of which in this case detailed local foundation conditions for either spillway nor details of the service spillway chute slab design.

List of Major Changes

- In general, this chapter provides more detail for what to include in each section of the STID to ensure the summary information is more comprehensive. Additional sections have been provided to document information related to appurtenant features, which was not clearly established in previous guidance.
- Section 9 (formerly "Spillway Gates") has been renamed as "Gates, Valves, and Other Reservoir Control Devices" and expanded accordingly. Documentation must be provided for all types of gates (not just radial spillway gates, as was often assumed to be the case) as well as valves (e.g., Howell Bunger valves) and other reservoir control devices (e.g., flashboards).
- In each section, the guideline provides a list of the types of references to be provided in the Digital Project Archive, which is replacing what was previously referred to as a companion DVD. Previous guidance was not sufficiently clear about what references to provide digitally or how to organize them. **This was identified as an issue by both the IFT and FAAP and the expectations for the provision and maintenance of digital records have been detailed.** In addition, the FERC has developed options for how to file the DPA since the Commission's eLibrary system has limits on file size and type, and it would be time-consuming to eFile dozens or hundreds of documents.

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15-1 INTRODUCTION

The guidelines presented in this chapter provide details regarding the preparation and maintenance of a Supporting Technical Information Document (STID) and Digital Project Archive (DPA). The STID and DPA serve as a compendium of knowledge and information about a project and are essential for the review and evaluation of the safety and performance of project works by licensees, consultants, and the FERC.

Section 15-2 contains general guidance for the STID and DPA, the outline for the STID, and discussion of filing procedures.

Section 15-3 provides detailed lists and descriptions of the information that should be included in each section of the STID, as well as examples of the type of references that should be included in the DPA.

15-1.1 Purpose

The STID is an organized summary of pertinent project information that should be useful for quick reference to gain an understanding of project features, potential failure modes, construction, design basis, surveillance and monitoring, and analyses. The STID should include sufficient information to understand the design and current engineering analyses for the project, and should provide most of the necessary information to someone previously unfamiliar with the project.

The DPA is a compilation of all relevant source material and additional supporting information, organized so that the licensee, the FERC, or consultants can identify and retrieve the information they need from original documents.

15-1.2 Applicability

All projects subject to 18 CFR Part 12D are required to prepare, submit, and maintain an STID and DPA, and to provide physical and digital copies to the D2SI Regional Engineer.[1] The FERC recommends, but does not require, that licensees and exemptees prepare an STID for projects not subject to 18 CFR Part 12D. The Regional Engineer may request that the licensee prepare an STID and DPA for other projects on a case-by-case basis.

[1] 18 CFR §12.12(d)

15-2 GENERAL GUIDANCE

The STID is a living document. When new data or analyses become available and accepted as part of the project record, they will be summarized in the STID and added to the DPA. Summaries of outdated material should be removed from the STID but the source documents should remain archived in the DPA.

15-2.1 Outline of the STID

Table 1 shows the outline of the STID; specific content that should be provided in each section is described later in this Guideline.

Table 1: STID Outline

Section No.	Section Name
-	Title
-	Revision Log
-	Table of Contents
1	Potential Failure Modes Analysis (PFMA) Report and Risk Analysis (RA) Report
2	Description of Project Structures
3	Construction History
4	Standard Operating Procedures
5	Geology, Seismicity, and Geotechnical Data
6	Hydrology and Hydraulics
7	Dam Safety Surveillance and Monitoring Plan
8	Stability and Stress Analyses of Dams and Water Conveyances
9	Gates, Valves, and Other Reservoir Control Devices
10	Pertinent Correspondence Related to the Safety of Project Works
11	Digital Project Archive Table of Contents

15-2.2 STID Contents and Format

The purpose of the STID is to provide a quick reference of the summary information that is most relevant for day-to-day use. To that end, when possible, consider using tables, figures, and drawings in the STID in lieu of text and do not include complete copies of the original source documents (except for the PFMA Report, Risk Analysis Report, and the DSSMP). For all other information, limit text to a summary of factual information from the original reports to provide clarity. Section 15-3 of this Guideline describes the minimum expectations of each section of the STID.

STID hard copies must be provided in a three-ring binder to facilitate periodic updates. The digital copy of the STID must be searchable. In addition, the FERC recommends the following practices:

- 8.5x11" pages can be printed on both sides to reduce the physical size of the document, if desired.
- Print 11x17" pages on one side and folded with an engineering (Z) fold.
- Include a page number and date of the most recent update (in the header or footer) on all pages.
- Print all figures and plots in color with appropriate legends.
- Provide tabs to separate each section of the STID.

15-2.3 DPA

The purpose of the DPA is to ensure that users of the STID have access to all relevant source material while limiting the STID itself to a single three-ring binder, if possible. **The DPA must contain legible copies of the source material used to develop the STID.** Include complete copies of the documents referred to in the STID, including design basis reports, project drawings, and additional reference information identified for each section of the STID. In addition to those items, each subsection in Section 15-3 ends with a list of the types of additional materials that should be included in the DPA, if applicable and available. Also be sure to include all additional documents reviewed in the PFMA session, if they are not already provided elsewhere in the DPA.

<u>File Structure/Organization</u>

Organize the DPA such that reference material can be located quickly for review in the event of a dam safety emergency. The FERC does not mandate a file tree or organizational system but strongly recommends that the DPA matches the top level sections in the STID outline for consistency and ease of use (e.g., 03 – Construction History, 06 – Hydrology and Hydraulics, etc.). If the DPA uses an alternate organizational structure, it must be logical and clearly defined.

Include individual references as separate files. It is not acceptable to combine separate references into a single file for simplicity (e.g., do not combine multiple reference documents into a single PDF or PDF portfolio).

<u>Table of Contents/Index</u>

The DPA must include a table of contents or file index that indicates the title, date, and file name of each reference. If the file tree does not correspond to the top level sections of the STID outline, it must be clearly explained in the DPA table of contents.

Additional Suggestions

The FERC recommends that the licensee consider the following practices:

- Combine drawings from a set (e.g., one construction project) into a single file.
- **To the extent practicable**, ensure all files on the digital reference are word searchable. (Note that the FERC does not expect licensees to convert scanned versions of original documents to a searchable format.)

15-2.4 Updating the STID and DPA

The STID and DPA should be periodically maintained in order to remain current and useful. The following sections discuss the scope of updates during Comprehensive Assessments (CAs), Periodic Inspections (PIs), and at other times between Part 12D Inspections.

Comprehensive Assessments

The scope of a CA includes a review and evaluation of the STID and comparison to the source documents. Prior to a CA, the licensee must provide the current STID and DPA to the Part 12D IC Team. If the licensee has made STID or DPA updates that have not been provided to the FERC, they should submit these updates to FERC in advance of the CA-Pre-Inspection Preparation Report (CA-PIPR).

It is likely that the IC Team will recommend specific updates to the STID and/or DPA in the Comprehensive Assessment Report (CAR). The licensee will be expected to provide a full reprint of the STID after completing the updates along with any necessary updates to the DPA.

- If the IC Team did not recommend any updates, the reprinted STID and DPA updates should be submitted within 60 days of submittal of the CAR.
- If the IC Team recommended updates, the reprinted STID and DPA updates should be submitted in accordance with the plan and schedule proposed by the licensee and accepted by the FERC. Unless the updates are extensive, this should be completed within six months of submitting the CAR.

Periodic Inspections

The scope of a PI does not include an evaluation of the STID; however, the STID should be current to ensure that the IC Team can review the material to prepare for their inspection. Prior to a PI, the licensee must provide the current STID and DPA to the Part 12D IC Team. If the licensee has made STID or DPA updates that have not been provided to the FERC, they should also submit these updates to FERC in advance of the field inspection.

Other Updates

The STID and DPA will likely require periodic updates between CAs, typically as analyses and studies are completed. After analyses and studies have been reviewed and accepted by the FERC, licensees should:

- Update the summary information in corresponding sections of the STID.
- Update the revision notice log in the front of the STID.
- Provide the STID updates to the FERC. The FERC recommends issuing updates as complete sections instead of individual pages, unless the updates are minor or contiguous.
- Update the DPA table of contents/file index.
- Provide the final reference files to the FERC for inclusion in the DPA.

15-2.5 Filing Procedures

15-2.5.1 Filing an STID

Licensees should provide the Commission physical and digital copies of the STID. The physical copies should be addressed and shipped to the appropriate Regional Engineer; the digital version should be eFiled.

When filing periodic updates to the STID, include instructions for FERC staff to remove/replace/insert specific pages and/or sections.

15-2.5.2 Filing a DPA

The FERC intends to maintain a working copy of the complete DPA for each project on its internal network. If the DPA and/or periodic updates cannot be submitted via eFiling, there are several acceptable alternative methods for transmitting the DPA and periodic updates to the FERC. Refer to guidance available on the Commission's website for specific procedures and restrictions related filing methods and information governance protocols. Please note that any materials submitted must be available on the Commission's eLibrary if the file type is supported.

When filing periodic updates to the DPA, include detailed instructions for FERC staff to remove/replace/insert specific files so the Commission's working copy of the DPA remains current.

15-3 CONTENT OF THE STID

The following sections describe the expected content for each section of the STID and provide additional guidance for information to include in the DPA.

The STID is to contain factual information; it should be written to avoid statements of opinion (e.g., "I/we determined that _____..." or "It is the opinion of the current IC that _____..."). If the STID reproduces or paraphrases the opinions of previous consultants or experts, introduce those statements accordingly and make them distinguishable from adjacent text. When using such a citation in the STID, provide a full copy of the document cited on the DPA.

15-3.1 Potential Failure Modes Analysis (PFMA) Report and Risk Analysis (RA) Report

In this section, include complete copies of the following reports, inclusive of attachments (with one exception noted):

- The current PFMA report; and
- The current risk analysis report.

In order to have the most up to date PFMA and risk analysis reports in the STID, licensees may include reports submitted to, but not yet approved by the Commission, provided the licensee notes the Commission has not approved the reports.

For projects where the licensee has not performed a risk analysis, that section of the STID can be left blank.

If a prior report is attached to the current report as a reference (e.g., a prior PFMA report attached to the current PFMA report), the prior report does not need to be printed for the STID. Only include the most recent PFMA report and risk analysis report in the STID.

Refer to Chapters 17 and 18 of the Commission's Engineering Guidelines for the Evaluation of Hydropower Projects for additional information on conducting a PFMA and risk analysis, respectively, and for completing the associated report.

15-3.1.1 Reference Materials for the DPA

Include complete copies of all previous PFMA and risk analysis reports and supplements, including any construction and feature-specific PFMA reports (e.g., focused spillway PFMAs).

15-3.2 Project Description

Provide a detailed description of the project and project works. Ensure that each project feature listed in the project license is discussed, or identify any project features not listed and document the reason for its omission. For projects comprising multiple developments with separate STIDs, only discuss the project features relevant to the particular development.

15-3.2.1 General Project Description

Provide a general narrative of the project including:

- Project location, including river/waterway name, county/counties, and nearest towns/cities;
- Licensee name (also provide the dam owner's name when the licensee does not own the dam);
- Project purpose;
- Project hazard potential classification, downstream structures (e.g., critical infrastructure such as roads, railroads, hospitals) affected by a dam failure, and the population at risk from a dam failure (e.g., a general description of the populated areas that would be affected, or a summary of results from any detailed Population at Risk (PAR) studies); and
- Elevation reference datum(s) for elevations used in the text of the STID. Include conversions, as needed, for other datum references used in documents on the digital reference.

15-3.2.2 Detailed Description of Project Features

Include detailed descriptions of each of the following project features:

- Reservoir – include reservoir surface area and storage capacity at normal pool, maximum and minimum operating pools, and flood pool. Include storage capacity at the dam crest if the elevation is different from maximum operating pool level.
- Spillway – include pertinent dimensions of the spillway such as height, crest elevation and width and slopes. Include a description of the type of spillway (uncontrolled weir, gated or ungated, morning glory, etc). Include a description of foundation materials at the spillway.
- Spillway Gates – include gate type, dimensions, and a description of equipment used to lift gates, including all backup power sources.
- Embankments – include description of materials used (soil, rock, etc), original placement method, height, crest width, crest elevation, and upstream and downstream slopes and any slope protection. Describe embankment core walls (materials and dimensions) if applicable. Include a description of foundation materials for all embankments.

- Non-overflow sections – include pertinent dimensions such as height, crest elevation and width and slopes. Include a description of the non-overflow section(s) foundation.
- Intake/powerhouse – include pertinent dimensions for the intake section and the trash rack system. For the powerhouse include structural dimension and construction type, number and type of generating units, and authorized generating capacity. Include a description of the foundation. Also, include a description of the tailrace.
- Outlet works – include any low-level outlet works, sand gates, etc. Provide dimensions of all outlet works.
- Water Conveyance Features – include pertinent dimensions and construction materials/methods for water conveyance features (penstocks, canals, etc.).
- Provide descriptions of other features associated with the project as necessary.

15-3.2.3 Record Drawings

Provide a list of drawings included in this section as well as a list of the sets of drawings that are included on the DPA. Include legible hard copies of the following drawings at a minimum:

- USGS Quad map or other location map (e.g., satellite image, drone image) with project facilities located, including the alignment of all water conveyances;
- A plan view of licensed project facilities with the project boundary adjacent to the facilities delineated; and
- Typical sections and profiles of key project works (e.g., dams, spillways, powerhouses, intakes, canals, tunnels, penstocks, flumes, surge chambers, inverted siphons, gates, etc.). Approved Exhibit F drawings may suffice for the STID.

15-3.2.4 Reference Materials for the DPA

Include all drawings from the original construction and all subsequent major modifications in the DPA. Provide as-built drawings, if available, in addition to the design drawings. Combine individual drawings from a set into a complete PDF file, if possible. If each individual drawing is stored on the media as a separate file, include a master table of contents that lists each sheet number and, title, and includes a hyperlinked reference to the associated file.

Drawings related solely to recreational or other facilities that are unrelated to the project works (e.g., Exhibit R drawings) do not need to be included.

15-3.3 Construction History

Include a detailed construction timeline beginning with the original site investigation and include the dates for original construction and all major modifications to project works completed to date. Provide general descriptions of the methods of excavation and construction for each project feature; highlighting any unique or contemporaneously non-standard methods or materials. Include representative photographs of critical periods during construction (e.g., foundation preparation) and key project features (e.g., a sheet pile cut-off wall beneath an embankment core, formed shear keys between concrete sections, etc.).

Base the information in this section on the following sources of information:

- Design reports and pertinent memoranda from licensing and permitting documents;
- Laboratory investigation and construction testing reports;
- Geotechnical investigations;
- Construction reports and photographs;
- Specification documents;
- Reports of major modifications conducted for dam safety;
- Documentation of major maintenance activities; and
- Other available documents.

Include a list of all available design and construction documents that are included in the DPA. It is not necessary to provide a printed list of the photographs that are included in the DPA.

15-3.3.1 Reference Materials for the DPA

Include all available design basis reports, construction progress reports, field and laboratory testing reports, specification documents, design basis memoranda, and original calculations (if not included in other sections) on the DPA.

If feasible, include all available construction photographs from the original construction and all major modifications to project works completed to date. Title each photograph and include a master table of contents file that lists each photograph and a brief description of the photograph contents. **If the number of available construction photographs makes it impractical to include them all on the DPA:**

- include a representative sample of the available construction photographs on the DPA, along with a brief description of each photograph; and

- provide a list and brief description of the sets of photographs stored by the licensee, such that the FERC and others can identify and request specific files as needed.

15-3.4 Standard Operating Procedures

Include in this section concise descriptions of the following:

- Project staffing, including number of hours and days of week when the project is staffed for normal operations, and procedures for response during periods when the project is not staffed
- Normal reservoir operations, including unit operating procedures and SCADA monitored instrumentation and alarms. Include reservoir rule curves for reservoir operations.
- Flood operations, including standard gate operating procedures if there are spillway gates, other gates, or reservoir control valves at the project. Include a gate opening sequence if available. Include project staffing levels for flood operations, if different than normal operations. Include standard protocols used for emergency spillway operation, if applicable.
- Low level outlet and similar control valve operating procedures.
- Winter/cold weather operations.
- Procedures for remote operations of spillway gates and generating units, including staffing of remote operation centers.
- Standard procedures for operating manually-tripped stoplogs or stanchions and other similar devices.
- Routine maintenance procedures, including how maintenance needs are identified and corrections are tracked.
- A list of all written operating procedures applicable to dam safety. The list should include the procedure number, title and revision date.

Do not include routine inspections or instrument reading procedures or any other procedures listed above that are part of the Dam Safety Surveillance and Monitoring Plan (DSSMP), which is covered in Section 15-3.7.

15-3.4.1 Reference Materials for the DPA

Include copies of all written standard operating procedures for the project in the DPA or a detailed list of the procedures with a reference to the location of the actual procedure document.

15-3.5 Geology, Seismicity, and Geotechnical Data

15-3.5.1 Geology

This section of the STID should include sufficient geologic data, analysis, and interpretation regarding geologic and foundation materials, structure, processes, and history to support a full understanding of the site subsurface conditions and foundation behavior. Where more detailed project related geologic information is available in other documents, publications, or reports, a summary of the information should be presented in the STID with full citations directing the reader to where the complete information can be found.

15-3.5.1.1 Regional Geology

Regional geology provides a framework for the site-specific geology. When site-specific geologic data is put in a regional geology context a more complete understanding of the subsurface conditions can be made. Since most geologic information depends on interpretation of subsurface conditions between known data points (i.e. borehole or outcrop locations), understanding the regional geology and geologic history can provide a more accurate and complete understanding of the local geologic and foundation conditions.

This subsection should provide a brief but complete description of the regional geologic and tectonic setting, which may include:

- Physiographic setting;
- Nature and source of available published geologic reports or maps;
- Stratigraphy and lithology of regional formations or geologic map units;
- Geologic structure, including folding, faulting, and discontinuity or fracture characteristics;
- Surface water features and regional drainage patterns;
- Regional groundwater and aquifer conditions;
- Geomorphology and surficial processes; and
- Regional geologic hazard identification and mapping.

15-3.5.1.2 Site Geology and Foundation Conditions

The adequacy of geologic information for hydroelectric projects depends on accuracy in the description and classification of subsurface materials, documenting how geologic and geotechnical investigations were conducted, and sound geologic interpretation. Materials should be described and classified according to their geologic and physical properties and their engineering behaviors. Interpretation of the unit depositional environments, tectonic and metamorphic histories, and weathering and erosion/scouring susceptibility should also be provided.

- Provide brief but complete descriptions of all geologic rock, soil units, any fill, and structural features mapped or inferred within the project area;
- Provide general soils and rock strength characteristics;
- Provide geologic maps and boring location plans, at readable scales – including plans, foundation maps, photographs of foundation excavations, cross-sections, and profiles – that show the foundation conditions under the dam(s) and other pertinent project works. Where available, provide cross sections of the geologic strata with clear labeling or notations;
- Describe geologic discontinuities (e.g., bedding, jointing, foliations, fractures, asperities, etc.);
- Provide local mapping and/or a database listing of adverse geologic or man-made features in the region (e.g., sinkholes, mining activity, etc.);
- Describe any geophysical investigations;
- Describe foundation excavations and preparations;
- Describe foundation treatments; and
- Clearly identify the source(s) of information used to develop geologic interpretations and maps.

15-3.5.1.3 Site Hydrogeology

Nearly all water-impounding structures (i.e., dams) have significant effects on the local groundwater and aquifer conditions. Conversely, the natural groundwater conditions can impact the performance or seepage conditions of a dam. Therefore, provide documentation of the pre-dam and post-dam site hydrogeology including the following, where available:

- Site-specific, pre-dam groundwater and aquifer conditions, if known;
- Surface water features, streams, and springs;
- General description of water-bearing units (aquifers) and non-water-bearing units (confining units);
- General description of groundwater flow directions and pressure heads;
- Identification of hydrogeologic boundaries; and
- Discussion of aquifer heterogeneities, and porous (soil) vs. conduit (rock fracture) groundwater flow.

15-3.5.1.4 Potential Foundation Weaknesses

Document the potential for weaknesses in the foundation in the context of potential failure modes (PFMs). The subsequent sections discuss common phenomena that should be specifically addressed even if they do not occur at the project site. Additional sections should be included, as needed, for projects with foundation weaknesses that do not fit into these general categories.

Slide Potential

Document potential landslides, loose rock formations, or adverse bedding orientations that could affect project works.

Sinkholes, Karst, Solutioning

Document any known or potential sinkholes, karst, solutioning, basalt flow (e.g., lava tubes) issues, or other similar conditions that could affect project works.

Weak or Erodible Materials

Document the existence of any potential weak materials in the foundation or spillway channel/tailrace, or rock types that are often found in conjunction with weak materials; this may include, but is not limited to, the following examples:

- Bentonite or soluble gypsum layers;
- Materials within a fault zone (e.g. gouge, highly fractured rock);
- Weathered shale/claystone layers;
- Highly jointed or fractured rock with low Rock Quality Designation (RQD);
- Clay interbeds;
- Coal seams; and
- Soil foundations with potentially erodible materials (e.g. gap-graded soils, uniform fine sands, poorly compacted well-graded cohesionless materials, dispersive soils).

Artesian Sources

Document artesian sources in the vicinity of the project; for example, geothermal sources or high abutments. Identify whether each is geologic in origin (i.e., they exist in the absence of the project reservoir) or if it is related to the reservoir (e.g., presence or volume of flow varies with pool elevation).

15-3.5.2 Seismicity

List the date, author, and summarize the procedures and findings of the most recent seismic study or Seismic Hazard Assessment (SHA). If a site-specific SHA has not been completed for the project, provide the best available information. Refer to Chapter 13 of the Engineering Guidelines for additional information on conducting a site-specific SHA.

Include summary discussion and provide the relevant figures and tables for the following items:

- A map of fault traces that affect the project. Differentiate between those traces that have been confirmed (by trenching or other means) and those that are inferred.
- A table of faults, distances, lengths of rupture, depths, magnitude at fault, and peak ground acceleration (PGA) for the considered sources, including the local (floating or random crustal) earthquake. Include the estimated recurrence interval for each, if known.
- A map of historic earthquake centers.
- A table and map showing controlling fault sources.
- Attenuation relationships.
- Maximum measured ground motions at the site.
- Seismic ground motions and design spectra used for analysis of project structures.
- Project performance during and after previous earthquakes.

The USGS website (http://earthquake.usgs.gov) may be a useful reference for general information on seismicity, and for the development of several of the required general figures. See Chapter 13 of the Guidelines for more information on the use of this website.

15-3.5.3 Geotechnical Data

This section provides a summary of geotechnical data obtained from original design, construction, and subsequent investigations, including drilling logs from the installation of instruments such as piezometers, inclinometers, etc. For embankment and foundation material properties, include a summary discussion and references to supporting documentation on the digital reference.

<u>Material Properties</u>

Summarize any laboratory and in-situ testing, including the results and procedures used to determine soil types and properties. For example:

- Laboratory testing: Atterberg limits, grain size distribution, hydraulic conductivity tests, direct shear test, Proctor compaction test, unconfined compression test, triaxial tests, etc.
- In situ testing: standard penetration test (SPT), cone penetration test (CPT), dynamic cone penetration test (DPT), Becker penetration test (BPT), pressure

meter test (PMT), seismic refraction test, downhole method, ground penetrating radar (GPR), rising/falling head hydraulic conductivity test, etc.

Clearly identify whether each material property was derived from in situ testing, laboratory testing, or was assumed from literature values. State the date for any testing

If in situ testing was conducted, note any site conditions that could potentially affect the recorded data (e.g., CPT in gravelly conditions, lack of recovery from split-spoon sampler, use of rope and cathead for SPT testing, uncalibrated manual and automatic hammer for SPTs, questionable accuracy of efficiency corrections for SPT, soil heave or artesian conditions, qualifications of staff on site, etc.). Document any correlation method that was applied to translate one testing method into another to approximate material properties (e.g., BPT data correlated to SPT values).

For any derived soil parameters, document the following information about the data set and methodology:

- State the number of tests used to derive each strength parameter;
- Include explanation for why any data points were excluded in derivations;
- Note the location of in situ testing (e.g., borings) and whether the location is an accurate representation of the embankment or foundation zone material (show locations on a cross-section or profile); and
- Note the statistical approach to apply the data for deriving material strength parameters (e.g., the mean, the lowest third of the lowest 33 percent, the lowest SPT value, etc.).

If values are selected from literature list the source title and date and provide a discussion of how the literature source was used in lieu of site-specific testing and data.

15-3.5.4 Reference Materials for the DPA

Include the following in the DPA:

- Geologic and geotechnical investigation report(s) from original design and construction;
- Reports from any subsequent geologic and geotechnical investigations;
- Boring and test pit logs and laboratory test data. If the boring is used as a monitoring well or piezometer and the boring log is provided in the DSSMP, do not include it here. If not provided in the DSSMP, include the instrumentation boring logs here; and
- Any seismicity studies and/or seismic hazard analysis reports.

15-3.6 Hydrology and Hydraulics

This section provides supporting information to document the development of the Probable Maximum Precipitation (PMP), Probable Maximum Flood (PMF), Inflow Design Flood (IDF), and routing of the IDF through the reservoir and project works. Include the following information as applicable. Provide clear citations to the source(s) of information used for development of the PMP.

15-3.6.1 Hydrology

Hydrometeorological Report (HMR) or Site-Specific Report Used

Specify the HMR or site-specific report(s) used to develop the PMP. Reproduce the information below (Probable Maximum Precipitation through Reservoir Inflow and Outflow Hydrographs) from the referenced source(s).

Probable Maximum Precipitation (PMP)

Document the PMP depth, area, duration, orientation, and center location for the critical PMP configuration. If applicable, identify any areal reduction factor applied to calculate the basin-wide PMP depth. Provide a hyetograph in graphical and tabular format showing the temporal distribution of the critical PMP. Provide a figure depicting the spatial distribution of the critical PMP configuration. Describe the storm type (e.g. tropical, general, local) and seasonality (e.g., all-season, cool season) of the critical PMP.

Provide a brief summary of other PMP configurations that were considered and not determined to be the critical PMP. Include a table showing the 1, 2, 6, 24, 48, and 72-hour PMP depths.

Drainage Basin

Provide a short description of the drainage basin (topography, soil cover, upstream lakes, and reservoirs). Include a figure that delineates the drainage basin and identifies the project location. If practical, include a separate figure delineating the sub-basins and indicate those sub-basins that are gaged versus ungaged.

Antecedent Conditions

Document the antecedent conditions for the basin, including storms preceding the PMF, snow depths, soil saturation, base flows in the river and any tributaries, reservoir level, and other relevant information.

Snowmelt

If snowmelt is a contributor, summarize the snowmelt model used, assumptions, and input data including snowpack water equivalent, wind speed, and temperature.

Basin and Sub-basin Precipitation/Runoff Models

Identify which hydrologic model(s) was used to transform precipitation to runoff and the routing of the runoff through the dam and the downstream reach. State the model name, developer, and version of the model used for the study of record. If practical, include the model on the digital reference

Loss Rates

State the loss rate method applied in the PMF hydrologic model and describe how the loss rates were developed (i.e. methodology) and applied to the basin and sub-basins (i.e. basin-averaged or distributed). Summarize the loss rates used for each sub-basin and document the key assumptions.

Unit Hydrograph

Describe the unit hydrograph method and how the unit hydrograph parameters were selected. Provide a table summarizing the unit hydrograph parameters for each sub-basin. Provide the unit hydrograph in tabular and graphical format.

Channel Routing Method

Describe the channel routing method and how the routing parameters were selected. Provide a table summarizing the routing parameters for each sub-basin reach.

Calibration and Validation

Summarize the calibration approach and the performance of the loss rates, unit hydrograph, and routing parameters with regard to replicating volume, peak, and timing of historic storm events, if applicable to the development of the hydrologic model. Describe any verification/validation that has been performed.

Reservoir Inflow and Outflow Hydrographs

Provide hydrographs and a table summarizing the total runoff volume from the watershed, total infiltration losses, peak inflow, regulated outflow, headwater elevation, and tailwater elevation for the events listed below. If any of the events do not apply or are not available, state so and document the reason for omitting the event.

- 100-year (1 percent annual chance event);
- Inflow Design Flood (IDF); and
- Probable Maximum Flood (PMF).

Flood Frequency Analysis

If a flood frequency analysis has been performed, describe the methodology and inputs (e.g., stream gages) used to determine the flood frequency events and identify any stream gages that are affected by upstream regulation. Provide a plot of the flood frequency analysis for the project, including confidence limits (if available). Provide the flood frequency curve and table. Include a summary of the methods used to develop the analysis.

Floods of Record

Document the top five floods of record at the project site, including floods which predate the project works. If the information is available, include the date, inflow, regulated outflow, peak reservoir elevation, tailwater elevation, and flood characteristics (e.g., ice jam, snowmelt, associated weather event) for each event. Summarize whether any project water control features (gates, stoplogs, flashboards, etc.) were operated to pass the flood. Summarize any changes to upstream flow regulation that have occurred since the floods of record. Provide an estimate of the return frequency for each event based on the current flood frequency analysis, or regional flood frequency regression equations, if insufficient streamflow data is available.

15-3.6.2 Hydraulics – Dams

This section documents the overall hydraulics of the project.

Project Discharge Rating Curve

Provide an overall discharge rating curve for the project. For projects with multiple contributors to the discharge capacity (e.g., spillway gates, outlet structures, powerhouse units, fuse plugs, overtopping, etc.), include the contribution of each component as well as the total capacity. List the percentage of total discharge for each component making up the discharge rating curve. A table is an acceptable method for presenting this information (each contributor, the total discharge for that contributor and the percentage of total discharge). Provide the total time to open all gates.

Tailwater Rating Curve

If available, provide a tailwater rating curve in graphical and tabular format. Include all tailwater rating curves developed for the project that are used in the record stability analyses for the project structures. Extend the curve(s) to include the IDF.

Freeboard

Document the available freeboard for each water-retaining structure under normal operating conditions and during the IDF, excluding the effect of wave action. Include a summary of the maximum expected wind-generated setup and wave run-up during normal and IDF conditions.

For embankment dams, state the elevation of the top of the earthen core or core wall, for comparison to the normal and maximum pool elevations. For other types of dams, identify and state the elevation of the lowest point of the crest.

Zero Freeboard Discharge Capacity

State the total discharge capacity of the project assuming zero freeboard (i.e., at the initiation of overtopping), excluding any wave allowance. State the elevation and identify the limiting project structure(s) at zero freeboard. State whether the spillway has capacity to pass the IDF.

Inflow Design Flood (IDF)

If the IDF is less than the PMF, provide a citation to the incremental hazard analysis used to establish the IDF. Provide pertinent information summarizing the dam breach analyses as discussed in Section 15-3.6.5.

15-3.6.3 Hydraulics – Spillways

Hydraulic Capacity

State the total hydraulic capacity of each spillway(s), for normal maximum pool and flood surcharge pool (if applicable). Provide a summary discussion on the overall spillway capacity with regard to downstream structures (e.g., training walls, flood protection measures, channel capacity).

Discharge Rating Curve(s)

For each gated spillway, provide a discharge rating curve that documents the discharge for a range of gate openings, including the maximum opening height, and pool elevations. (Note that ungated spillway rating curves should be adequately represented on the Project Discharge Rating Curve, as discussed in the preceding section.) Clearly identify the transition between free flow and orifice flow, if applicable. Identify the total time to open all gates. Include a summary of the procedures, assumptions and discharge coefficients used to develop the curve(s). Summarize any hydrodynamic analyses (e.g., computational fluid dynamics models) completed to support stability analyses of the spillway.

Freeboard

Document the minimum available freeboard along the alignment of any spillway chute for the maximum discharge during the PMF. If any portion of the chute walls is expected to overtop during normal or flood conditions:

- Document the maximum flow that can be discharged without overtopping the chute walls; and
- Clearly indicate the areas that are expected to overtop and the expected depth of overtopping for each flow considered.

Scour

Describe the channel material and scour and cavitation protection measures in place (e.g. rock, riprap, armor, baffle blocks, plunge pools, etc.) and their design resistance to scour and cavitation. Provide a brief summary of any scour and/or cavitation analyses and scour protection design that have been performed for the project including the expected scour potential for flows up to the IDF. If applicable, provide a brief summary of the analysis the stilling basin/apron and its adequacy to contain the hydraulic jump.

Describe the velocities and expected shear stresses for flows up to the IDF at the following locations:

- exit of each spillway,
- within the channel of any unlined erodible spillway,
- around any bridge piers that are part of the project, and
- at the toe of non-overflow sections.

Summarize the findings of any quantitative evaluations of scour potential; if none have been completed, describe the scour potential qualitatively.

15-3.6.4 Hydraulics – Other Water Conveyance Systems

List each water conveyance system. As applicable, document the following for each system:

- Total hydraulic capacity;
- Normal operating freeboard of any non-enclosed components of the system (i.e., conveyances with open channel flow, such as flumes and canals);
- Maximum rated discharge capacity of each component of the system (e.g., individual turbine-generator units) under controlled conditions (i.e., functioning as intended without a rupture or other failure) with documentation of the headwater/tailwater elevations where the ability to operate the turbine-generators is lost; and
- Hydraulic considerations related to transient analyses (e.g., physical limitations that affect the minimum closure time for wicket gates, valves, etc.).
- Range of flow velocities associated with normal and maximum discharge capacities.

15-3.6.5 Dam Breach Studies

Summarize pertinent information related to any dam breach analyses, including assumptions such as:

- Description of hydraulic model and version used in the analysis.

- Breach width (bottom, top, and average), shape, bottom of breach elevation, top of breach elevation, side slopes and formation time. Include a description of the rationale for selection of the parameters used.
- Breach location(s) considered in the analysis.
- Summarize sensitivity analysis of breach parameters.
- Reservoir water surface and inflow/outflow at breach initiation.
- Reservoir volume for the breach including discussion of the effects of sediment depth, as applicable.
- Downstream lateral inflow from tributaries.
- Manning's "n" values used in routing breach flow downstream.
- Gate operations prior to breach initiation, and a comparison of the assumed operations to standard operating procedures.
- Cascading (domino) failure(s) including downstream dam breach initiation and parameter assumptions.
- Summarize the downstream incremental rise and impacts to downstream structures during the sunny day and IDF conditions. Include reference to the Emergency Action Plan (EAP) document for detailed inundation maps.

15-3.6.6 Reference Materials for the DPA

Include the following in the DPA:

- The current and any previous PMP and PMF studies, including (if available) all supporting digital hydrologic model input and output files.
- Any documentation related to an incremental hazard analysis to develop an IDF, including dam breach studies.
- Reports on physical or analytical model studies.
- Flood frequency analysis supporting calculations.
- Input and output files for dam breach and computational fluid dynamics (CFD) hydraulic models.
- Other supporting calculations/documentation for the following:
    - Flood frequency analysis.
    - Rating curves.
    - Wave run-up analysis.
    - Scour analyses.

To the extent practical, provide digital versions of other calculations and supporting files, such as: spreadsheets, CAD drawings, ArcGIS shapefiles, and Digital Elevation Model (DEM) files.

15-3.7 Dam Safety Surveillance and Monitoring Plan (DSSMP)

Include a complete copy of the current DSSMP, exclusive of its appendices, in Section 7 of the STID. If the DSSMP is voluminous, it is acceptable to provide the DSSMP as separate binder with an appropriate reference to it on a placeholder page in the STID. Refer to Chapter 9 of the Commission's Engineering Guidelines for the Evaluation of Hydropower Projects for details on the content of the DSSMP.

15-3.7.1 Reference Materials for the DPA

Include the following in the DPA:

- A searchable PDF copy of the current DSSMP, including all appendices.
- Digital copies of previous DSSMRs (if historical monitoring information is well documented in the current DSSMR, providing the two most recent DSSMRs in digital form would suffice. However, if there are discontinuities in historical data reported in the current DSSMR, relevant previous DSSMRs should be provided so that a complete understanding of all historical monitoring activities can be obtained.).
- Standard Operating Procedures (SOPs) for operating and recording data from instrumentation.
- Historical instrumentation readings data in Excel file or similar format applied in populating instrumentation plots.
- Historical maintenance and/or testing of instrumentation (e.g., piezometer falling head permeability tests).
- Special Inspection Reports (e.g., annual dive inspection reports). If there is no notable difference in the findings of the special inspections, providing the last 3 reports is acceptable. However, if there are notable changes over time, provide the relevant previous reports so that a comprehensive understanding of the changes over time is obtained.
- Any documentation of instrument installation and associated collected data, including boring logs and as-built drawings of observation wells/ piezometers showing the sensing zones and the subsurface stratigraphy.
- Instrumentation assessment reports.

15-3.8 Stability, Stress, and Other Analyses of Dams and Water Conveyances

This section provides documentation of the stability, stress, and other analyses of all project structures except gates, valves, and other reservoir control devices (which are to be documented in the subsequent section). The relevant sections for each structure type shall be included for each distinct project feature. For example, if there are multiple gravity sections – such as a spillway, an integral intake/powerhouse, and non-overflow sections on either side – the gravity structure information must be provided for each of those sections.

15-3.8.1 Summary of Results

At the beginning of Section 8 of the STID, include a table that lists each of the water-retaining and water-conveying project features and summarizes the resulting factors of safety, compared to the FERC recommended minimum value (or industry standard, in the absence of FERC guidance) for each load case, or the conclusion, as appropriate for each type of project feature, analysis, and load case. **These summary tables should document the best estimate analyses; findings related to sensitivity analyses of structures (e.g., concrete gravity dams assuming various levels of foundation drain effectiveness) should be documented in the appropriate subsection for each project feature.** Examples for several types of project features are provided below. For some structures, such as arch dams, the summary of results may be more suited to paragraph format to document expected deflections, joint openings, etc.

Table 2: Concrete Gravity Stability Results (EXAMPLE)

Structure	Load Case	% Base in Compression	Calculated Factor of Safety	FERC Minimum Factor of Safety
Spillway section (concrete-rock interface)	Normal	100%	1.8	1.5
	Flood (PMF)	92%	1.5	1.3
	Post-EQ	100%	1.8	1.3
Spillway section (critical lift joint)	Normal	85%	1.6	1.5
	Flood (PMF)	72%	1.3	1.3
	Post-EQ	78%	1.4	1.3
Right gravity section (concrete-rock interface)	Normal	*Include data similar to above.*		
	Flood (PMF)			
	Post-EQ			

Structure	Load Case	% Base in Compression	Calculated Factor of Safety	FERC Minimum Factor of Safety
Right gravity section (critical lift joint)	Normal			
	Flood (PMF)			
	Post-EQ			

Table 3: Embankment Slope Stability Results (EXAMPLE)

Structure	Load Case	Slope Analyzed	Calculated Factor of Safety	FERC Minimum Factor of Safety
Main embankment	Steady seepage, maximum normal pool	Upstream	1.8	1.5
		Downstream	1.9	1.5
	Steady seepage, surcharge pool (PMF)	Upstream	1.6	1.4
		Downstream	1.7	1.4
	Rapid drawdown from maximum normal pool	Upstream	1.2	1.1
	Rapid drawdown from spillway crest	Upstream	1.4	1.2
	Earthquake	Upstream	1.2	1.0
		Downstream	1.3	1.0

Structure	Load Case	Slope Analyzed	Calculated Factor of Safety	FERC Minimum Factor of Safety
Saddle dam embankment	Steady seepage, maximum normal pool	Upstream	1.8	1.5
		Downstream	1.9	1.5
	Steady seepage, surcharge pool (PMF)	Upstream	1.6	1.4
		Downstream	1.7	1.4
	Rapid drawdown from maximum normal pool	Upstream	1.2	1.1
	Rapid drawdown from spillway crest	Upstream	1.4	1.2
	Earthquake	Upstream	1.2	1.0
		Downstream	1.3	1.0

15-3.8.2 Analyses of Record

Provide a summary table documenting the current analysis of record for each project feature. An example table is provided below (Table 4). The intent is to make it easy to identify which analysis of record covers which project feature(s) and loading condition(s), and for each report to be easily located on the digital reference.

Table 4: Analyses of Record Summary (EXAMPLE)

Project Feature	Load Case(s)	Report/Consulting Firm Name & Date
Right gravity section	Normal, Flood, Seismic	Great Consultants (2008)
Spillway section	Normal, Seismic	Best Dam Consultants (2012)
Spillway section	Flood	Best Dam Consultants (2017)
Main embankment dam	Normal, Flood, Seismic	Best Dam Consultants (2012)
Main embankment dam	Filter compatibility	Soil Sciences (2015)
Saddle dam embankment	Normal	Best Dam Consultants (2012)
Saddle dam embankment	Flood, Seismic	Saddle Dam Stability Study (2017)
Saddle dam embankment	Filter compatibility	Soil Sciences (2015)
Penstock	Normal, Transient	Power Pipe Designs (2002)

15-3.8.3 General Information Required for All Sections

In the appropriate section for each project feature, document the following information:

- List the load cases analyzed and any relevant input parameters (e.g., headwater and tailwater elevations; tailwater force ratio; silt loads; seismic acceleration; operating and transient pressures for penstocks; etc.).
- State the method of analysis; if a computer program was used, identify the program and version.
- Document the material properties and clearly indicate whether they are based on site-specific tests or assumed based on literature values. If the former, include representative test data and summary sheets; if the latter, provide a clear citation to the reference and screenshots or quotes, as appropriate. It is acceptable to include a reference to the corresponding information provided in accordance with Section 15-3.5.3, if the relevant information is thoroughly documented there.
- Provide input time-history plots and/or response spectra, as applicable, for any structures evaluated for seismic loading conditions. Describe any steps taken to adjust the seismic loads for application to any computer models (e.g., deconvolution).
- List the codes, standards and/or other criteria used in the analyses including version and year of release details (e.g., ACI 318-95, ASTM D1557-07, etc.).

15-3.8.4 Gravity Structures

In addition to the information listed in Section 15-3.8.3, document the following, as applicable, in the list of load cases analyzed: gate configurations (e.g., a surcharged reservoir with spillway gates partially submerged), spillway discharge (particularly for overflow structures that may experience negative crest pressures), and dewatering conditions (e.g., use of a spillway bulkhead or stoplogs).

Provide a cross-section of each gravity structure and list key elevations, lateral dimensions, and other key physical information (e.g., the locations of piezometers and foundation and/or body drains). If there are any anchors, provide details. Include references to as-built drawings, field surveys, etc. with respect to the assumed key dimensions. Also, provide details of any keying of the dam-foundation interface.

If drains are assumed to be effective at reducing uplift pressures in the analyses, document how drain flows are discharged (e.g., gravity, pumped from a gallery, etc.) and the location of the discharge. Summarize and provide any monitoring data used to support the drain effectiveness used in the analysis. If piezometers are used to justify uplift assumptions, provide a detailed discussion of the justification including any supporting monitoring data.

<u>Interface Parameters</u>

List the interface strength parameters, including material strengths, base friction angle, effective friction angle, and cohesion value (if applicable) for all failure planes evaluated. Summarize any justification for the failure planes that were selected for analysis. Document any investigations or review performed to validate the assumed parameters. If cohesion is considered to contribute to stability for any load condition, provide detailed documentation of any investigations performed to justify the use of cohesion and document the sensitivity to the amount of cohesion assumed.

Provide brief descriptions of foundation geologic conditions as they relate to gravity structure stability; for example, bedding planes, dip directions, and joints/fractures in rock foundations.

<u>Free Body Diagrams</u>

For each gravity structure and load case, provide a free-body diagram (cross-section) of the structure being analyzed. The diagram should include a graphical depiction of the resultant force and its location along the assumed failure plane, as well as all applicable loads, including:

- Self-weight.
- Uplift pressure.
- Silt load.
- Hydrostatic and hydrodynamic loading, including the effects of flow discharge as applicable (e.g., negative crest pressures, bucket pressures, etc.).

- Ice load.
- Anchor loads.
- Other point or distributed loads, as needed (e.g., gates, permanent machinery, bridges, etc.). For distributed loads (e.g., uplift pressure), show the distribution as well as the resultant and its location.
- For pseudodynamic calculations, include representations of any inertia load; hydrodynamic force distributions; and soil liquefaction.

Finite Element Models

For gravity structures evaluated using a finite element model, include:

- A concise description of the finite element model, including boundary conditions, interface definitions, methods of load application etc.
- Discussion of model verification procedures, including any evaluations of convergence with respect to mesh resolution selection, and results.
- Graphical presentation of the finite element mesh.
- Representative stress contour plots and magnified deflection plots for each load case.

Other Information

- Document the potential for or evidence of alkali-aggregate reactivity (AAR) in the gravity structures.
- Summarize the results of any concrete testing, including unconfined and splitting tensile strength, compressive strength, and shear strength.
- Summarize the results of any thermal studies or performance-based testing.

15-3.8.5 Embankment Dams

In addition to the information listed in Section 15-3.8.3, document the following, as applicable, in the list of load cases analyzed:

Computer-Based Analyses

For computer-based analyses of embankment dams, include a summary discussion, with references to supporting documentation on the digital reference, to document the basis for any assumptions related to the following:

- Representative section(s) selected to account for the variations in foundation soil/rock profile, composition of the embankment materials and geometries specific to selected sections (upstream and downstream slopes, and slopes of different zones).

- Boundary conditions (e.g. seepage behavior in and out of model, allowed movement during seismic loading, modeling of foundation/bedrock, interfaces, etc.).
- Interfaces with adjoining structures (e.g. concrete training walls, adjacent multiple arch dam, natural rock abutments).
- Internal behavior or composition of embankment materials (e.g. material interfaces, hydraulic conductivity, moisture content, uniformity of gradation of a material zone, uniformity of compaction/density of a material zone, performance parameters of a geotextile or geomembrane).
- Details on the methods applied to model structural components (e.g., tie-back anchors, core walls, cutoff walls, upstream reinforced concrete faces, shotcrete, gunite, etc.).
- The phreatic surface location and how it was derived (e.g., piezometer data, seepage analysis, etc.).

Summary of Static and Hydraulic Analyses

For each embankment structure, include a plan view noting the location(s) of analyzed cross-section(s). For each load case, as applicable, include summary discussion and relevant cross-section(s) showing:

- Documentation of the most critical failure planes based on the normal maximum water surface, PMF/IDF loading conditions, and other loading conditions as appropriate.
- Dimensions and location of any core wall/cut-off wall and details regarding the material stratum that provides cut-off from under seepage.
- Summary of the seepage analyses for different loading conditions.
- If overtopping occurs during the PMF/IDF, a summary of the through-flow analyses and/or associated stability and erodibility analyses for overtopping conditions.
- Summary of evaluations of filter compatibility, including clear references to the evaluation criteria (e.g., FEMA: Filters for Embankment Dams (Oct 2011), NRCS, USBR, etc.). Include cross-sections that identify the locations of each zone/material and the applied hydraulic loading being evaluated.
- Discussion of the potential for uncontrolled seepage exiting at the toe or along the abutments based on the seepage analysis results. Include a discussion on vertical and horizontal exit hydraulic gradients at applicable sections of the dam.

Summary of Liquefaction Analyses

- A summary of seismic records applied and whether the records were scaled or altered. Include the reference and date of the site-specific Seismic Hazard Assessment used for the selection of the critical seismic loads.
- Representative cross-sections, elevations, and profiles documenting the anticipated extent of liquefaction. Include the finite-element-model grid if applicable.
- Plots of the input time-histories.
- A summary of the data that the liquefaction analyses were based on. Include a detailed evaluation of the limitations of the liquefaction screening methodology and in-situ and laboratory testing and their potential impact on the reliability of the liquefaction potential assessment. If the analyses are not based directly on analysis of site-specific embankment and/or foundation materials, a clear statement that this is the case along with a technical justification supporting the adequacy of the assumptions made should be included.
- The magnification on deformation resulting from liquefaction plots.
- A summary of all resulting settlement and how this affects the short-term and long-term performance of the dam (for example, will the initial movement lead to potentially more progressive slides and deformations that may affect the dam's ability to retain pool?).

Summary of Deformation Analyses

- A summary of seismic records applied and whether the records were scaled or altered. Include the reference and date of the site-specific Seismic Hazard Assessment used for the selection of the critical seismic loads.
- Representative cross-sections, elevations, and profiles documenting the anticipated deformation due to seismic loading. Include the finite-element-model grid if applicable.
- Plots of the input time-histories.
- The magnification on deformation result plots.
- A summary of the predicted movement whether the analysis indicates it would be expected to continue (e.g., progressive slumping) or if the remaining section would be expected to retain the reservoir.

15-3.8.6 Arch Dams

In addition to the information listed in Section 15-3.8.3, document the following, as applicable:

- Any keying of the dam-foundation interface;

- Foundation modulus of deformation; and
- Contraction joint details/treatment.

Finite Element Models

For arch dams evaluated using a finite element model, include:

- A concise description of the finite element model, including boundary conditions, interface definitions, methods of load application etc.
- Discussion of model verification procedures, including any evaluations of convergence with respect to mesh resolution selection, and results.
- Graphical presentation of the finite element mesh.
- Representative stress contour plots and magnified deflection plots for each load case.

Other Information

- Document any evaluations of abutment stability, including block stability analyses and overtopping erosion evaluations, to an appropriate level of detail.
- Summarize the results of any thermal studies or performance-based testing.

15-3.8.7 Buttress Dams

In addition to the information listed in Section 15-3.8.3, document the following, as applicable:

- Stress analyses of buttresses, slabs, and corbels; and
- The response of the dam when subject to earthquake loads applied in both the stream direction and cross-valley direction.

Finite Element Models

For buttress dams evaluated using a finite element model, include:

- A concise description of the finite element model, including boundary conditions, interface definitions, methods of load application etc.;
- Discussion of model verification procedures, including any evaluations of convergence with respect to mesh resolution selection, and results;
- Graphical presentation of the finite element mesh;
- Representative stress contour plots and magnified deflection plots for each load case.

Other Information

- Document any evidence of deterioration, cracking, leakage, and offsets between members that could indicate movement.
- Summarize the results of any thermal studies or performance-based testing.

15-3.8.8 Spillway Piers

In addition to the information listed in Section 15-3.8.3, document the following, as applicable:

- Stress analyses of each typical section of spillway piers.
- A description of the pier reinforcement and the controlling capacity (e.g., unreinforced flexural, reinforced flexural, shear, tension).
- The response of the piers when subject to earthquake loads applied in both the stream direction and cross-valley direction, including any point and distributed loads (e.g., hydrodynamic loads applied directly or translated to the piers through the trunnion anchorage(s), and bridge loads).
- Any observed evidence of deterioration or cracking that may affect the capacity or performance of the spillway piers.

Finite Element Models

For spillway piers evaluated using a finite element model, include:

- A concise description of the finite element model, including boundary conditions, interface definitions, methods of load application etc.;
- Discussion of model verification procedures, including any evaluations of convergence with respect to mesh resolution selection, and results;
- Graphical presentation of the finite element mesh;
- Representative stress contour plots and magnified deflection plots for each load case.

15-3.8.9 Spillway Chutes

Document any stress and stability analyses that have been performed for components of any spillway chute, including slab panels, slab anchors, wall panels, training walls (headworks and chute), drains and their capacities, and energy dissipation systems for a range of flows up to the rated capacity. Spillway aprons that limit the potential for foundation erosion at the toe of a gravity structure may require similar documentation. If a scour evaluation of an unlined spillway chute is already documented per the guidance in Section 15-3.6.3, provide a reference to that section here.

15-3.8.10 Penstocks and Other Water Conveyances

For each penstock and other water conveyance that has a credible potential failure mode (urgent or otherwise), document any associated analyses such as the stress and stability analyses, hydraulic analyses (e.g. cavitation and water hammer), etc. Provide a graphical depiction of each water conveyance, identifying each location that was analyzed. Also include free body diagrams for any supporting features that were evaluated (e.g., concrete saddles or thrust blocks). Include results from any pressure relief valve testing, vacuum relief valve testing, and penstock thickness measurements.

Clearly state the material properties; original penstock thicknesses, especially if steel; loading conditions, including the valve or gate closure timing for transient loading; section(s) analyzed; evaluation criteria; and results.

15-3.8.11 Other Structures

Include summary discussion of analyses related to other types of dams (e.g, timber crib dams, rubber dams, etc.) and appurtenances, such as surge tanks, air vent structures, lock walls, lock gates, power canal walls, etc.

15-3.8.12 Reference Materials for the DPA

Include the following in the DPA:

- The report on the analysis of record for each project feature, including any spreadsheet or hand calculations that may have been completed;
- All previous analysis reports, if available (clearly note which analyses (or portions of the analyses) have been superseded);
- Any previous spillway inspection reports, if available (or provide a reference thereto if they are already included in Section 7 of the STID); and
- Input files for stress and stability analysis models, if available. Electronic files for all model runs also should be provided when available.

15-3.9 Gates, Valves, and Other Water Level Control Devices

This section includes documentation related to radial spillway gates, other gates, valves and other water level control devices. When determining whether a feature has to be documented in the STID, it may be helpful to consider whether the discharge provided by the feature is critically important for ensuring safe passage of the IDF/PMF. If so, the feature must be documented; if not, it may still need to be documented (err on the side of providing too much information rather than not enough).

Provide a plan drawing or aerial image of the project with the location and type of each gate identified, along with any relevant gate numbering. Include a summary table documenting basic information for all spillway gates, other gates, and reservoir control valves. An example table is provided below:

Table 5: Gate and Valve Summary (EXAMPLE)

Gate/Valve Type	No. of Type of Gate/Valve	Dimensions (WxH or Dia.)	Maximum Discharge (cfs)	Time to Fully Open
Radial	2	30’ x 25’	15,000 cfs each	30 minutes
Flashboards	12	12’ x 6’	8,000 cfs total	5 minutes
Howell-Bunger valve	1	6’ diameter	2,300 cfs	10 minutes

In the appropriate subsection for each gate, valve, or other reservoir control device, list the material properties of structural elements and fasteners; state the source of this information (e.g., original specifications, subsequent material testing, etc.). If material properties are unknown, state the most likely material based on the era of construction, literature values, etc., and include a citation.

Include a thorough description of each gate/valve operating system. Describe the physical components of the system (electrical motors including nameplate specifications, gear boxes, couplings, etc.), power sources, and pathways for power, communication and/or control. Document any physical and logical controls that govern and/or indicate gate/valve position, or maintain alignment within operating slots, including limit switches that may prevent over-loading of and damage to gate chains, cables, hoists or operator’s bridge. Discuss methods for verifying the operation and percent open of remotely-operated gates. Also include discussion of performance history including any failure incidents and repairs.

15-3.9.1 Radial Gates

Provide the following additional information for radial gates:

- Document the materials and date of installation of the trunnion, trunnion anchorage, trunnion bearings, and thrust washer (as applicable).
- Describe the trunnion lubrication procedures and lubricant specifications; if none, state that no lubrication is performed.
- Provide a summary of the gate hoist motor load tests to-date (motor name plate rating, line-line voltage, amperage draw, reservoir level, and initial draw if available). This can be supported by annual gate certifications in the DPA but this section should include a summary of the expected values and equipment ratings.

- Summarize the findings and recommendations from the most recent hands-on gate inspection report.

Stress Analyses

Include a graphical representation of the gate model used for the stress analysis. State the computer program, version, and the year the analysis was completed. Describe the following:

- Load cases, including the magnitude and method of application of each load;
- Boundary conditions;
- Section properties and connectivity;
- Model verification; and
- Other relevant information, as needed.

Provide a summary of the stress analysis results for each load case, including:

- A table of stresses and/or demand-capacity ratios in each member and connection;
- A graphical representation of the gate with any overstressed members identified; and
- Documentation of any trunnion friction threshold evaluations (i.e., the maximum coefficient of friction that results in acceptable stress results).

If any members or connections are overstressed, provide additional results documenting the stresses and/or demand-capacity ratios with the overstressed members deleted from the model. If the gate anchorage has been evaluated with a stress analysis, provide pertinent information as appropriate; otherwise state that the anchorage was not evaluated.

15-3.9.2 Other Gates

Document any analyses related to the stability and/or structural adequacy of other gates, such as: sector gates, drum gates, fixed wheel vertical lift gates, slide gates, bear trap gates, inflatable gates (e.g., Obermeyer), etc., and their supporting structures.

Summarize the findings of the most recent hands-on gate inspection, if one has been performed.

15-3.9.3 Reservoir Control Valves

Document any analyses related to the stability and/or structural adequacy of reservoir control valves.

15-3.9.4 Other Reservoir Control Devices

Document any analyses related to the stability and/or structural adequacy of other reservoir control devices. For automatic-trip devices (e.g., flashboards, fuse gates, etc.), include documentation of the calculations related to the trigger elevation/flow at which the device is designed to activate.

15-3.9.5 Reference Materials for the DPA

Include the following in the DPA:

- Reports on stress and stability analyses of gates and valves;
- Reports on any internal, up-close, or non-destructive examination of gates and valves, including all previous 10-year Gate Inspection Reports;
- Input files for any gate analyses, if available, in a universal (text-based) format (e.g., if the model was performed using SAP2000, include the .$2k files);
- Annual spillway gate certifications completed since the last STID update including time-history plots of volt/amp readings;
- Manufacturer's specifications and catalog cuts of standard gates, valves and other components, as available; and
- Other relevant information as needed.

15-3.10 Pertinent Correspondence Related to the Safety of Project Works

Provide two printed lists of pertinent correspondence:

- All correspondence between the FERC and the licensee related to safety of project works since the previous Part 12D report; and
- Significant correspondence from the entire project history (e.g., completion or FERC acceptance of major studies; mandatory drawdowns; notification of dam safety incidents; etc.).

Other than the two lists, no additional information is required in the hard copy of this section.

15-3.10.1 Additional Information for the Digital Reference

Include digital copies of the pertinent correspondence listed in the STID on the DPA.

15-3.11 References

In the STID, provide a complete table of contents of the information included in the DPA. The information should be presented in a manner that enables a user to quickly locate relevant information and subsequently access the file In the DPA. For projects with large number of drawings and photographs, individual drawing names and photograph descriptions need not be provided in the hard copy, though collections should be listed (e.g., “Original Construction As-Built Drawings – Embankment Dam,” “Photos from 2014 Underwater Inspection,” etc.). Refer to the guidance in previous sections of this chapter for details.

15-3.11.1 Reference Materials for the DPA

Includee digital copies of any important reference material that has not already been provided for the preceding sections.