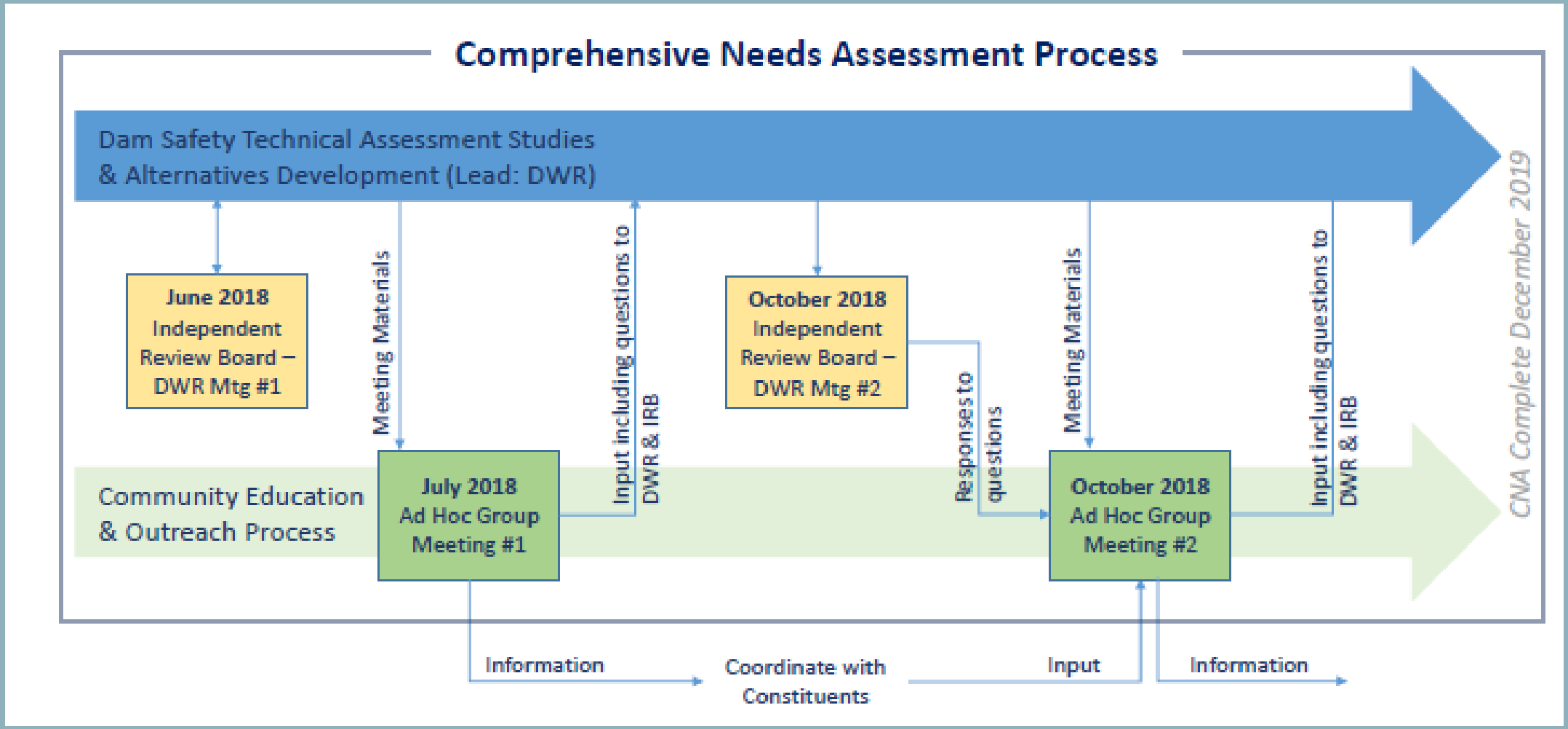
CNA Ad Hoc Group

July 18, 2018

Presentation Contents

- Introductory Comments
- Ad Hoc Group Process
- Charter
- Topics and Venues

Ad Hoc Group Process Diagram



Charter

- Purpose
- Background
- Roles and Responsibilities
  - Ad Hoc Group members
  - DWR support
- Rules of Engagement
  - Meeting process
  - Attendance and participation
  - Agendas, summaries, and meeting logistics
  - Meeting order, conduct and decorum

Topics and Venues

	Topics Within the Scope of the Oroville Dam Safety Comprehensive Needs Assessment	Topics Outside of the Scope of the CNA with an Existing Forum	Topics Outside of the Scope
How questions or comments on these topics are addressed:	• Discussed with the CNA	• Not discussed within the CNA • DWR will record these questions and comments • Addressed in the appropriate existing forum • Information from the CNA informs the discussion in the appropriate existing forum	• Not discussed within the CNA • DWR will record these questions and comments • A suitable forum for discussing is identified or created outside of the CNA • Information from the CNA informs the discussion in the appropriate existing forum

CNA Ad Hoc Group Part 2

July 18, 2018

Presentation Contents

- Oroville Reservoir and Dam Facilities
- Public Safety
- CNA Project
- Independent Review Board
- Questions

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Oroville Reservoir and Dam Facilities

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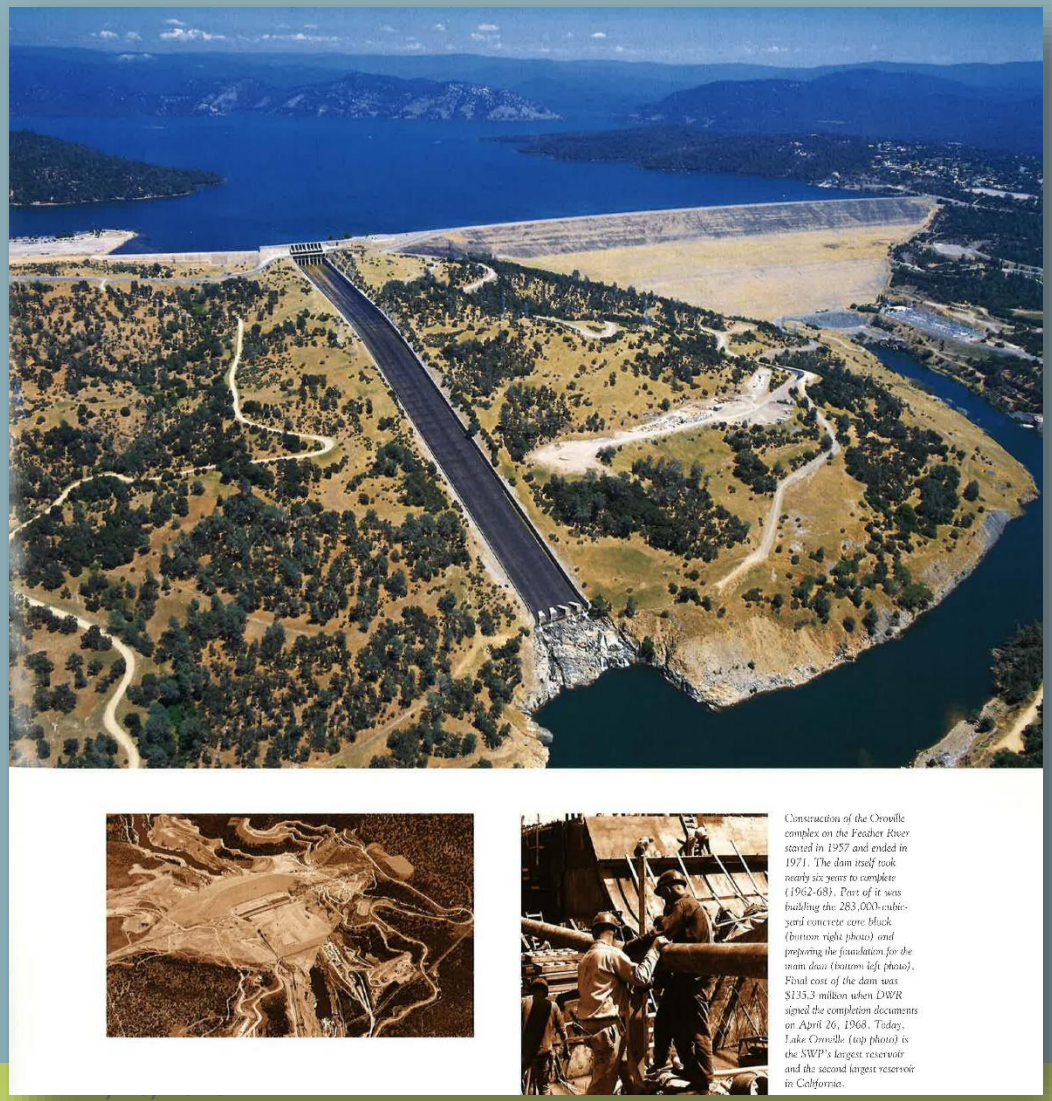
Feather River Project



Construction of the Oroville complex on the Feather River started in 1957 and ended in 1971. The dam itself took nearly six years to complete (1962-68). Part of it was building the 283,000-cubic-yard concrete core block (bottom right photo) and preparing the foundation for the main dam (bottom left photo). Final cost of the dam was $133.3 million when DWR signed the completion documents on April 26, 1968. Today, Lake Oroville (top photo) is the SWP's largest reservoir and the second largest reservoir in California.

- 1951, report to Legislature by State Engineer
- Multi-purpose dam and reservoir near Oroville
- Planning authorized in 1951
- 1955 Flood, 64 lives lost and $200 million in property damage
- 1957, $25 million appropriation to begin construction

Actions After 1955 Flood

Marysville surrounded by flood waters from Feather and Yuba rivers.

1956	Department of Water Resources created
1957	Oroville construction began
1958	Burns-Porter Act passed
1960	California voters approved bond act
1962	Federally-funded flood control

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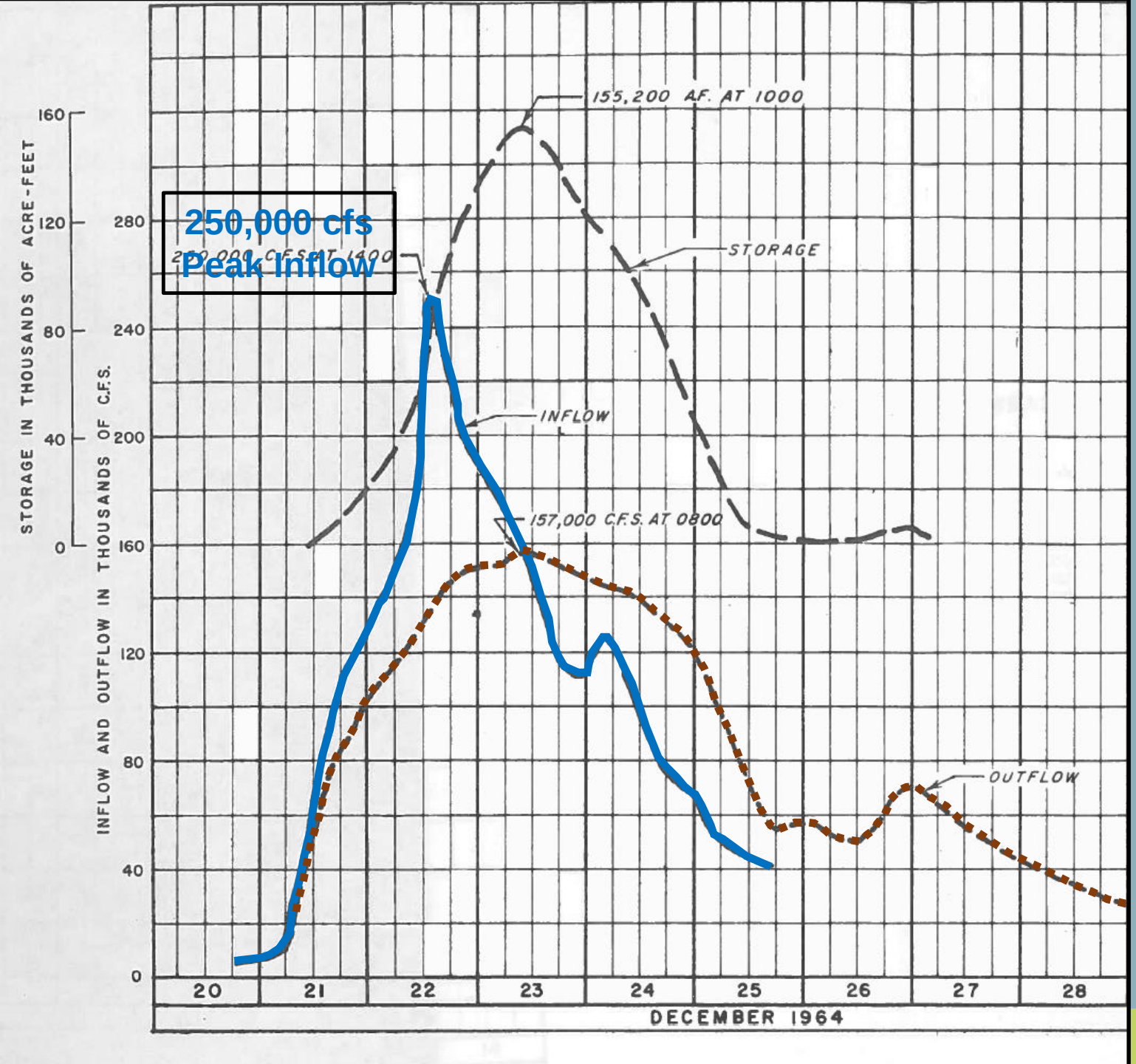
Multiple Benefits

- Flood Control
- Water Supply
- Power Generation
- Environmental
- Recreation

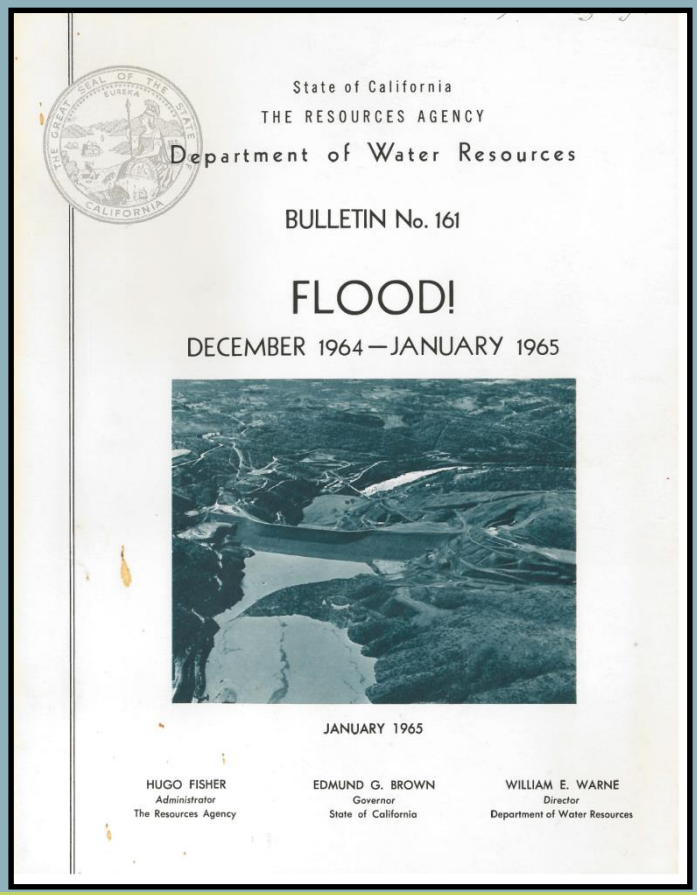
Flood Control

- Annual flood control reservation of up to 750,000 acre-feet.
- Spillway releases limited to 150,000 cfs under the standard project flood
- Maintain maximum flows at the confluence of the Yuba and Feather rivers at 300,000 cfs or less.



December 1964 Flood:

- 250,000 cfs Peak Inflow
- 157,000 Peak Outflow through Diversion Tunnels



Major Flows on Feather River
Post Oroville Construction

Yuba-Feather system flows with and without Oroville Reservoir

1986 Event

Location	Discharge w/o Oroville Dam (cfs)	Discharge w/ Oroville Dam (cfs)
Outlet	217,881	148,241
D/S Confluence	319,933	282,302

1997 Event

Location	Discharge w/o Oroville Dam (cfs)	Discharge w/ Oroville Dam (cfs)
Outlet	324,999	155,710
D/S Confluence	430,226	312,062

2017 Event

Location	Discharge w/o Oroville Dam (cfs)	Discharge w/ Oroville Dam (cfs)
Outlet	190,435	100,000
D/S Confluence	270,102	135,700

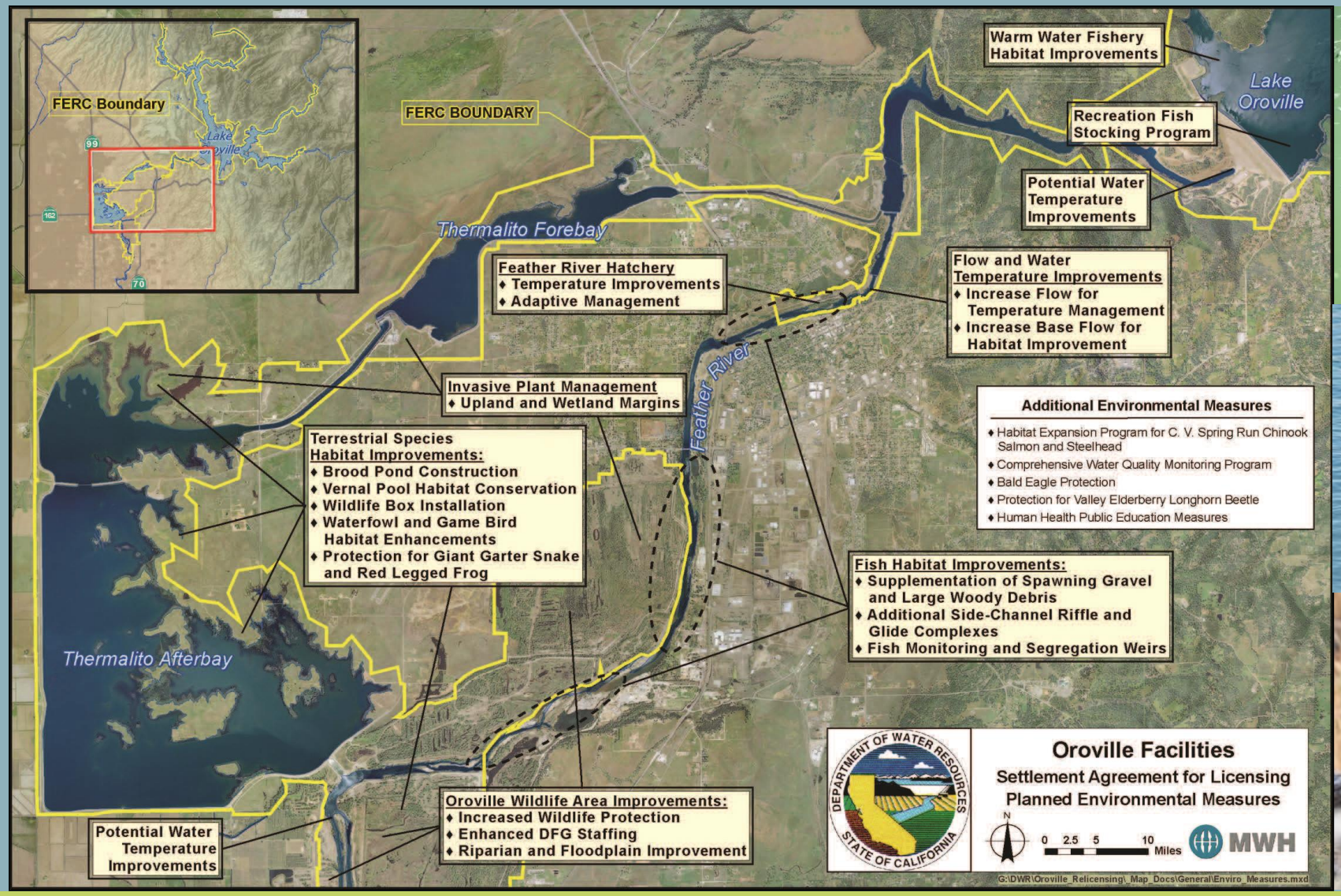
Water Supply

- Total reservoir capacity of 3.5 MAF
- Average delivery of 2.8 MAF
- 25 million residents
- 750,000 acres of farmland

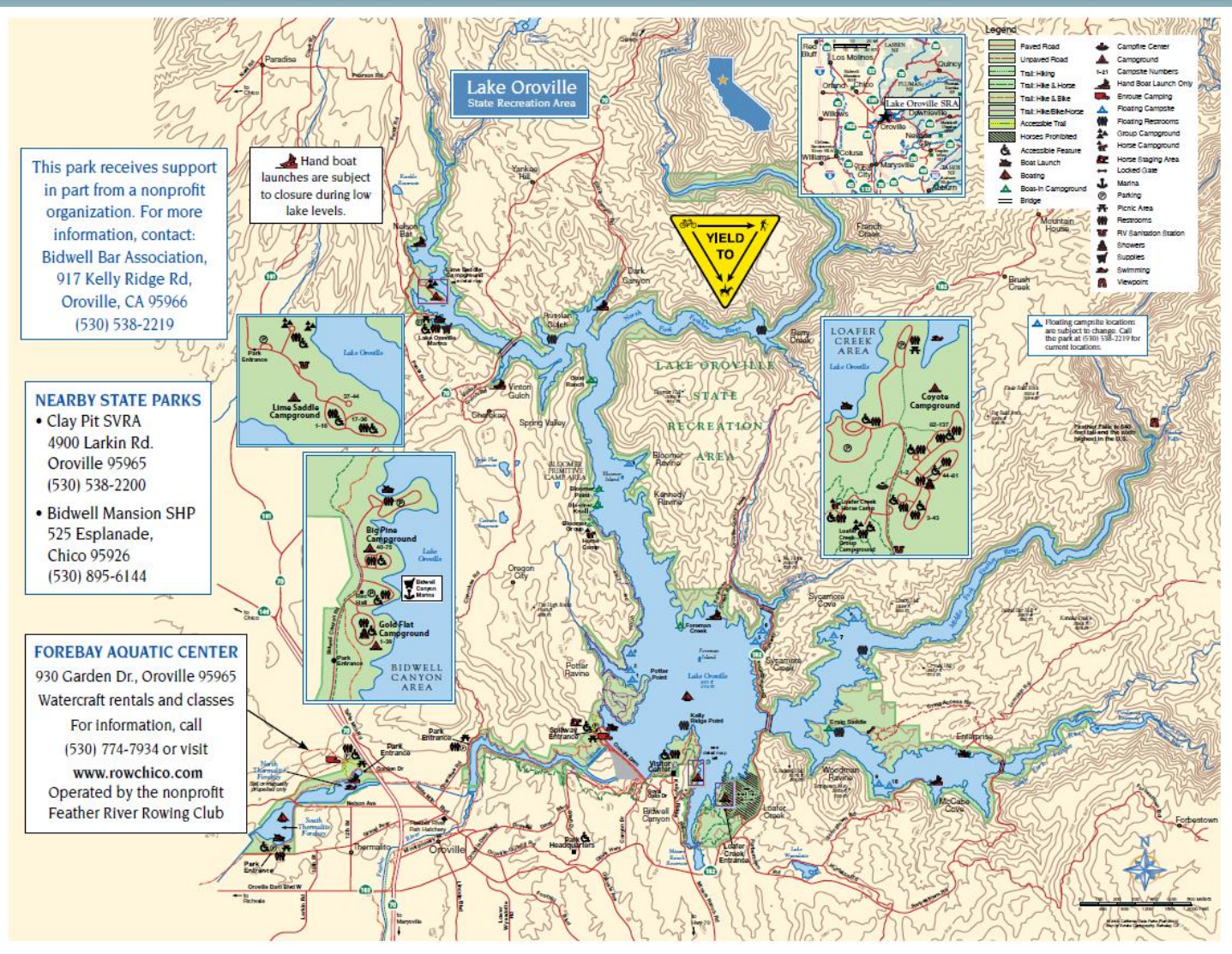
Power Generation

- 615 ft hydraulic head
- 6 turbines with an installed capacity of 819 MW, 16,950 cfs
- Annual average generation of approximately 1,630 GWh

Environmental



Recreation


Lake Oroville
State Recreation Area
This park receives support in part from a nonprofit organization. For more information, contact:
Bidwell Bar Association,
917 Kelly Ridge Rd,
Oroville, CA 95966
(530) 538-2219
Hand boat launches are subject to closure during low lake levels.
NEARBY STATE PARKS
• Clay Pit SVRA
4900 Larkin Rd.
Oroville 95965
(530) 538-2200
• Bidwell Mansion SHP
525 Esplanade,
Chico 95926
(530) 895-6144
FOREBAY AQUATIC CENTER
930 Garden Dr., Oroville 95965
Watercraft rentals and classes
For information, call
(530) 774-7934 or visit
www.rowchico.com
Operated by the nonprofit
Feather River Rowing Club
YIELD TO
LAKE OROVILLE STATE RECREATION AREA
LOAFER CREEK AREA
Coyote Campground
Lime Saddle Campground
Big Pine Campground
Gold Flat Campground
BIDWELL CANYON AREA
Floating campsite locations are subject to change. Call the park at (530) 538-2219 for current locations.
Legend
Paved Road
Unpaved Road
Trail: Hiking
Trail: Hike & Horse
Trail: Hike & Bike
Trail: Hike/Bike/Horse
Accessible Trail
Horses Prohibited
Accessible Feature
Boat Launch
Boating
Boat-In Campground
Bridge
Campfire Center
Campground
Campsite Numbers
Hand Boat Launch Only
Enroute Camping
Floating Campsite
Floating Restrooms
Group Campground
Horse Campground
Horse Staging Area
Locked Gate
Marina
Parking
Picnic Area
Restrooms
RV Sanitation Station
Showers
Supplies
Swimming
Viewpoint

Public Safety

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Public Safety Laws and Regulations

- Flood Control
  - *Flood Control Manual (USACE)*
- Dam Safety
  - *Division 3 California Water Code (DSOD)*
  - *Federal Power Act, Part 12 (FERC)*

US Army Corps of Engineers

CNA Project

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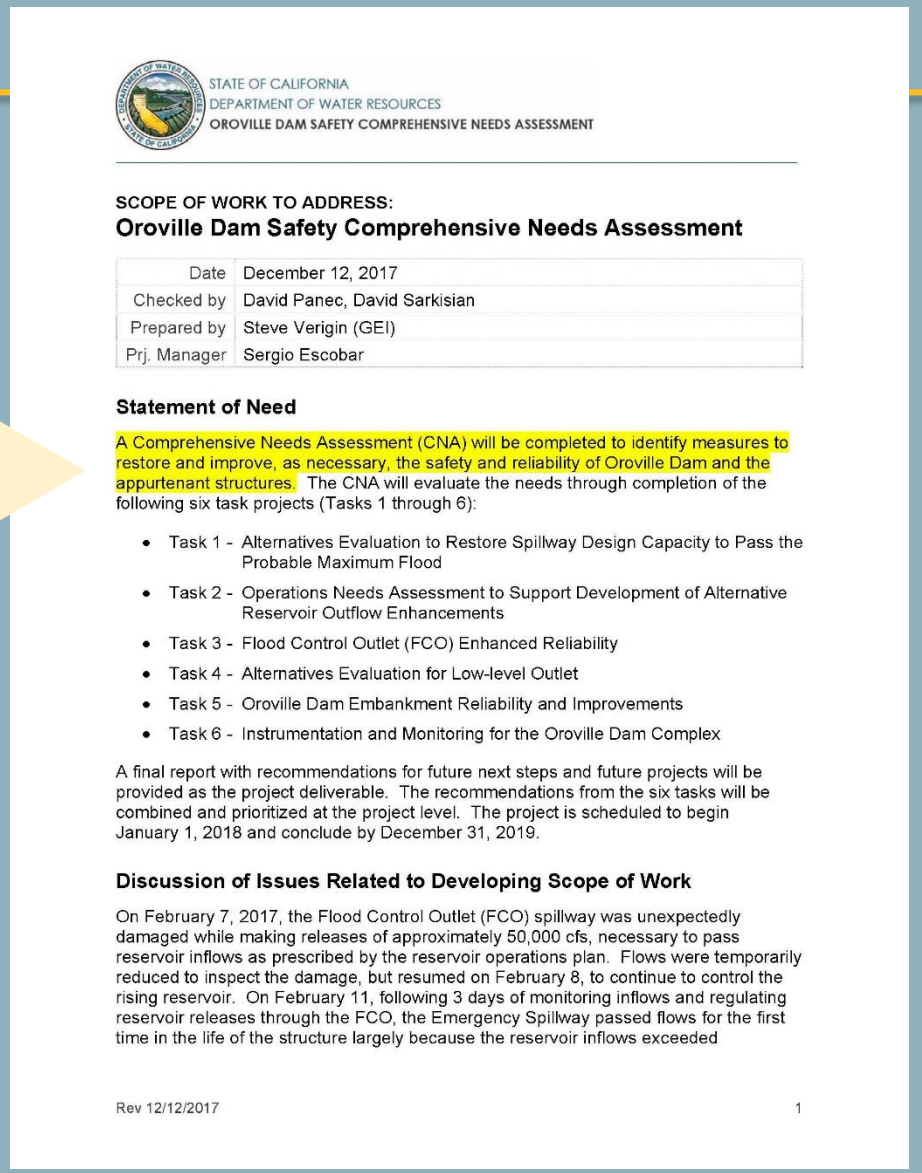
Project Need

"…to identify measures to restore and improve, as necessary, the safety and reliability of Oroville Dam and the appurtenant structures."



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Oroville Dam Safety Comprehensive Needs Assessment

Date	December 12, 2017
Checked by	David Panec, David Sarkisian
Prepared by	Steve Verigin (GEI)
Prj. Manager	Sergio Escobar

Statement of Need

A Comprehensive Needs Assessment (CNA) will be completed to identify measures to restore and improve, as necessary, the safety and reliability of Oroville Dam and the appurtenant structures. The CNA will evaluate the needs through completion of the following six task projects (Tasks 1 through 6):

- Task 1 - Alternatives Evaluation to Restore Spillway Design Capacity to Pass the Probable Maximum Flood
- Task 2 - Operations Needs Assessment to Support Development of Alternative Reservoir Outflow Enhancements
- Task 3 - Flood Control Outlet (FCO) Enhanced Reliability
- Task 4 - Alternatives Evaluation for Low-level Outlet
- Task 5 - Oroville Dam Embankment Reliability and Improvements
- Task 6 - Instrumentation and Monitoring for the Oroville Dam Complex

A final report with recommendations for future next steps and future projects will be provided as the project deliverable. The recommendations from the six tasks will be combined and prioritized at the project level. The project is scheduled to begin January 1, 2018 and conclude by December 31, 2019.

Discussion of Issues Related to Developing Scope of Work

On February 7, 2017, the Flood Control Outlet (FCO) spillway was unexpectedly damaged while making releases of approximately 50,000 cfs, necessary to pass reservoir inflows as prescribed by the reservoir operations plan. Flows were temporarily reduced to inspect the damage, but resumed on February 8, to continue to control the rising reservoir. On February 11, following 3 days of monitoring inflows and regulating reservoir releases through the FCO, the Emergency Spillway passed flows for the first time in the life of the structure largely because the reservoir inflows exceeded

Rev 12/12/2017 1

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Anticipated Outcomes

- Prioritized dam safety and operational reliability recommendations will be produced.
- Recommendations evaluated by DWR Management.
- Identify projects that provide significant public safety and risk reduction for early implementation.
- Project will be coordinated with DSOD and FERC.
- Reservoir operations will be coordinated with participating agencies.

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Benefits of CNA Initiatives

Increased facility and system reliability to:

- Maintain public safety and infrastructure
- Reduce flood risks
- Provide for continued environmental and recreational benefits

CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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A Four-Phase Planning Study Approach

Phase I: Problems, Objectives, Constraints, Opportunities

Phase II: Inventory Historical and Current Conditions, Forecast Future Conditions

Phase III: Plan Formulation

Phase IV: Plan Evaluation and Comparison

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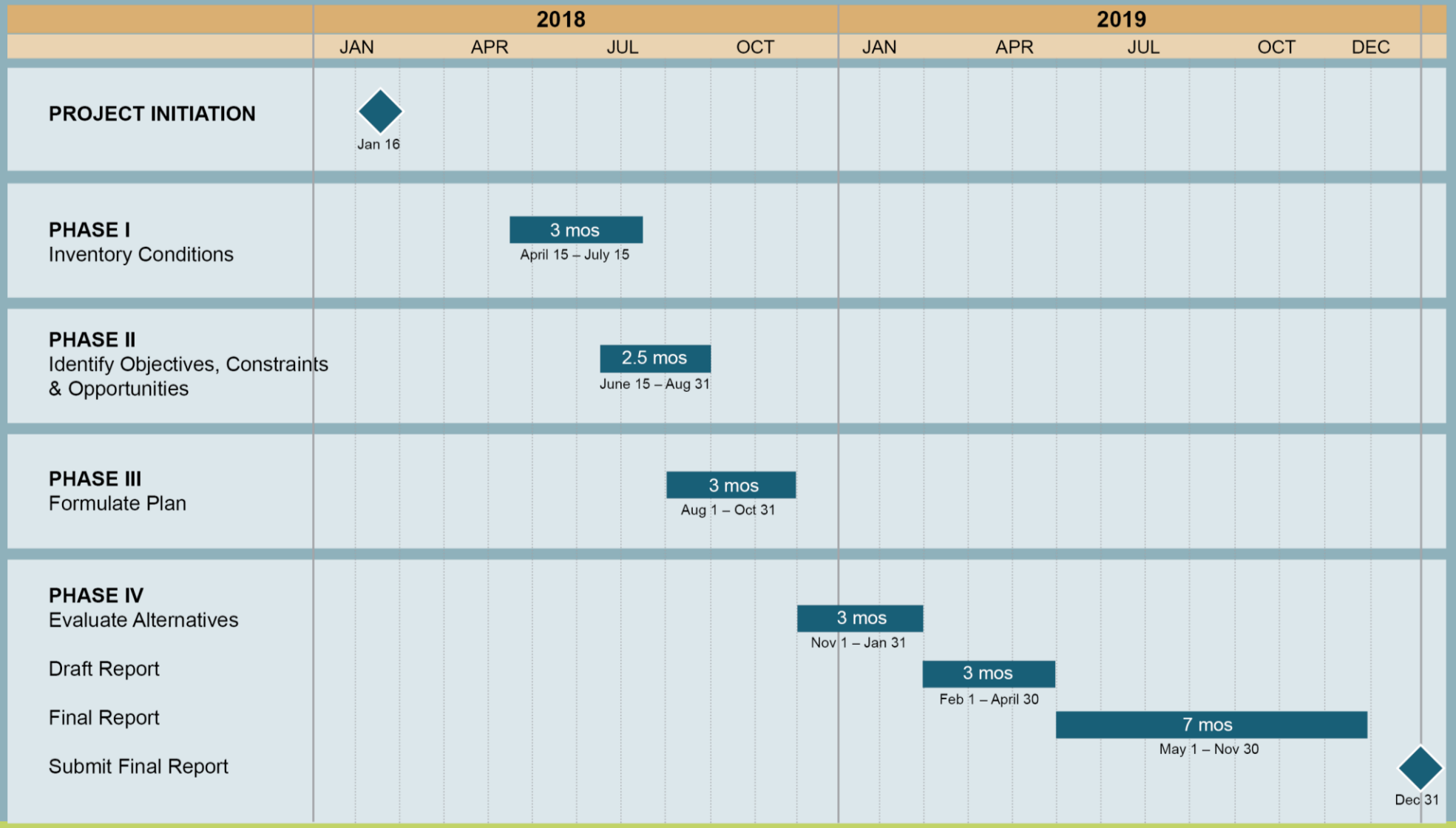
High-Level Work Plan



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Independent Review Board

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Independent Review Board

- **Role**
  - Provide independent review, comments, and recommendations to DWR on the approach, content, and execution of CNA project tasks, and draft and final reports.
- **Diversity of experience**
  - Composed of a group of technical experts of varied but complementary backgrounds, education, and professional experience.

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Independent Review Board Members

- Independent dam safety expert
- Independent water system operations expert
- Independent water resources project expert
- Oroville Emergency Recovery – Spillways, Board of Consultants
- Oroville 2018 Part 12D Review Consulting Board Representative

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Questions

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CNA Tasks

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CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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Task 1

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Task 1 - Alternatives Evaluation to Restore Spillway Design Capacity to Pass the Probable Maximum Flood

Date	December 12, 2017
Checked by	David Panec, David Sarkisian
Prepared by	Steve Verigin (GEI)
Task Manager	Steve Verigin

Statement of Need

The Department of Water Resources (DWR) will perform a comprehensive needs assessment (CNA) of the Oroville Dam Complex[1] that identifies major dam safety needs and improvements to maintain dam safety standards and ensure the reliability of the facility. As part of the assessment, a coordinated plan and schedule will be developed by completing a number of studies to evaluate critical aspects of the dam, appurtenant structures and operational procedures. The scope described in this document is one component of the overall assessment and pertains only to the restoration of the Flood Control Outlet (FCO) and emergency spillway to safely pass the Spillway Design Flood (SDF) which for Oroville is the Probable Maximum Flood (PMF).

Review and Discussion of Issues with Developing Scope of Work

The results of the February incident in 2017 left the FCO (main spillway chute and gated structure) and emergency spillway in damaged conditions incapable of safely passing the current PMF design flood. Work began immediately after the incident to restore the spillway capacity of both structures to a combined capacity of 307,000 cubic feet per second (cfs), FCO: 277,000 cfs and emergency spillway: 30,000 cfs. The primary objective of the first construction phase is to repair and reconstruct the main spillway chute to handle flows of 100,000 cfs and repair the emergency spillway to handle flows up to 30,000 cfs for the upcoming 2017-2018 flood season. Future phases will restore the FCO to original design capacity.

After construction is complete, both structures will have a combined capacity of 307,000 cfs, less than one-half of the current PMF design outflow of 655,000 cfs. However, the

[1] includes the Oroville Dam, Flood Control Outlet (FCO, which includes main spillway chute and gated structure), emergency spillway, Edward Hyatt Powerplant, Hyatt Powerplant intake structure, Hyatt Powerplant water conveyance system, Bidwell Bar Canyon Saddle Dam, Parish Camp Saddle Dam, River Valve Outlet System (RVOS, or also known as Feather River outlet), and Palermo tunnel and outlet.

Project Objective

Reduce the risk from Oroville Spillway releases to:

As low as reasonably possible

(ALARP)

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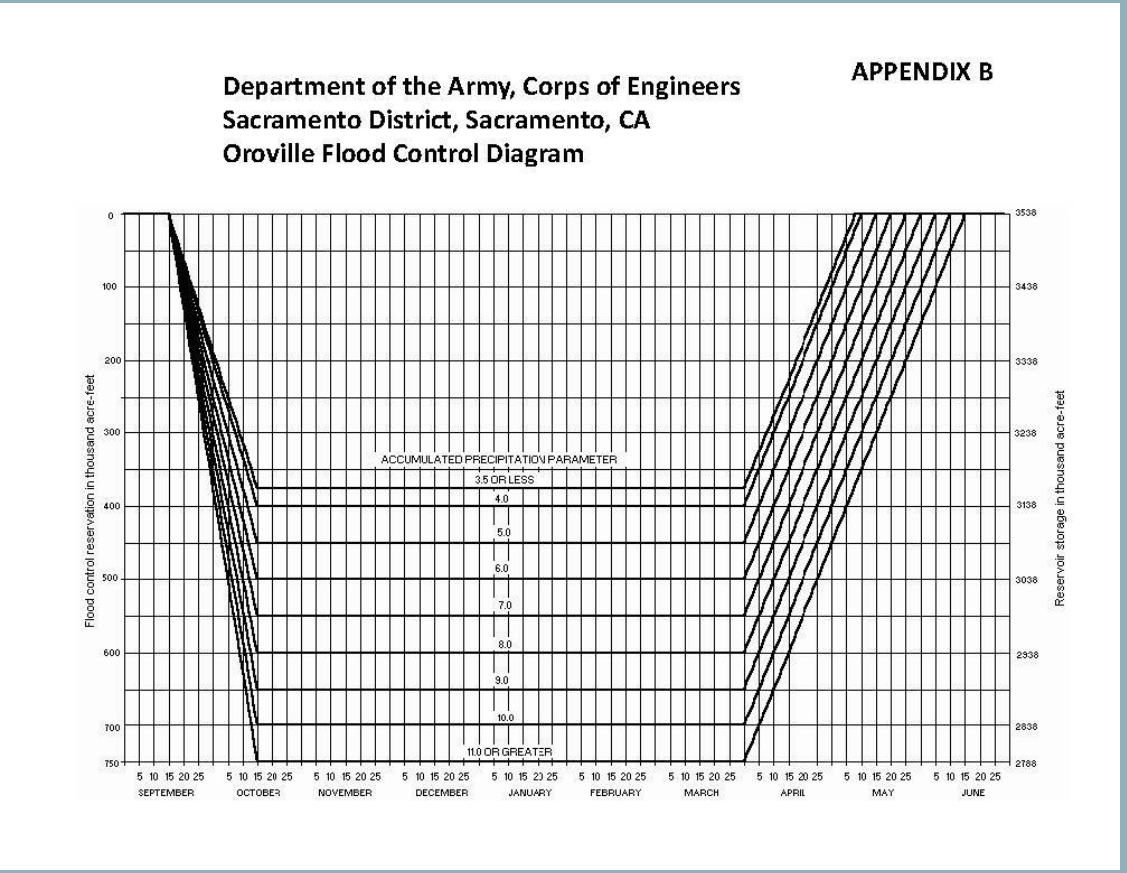
Regulatory Requirements for Compliance

- FERC and DSOD – Sufficient spillway capacity to safely pass the SDF (PMF)

- USACE – Water Control Manual:



CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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Task 2

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Task 2 - Operations Needs Assessment to Support Development of Alternative Reservoir Outflow Enhancements

Date	December 12, 2017
Checked by	David Panec, David Sarkisian
Prepared by	John Leahigh, Molly White, Marianne Kirkland
Task Manager	Dustin Jones

Statement of Need

The Department of Water Resources (DWR) will perform a comprehensive needs assessment (CNA) of the Oroville Dam Complex[1] that identifies major dam safety needs and improvements to maintain dam safety standards and ensure the reliability of the facility. As part of the assessment, a coordinated plan and schedule will be developed by completing a number of studies to evaluate critical aspects of the dam, appurtenant structures and operational procedures. The scope described in this document is one component of the overall assessment and pertains only to operations of the reservoir in a manner that maintains dam safety standards and federal investments in flood control while considering additional actions to mitigate potential impacts to other major project purposes such as water supply deliveries.

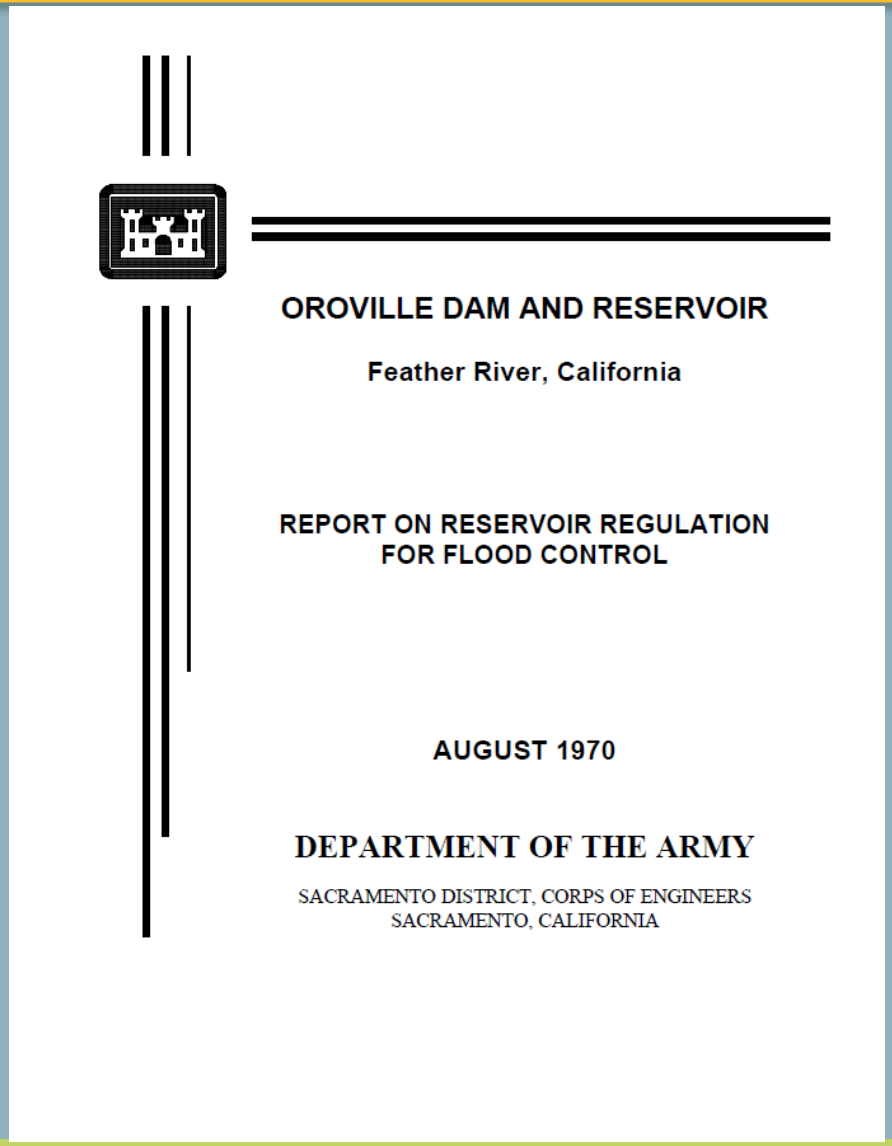
Review and Discussion of Issues Associated with Developing Scope for Recommendation

A series of interim operations plans as well as a long-term revision to the United States Corps of Engineers (USACE) Flood Control Manual (FCM) will likely be developed over several years at a minimum. The first couple of interim operations plans will be during the current Kiewit construction contract, during which the FCO (main spillway chute and gated structure) and emergency spillway outflow capabilities are compromised. These first sets of plans will require approval by the Federal Energy Regulatory Commission (FERC), the California Division of Safety of Dams (DSOD) from a dam safety aspect as well as from USACE for downstream flood requirements.

[1] includes the Oroville Dam, Flood Control Outlet (FCO, which includes main spillway chute and gated structure), emergency spillway, Edward Hyatt Powerplant, Hyatt Powerplant intake structure, Hyatt Powerplant water conveyance system, Bidwell Bar Canyon Saddle Dam, Parish Camp Saddle Dam, River Valve Outlet System (RVOS, or also known as Feather River outlet), and Palermo tunnel and outlet.

Current Flood Control Regulation

- Last updated in 1970
  - Does not reflect recent hydrology
  - Assumes system infrastructure that was not built
  - Assumes use of emergency spillway in an auxiliary manner
  - Does not account for improvements in forecasting



OROVILLE DAM AND RESERVOIR

Feather River, California

REPORT ON RESERVOIR REGULATION
FOR FLOOD CONTROL

AUGUST 1970

DEPARTMENT OF THE ARMY

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

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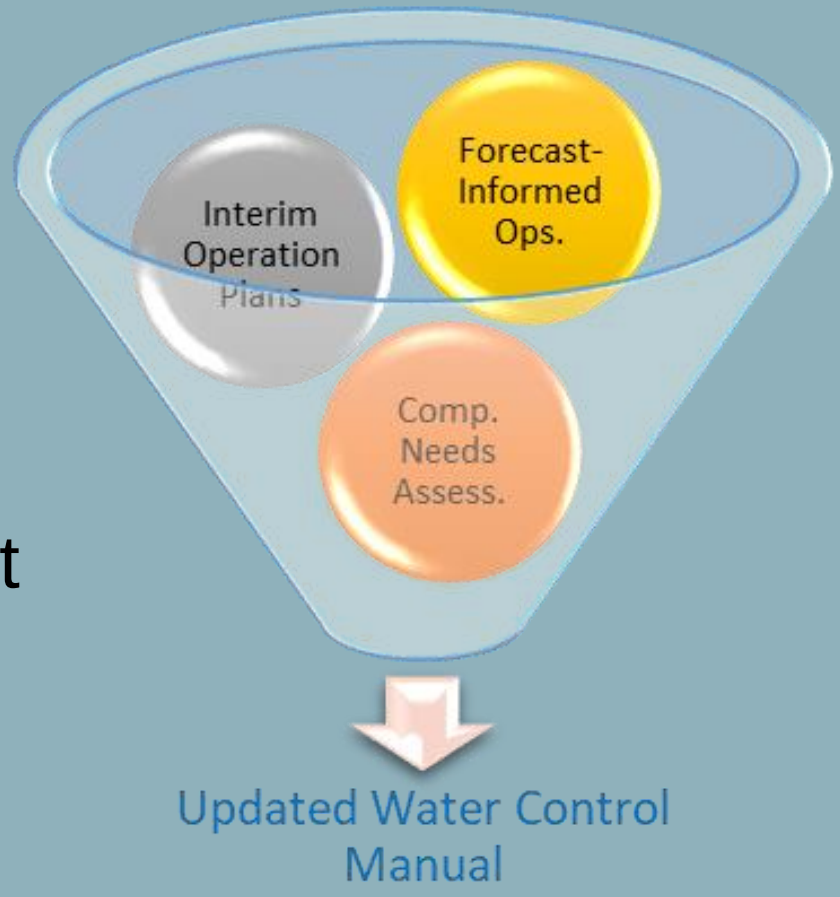
Task 2 Scope

- Develop informal interim operation plans that maintain flood control standards:
  - Outflows within downstream channel capacities
  - Avoid use of emergency spillway
- Analyze CNA alternatives with respect to operation impacts
- Use adopted CNA alternatives to inform final water control manual update



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CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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Task 3

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Task 3 - Flood Control Outlet (FCO) Enhanced Reliability

Date	December 12, 2017
Checked by	Jamie Lubeck
Prepared by	David Sarkisian
Task Manager	Phoebe Percell

Statement of Need

The Department of Water Resources (DWR) will perform a comprehensive needs assessment (CNA) of the Oroville Dam Complex[1] that identifies major dam safety needs and improvements to maintain dam safety standards and ensure the reliability of the facility. As part of the assessment, a coordinated plan and schedule will be developed by completing a number of studies to evaluate critical aspects of the dam, appurtenant structures and operational procedures. The scope described in this document is one component of the overall assessment and focuses on achieving the long-term reliability of the Flood Control Outlet (FCO), which includes the main spillway chute and gated structure.

Review and Discussion of Issues with Developing Scope of Work

The FCO represents a critical structure at Oroville Dam for its role in executing flood control operations, water storage, and for passing flows/water deliveries to the Diversion Pool and Feather River during outages at Edward Hyatt Powerplant. The FCO must operate reliably to ensure the dam's safety during periods of high inflow to Lake Oroville.

Assumptions for Developing Scope of Work

DWR has identified or initiated a number of projects that enhance the FCO's operational reliability, increase our understanding of its predicted performance under extreme loads, and address dam safety recommendations and regulatory requirements. In addition, a

[1] includes the Oroville Dam, Flood Control Outlet (FCO, which includes main spillway chute and gated structure), emergency spillway, Edward Hyatt Powerplant, Hyatt Powerplant intake structure, Hyatt Powerplant water conveyance system, Bidwell Bar Canyon Saddle Dam, Parish Camp Saddle Dam, River Valve Outlet System (RVOS, or also known as Feather River outlet), and Palermo tunnel and outlet.

Flood Control Outlet (FCO) Background

- Top seal radial gate structure
- Release capacity @ Normal RWS El. 900: ~260,000 cfs
- Operation history will inform process
- Existing uncertainties
  - Condition of drains under control structure
  - Designed for seismic event with PHGA of 0.1g
  - Expected 84% PHGA of 0.58g for MCE.
  - Radial Gate Anchor Rods – 2 rod failures (below the grip nuts) attributed to stress corrosion cracking; non-destructive examination studies are on going.

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CNA Task 3 – FCO Enhanced Reliability

- Survey of O&M and Planning Needs - Completed
- Potential Failure Mode Analysis
- Development of Newly Identified FCO Needs Projects

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CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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Task 4

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Task 4 - Alternatives Evaluation for Low-Level Outlet

Date	December 12, 2017
Checked by	David Panec, David Sarkisian
Prepared by	Steve Verigin (GEI)
Task Manager	Les Harder (HDR)

Statement of Need

The Department of Water Resources (DWR) will perform a comprehensive needs assessment (CNA) of the Oroville Dam Complex[1] that identifies major dam safety needs and improvements to maintain dam safety standards and ensure the reliability of the facility. As part of the assessment, a coordinated plan and schedule will be developed by completing a number of studies to evaluate critical aspects of the dam, appurtenant structures and operational procedures. The scope described in this document is one component of the overall assessment and pertains only to the evaluation of alternatives to increase the low-level outlet capacity.

Review and Discussion of Issues with Developing Scope of Work

During the emergency operations for the February incident in 2017, it became evident that the Oroville Dam facilities are not capable of passing large reservoir outflows other than through the Flood Control Outlet (FCO). The River Valve Outlet System (RVOS) and Hyatt Powerplant have maximum outlet capacities of approximately 5,000 and 15,000 cfs, respectively and are adequate to make low-level releases under normal operating conditions.However, the RVOS and Hyatt Powerplant are not adequate for reservoir regulation in flood or emergency conditions.

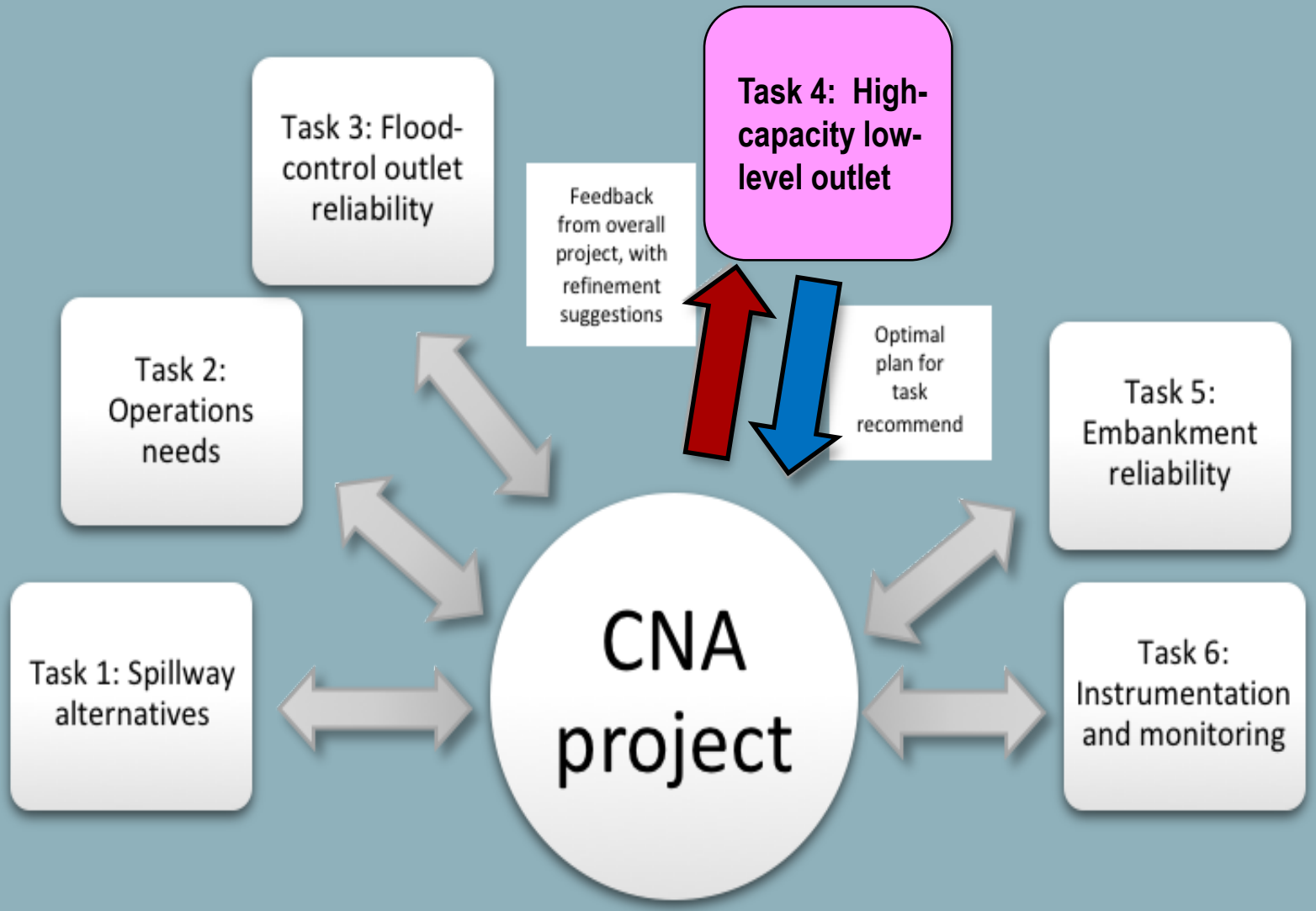
The absence of a high capacity low-level outlet is a condition that has been known and acknowledged for some time; however, it was not thought to be a deficiency since the FCO had such great drawdown capacity of the upper approximate 90 feet of reservoir storage. The FCO capacity has been previously considered adequate for dam safety and flood regulation. With the damage to the FCO and an inability to pass substantial

[1] includes the Oroville Dam, Flood Control Outlet (FCO, which includes main spillway chute and gated structure), emergency spillway, Edward Hyatt Powerplant, Hyatt Powerplant intake structure, Hyatt Powerplant water conveyance system, Bidwell Bar Canyon Saddle Dam, Parish Camp Saddle Dam, River Valve Outlet System (RVOS, or also known as Feather River outlet), and Palermo tunnel and outlet.

Summary of Reservoir Release Outlets

Outlet	Approx. Maximum Discharge (cfs) @ Max. Reservoir	Minimum Reservoir Elevation (feet)	Notes
1. FCO Spillway	260,000	813.6	
2. Hyatt PP	17,000	640	Flows limited during FCO discharges
3. RVOS	4,000	-	Flows impacted by Hyatt PP discharges
4. Palermo Outlet	40	549	

Task 4 Project Scope Strategy



- ✓ **The optimal Low-Level Outlet Alternative(s) will be coordinated and integrated with the optimal plans from other plans**
- ✓ **Benefits (Risk Reduction) of Low-Level Outlet Alternatives will depend upon optimal plans developed for other CNA Initiatives**

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CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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Task 5

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Task 5 - Oroville Dam Embankment Reliability and Improvements

Date	December 12, 2017
Checked by	David Panec, David Sarkisian
Prepared by	Ryan P. Cooper, Jaime Lubeck
Task Manager	Tim Wehling

Statement of Need

The Department of Water Resources (DWR) will perform a comprehensive needs assessment (CNA) of the Oroville Dam Complex[1] that identifies major dam safety needs and improvements to maintain dam safety standards and ensure the reliability of the facility. As part of the assessment, a coordinated plan and schedule will be developed by completing a number of studies to evaluate critical aspects of the dam, appurtenant structures and operational procedures. The scope described in this document is one component of the overall assessment and pertains only to the continued reliability and improvement of the Oroville Dam embankment.

Review and Discussion of Issues with Developing Scope of Work

The primary requirements of a dam are to safely retain water, safely pass seepage and remain stable with very limited deformations under all loading conditions. The embankment height and depth of water stored behind the dam impact seepage pressures that must be accounted for by design. The embankment height, slope inclination, crest width, material properties, and phreatic surface are all factors that affect stability. The design shape of a dam is dictated by the amount of material needed to mitigate seepage and maintain stability. The geometry of the dam may limit the ability of the dam to perform its required functions that include water conservation, power generation, flood control, recreation, and fish and wildlife management. Accordingly, the essential functions of Oroville Dam are fundamentally dependent on the reliability and stability of the embankment.

[1] includes the Oroville Dam, Flood Control Outlet (FCO, which includes main spillway chute and gated structure), emergency spillway, Edward Hyatt Powerplant, Hyatt Powerplant intake structure, Hyatt Powerplant water conveyance system, Bidwell Bar Canyon Saddle Dam, Parish Camp Saddle Dam, River Valve Outlet System (RVOS, or also known as Feather River outlet), and Palermo tunnel and outlet.

Project Background and Scope

- Oroville Seepage and Slope Stability Project
  - Initiated 2016
  - Result of Ninth Five Year Part 12D - 2014 Director's Safety Review Board
    - Recommendations R-10 and R-18
  - DOE and HDR joint task force
- CNA Scope

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Scope of Work
Board Recommendation – R-10

- Embankment Materials Properties
  - Review of design, construction, and performance data on the embankment and foundation properties (grad, PI, density, RC, perm)
- Filter Compatibility Analysis
  - Review of filter compatibility between zones in the embankment and assessment of the potential for internal erosion.
- Case Histories of Internal Erosion
  - A review of case histories of internal erosion of dams and of observed seepage quantities associated with internal erosion in conditions relevant to those of Oroville Dam.
- Precipitation Study (Analysis of Rainfall Impacts)
  - Analysis of the impact of rainfall on the historical seepage data.
- Analysis and Modeling Criteria
  - Workplan describing the modeling approach

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Scope of Work
Board Recommendation – R-10 cont…

- Piezometric and Seepage Data Analysis
  - Review of piezometric and seepage data since construction and of their relation to reservoir level using computational analysis as appropriate.
  - Prepare an Analysis Approach Technical memorandum to outline the analyses workplan
- Computational Seepage Analysis
  - Computational analysis of seepage and considering seepage through the foundation and through or around the toe seepage barrier.
- Uncertainty will be evaluated in all Subtasks

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Scope of Work
Board Recommendation – R-18

- Vegetated Area Document Review Summary
  - Vegetated Area Material Property Summary
  - Vegetated Area Limit and Data Correlation
- Slope Stability Analysis
  - Perform computational slope stability analysis of the Vegetated Area

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Scope of Work
CNA Task 5

- Parish Camp Saddle Dam and Bidwell Bar Canyon Saddle Dam
  - Review and evaluate the seepage and stability reliability
- Oroville Dam Embankment Around Monolith 30
  - Review and evaluate the seepage and stability reliability
- PFMA – Probability Calculations
  - Calculate the probabilities of occurrence of each probable failure mode identified during the last PFMA workshop

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CNA Tasks

Task 1 – Spillway Capacity Restoration

Task 2 – Operations Needs Assessment

Task 3 – FCO Enhanced Reliability

Task 4 – Low Level Outlet

Task 5 – Embankment Reliability and Improvements

Task 6 – Instrumentation and Monitoring

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Task 6

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
OROVILLE DAM SAFETY COMPREHENSIVE NEEDS ASSESSMENT

SCOPE OF WORK TO ADDRESS:

Task 6 - Instrumentation and Monitoring for Oroville Dam Complex

Date	December 12, 2017
Checked by	David Panec, David Sarkisian
Prepared by	Jaime Lubeck (HDR)
Task Manager	Elena Sossenkina

Statement of Need

The Department of Water Resources (DWR) will perform a comprehensive needs assessment (CNA) of the Oroville Dam Complex[1] that identifies major dam safety needs and improvements to maintain dam safety standards and ensure the reliability of the facility. As part of the assessment, a coordinated plan and schedule will be developed by completing a number of studies to evaluate critical aspects of the dam, appurtenant structures and operational procedures. The scope described in this document is one component of the overall assessment and only focuses on instrumentation and monitoring for the Oroville Dam Complex.

Review and Discussion of Issues with Developing Scope of Work

An established instrumentation and monitoring program is continuously reviewed and evaluated to maintain dam safety purposes and regulatory compliance directives. However, as instrumentation installed for purposes of construction and initial performance becomes obsolete, there is opportunity for new functional instrumentation tools throughout Oroville Dam to improve performance surveillance. To enhance the safety and functionality of the Oroville Dam Complex, the existing instrumentation will be reviewed and re-evaluated to determine instrumentation that requires replacement, abandonment, and future enhancements. Further, opportunities for new instrumentation and remote monitoring will be identified and evaluated within the Oroville Dam Complex, including embankments, core block and galleries, tunnels and foundation as well as physical security and reservoir operations.

[1] includes the Oroville Dam, Flood Control Outlet (FCO, which includes main spillway chute and gated structure), emergency spillway, Edward Hyatt Powerplant, Hyatt Powerplant intake structure, Hyatt Powerplant water conveyance system, Bidwell Bar Canyon Saddle Dam, Parish Camp Saddle Dam, River Valve Outlet System (RVOS, or also known as Feather River outlet), and Palermo tunnel and outlet.

CNA Task 6 Scope

1. Review of Instrumentation and Monitoring Documents
2. Research Emerging Technologies
3. Instrumentation Workshops
4. Dam Safety Instrumentation Installation Plan for Oroville Dam Complex

Task 6 Overview

- Dam Safety Instrumentation and Monitoring Needs
  - Oroville Dam
  - Bidwell Bar Canyon Saddle Dam
  - Parish Camp Saddle Dam
  - Flood Control Outlet (FCO)
  - Emergency Spillway
  - Edward Hyatt Powerhouse and appurtenant structures

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Goals and Objectives

- Identify opportunities for improvements:
  - Dam Safety Monitoring Priorities
  - Existing instrumentation that requires replacement or abandonment
  - New instrumentation and remote monitoring technologies
- Focus on “existing” conditions at the end of 2019
- Provide input to alternatives developed under CNA Tasks

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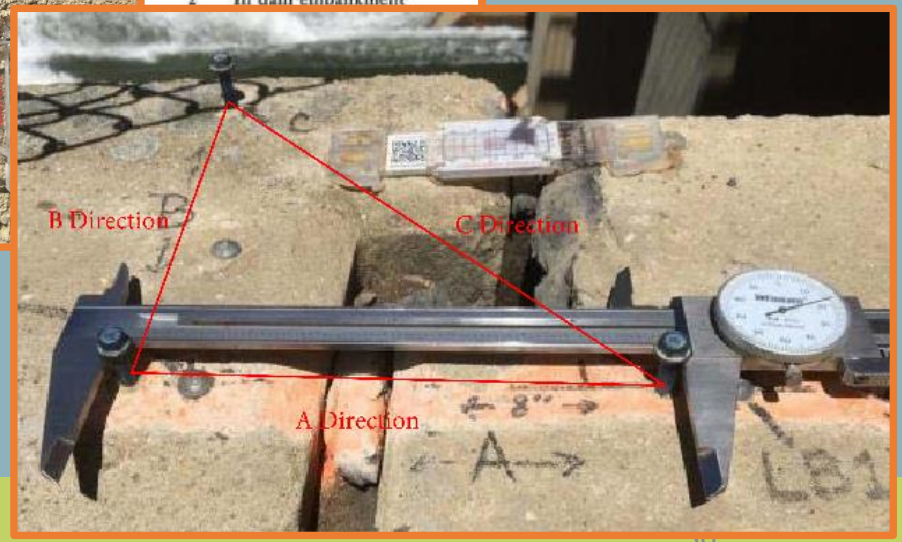
Instrumentation and Monitoring Overview & Examples

- Automated & manual survey monuments
- Joint gages
- Crack gages
- Staff gages
- Piezometers
- Inclinometers
- Weirs
- Seepage monitors
- Pore pressure cells
- Concrete strain meters
- Cameras, drones
- Etc., etc.

Instrumentation

Dam. The following is a summar
strumentation in Oroville Dam:

Instrument	*Number*	*Gener*
Hydraulic Piezometers	54	In dam emb
Hydraulic Piezometers	2	In dam fou
Electric Pore Pressure Cells	2	In rock nex gallery
Dynamic Electric Pore Pressure Cells	6	In dam emb stream of
Cross-arm Settlement Devices	2	In dam emb stream of
Fluid Level Settlement Devices	36	In dam emb
Surface Settlement Points	100	Along crest on upstre stream sl
Horizontal Movement Units	Units 2	In embankr
Units		stream of
Soil Stress Meters,	32	Embedded and grout adjacent material
	27	In dam embankment
	15	In downstream Zone 3
	9	In core block and grout gallery adjacent to foundation rock
	8	In downstream face of core block parapet
	2	In dam embankment



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