UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 18, 2017

Mr. Edward D. Halpin
Senior Vice President, Generation
and Chief Nuclear Officer
Pacific Gas and Electric Company
P.O. Box 56
Mail Code 104/6
Avila Beach, CA 93424

SUBJECT: DIABLO CANYON POWER PLANT UNIT NOS. 1 AND 2 – STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (CAC NOS. MF6039 AND MF6040: EPID L-2015-JLD-005)

Dear Mr. Halpin:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 11, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15071A045), Pacific Gas and Electric Company (PG&E, the licensee) responded to this request for Diablo Canyon Power Plant, Unit Nos. 1 and 2. By letter dated February 8, 2016, PG&E submitted a revised response that contained a new local intense precipitation and associated site drainage analysis (ADAMS Accession No. ML16040A009).

By letter dated March 30, 2016 (ADAMS Accession No. ML16083A552), the NRC staff sent PG&E a summary of the staff's review of the licensee's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the letter. As stated in the letter, the reevaluated flood hazard result for local intense precipitation was not bounded by the current design-basis flood hazard. The NRC staff notes that the licensee performed and documented a flooding mitigation strategies assessment (MSA) and a flooding focused evaluation (FE) for LIP in letters dated April 6, 2017 (ADAMS Accession No. ML17096A766) and July 19, 2017 (ADAMS Accession No. ML17200D161), respectively. The staff's assessment of the licensee's flooding MSA and flooding FE can be found in letters dated December 18, 2017 (ADAMS Accession No. ML17321B040, and ML17328A249, respectively).

This closes out the NRC's efforts associated with CAC No. MF6039 and MF6040.

If you have any questions, please contact me at (301) 415-1132 or e-mail at Joseph.Sebrosky@nrc.gov.

Sincerely,

Joseph M. Sebrosky, Senior Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket Nos. 50-275 and 50-323

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

cc w/encl: Distribution via Listserv

STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2

DOCKET NOS. 50-275 AND 50-323

1.0 INTRODUCTION

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (hereafter referred to as the "50.54(f) letter") (NRC, 2012a). The request was issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi Nuclear Power Plant as documented in the Near-Term Task Force (NTTF) report (NRC, 2011a). Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance (NRC, 2011a). Subsequent staff requirements memorandum associated with SECY-11-0124 (NRC, 2011b) and SECY-11-0137 (NRC, 2011c), directed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f) to address this recommendation.

Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazards for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that the NRC staff would provide a prioritization plan indicating the Flooding Hazard Reevaluation Report (FHRR) deadlines for each plant. On May 11, 2012, the NRC staff issued its prioritization of the FHRRs (NRC, 2012c).

By letter dated March 11, 2015, Pacific Gas and Electric Company (PG&E, the licensee) provided the FHRR for the Diablo Canyon Nuclear Power Plant, Unit Nos. 1 and 2 (Diablo Canyon) (PG&E, 2015a). By letter dated February 8, 2016, the licensee submitted a revised FHRR, which contained a new local intense precipitation (LIP) and associated site drainage analysis (PG&E, 2016b). On March 17, 2016, the NRC staff conducted an audit of the licensee's FHRR submittal (NRC, 2015a). The audit was summarized in the "Nuclear Regulatory Commission Report for the Audit of Pacific Gas and Electric Company's Flood Hazard Revaluation Report Submittal Relating to the Near-Term Task Force Recommendation 2.1-Flooding for Diablo Canyon Power Plant, Units Nos. 1 and 2" (NRC, 2016d).

On March 30, 2016, the NRC issued an interim staff response (ISR) letter to the licensee (NRC, 2016b). The purpose of the ISR letter is to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049, "Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (NRC, 2012b) and the additional assessments associated with Recommendation 2.1: Flooding. The ISR letter also made reference to this staff assessment, which documents the NRC staff's basis and conclusions. The flood hazard mechanism values presented in the letter's enclosures match the values in this staff assessment without change or alteration. However, the NRC staff corrected the current design basis (CDB) entries for Ice-Induced Flooding and Channel Migrations or Diversions in Table 3.1-2. These changes did not alter any values or change any conclusions transmitted in the ISR letter.

The reevaluated flood hazard results for the LIP flood-causing mechanism is not bounded by the plant's CDB. Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 and Japan Lessons-Learned Directorate (JLD) Interim Staff Guidance (ISG) JLD-ISG-2016-01, Revision 0 (NRC, 2012a; NRC, 2015b; NRC, 2016c), the NRC staff notes that in a letter dated July 19, 2017 (PG&E, 2017b) the licensee performed and documented a focused evaluation (FE) for LIP that assessed the impact of the LIP hazard on the site. The staff's assessment of the FE can be found in a letter dated December 18, 2017 (NRC, 2017b). Additionally, for any reevaluated flood hazards that are not bounded by the plant's CDB hazard, the licensee is expected to develop any flood event duration (FED) and associated effect (AE) parameters not provided at the time of the FHRR to conduct the mitigating strategies assessment. The licensee's updated FED and AE analysis for LIP can be found in a letter dated April 6, 2017 (PG&E, 2017a). The staff's assessment of the updated FED and AE analysis can be found in a letter dated December 18, 2017 (NRC, 2017a).

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that the licensee reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for ESPs and COLs. This section of the staff assessment describes present-day regulatory requirements that are applicable to the FHRR.

Sections 50.34 (a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR, describe the required content of the preliminary and final safety analysis report, including a discussion of the facility site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should provide any pertinent information identified or developed since the submittal of the preliminary safety analysis report in the final safety analysis report.

Diablo Canyon was designed to comply with the General Design Criteria (GDC) published in 1967. For the purpose of the FHRR, the difference between the 1967 version of the GDC and the current GDC are not material. As a result, the NRC staff evaluated the analysis provided by the licensee against current GDC standards. In GDC 2 of Appendix A of Part 50 it states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Section 50.2 of 10 CFR defines the "design basis" as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design which each licensee is required to develop and maintain. These values may be: (a) restraints derived from generally accepted "state of the art" practices for achieving functional goals; or (b) requirements derived from analysis (based on calculation, experiments, or both) of the effects of a postulated accident for which a SSC must meet its functional goals.

Section 54.3 of 10 CFR defines the "current licensing basis" (CLB) as: "the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect." This includes 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 52, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications as well as the plant-specific design-basis information, as documented in the most recent final safety analysis report. The licensee's commitments made in docketed licensing correspondence that remain in effect are also considered part of the CLB.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for applications on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites include the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21(d)).

2.2 Enclosure 2 to the 50.54(f) Letter

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter (NRC, 2012a) requested, in part, that licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews.

2.2.1 Flood-Causing Mechanisms

Attachment 1 to Enclosure 2 of the 50.54(f) letter discusses flood-causing mechanisms for the licensee to address in its FHRR (NRC, 2012a). Table 2.2-1 lists the flood-causing mechanisms that the licensee should consider, and the corresponding Standard Review Plan (SRP) (NRC, 2007) sections and applicable ISG documents containing acceptance criteria and review procedures.

2.2.2 Associated Effects

The licensee should incorporate and report AEs per "Guidance for Performing the Integrated Assessment for External Flooding," JLD-ISG-2012-05 (NRC, 2012d), in addition to the maximum water level associated with each flood-causing mechanism. Guidance document JLD-ISG-2012-05 (NRC, 2012d), defines "flood height and associated effects" as the maximum stillwater-surface elevation plus:

- Wind waves and run-up effects
- Hydrodynamic loading, including debris
- Effects caused by sediment deposition and erosion

- Concurrent site conditions, including adverse weather conditions
- Groundwater ingress
- Other pertinent factors

2.2.3 Combined Effects Flood

The worst flooding at a site that may result from a reasonable combination of individual flooding mechanisms is sometimes referred to as a “combined effects flood.” Even if some or all of these individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism described in the 50.54(f) letter (see SRP Section 2.4.2, “Areas of Review” (NRC, 2007)). Attachment 1 of the 50.54(f) letter described the “combined event flood” as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992), as follows:

> For flood hazard associated with combined events, American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

If two less severe mechanisms are plausibly combined per ANSI/ANS-2.8-1992, then the NRC staff will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding are plausible combined events and should be considered.

2.2.4 Flood Event Duration

“Flood event duration” as defined in JLD-ISG-2012-05 (NRC, 2012d), is the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2-1 illustrates the FED.

2.2.5 Actions Following the FHRR

For the sites where a reevaluated flood elevation is not bounded by the CDB flood hazard for any flood-causing mechanism, the 50.54(f) letter (NRC, 2012a) requests licensees and construction permit holders to:

- Submit an interim action plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard.

- Perform an integrated assessment to: (a) evaluate the effectiveness of the CDB (i.e., flood protection and mitigation systems); (b) identify plant-specific vulnerabilities; and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the duration of the flood event.

If the reevaluated flood hazard is bounded by the CDB flood hazard for all flood-causing mechanisms at the site, licensees were not required to perform an integrated assessment.

COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c) outline a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with LIP hazards exceeding their CDB flood will not be required to complete an integrated assessment, but instead will perform a focused evaluation that assesses the impact of the LIP hazard on their sites and then evaluate and implement any necessary programmatic, procedural or plant modifications to address the hazard exceedance. For other flood hazard mechanisms that exceed their CDB, licensees can assess the impact of these reevaluated hazards on their site by performing either a focused evaluation or an integrated assessment (NRC, 2015b; NRC, 2016c).

3.0 TECHNICAL EVALUATION

The NRC staff reviewed the information provided for the flood hazard reevaluation of Diablo Canyon. The licensee conducted the flood hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews. To provide additional information in support of the summaries and conclusions in the FHRR, the licensee made calculation packages available to the NRC staff via an electronic reading room. The licensee also submitted input/output files of modeling used to estimate the reevaluated flood hazard elevation. The NRC staff's review and evaluation is provided below.

3.1 Site Information

3.1.1 Detailed Site Information

In its FHRR (PG&E, 2016b) the licensee stated that the elevation of the Diablo Canyon powerblock varies from 152.9 to 62.9 feet (ft) North American Vertical Datum of 1988 (NAVD88). The licensee further stated that the nominal grade for the powerblock is elevation 87.9 ft NAVD88. Unless otherwise stated, all elevations in this staff assessment are given with respect to NAVD88 and are rounded to the nearest one-tenth of a foot. For reference, the mean lower low-water level is 0.32 ft above NAVD88. Mean sea level (MSL) is 2.92 ft above NAVD88.

The reactor site physically occupies a marine coastal terrace that overlooks the Pacific Ocean (see Figure 3.1-1). The Diablo Canyon site extends over 750 acres (ac) of which about 12 ac is occupied by the powerblock. At its widest point, the width of the kidney-shaped powerblock is about 1,000 ft. The topography of the powerblock is such that the grade of the site dips (slopes) away from major Diablo Canyon structures principally toward the Pacific Ocean and to a lesser extent the Diablo Creek. The seaward-facing edge of the Diablo Canyon site is a near-vertical cliff. Piping associated with the safety-related Auxiliary Salt Water (ASW) system is protected by man-made gabion mattresses at the lower elevations.

The Diablo Creek is adjacent to the site along its northern perimeter where it ultimately discharges into the Pacific Ocean at Diablo Cove; the PG&E property includes 165 ac north of the creek. The 5-mile long creek was described by Hoyt and Wood (1913) and is associated with the San Luis Mountain drainage basin; flow within the Diablo Creek is intermittent and is likely controlled by perched groundwater. The watershed that includes the Diablo Canyon site is relatively small extending over 5.2 square miles (mi^2).

Normal and emergency core cooling water needs are provided by the ASW pump system and are housed within the Service Water Intake Structure (SWIS) located along the South Cove shoreline below the Diablo Canyon powerblock terrace. The SWIS is of a reinforced concrete box type of construction intended to ensure that the ASW pump room is watertight. The top deck elevation of the SWIS is 20.4 ft NAVD88 (17.5 ft above MSL). The top elevation of the ASW snorkel intakes is 52.3 ft NAVD88 (49.4 ft above MSL)(PG&E, 2016b); the snorkel openings themselves range in elevation from 48.5 to 52.3 ft NAVD88. Two pre-cast, reinforced concrete breakwaters protect the ASW intake structure; unlike the ASW system, the SWIS breakwaters are not designated as safety-related structures. The ASW system has been previously described by the licensee in updates to its Updated Final Safety Analysis Report (UFSAR).

Water supply needs at the Diablo Canyon site are supplemented by two Raw Water Storage Reservoirs (RWSRs) (PG&E, 2016b). The RWSRs are located above and behind the powerblock on a separate terrace located in the Irish Hills area, at an elevation of about 312.9 ft NAVD88; each reservoir has a storage capacity of about 2.5 million gallons, which feed the following systems via gravity: emergency firewater, plant site domestic water, and power production makeup water. Also inland and in close proximity to the RWSRs are the 230 kilovolt (kV) and 500 kV switchyards.

The licensee has previously noted (PG&E, 2013b), that it has relied on the local topography and plant site arrangement to limit flood design considerations due to local floods from the Diablo Creek and wave action from the Pacific Ocean. Consequently, the licensee reported that the only structure susceptible to coastal-source flooding at the Diablo Canyon site is the ASW pump system located on the South Cove shoreline. Table 3.1-1 provides the summary of reevaluated flood-causing mechanisms, including wind wave and run-up that the licensee computed to be higher than the respective powerblock elevations.

3.1.2 Design-Basis Flood Hazards

The CDB flood levels are summarized by flood hazard mechanism in Table 3.1-2. The NRC staff notes that the licensee clarified in its February 8, 2016, letter (PG&E, 2016b) that for purposes of the FHRR it considers the CDB and CLB to be interchangeable terms. The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.3 Flood-Related Changes to the Licensing Basis

The licensee reported that there were past modifications to the ASW system at the South Cove (PG&E, 2016b). These modifications included the installation of certain protective measures such as gabion mattresses and an armored embankment southeast of the ASW intake structure. Design modifications included increasing the height of the snorkels to improve the resistance of the SWIS against the destructive effects of ocean-borne waves (PG&E, 2016b). The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to the 50.54(f) letter.

3.1.4 Changes to the Watershed and Local Area

The licensee did not identify any specific changes within the watershed that includes the Diablo Canyon site; most of the watershed is owned or controlled by the licensee and is undeveloped (PG&E, 2016b). Further, there were no changes reported by the licensee for features within the controlled area. Lastly, in connection with the walkdown analysis of the Diablo Canyon site, no planned flood protection enhancements or flood mitigation measures were identified by the licensee (PG&E, 2014). The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to the 50.54(f) letter.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

There are several different types of flood protection features credited in the Diablo Canyon CLB (PG&E, 2016b). Foremost of these features is the selection of the reactor site itself – an elevated terrace that is isolated from the effects of ocean-generated waves as well as potential flooding associated with a probable maximum flood (PMF) in Diablo Creek. Those features include: roof drainage systems, drainage ditches, protective berms, and existing site grading. The licensee also noted that the areas around buildings designated as important to safety (i.e., Design Class I buildings) had been graded to slope away from those structures (PG&E, 2016b). The NRC staff reviewed the flood hazard information provided in the FHRR and determined that sufficient information was provided to be responsive to the 50.54(f) letter.

3.1.6 Additional Site Details to Assess the Flood Hazard

The licensee submitted electronic copies of the input files for computer models related to the flood hazard reevaluations, and topographic and bathymetric data for use in those models as part of the audit for the NRC staff to review. The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable (NRC, 2012a). The 50.54(f) letter also asked the licensee to report any relevant information from the results of the plant walkdown activities.

By letter dated November 27, 2012 (PG&E, 2012), PG&E provided the Walkdown Report for the Diablo Canyon site. The walkdown report was supplemented by a response to a request for additional information dated January 29, 2014 (NRC, 2013c; PG&E, 2014). The NRC staff issued a staff assessment report on June 23, 2014, to document its review of the Walkdown Report, which concluded that the licensee's implementation of flooding walkdown methodology met the intent of the walkdown guidance (NRC, 2014).

3.2 Local Intense Precipitation and Associated Site Drainage

In its FHRR, the licensee reported that the reevaluated flood hazard for LIP results in a range of stillwater-surface elevations at multiple door locations from 87.3 to 117.9 ft NAVD88 (PG&E, 2016b). The effects of wind waves and run-up were not included by the licensee in the flood reevaluation as the LIP inundation depths were considered too shallow to produce significant wind/wave effects. This flood-causing mechanism is discussed in the licensee's CDB, but no PMF elevation was reported as the licensee determined that flooding was unlikely (PG&E, 2016b).

The licensee reevaluated the flood hazard due to an LIP event using the FLO-2D Pro computer code (Build No. 14.08.09) (FLO-2D, 2014). The NRC staff considers the selection of FLO-2D for LIP modeling to be reasonable and consistent with current engineering practice. The licensee stated that its LIP flood analysis was consistent with the Hierarchical Hazard Assessment process described in NUREG/CR-7046 (NRC, 2011d).

3.2.1 Site Drainage and Elevations

By virtue of its topography, the Diablo Canyon site can be treated as three distinctive areas for the purposes of the LIP flood hazard reevaluations: a highland (upper) area consisting of the two switchyards and the RWSRs, a terrace area that includes the powerblock, and the Diablo Cove location where Diablo Creek enters the Pacific Ocean. The topography of the powerblock terrace is such that its grade dips (slopes) away from major Diablo Canyon structures toward the Pacific Ocean. By contrast, the grading of the highland area is such that rainwater runoff flows into Diablo Creek as a result of grading and the pre-existing topography. As the two areas do not communicate hydraulically, the licensee selected the switchyard access road traversing the Diablo Canyon site as the eastern boundary for the purposes of LIP modeling.

Ground-surface elevations across the Diablo Canyon site vary from about 308 ft to about 42 ft NAVD88 (north to south). The elevations reported there are based on an existing licensee-prepared topologic map of the site with 0.5-ft contours. The licensee also used a digital elevation map based on a Light Detection and Ranging (LiDAR) survey prepared for the State of California to provide topographic coverage for the area between the eastern margin of the powerblock to the highland area containing the RWSRs and the switchyards. The horizontal resolution of those LiDAR data were 1 meter or about 3 ft. The licensee relied on a U.S. Geological Survey (USGS) quadrangle imagery map to extract the land-use information for the site. The licensee integrated the LiDAR data with topographic data and land-use data using a Geographic Information System tool to develop raster point elevations which were in turn used to generate grid cell elevations in the FLO-2D computer model. The computational domain of the licensee's FLO-2D model is the shaded area depicted in Figure 3.2-1.

Upon inspection and spot checks of the licensee-provided topographic maps, as well as the configuration and elevations obtained from a recent Google imagery map of the site, the NRC staff confirmed that major Diablo Canyon structures and surface water flow features within the powerblock were represented in the licensee's FLO-2D model. The NRC staff considers the licensee's use and implementation of the combined imagery and LiDAR elevation dataset reasonable for the purposes of the FHRR LIP analysis.

3.2.2 Local Intense Precipitation

For ESPs and COLs, current NRC guidance for LIP evaluation is to select the appropriate probable maximum precipitation (PMP) event reported in the National Weather Service's Hydrometeorological Reports (HMRs) applicable to the site (NRC, 2007). For the Diablo Canyon site, the PMP parameter value obtained from the applicable HMRs – in this case National Oceanic and Atmospheric Administration (NOAA) HMR-58 (NOAA, 1998) and HMR-59 (NOAA, 1999) – is 5.5 inches (in.) for a 1-hour (h), 1-mi^2 event. Alternatively, a site specific PMP (ssPMP) estimate was derived by the licensee; that PMP value estimated was 4.5 in. for a

1-h, 1-mi^2 event (PG&E, 2016b). After deriving that parameter, the licensee performed flood simulations to evaluate the influence of five different temporal rainfall distributions on flooding depths at the site; the licensee chose to use the peak rainfall intensity of the end-peak loading scenario that resulted in the highest (most conservative) estimated water surface elevations (WSEs) at the Diablo Canyon site (PG&E, 2016b).

In order to determine the significance of the ssPMP parameter on the estimated LIP flood hazard at the Diablo Canyon site, the NRC staff independently evaluated the sensitivity of the licensee's FLO-2D model to that parameter using an alternative precipitation value obtained from HMRs 58 and 59. As noted above, the HMR-based PMP value was 5.5 in. or about 18 percent larger than the licensee's ssPMP value. A parametric sensitivity analysis of flooding due to an HMR-derived precipitation estimate was performed by the NRC staff using the licensee's FHRR FLO-2D model. Aside from changing the PMP value, no other changes were made to the licensee-generated LIP model. A comparison of the WSEs using the HMR-based PMP input versus the ssPMP value at the same 40 access door locations reported by the licensee in its FHRR (Table 3.2-1) by the staff indicated that, on average, the differences in respective water depths were approximately 0.14 ft. The NRC staff also observed that the maximum difference in the estimated water depth was 0.36 ft, at Door Unit No. 191-2 – the monitoring location between the Containment and Turbine buildings for Unit 2. In light of the small elevation differences in the two sets of results, the NRC staff concluded that the licensee's use of an ssPMP-based estimate as opposed to a value derived from an HMR was reasonable, and that a review of the methodology used to derive the ssPMP estimate was not necessary.

3.2.3 Site Land Cover

The licensee estimated that more than 70 percent of the modeling area is covered by roads, buildings, concrete, and other types of impervious surfaces (PG&E, 2016a). The Manning's surface roughness coefficients (n-values) were selected by the licensee based on the type of land covers identified through a visual examination of available topographic maps and aerial photography. As a result of that examination, the licensee identified three distinct land cover types: concrete/asphalt, grass cover, and gravel (PG&E, 2016a).

The respective Manning's n-values corresponding to each of those land cover types is 0.022, 0.35 and 0.04 according to the FLO-2D Reference Manual (FLO-2D, 2014). That manual notes that flow resistance generally decreases in proportion to increasing flow depths, and to account for this behavior, the FLO-2D computer code has the ability to automatically adjust n-values during a computer simulation as the flow depth increases. The licensee stated that, in such circumstances, the simulated flood levels with the model become insensitive to the magnitude of the Manning's surface roughness coefficient (PG&E, 2016a).

The NRC staff confirmed that the selection of the Manning's n-values were within the ranges recommended in the FLO-2D Reference Manual (FLO-2D, 2014) for the types of land covers identified by the licensee. The NRC staff also reviewed the recommended Manning's n-values described in Chow (1959). Based upon its review, the NRC staff concluded that the values used by the licensee were reasonable.

3.2.4 Runoff Analysis

The licensee relied on a uniformly-sized, 10-ft by 10-ft grid system to serve as the FLO-2D computational domain for the LIP analysis (PG&E, 2016a). The licensee-assigned surface elevations to each grid cell consistent with the data sources described in Section 3.2.1. The boundary of the LIP model is depicted in Figure 3.2-1.

The licensee stated that the selection of a grid size for the analysis was based on a balance between simulation time and numerical stability of the computer code estimates (PG&E, 2016a). The licensee reported that when the cell size was less than 10-ft by 10-ft, the computer code simulation time exceeded 6-h. When the number of grid cells was increased to allow for finer computational resolution, the licensee also observed the introduction of computational instabilities without any significant change in estimated WSEs (PG&E, 2016a). The NRC staff determined that the licensee's justification of grid cell size was reasonable.

The licensee described that the physical features in the Diablo Canyon powerblock (i.e., buildings, tanks, barriers, curves, berms) were incorporated into the FLO-2D LIP model (PG&E, 2016a). The following assumptions were relied on in the LIP computer modeling: (a) the runoff losses, such as initial and constant losses, are ignored to maximize runoff volume; (b) all drainage system components (e.g., gravity storm drain systems, culverts, inlets) were non-functional or completely blocked; (c) building roof runoffs discharge to the ground without delay by parapets, gutters, and drain pipes; (d) the boundary condition is assumed normal depth of flow; and (e) area reduction factors were used to moderate surface flow from building tops to the adjoining ground surface (PG&E, 2016a). Based on the review of the model input files, available topographic maps, and Google imagery, the NRC staff determined that the configuration of the licensee's modeling domain was reasonable and that the parameter values used in the model were reasonable.

In reviewing the licensee's FLO-2D model, the NRC staff noted that the eastern boundary of the model ended at the access road leading to the RWSRs, the switchyards, and the Independent Spent Fuel Storage Installations. To the east of that road is an area dominated by a topographic promontory that overlooks the Diablo Canyon site (Figure 3.1-1). Moreover, based on an inspection of the USGS topographic map that included the power plant site, the NRC staff noted that there is the potential for sheet flow associated with this promontory area to travel over the access road and continue in the direction of the Diablo Canyon powerblock. To establish whether the higher topographic area to the east of the access road introduces additional precipitation-related sheet flow into the powerblock yard, the NRC staff performed an additional FLO-2D computer simulation that included the flow generated from this expanded area. Based on a review of the USGS topographic map, the NRC staff delineated two new sub-basins, designated Sub-basins 1 and 2, to the east of the access road (Figure 3.2-2). The surface areas for each of these sub-basins is, respectively, 13.4 ac and 13.1 ac; this additional area expanded the total size of the modeling area by about 34 percent. Based on an inspection of the topography, the staff would expect that runoff from the Sub-basin 1 would flow directly into the powerblock area whereas the disposition of runoff associated with Sub-basin 2 was less clear.

To evaluate the effect of additional runoff from the two staff-identified eastern sub-basins, the NRC staff conducted its independent modeling analysis in two steps. The first step was to use the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) computer code (USACE, 2010b) to estimate the runoff from the two sub-basins. The HEC-HMS model with the Soil Conservation Service (SCS, 1986) unit hydrograph option was used to simulate the sub-basin runoff hydrographs. The second step was to reevaluate LIP at the site by using the HEC-HMS outflow hydrographs obtained from the first step as a new upstream inflow boundary condition in the FLO-2D model. Both HEC-HMS and FLO-2D used the same ssPMP rate developed by the licensee. As a conservatism, the

NRC staff also assumed no canopy and no surface losses within the two sub-basins. The HEC-HMS SCS unit hydrograph method also required the specification of a basin lag time as an input parameter. The NRC staff estimated lag times of 3.3 and 3.6 minutes (min), respectively, for sub-basins 1 and 2 based on the SCS equation described in the USACE's Hydrologic Engineering Center Rivers and Streams Analysis (HEC-RAS) *User Manual* (USACE, 2010a). The sub-basin runoff hydrographs subsequently obtained peak runoff rates of 55 cubic feet per second (ft^3/s) and 33 ft^3/s, respectively, for sub-basins 1 and 2.

To account for the additional sub-basin inflow, the NRC staff modified the licensee's FLO-2D LIP model by adding 10 inflow nodes along the eastern boundary at the access road location, as shown in Figure 3.2-2. The HEC-HMS simulated sub-basin flow rates were distributed evenly to 10 inflow nodes.

The results of the NRC staff's independent analysis at the 46 monitoring points of interest revealed only modest increases in elevations. On average, there was a 0.04 ft increase in water depth with a maximum increase of 0.14 ft along the east face of the Auxiliary and Fuel Handling buildings. Based on its independent runoff analysis, the NRC staff determined that licensee's FLO-2D modeling domain for LIP was reasonable.

3.2.5 Water Level Determination

The licensee identified multiple potential flow path locations around each of the two reactor units and other structures by which flood water could potentially affect plant safety. In Table 3-5 of its FHRR (PG&E, 2016b), the licensee identified a variety of locations, including both safety-related and non-safety-related buildings, for which the CDB was exceeded by the reevaluated LIP hazard elevation. Key monitoring locations around the two reactor units and turbine building identified by the licensee are shown in Figures 3.2-3 and 3.2-4. Table 3.2-1 summarizes the results of the licensee's LIP flood reevaluation. The licensee reported the reevaluated flood hazard as a maximum flood depth ranging from about 0.1 ft to 0.7 ft at the locations identified (PG&E, 2106). The licensee compared the estimated flood depth to the inlet height of doors and hatches at each of the potential pathway locations. The licensee reported that maximum flood depths were greater than some door/hatch inlet heights for safety-related structures. The licensee also acknowledged that there was a temporal aspect to those flood depths that varied by location when the drainage characteristics and geometry of the powerblock were taken into account. The maximum inundation depth of 0.7 ft was expected to occur at the monitoring location Door/Unit #192-1, between the Unit 1 Containment and Turbine buildings with a maximum WSE of 88.2 ft NAVD88.

3.2.6 Conclusion

The NRC staff verified the results reported in the FHRR using the computer input/output files provided by the licensee. The NRC staff found that: (a) mass balance errors were acceptably small, (b) flow pathways and areas of inundation appeared reasonable, (c) flow velocities were reasonable, and (d) no indication of numerical instabilities nor unexpected supercritical flow conditions were identified near potential flooding pathways. Based on these results, the NRC staff concluded the licensee's LIP FLO-2D simulations are reasonable.

Therefore, the NRC staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP is not bounded by the CDB flood hazard at the Diablo Canyon site. The NRC staff notes that the licensee submitted a FE for LIP in a letter dated July 19, 2017 (PG&E, 2017b) consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and

JLD-ISG-2016-01, Revision 0 (NRC, 2016c). The NRC staff's assessment of the FE is documented in a letter dated December 18, 2017 (NRC, 2017b).

3.3 Streams and Rivers

The licensee reported in its FHRR that the reevaluated flood hazard for streams and rivers taking into account wind wave effects is 77.9 ft NAVD88 (PG&E, 2016b). This flood-causing mechanism is discussed in the licensee's CDB, but no specific flood hazard elevation was reported (PG&E, 2016b); however, based on the licensee's FHRR narrative, an elevation of 81.9 ft was inferred by the NRC staff. In its UFSAR (PG&E, 2013b), the licensee reported that the hydraulic characteristics of Diablo Creek were adequate to handle a PMF and thus reported that the floodwater depth at the plant location was zero ft. The licensee further noted that CDB PMF elevation for streams and rivers is approximately 6 ft below the nominal plant grade of about 87.9 ft NAVD88 (85ft MSL) (PG&E, 2016b).

The licensee's reevaluation of flooding on streams and rivers described in the FHRR included three analysis components: (a) defining a PMP event, (b) simulating the PMF associated with the PMP event, and (c) evaluating the effect of combined flooding events (PG&E, 2016b). The licensee evaluated the PMF for the 5.2 mi^2 Diablo Creek watershed. The extent of the Diablo Creek drainage basin is shown in Figure 3.3-1. The licensee stated in the FHRR (PG&E, 2016b) that the methods used in reevaluating flooding on streams and rivers at the site were consistent with NUREG/CR-7046 (NRC, 2011d).

For the purposes of the FHRR riverine analysis, the licensee modeled overland flow within the Diablo Creek sub-basins following a simulated PMP event using the USACE's HEC-HMS computer code (USACE, 2010b). Using synthetic hydrographs produced from that computer model as input, the licensee continued to model river flow within the Diablo Creek using the HEC-RAS computer code (USACE, 2010a). The output from that computer analysis provided an estimated riverine PMF flow rate and maximum reevaluated hazard elevation reported in the FHRR.

3.3.1 Probable Maximum Precipitation

The licensee's PMP reevaluation was conducted using current guidance contained in HMR-58 (NOAA, 1998) and HMR-59 (NOAA, 1999). The NRC staff guidance in NUREG/CR-7046 (NRC, 2011d) recommends that the precipitation values estimated as input to the riverine PMF consider three specific hydrologic scenarios to ascertain which scenario would produce the maximum (highest) WSE at a particular reactor site. Those PMP scenarios include the following:

- PMP Alternative 1 – a combination of mean monthly base flow; median soil moisture; antecedent rain; the all season PMP; and the 2 year (yr) wind waves along the critical direction.

- PMP Alternative 2 – a combination of mean monthly base flow; snowmelt from the probable maximum snowpack; a 100-yr, cool-season rainfall event; and 2-yr wind waves along the critical direction.

- PMP Alternative 3 – a combination of mean monthly base flow; snowmelt from a 100-yr snowpack; the cool-season PMP; and 2-yr wind waves along the critical direction.

The licensee's PMP evaluation also reflected consideration of both the 100-yr and the probable maximum snowpack. The FHRR indicates that the requisite snowpack calculations were conducted using snow depth data from several NOAA Climate Stations near the Diablo Canyon site (PG&E, 2016b).

All three precipitation scenarios were evaluated by the licensee for the purposes of the Diablo Canyon FHRR (PG&E, 2016b). The maximum computed PMP depths reported for each of the three alternatives were, respectively, 30.90, 20.33, and 32.09 in. To ensure that all precipitation events capable of maximizing surface runoff were considered, five temporal storm distributions (Alternative A in NUREG/CR-7046) were evaluated based on the three precipitation alternatives. Those distributions place the peak precipitation at the front, one-third, center, two-thirds, and end of the storm event. The five temporal distributions for the PMP event described in Alternative A were assessed. Twenty PMP events corresponding to the three aforementioned precipitation alternatives were evaluated using the HEC-HMS computer code to determine which alternative combination produced the largest runoff hydrograph (PG&E, 2016b). PMP data was calculated and input into the computer code based on 15-min increments. The U.S. Bureau of Reclamation (USBR) synthetic unit hydrograph method for the coast and cascade topographic ranges of California, Oregon, and Washington (USBR, 1992) was used to estimate the rainfall to runoff transformation occurring in the Diablo Creek watershed (PG&E, 2016b). Through this process, the licensee determined that the critical riverine PMF peak discharge resulting from a PMP in the Diablo Creek watershed was 6,541 ft^3/s.

The NRC staff reviewed the licensee's estimation of PMP against relevant regulatory criteria based on present-day methodologies and regulatory guidance. The methods presented in the HMRs and HEC-HMS referenced by the licensee are considered reasonable methods for estimating, respectively, PMP and peak riverine PMF discharge values. In order to determine the significance of the peak riverine PMF discharge values on the estimated flood hazard at the Diablo Canyon site, the NRC staff independently evaluated the sensitivity of the HEC-HMS estimate of that parameter using an alternative rainfall-to-runoff transformation method. As an independent check, the NRC staff estimated the critical riverine PMF peak discharge for the Diablo Creek watershed using the Synder unit hydrograph method (1938). The synthetic hydrograph using that alternative transformation estimated by the NRC staff was 5,635 ft^3/s. As both transformation methods are considered acceptable, the NRC staff determined that the licensee's larger, more conservative riverine PMF peak discharge estimate was reasonable for use in the riverine PMF reevaluated flood hazard analysis.

3.3.2 Probable Maximum Flood Elevation

Using the synthetic PMF flow hydrographs produced from the HEC-HMS computer code, the licensee then modeled river flow within the Diablo Canyon watershed using Version 4.1 of the HEC-RAS computer code (PG&E, 2016b). The output from that computer analysis provided the riverine PMF flow rate and maximum reevaluated flood hazard elevations reported in the FHRR. The licensee noted that the geometry of the Diablo Creek channel was developed using HEC-GeoRAS (Version 10.1). To achieve accurate modeling results, about 30 vertical cross sections were spaced generally at 200-ft horizontal intervals. For the purposes of flood modeling, the licensee noted that the Diablo Creek flow path/watershed could be divided into three segments: a lower reach, a middle reach, and an upper reach (PG&E, 2016b). The characteristics of these modeling segments and their relationship to the Diablo Canyon controlled area is summarized in Table 3.3-1.

Channel banks and other topographic features were delineated using contours created from the surface model and using geospatial imagery in ArcGIS as background maps (PG&E, 2016b). The licensee noted that Manning's roughness coefficients (or n values) were selected based upon reviews of aerial photography and site mapping; the specific values selected were based upon ground cover types (e.g. vegetation, pavement, dirt, etc.). The HEC-RAS User's Manual (USACE, 2010a) provides a range of recommended Manning's n values for different types of ground cover. Upon inspection, the NRC staff found that the licensee relied on the application of higher n values of the recommended ranges in the HEC-RAS model; depending on the type of ground cover, the values described ranged from 0.025 up to 0.08; the NRC staff confirmed these values by consulting Chow (1959). Because the licensee-assigned Manning's n coefficient values for the floodplain and channel were judged to be conservative, the NRC staff considered this decision to be an appropriate modeling assumption by the licensee. The NRC staff concluded that the licensee's approach to these modeling issues was reasonable and met the general intent of the 50.54(f) letter.

Upon review, the NRC staff determined that it was not necessary to perform an independent HEC-RAS computer simulation of the riverine PMF for the Diablo Creek drainage basin. The maximum riverine PMF hazard elevation on the Diablo Creek reported by the licensee was well below the minimum finished grade the Diablo Canyon site as indicated in Table 3.3-2. The simulation results indicate that depending on the location of the HEC-RAS cross-section, the amount of freeboard present in relation to the local topography in the lower reach of the Diablo Creek ranged from +9.3 to +200 ft; hence, based on the computer simulation results, it was not possible for the powerblock yard to flood as the result of a PMF. The licensee did report that the 230kV switchyard (non safety-related) would flood during the postulated riverine PMF (see Figure 3.3-1).

The NRC staff agrees with the licensee's conclusion that it was not possible for a PMF on Diablo Creek to flood the Diablo Canyon powerblock. The NRC staff found that the site's topography, powerblock grading, and the orientation of important powerblock structures in relation to the creek would be expected to act in unison to passively divert potential flood waters away from reactor structures and systems designated to be important to safety. The NRC staff reviewed the licensee's estimation of the riverine PMF analysis against relevant regulatory criteria based on present-day methodologies and regulatory guidance. The methods presented in the HEC suite of computer codes referenced by the licensee are considered reasonable methods for estimating riverine PMF reevaluated elevations.

3.3.3 Combined Effects Flood

The licensee performed a combined effects flood analysis to determine the effects of coincident wind wave activity on the PMF elevation estimated on Diablo Creek. The FHRR stated that the wind speed and maximum wind wave height analysis was consistent with the guidance contained in ANSI/ANS-2.8 (ANSI/ANS, 1992; PG&E, 2016b). The guidelines provided in the *Coastal Engineering Manual* (USACE, 2008) were also used to perform wind speed adjustments, calculate the wind wave generation and run-up, and determine wind setup (PG&E, 2016b). The boundary of the riverine PMF was used to estimate the length of the fetch line (PG&E, 2016b). Consistent with the definition of fetch, the licensee identified the locations of safety-related structures within the powerblock and then the longest unobstructed flow path along which wind could travel in open water. As indicated in Figure 3.3-2, the postulated fetch line extends from a location slightly above HEC-RAS cross-section station number location 11+50 to a location adjacent to the Diablo Creek retaining wall at HEC-RAS cross-section station number location 4+06, or a horizontal distance of about 744 ft. The NRC staff notes that station numbers refer to the HEC-RAS cross-section location naming convention used by the licensee in its riverine analysis. HEC-RAS Station 11+50, for example, refers to a horizontal map distance corresponding to a location 1,150 ft upstream from the mouth of Diablo Creek.

The critical fetch line location was oriented in such a way that the wind-generated wave would impact the north-western face of the powerblock. At this location, the licensee reports that there is a retaining wall that had been constructed to prevent erosion of the Diablo Creek channel slope. This location is considered critical by the licensee because of the possibility of a wind/wave run-up overtopping the retaining wall and progressing toward the turbine building. For this reason, the licensee stated that the input parameters contributing to the wind/wave run-up analysis would be the most conservative at this location. The maximum WSE for this combined effects flood was estimated by the licensee to be 77.9 ft NAVD88. The top of the retaining wall at the licensee-specified critical location is approximately 86.3 ft NAVD88, which is about 8.4 ft above the maximum WSE of the riverine PMF coincident with wind/wave activity. Consequently, the licensee reported that there was no hazard posed to the Diablo Canyon powerblock from a combined effects flood on Diablo Creek (PG&E, 2016b). The NRC staff reviewed the licensee's wind wave evaluation and determined that the licensee followed appropriate procedures and that the results are reasonable.

3.3.4 Conclusion

In summary, the NRC staff confirmed the licensee's conclusion that the reevaluated hazard for flooding due to a riverine PMF is bounded by the CDB flood hazard at the Diablo Canyon site. Therefore, the NRC staff does not expect that the licensee will submit a focused evaluation or an integrated assessment for the streams and rivers flood-causing mechanism consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee reported in its FHRR that the reevaluated hazard for dam-related flooding effects is not applicable to the Diablo Canyon site. Further, this flood-causing mechanism is described in the licensee's CDB, but no PMF elevation was reported as the licensee determined that flooding was unlikely (PG&E, 2016b).

The Diablo Canyon powerblock is contiguous with the Diablo Creek for approximately the first 1.2 miles of the creek's length; there are no dams or other regulated hydrologic structures physically located within the Diablo Creek watershed. There are, however, two RWSRs located within the Diablo Canyon controlled area; they are sited on the promontory overlooking the reactor powerblock. Both storage features are adjacent to each other and may be considered to be "off stream" in that they are not associated with managing flow conditions within the Diablo Creek. Consequently, the licensee determined that no dam breach analysis was necessary for the purposes of the 50.54(f) letter response (PG&E, 2016b).

The methodology previously used by the licensee to evaluate the consequences of a breach of the two RWSRs was evaluated by the NRC staff during the initial licensing of the Diablo Canyon site. In connection with that earlier licensing action, the licensee demonstrated that the RWSR foundation materials (consisting of bedrock) were seismically-qualified and that the reservoirs would maintain their containment function during the design-basis earthquakes (NRC, 1978). To provide additional assurance against any reservoir breach, the RWSRs were designed so that their respective free surfaces were below grade thereby eliminating the potential for a dike-breach scenario (PG&E, 2016b). Based on this design feature configuration, should the RWSRs experience some type of breach, the licensee contends that rather than flow onto the powerblock site, the reservoir's contents would discharge into the adjacent Diablo Creek as that is a shorter travel path (PG&E, 2016b). After examining a topographic map of the area including the location of the RWSRs, the NRC staff finds the licensee's scenario reasonable as the shortest distance to the location with the greatest topographic gradient occurs between the RWSR and Diablo Creek rather than the Diablo Canyon powerblock.

The NRC staff reviewed the flooding hazard from the failure of dams or other storage reservoirs, against the relevant regulatory criteria based on present-day methodologies and regulatory guidance. The NRC staff's review consisted of three actions. The first independent action was an examination of the USACE National Inventory of Dams data base (USACE, 2016b) to confirm that there are no dams or storage reservoirs that co-occupy the Diablo Creek watershed, which was confirmed.

To better understand what flooding risk the RWSRs might represent to the portion of the Diablo Canyon powerblock adjacent to Diablo Creek, the second independent NRC staff action was to perform a flood hazard analysis based on the failure of a hypothetical dam on Diablo Creek at a location corresponding to the RWSRs, which are approximately 50 ft above the floor of Diablo Creek. A hypothetical dam of comparable height was assumed to be present within the channel. The NRC staff estimated an initial peak outflow from that location based on the USBR's (1982, 1983) recommendations, which rely on an empirical formula that was then used to estimate peak discharge at other HEC-RAS modeling stations located farther downstream. Having obtained those peak discharge estimates, the NRC staff then estimated a flood water depth based on the Manning's velocity equation. Through a trial-and-error spreadsheet procedure, the magnitude of the water depth parameter was varied until the discharge value obtained from Manning's equation was approximately equal to that value obtained using the USBR empirical equation. When the two discharge estimates were within 1 percent of each other, the NRC staff concluded that convergence had been achieved in the analysis and that the WSE due to a hypothetical dam failure at the location of interest had been determined. As a conservatism, no fluid mass losses were assumed due to infiltration or attenuation. The results of the NRC staff's independent spreadsheet analysis is summarized in Table 3.4-1. Two scenarios were evaluated using two different Manning's n coefficient values – 0.025 and 0.035. As indicated by the table, the NRC staff's independent analysis suggests that if flooding of the Diablo Canyon powerblock would occur in response to a hypothetical dam failure, it would be limited to the Warehouse A location – a structure that the licensee has designated to be non-safety-related.

The third independent NRC staff action was to estimate the WSE due to backwater. There is a culvert at the Station 4+36 location that extends across the Diablo Canyon site. In the event of a hypothetical dam failure scenario, some entrained channel material could be transported downstream and accumulate at the culvert. With the accumulation of flood debris, the height of the culvert can also be expected to increase, creating a dam, and leading to the formation of a backwater. The backwater effects were estimated by calculating the volume of the Diablo Creek channel behind the culvert and determining which floodwater depth corresponds to the RWSR storage capacities. By treating the channel geometry of Diablo Creek as a prism, NRC staff estimated the volume of the prism between two consecutive HEC-RAS modeling stations assuming a particular backwater depth (i.e., prism height). Prism volume segments were summed until the collective volume equaled that of one or both of the RWSRs.

An initial WSE elevation of 80 ft NAVD88 corresponded to the top of the hypothetical obstruction at the culvert location. This initial elevation is below the grade of the Diablo Canyon powerblock (estimated to be approximately 87 ft NAVD88 at the Station 4+36 location). Once again, through a trial-and-error spreadsheet procedure, the depth dimension of the Diablo Creek backwater was varied until the backwater volume was approximately equal to that of the RWSRs. When the two volume estimates were within 1 percent of each other, the NRC staff concluded that convergence had been achieved and that the backwater height had been determined. Assuming that only one of the RWSRs failed, the NRC staff's estimated backwater elevation was 74.5 ft NAVD88. Based on this elevation, backwater effects did not extend beyond Station 7+74 or the northernmost point of the Diablo Canyon powerblock where the elevation is approximately 95 ft NAVD88. When the failure of both RWSRs were analyzed, the NRC staff's estimated backwater flooding elevation was 81 ft NAVD88; this estimated WSE did not extend beyond Station 11+50 and was also below the elevation of the powerblock. Based on these independent analyzes, the NRC staff concluded that sufficient freeboard (physical margin) exists to ensure that failure of both RWSRs could not flood the Diablo Canyon site.

The NRC staff reviewed and confirms the licensee's conclusion that the reevaluated hazard for flooding due to the failure of dams and onsite water storage structures is bounded by the CDB flood hazard at the Diablo Canyon site. Therefore, the NRC staff does not expect that the licensee will submit a focused evaluation or an integrated assessment for the failure of dams flood-causing mechanism consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.5 Storm Surge

The licensee reported that the reevaluated PMF elevation due to the probable maximum storm surge (PMSS) is 44.59 ft NAVD88 on the ocean-side of the Diablo Canyon South Cove (PG&E, 2016b). At the ASW location, the estimated maximum WSE due to storm surge is 12.8 ft NAVD88. This flood-causing mechanism is discussed in the licensee's CDB, but a specific flood hazard elevation was not reported.

The FHRR described how the licensee used the DELFT3D-WAVE computer code (Deltares, 2016) to estimate the WSE attributed to storm surge (PG&E, 2016b). The scenario evaluated was a storm event with a 200-yr return period combined with an antecedent 10 percent exceedance high tide. In the analysis, the licensee used wave measurements recorded at the Diablo Canyon Waverider Buoy (designated National Data Buoy Center (NDBC) 46215). Additional data were obtained from four other NOAA-operated buoys all of which were located along the central California coastline (specifically buoys NDBC 46028, NDBC 46011, NDBC 46023, and NDBC 46218). The licensee's calibrated numerical model had as its western boundary the edge of the continental shelf; the computational domain extended to the north of Monterey (California) and to Point Arguello, near Lompoc (California) to the south. That model was based on a nested-grid approach to account for both deep water (regional) and shallow (local) water bathymetry as well as the coastal topography of the Diablo Canyon breakwater and the ASW area. Numerical processing of the NOAA buoy data was achieved using the **S**imulating **WA**ves **N**earshore (a.k.a. SWAN) feature of the DELFT3D computer code. The licensee stated that several of the default parameters in that computer code were used without amendment. The licensee's antecedent WSEs for the numerical model included a high antecedent water level of 7.0 ft NAVD88 and an alternate high antecedent water level (HHWL) of 8.7 ft NAVD88 (PG&E, 2016b).

In order to address storm surge (associated with low atmospheric pressures) the licensee used historically-measured average and minimum pressures at NDBC Buoy 46028; those data were used to define a surge antecedent water level of 9.9 ft NAVD88 (PG&E, 2016b). Based on its modeling results, the licensee stated that the crested wave height inside the breakwater was less than the CDB probable maximum tsunami wave height of 34.9 ft NAVD88. Consequently, the licensee concluded that the reevaluated PMSS is bounded by the Diablo Canyon CDB flooding hazard.

As part of the independent review of the licensee's PMSS estimate, the NRC staff familiarized itself with the local climatology, bathymetry, and the geography of the Diablo Canyon site and environs. Through that process, the NRC staff observed that the meteorology, bathymetry, and ocean wave spectral characteristics of the greater Pacific Coast region are distinctly different from those of their counterparts for the Atlantic and Gulf of Mexico seaboards where many nuclear power plants currently operate. Moreover, while the dominant source of coastal flooding on the Atlantic seaboard locations is associated with large storm surge (up to and in excess of 20 ft) caused by high-wind stresses that evolve over broad and shallow continental shelves, the narrow continental shelves of the Pacific Coast preclude surge heights greater than a few feet. The differences in wave types are due to the formation of longer-period waves originating from distal storm-generation locations in the Pacific Ocean. Moreover, the dominant storm waves on the California coast are typically associated with winter storms that formed to the south of the Aleutian Archipelago. From that location, the fetch is often more than 600 mi such that wave height and wave period are controlled by wind speed and duration (Federal Emergency Management Agency (FEMA), 2005; FEMA 2014).

For storm surge, the physical-bounding limitation of surge at the Diablo Canyon site can be approximated by considering the following equation (Dean and Dalrymple, 1984):

$$\frac{\partial \eta}{\partial x} = \frac{n\tau_{zx}(\eta)}{\rho g(h+\eta)}$$

where:

- η = surge height;
- τ = wave period;
- x = horizontal position relative to shore;
- z = wave elevation above still water line;
- ρg = water pressure due to gravity; and
- h = water height (seafloor to MSL).

Thus, storm surge is directly proportional to the width of the continental shelf and inversely proportional to average water depth. Since the width of the continental shelf on the Pacific Coast is approximately one-third to one-half of that of either the Atlantic or Gulf Coasts, storm surge on the Pacific Coast is expected to be on the order of 6 to 10 ft, based on the equation cited above. Similarly, when water depth is taken into account, surge height is expected to be further reduced to a WSE on the order of 5 ft, or less.

For wind-generated waves, it is generally accepted that ocean waves break when the wave height is approximately 78% of the water depth as a result of shoaling phenomena. Water depth outside the Diablo Canyon breakwater is approximately 36 to 43 ft on the ocean side, and 34 ft inside South Cove (Bechtel, 2012; Ehler et al., 2002). Thus, consistent with prevailing shallow water wave theory, ocean waves would break at heights approximately 34 ft outside of the breakwater and 27 ft inside of it. Normal wave activity in the vicinity of the Diablo Canyon site is in the 5- to 10-ft range, with storm-generated waves between 20 and 30 ft (Ehler et al., 2002; Bechtel, 2012). Thus, based on consideration of empirical wave physics theories, the NRC staff confirmed that PMSS alone could not inundate the Diablo Canyon site and that the reevaluated hazard for flooding from storm surge is bounded by the CDB flood hazard.

The NRC staff confirms the licensee's conclusion that the reevaluated flood hazard for storm surge is bounded by the CDB flood hazard. Therefore, the NRC staff does not expect that the licensee will submit a focused evaluation or an integrated assessment for the storm surge flood-causing mechanism consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.6 Seiche

The licensee reported that the reevaluated hazard for site flooding due to seiche does not inundate the Diablo Canyon site. This flood-causing mechanism is considered in the licensee's CDB as part of storm surge flood-causing mechanism, but a specific flood hazard elevation was not reported (PG&E, 2016b).

The licensee reevaluated the potential for seiche-related flooding at two potential locations: inland, at the location of the RWSRs, and at the South Cove where the ASW pump system is sited. At the RWSR location, the sloshing effects resulting on seismic loading of the two reservoirs were evaluated using a finite element model based on the Arbitrary Lagrangian-Eulerian Methodology (e.g., Donea et al., 1982). The ground motion response spectra selected as the seismic input to the analysis was an earthquake associated with the Hosgri fault zone (with a probable magnitude in the 6.5 to 7.5 range), as well as consideration of data obtained from the licensee's Long-Term Seismic Program. The licensee's reevaluation determined that the seismic-induced water sloshing height at the RWRSs would be approximately 2 ft with a loss of less than one percent of the capacity of each reservoir.

In the matter of seiche effects at the South Cove location, the licensee estimated seiche-related wave heights of less than 3.2 ft; these heights are well below the intake structure's top deck elevation of 20.4 ft NAVD88 (17.5 ft MSL)(PG&E, 2016b). In light of these estimated wave heights, the licensee concluded that flooding due to seiche effects would not impact the Diablo Canyon site.

The NRC staff reviewed the hazard from seiche-related flooding against the relevant regulatory criteria based on present-day methodologies and regulatory guidance. As part of its review, the NRC staff also independently reviewed FHRR-cited references that described the licensee's analysis. Those references included technical reports, topology plant structure locations, and local bathymetry (Ehler et al., 2002; Bechtel, 2012). In the matter of the RWSRs, the NRC staff noted the following factors influencing the potential for flooding effects due to seiche: (a) that the maximum diagonal distance of either impoundment was on the order of about 280 ft; and (b) that the static WSE of each impoundment was below grade as the basins for these structures were constructed in excavated rock as an additional measure intended to ensure seismic safety. Based on the limited fetch length of the respective reservoirs, the NRC staff concluded that if seiche-related flooding phenomena were to occur, that the effects would be inconsequential and be bounded by the LIP flooding scenario. The South Cove area is essentially a man-made feature as a result of the installation of a jetty during the construction of the power plant. The jetty effectively limits the length of fetch that might support seiche formation – a maximum of about 940 ft at a location perpendicular to the ASW. After consulting the Sverdrup-Munk-

Bretschneider Nomogram (USACE, 2008), the NRC staff confirmed that the occurrence of seiche-related phenomena in the South Cove would be below the elevation of the ASW's top deck (20.4 ft NAVD88) based on the dimensions of the cove.

In summary, the NRC staff reviewed and confirms the licensee's conclusion that the reevaluated flood hazard for seiche is bounded by the CDB flood hazard at the Diablo Canyon site. Therefore, the NRC staff has determined that flooding from seiche does not need to be analyzed in a focused evaluation or an integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.7 Tsunami

The licensee reported that the reevaluated flood hazard elevation due to tsunami is 32.8 ft NAVD88 at the ASW intake structure location, in the South Cove. The licensee also reported that the reevaluated hazard for site flooding due to tsunami does not inundate the Diablo Canyon powerblock. Wave run-up on the steep slope immediately behind the intake structure was reported to an elevation of 62.3 ft NAVD88 (PG&E, 2016b) and does not affect any safety-related structures, systems, or components within the powerblock. See Figure 3.7-1. This flood-causing mechanism is discussed in the licensee's CDB and has a maximum elevation of 30.3 ft NAVD88 for distantly-generated tsunamis and an elevation of 34.9 ft NAVD88 for near-shore tsunamis at the area of the ASW, inside the South Cove breakwater (PG&E, 2016b).

The licensee evaluated the tsunami hazard in accordance with the guidelines described in NUREG/CR-6966 (NRC, 2009). The licensee's FHRR analysis began with an examination of the scientific literature to establish the PMT at the site based on the published reports (PG&E, 2016b). Both a regional- and site-screening evaluation was performed to identify potential tsunamigenic sources capable of generating what the licensee described as a "Reevaluated Probable Maximum Tsunami" at the Diablo Canyon site. Four far-field and five near-field locations around the Pacific Ocean basin were selected as RPMT generating sites; those locations were selected based on a review of: (a) the historical records from Port San Luis (PSL) and Avila Beach (AB) tidal gauge records for all historical far-field coseismic tsunamis since 1946; (b) previous tsunami modeling studies along the California coastline; and (c) consideration of potential submarine mass failure (SMF) scenarios, also having occurred along the west coast.

As a result of that review, the licensee found that since 1946, 32 historic tsunamis were recorded near the Diablo Canyon site as a result of far-field earthquake events (see FHRR Table 3-13). The maximum recorded tsunami wave amplitude (i.e., the maximum water surface elevation above MSL at the time of the event) identified was a 6.6 ft wave that was attributed to the 2011 Tohoku Japan earthquake. In addition to those far-field events, there were also other large earthquakes reported along the Pacific Ocean basin, but the literature indicates that those events did not produce a measurable tsunami signal at the PSL/AB tide gauges. The licensee also identified natural analogs to historic SMF scenarios on the central California seafloor that could represent potential tsunami generating source zones. Those potential analog sites included the Goleta slide complex, the smaller Gaviota slide, and the Big Sur slide. Four far-field tectonic sources also modeled by the licensee and included the Aleutian Alaska Subduction Zone, the Semidi Subduction Zone, the Kamchatka Subduction Zone, and the Japan Subduction Zone (see FHRR Figure 3-11). The five near-field sources modeled by the licensee included two seismic sources (Hosgri fault and San Lucia fault) and two SMF scenarios (the Goleta proxy and Big Sur proxy). The NRC staff notes that the term "proxy" used here means that the SMF event was superimposed from its original location to a location immediately offshore from the Diablo Canyon site

For each of the selected tsunami generating events, the licensee used the long-wave model FUNWAVE-TVD (Shi et al., 2012) to estimate the PMT based on a series of nested grids of increasingly finer resolution toward the Diablo Canyon site (PG&E, 2016b). For the near-field (or SMF) sources, the licensee used the NHWAVE 1.1 computer model (Ma et al., 2012) to compute the initial sea surface and water wave velocities based on slide motion along the seafloor. The NHWAVE computer model is a fully nonlinear, non-hydrostatic, three-dimensional (3D) solver for surface wave motion.

The licensee then propagated the generated waves toward the site using the FUNWAVE-TVD computer code. In accordance with NUREG/CR-6966, the licensee calculated an antecedent water level using verified tide data from the Port San Luis NOAA station (Station 9412110) the location of which is approximately 6 mi southeast of the Diablo Canyon site. The calculated 10 percent exceedance high tide was 7.0 ft. For sea level rise, the licensee used the observed average (linear) rate of increase at the Port San Luis gauge for the period 1946 to 2006 or 0.0311 in./yr based on regional/global trends and compared that result to the regional/global trend documented in a California Coastal Commission report (California Coastal Commission, 2013). The licensee used the higher of the two values, in this case from the California Coastal Commission report. Thus, the licensee used a sea level rise of 1.7 ft. The licensee's total antecedent water level was calculated to be 8.7 ft (PG&E, 2016b).

The licensee's computer simulations indicated that the Goleta proxy was the controlling SMF event responsible for producing the PMT at the Diablo Canyon site with a calculated WSE of 32.8 ft NAVD88 (in the vicinity of the ASW intake structure location) (PG&E, 2016b). The estimated wave run-up (i.e., the wave surge at the slope immediately behind the intake structure) was estimated at 62.3 ft NAVD88 (see FHRR Table 3-17), which is below the nominal grade elevation of the Diablo Canyon powerblock. The NRC staff notes that a tsunami-like wave will also break once it reaches some shoreline. The amplitude of the PMT reported reflects the maximum WSE the wave achieves at the ASW location before breaking. In order to conserve energy, following breaking, the tsunami wave will continue to travel inland, inertially, but now taking on the form of a surging bore. Behind the ASW is a cliff face that extends up to the Diablo Canyon powerblock location. The 62.3 ft elevation reported is the estimated maximum vertical elevation the remnants of the breaking wave (or bore) would reach as surge; those computer simulation results are less than the nominal grade elevation of the Diablo Canyon powerblock of 87.9 ft NAVD88.

The licensee stated that the ASW system was the only safety-related system that could be affected by a tsunami, which has a top deck elevation of 20.4 ft NAVD88 (see Figure 3-19 in the FHRR). The openings of the ASW ventilation snorkels range in elevation from 48.5 to 52.3 ft NAVD88.[1] Therefore, the licensee concluded that the reevaluated PMT of 32.8 ft NAVD88 is bounded by the PMT CDB of 34.9 ft NAVD88.

[1] As described in Section 2.3.3 of the February 8, 2016 FHRR (PG&E, 2016b) each ASW pump motor is housed in its own watertight room within the intake structure. These rooms are designed for a combination tsunami-storm wave activity to 48.3 ft NAVD88. In addition, the ASW buried piping outside of the intake structure has erosion protection consisting of gabion mattresses, reinforced concrete slabs, and pavement above the buried piping, and an armored embankment southeast of the intake structure are installed to resist the effects of tsunami and storm waves.

The NRC's technical assistance contractor, Taylor Engineering, developed an analysis to support the staff's review (Taylor Engineering, 2017) This analysis relied on a Boussinesq-based computer model COULWAVE (Lynett et al., 2008) to numerically evaluate three different tsunami generating sources (see Table 3.7-1); in connection with those simulations, conservative parameter values were used. Upon completion of those simulations, the NRC staff determined that the maximum PMT elevation at the Diablo Canyon site was associated with a large, local SMF (i.e., Goleta-like slide with a greater than 100,000-yr return period) at a proxy location immediately to the west of the Diablo Canyon site along the continental shelf/continental slope transition (Taylor Engineering, 2017).

Based on the site specific COULWAVE analysis performed by Taylor Engineering the PMT WSE at the ASW's ventilation snorkel location was estimated to be 47.7 ft NAVD88 (when accounting for the antecedent water level) (Taylor Engineering, 2017). To estimate the antecedent water level boundary condition at the Diablo Canyon site Taylor Engineering performed an analysis based on a 10 percent exceedance high tide; NOAA NOS CO-OPS tidal gage data from the Port San Luis tidal station to the south of the Diablo Canyon site were used. For the 18 years examined (1983–2001, inclusive), the 10 percent exceedance high tide water level was determined to be +7.5 ft NAVD88 (Taylor Engineering, 2017). The effects of long-term sea level rise was also evaluated – estimated as 0.0311±0.0189 in/yr based again on NOAA NOS-CO-OPS data. Thus, the estimated antecedent WSE for high-water predictions used for the purposes of the NRC staff's independent assessment is 7.5 ft (10 percent exceedance water level) plus 0.2 ft (40-yr sea level rise accounting for design life rise) or 7.7 ft NAVD88. The 10 percent exceedance low tide, from the same NOAA data, is -2.1 ft NAVD88, and this is taken as the antecedent WSE for low-water predictions. The NRC staff noted that at the Port San Luis tidal station there is a 2.9 ft difference between NAVD88 and msl (where NAVD88 is lower).

As part of the FHRR review, the NRC staff compared the CDB PMT elevation for the Diablo Canyon site to the WSE also reported in the FHRR (PG&E, 2016b), and those two WSEs of interest can be found in Table 3.7-2. This table also includes the NRC staff's independent PMT estimate obtained from Taylor Engineering (Taylor Engineering, 2017). All licensee- and NRC-estimated WSE elevations listed in Table 3.7-2 reflect conservative tidal levels (events) as well as sea level rise. The table indicates that the maximum WSEs at the SWIS estimated by both the licensee and the NRC staff are less than the design elevation associated with the snorkel ventilation opening. Also noteworthy is that the estimated wave crest of the PMT does not exceed the minimum ASW snorkel ventilation opening elevation of 48.5 ft NAVD88. Lastly, as the PMT wave continues to travel inland, the analysis performed by Taylor Engineering estimated that its maximum run-up elevation against the cliff face immediately behind the SWIS is 70.9 ft NAVD88 (Taylor Engineering, 2017), which is less than the nominal powerblock grade of 87.9 ft NAVD88.

In considering the information reported in Table 3.7-2, there is about a 15-ft difference in the respective WSE estimates; the tsunami wave elevation estimates made by Taylor Engineering (Taylor Engineering, 2017) were higher than those estimated by the licensee at the SWIS location. The various factors that account for the differences in the respective estimates are discussed below.

First, the licensee's and the NRC staff's estimates are both based on an abstraction of the Goleta slide complex. This geologic feature represents about 24 major and minor flow lobes and slump blocks that occurred for the first time about 200,000 years before present; the most recent slide event is estimated to have occurred about 7,500 years before present. Green and others (2006) estimate that the complex has a combined volume of about 0.36 mi^3 of displaced marine sediment over a runout length of 6.5 mi. As the slide complex represents a composite event, geologically, in both time and in space, there are multiple ways to interpret this feature for the purposes of numerical modeling. However, in its independent analysis, Taylor Engineering assumed a very-conservative average slide thickness for the slide complex of about 410 ft (Taylor Engineering, 2017). This thickness was determined by NRC's contractor through analyzing pre-slide and post-slide bathymetry transects of the various Goleta slide events, whereas the licensee elected to select an average slide thickness of about 250 ft.

As both analyses assumed the same approximate slide volume (and length) for the Goleta slide complex for the respective computer simulations, to comport with the volume-length assumption, the Taylor Engineering simulation would require a horizontal width of 3.1 mi whereas the licensee's width was 4.7 mi based on a thinner average slide thickness. Earlier computer modeling of tsunamis (e.g., Lynett and Liu, 2005) suggest that the initial tsunami wave amplitude along the landslides' centerline is proportional to the thickness of the event selected for the computer simulation. Thus, the simplest explanation for the differences in the respective WSE estimates at the SWIS location is that the computer simulations performed by Taylor Engineering relied on a thicker slide over a smaller area than the one assumed by the licensee. Stated somewhat differently, the Taylor Engineering analysis was more conservative than that performed by the licensee in that it relied on a more-focused tsunami wave occurring over a narrower area, with higher energy, than the scenario modeled by the licensee (e.g., a longer-period wave with energy directed over a broader area, but not focused along the centerline toward shore). The conservatism introduced by this modeling paradigm of the Taylor Engineering (Taylor Engineering, 2017) analysis is judged to potentially overestimate the magnitude of the estimated WSEs at the Diablo Canyon site by a factor of about 1.7 (Lynett and Lui, 2017).

A second reason for differences in the respective analyses is that the 50.54(f) letter did not request licensees to consider alternative system states in connection with its model abstractions, while the Taylor Engineering approach featured a parametric study evaluating 50 different source locations for the landslide. There are likely other factors that contribute to minor differences in the respective run-up elevation estimates at the Diablo Canyon site, however these are smaller contributors to total water height as compared to the selection of a parametric approach and conservative, thicker, landslide by Taylor Engineering (Taylor Engineering, 2017). Therefore, and although there are differences in the maximum WSE values at the SWIS, both the licensee and the NRC staff's independent contractor results agree that that the maximum reasonable values are below the design elevation associated with the snorkel ventilation opening.

Overall, the NRC staff concluded that the licensee's analysis relied on information and methods found in peer-reviewed literature and used relevant regulatory criteria based on present-day methodologies and regulatory guidance. Additionally, the NRC staff concluded that the licensee's PMT analysis was conservative in the selection of the Goleta slide complex at a proxy location for the SMF scenario. This Goleta event was a multi-landslide event that displaced a large volume of material (greater in volume than any SMF known to have occurred along the continental margin sufficient to generate a PMT near the Diablo Canyon site).

Therefore, as stated in the introduction to this assessment, the staff concludes that the tsunami flood hazard calculation values reported in the staff's March 30, 2016, ISR letter (NRC, 2016b), which are consistent with the values submitted by the licensee, are an appropriate representation of the reevaluated tsunami hazard at the Diablo Canyon site and sufficient to respond to the NRC's 50.54(f) information request for the tsunami hazard mechanism. Moreover, the staff regards the independent confirmatory analysis (Taylor Engineering, 2017) solely as additional context to provide assurance that the site's passive, permanent, physical-protection features could withstand an even more-conservative tsunami scenario than what the licensee proposed in the FHRR. Therefore, the NRC staff has determined that the potential for flooding from the tsunami hazard mechanism does not need to be analyzed in any future assessments of the plant or plant response consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.8 Ice-Induced Flooding

The licensee reported in its FHRR, that the reevaluated hazard for ice-induced flooding effects are not applicable at the Diablo Canyon site. This flood-causing mechanism is discussed in the licensee's CDB, however no impact to the site was identified (PG&E, 2016b).

The licensee stated in its FHRR, that the climate at the Diablo Canyon site is generally considered to be "Mediterranean," with annual temperatures ranging from 40° to 70° Fahrenheit; consequently, any water bodies located in and around the Diablo Canyon site would not be subject to freezing (PG&E, 2016b). Given the intermittently-flowing Diablo Creek as well as the ambient mild weather, the potential for the formation of ice dams/jams producing subsequent floods at the site is considered by the licensee to be unlikely.

The NRC staff reviewed the flooding hazard potential from ice-induced flooding against the relevant regulatory criteria based on present-day methodologies and regulatory guidance. The NRC staff queried the database maintained by the USACE's Cold Regions Research and Engineering Laboratory (CRREL) that contains historic reports of ice jams on waterways found within the contiguous 48 states and Alaska. Upon review of the CRREL database (USACE, 2016a), the NRC staff found that there were no historic reports of ice jams having formed in the vicinity of the Diablo Canyon site, which is consistent with the mild weather typical of the Diablo Canyon site and surrounding region. Furthermore, depending on the amount of recent rainfall, the Diablo Creek sometimes has no measurable flow (PG&E, 2016b). The NRC staff confirms the licensee's conclusion that the reevaluated hazard for flooding due to ice dams is not applicable to the Diablo Canyon site.

The NRC staff reviewed and confirms the licensee's conclusion that the reevaluated hazard for ice-induced flooding is bounded by the CDB flood hazard at the Diablo Canyon site. Therefore, the NRC staff has determined that flooding from ice-induced flooding does not need to be analyzed in a focused evaluation or an integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR, that the reevaluated hazard for channel migrations or diversions is not applicable at the Diablo Canyon site. This flood-causing mechanism is discussed in the licensee's CDB, but no impact to the site was identified (PG&E, 2016b).

The NRC staff reviewed the flooding hazard potential from channel migrations or diversions against the relevant regulatory criteria based on present-day methodologies and regulatory guidance, as described below. The NRC staff guidance described in NUREG/CR-7046 (NRC

2011d) acknowledges that there are no well-established predictive models for estimating the potential for channel diversion in a riverine environment.

In the case of the Diablo Canyon site, the licensee reports that the powerblock is wholly underlain by the Monterey sandstone (PG&E, 2013b). The licensee has previously described this geologic unit as well-indurated and firm. Where exposed on the hillslope defining the Diablo Canyon, the licensee further notes that the country rock (including the Monterey sandstone) has been described to be markedly resistant to erosion. The licensee reports that the Diablo Creek has a "V-shaped" geometry; geomorphically, this detail suggests that the country rock has a high physical resistance to stream erosion (e.g., Ritter, 1986). Based on information provided by the licensee, Diablo Creek can be classified as an ephemeral stream not subject to high erosion rates. Based on these facts, the NRC staff can reasonably conclude that the Diablo Creek is not subject to lateral channel migration.

A review of historic topographic maps maintained by the USGS (2016) of the Diablo Canyon site (beginning with the Port Harford 1:62,500-scale sheet dated 1897) by the NRC staff indicates that the position of the Diablo Creek has remained essentially fixed for well over a hundred years. The further review of the USGS's historic data base of topographic maps of the Diablo Canyon site and environs by the NRC staff did not reveal any evidence of meandering of the Diablo Creek. Further inspection of the topographic sheets show no geomorphic evidence of channel migration. This comparison led the NRC staff to conclude that there is no physical evidence of river meandering and/or channel diversion for at least the last century, and therefore the NRC staff confirms the licensee's conclusion that the reevaluated hazard for flooding due to channel migrations or diversions is not applicable to the Diablo Canyon site.

In summary, the NRC staff confirms the licensee's conclusion that the reevaluated hazard for flooding due to channel migration or diversion is bounded by the CDB flood hazard at the Diablo Canyon site. Therefore, the NRC staff has determined that flooding from channel migration or diversion did not need to be analyzed in the FE the licensee submitted in a July 19, 2017, letter (PG&E, 2017b) consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c). The NRC staff's assessment of the licensee's FE can be found in a letter dated December 18, 2017 (NRC, 2017b).

4.0 REEVALUATED FLOOD HEIGHT, EVENT DURATION AND ASSOCIATED EFFECTS FOR HAZARDS NOT BOUNDED BY THE CDB

4.1 Reevaluated Flood Height for Hazards Not Bounded by the CDB

Section 3 documents the NRC staff's review of the licensee's flood hazard water elevation results. Table 4.1-1 contains the maximum flood elevation results, including wave effects, for flood mechanisms not bounded by the CDB. The NRC staff agrees with the licensee's conclusion that the LIP flood-causing mechanism is not bounded by the CDB. Consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016c), the NRC notes in a letter dated July 19, 2017 (PG&E, 2017b) the licensee will submitted a FE the LIP flood-causing mechanism. The NRC staff's assessment of the licensee FE can be found in a letter dated December 18, 2017 (NRC, 2017b).

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided in PG&E's 50.54(f) response (PG&E, 2016b) regarding the FED parameters needed to perform the additional assessments of the plant response for flood hazards not bounded by the CDB. The FED parameters for the flood-causing mechanisms not bounded by the CDB are summarized in Table 4.2-1 and Table 4.2-2.

The licensee did not provide the LIP warning-time parameter, however the licensee has the option to use NEI guideline 15-05 (NEI, 2015a), if necessary. The period of recession associated with LIP flooding is generally minimal. The licensee provided the period of inundation for door locations impacted by the LIP flood, which are reported in Table 4.2-2. The NRC staff reviewed the FED values reported in Tables 4.2-1 and 4.2-2, and finds them reasonable for use in future assessments of plant response discussed in NEI 12-06 (Revision 2), Appendix G (NEI, 2015b), and outlined in COMSECY-15-0019 (NRC, 2015b), JLD-ISG-2012-05 (NRC, 2012d), JLD-ISG-2012-01, Revision 1 (NRC, 2016a), and JLD-ISG-2016-01, Revision 0 (NRC, 2016c), respectively. The staff notes that an updated assessment of LIP was provided by the licensee in a letter dated April 6, 2017 (PG&E, 2017a). The staff's assessment of the FED for this updated assessment can be found in a letter dated December 18, 2017 (NRC, 2017a).

4.3 Associated Effects for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided in PG&E's 50.54(f) response (PG&E, 2016b) regarding AE parameters needed to perform future additional assessments of plant response for flood hazards not bounded by the CDB. The AE parameters directly related with maximum total water elevation, such as waves and run-up, are provided in Table 4.1-1. The AE parameters not directly associated with total water elevation are listed in Table 4.3-1.

The licensee reported maximum flow depths, maximum velocity, hydrostatic and hydrodynamic loads at impacted building locations due to LIP-related flooding at the Diablo Canyon site (PG&E, 2016b). Based on the relatively low flood depths and corresponding flow velocities, the NRC staff agreed that these AEs are reasonable. The licensee also indicated that debris loading would be minimal at all building locations at the Diablo Canyon site for LIP-related flooding, and the NRC staff agrees that the effects would be minimal given the low flood depths and velocities. The NRC staff would expect the AE from sediment loading for LIP to be minimal.

The NRC staff have reviewed the AE values reported in Tables 4.3-1, and finds them reasonable for use in future assessments of plant response.as discussed in NEI 12-06 (Revision 2), Appendix G (NEI, 2015b), and outlined in COMSECY-15-0019 (NRC, 2015b), JLD-ISG-2012-05 (NRC, 2012d), JLD-ISG-2012-01, Revision 1 (NRC, 2016a), and JLD-ISG-2016-01, Revision 0 (NRC, 2016c), respectively. The staff notes that an updated assessment of LIP was provided by the licensee in a letter dated April 6, 2017 (PG&E, 2017a). The staff's assessment of the AEs values for this updated assessment can be found in a letter dated December 18, 2017 (NRC, 2017a).

4.4 Conclusion

Based upon the preceding analysis, NRC staff confirms that the reevaluated flood hazard information discussed in Section 4 is appropriate input to the additional assessments of plant response as described in the 50.54(f) letter (NRC, 2012a), COMSECY-15-0019, (NRC, 2015b), JLD-ISG-2012-01, Revision 1 (NRC, 2016a), and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms for Diablo Canyon Nuclear Power Plant, Units 1 and 2. Based on its review of available information provided in PG&E's 50.54(f) letter response (PG&E, 2012; PG&E, 2014, PG&E, 2016b), the NRC staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirms that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, the NRC staff confirms the licensee's conclusions that: (a) the reevaluated flood hazard result for the LIP flood-causing mechanism is not bounded by the CDB flood hazard; (b) a focused evaluation of plant response will be performed for LIP; and (c) the reevaluated flood-causing mechanism information is appropriate input to additional assessments of plant response, as described in the 50.54(f) letter (NRC, 2012a), COMSECY-15-0019 (NRC, 2015b), JLD-ISG-2012-01, Revision 1 (NRC, 2016a), and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

6.0 REFERENCES

Notes: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http://www.nrc.gov/reading-rm/adams.html.

U.S. Nuclear Regulatory Commission Documents and Publications

NRC, 1974, NUREG-0675, "Safety Evaluation Report Related to the Operation of Diablo Canyon Nuclear Power Plants, Units 1 and 2," original and as supplemented.

NRC, 2007, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition", NUREG-0800, March 2007, available online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/.

NRC, 2009, "Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America – Final Report," NUREG/CR-6966, March 2009, ADAMS Accession No. ML091590193.

NRC, 2011a, "Near-Term Report and Recommendations for Agency Actions Following the Events in Japan," Commission Paper SECY-11-0093, July 12, 2011, ADAMS Accession No. ML11186A950.

NRC, 2011b, "Recommended Actions to be Taken Without Delay from the Near-Term Task Force Report," Commission Paper SECY-11-0124, September 9, 2011, ADAMS Accession No. ML11245A158.

NRC, 2011c, "Prioritization of Recommended Actions to be Taken in Response to Fukushima Lessons Learned," Commission Paper SECY-11-0137, October 3, 2011, ADAMS Accession No. ML11272A111.

NRC, 2011d, "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United State of America," NUREG/CR-7046, November 2011, ADAMS Accession No. ML11321A195.

NRC, 2012a, Letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, Subject: "Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident," March 12, 2012, ADAMS Accession No. ML12056A046.

NRC, 2012b, Letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation and Michael R. Johnson, Director, Office of New Reactors,, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, Subject: "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Order EA-12-049, March 12, 2012, ADAMS Accession No. ML12054A736.

NRC, 2012c, Letter from Eric J. Leeds, Director, Office of Nuclear Reactor Regulation, to All Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status, Subject: "Prioritization of Response Due Dates for Request for Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Flooding Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident," May 11, 2012, ADAMS Accession No. ML12097A510.

NRC, 2012d, "Guidance for Performing the Integrated Assessment for External Flooding," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2012-05, Revision 0, November 30, 2012, ADAMS Accession No. ML12311A214.

NRC, 2013a, "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2012-06, Revision 0, January 4, 2013, (2013a), ADAMS Accession No. ML12314A412.

NRC, 2013b, "Guidance For Assessment of Flooding Hazards Due to Dam Failure," Japan Lessons-Learned Project Directorate, Interim Staff Guidance JLD-ISG-2013-01, Revision 0, July 29, 2013, ADAMS Accession No. ML13151A153.

NRC, 2013c, "Request for Additional Information Associated with Near-Term Task Force Recommendation 2.3, Flooding Walkdowns," December 23, 2013, ADAMS Accession No. ML13325A891.

NRC, 2014, "Diablo Canyon, Units 1 and 2 – Staff Assessment of the Flooding Walkdown Report Supporting Implementation of Near-Term Task Force Recommendation 2.3 Related to the Fukushima Dai-Ichi Accident (TAC Nos. MF0221 and MF0222)," June 23, 2014, ADAMS Accession No. ML14136A194.

NRC, 2015a, Letter from Victor E. Hall (NRC), to Edward D. Halpin, (PG&E), "Nuclear Regulatory Commission Plan for the Audit of Pacific Gas and Electric Company's Flood Hazard Reevaluation Report Submittal Relating to the Near-Term Task Force Recommendation 2.1-Flooding for Diablo Canyon Power Plant, Units. 1 and 2", June 10, 2015, ADAMS Accession No. ML15148A207.

NRC, 2015b, "Closure Plan for the Reevaluation of Flooding Hazard for Operating Nuclear Power Plants," Commission Paper COMSECY-15-0019, June 30, 2015, ADAMS Accession No. ML15153A104.

NRC, 2016a, "Compliance with Order EA-12-049 Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events", Interim Staff Guidance JLD-ISG-2012-01, Revision 1, January 22, 2016, ADAMS Accession No. ML15357A163.

NRC, 2016b, "Diablo Canyon Power Plant, Units 1 and 2 – Interim Staff Response to Reevaluated Flood Hazards Submitted in Response to 10 CFR 50.54(f) Information Request – Flood-Causing Mechanism Reevaluation (CAC Nos. MF6039 and MF6040)," March 30, 2016, ADAMS Accession No. ML16083A552.

NRC, 2016c, "Guidance for Activities Related to Near-Term Task Force Recommendation 2.1, Flooding Hazard Reevaluation; Focused Evaluation and Integrated Assessment," Interim Staff Guidance JLD-ISG-2016-01, Revision 0, July 11, 2016, ADAMS Accession No. ML16162A301.

NRC, 2016d, Letter from Robert Bernardo, (NRC), to Edward D. Halpin, (PG&E), "NRC Report for the Audit of Pacific Gas and Electric Company's Flood Hazard Revaluation Report Submittal

Relating to the Near-Term Task Force Recommendation 2.1-Flooding for Diablo Canyon Power Plant, Units Nos. 1 and 2", December 1, 2016, ADAMS Accession No. ML16176A058.

NRC, 2017a, "Diablo Canyon Power Plant Unit Nos. 1 and 2 – Flood Hazard Mitigation Strategies Assessment," December 18, 2017, ADAMS Accession No. ML17321B040.

NRC, 2017b, "Diablo Canyon Power Station, Units 1 and 2 Staff Assessment of Flooding Focused Evaluation," December 18, 2017, ADAMS Accession No. ML17328A249.

Codes and Standards

ANSI/ANS (American National Standards Institute/American Nuclear Society), 1992, ANSI/ANS-2.8-1992, "Determining Design Basis Flooding at Power Reactor Sites," American Nuclear Society, LaGrange Park, IL, July 1992.

Other References

Bechtel (Bechtel Power Corporation), 2012. "Confirmatory Third-Party Interim Technical Assessment for the Intake Relocation for Diablo Canyon Power Plant", Prepared for PG&E and the State Water Resources Control Board Nuclear Review Committee, Bechtel Power Corporation Report Number 25762-000-30R-G01G-00003 Rev 0, July 11, 2012.

California Coastal Commission, 2013, "California Coastal Commission Draft Sea-Level Rise Policy Guidance," Public Review Draft, October 14, 2013, available online at https://documents.coastal.ca.gov/reports/2013/12/Th9-12-2013.pdf.

Chow, V.T., 1959, *Open-Channel Hydraulics*, McGraw-Hill, New York.

Dean, R.G., and R.A. Dalrymple, 1984, *Water Wave Mechanics for Engineers and Scientists*, New York, Prentice-Hall Inc., 1984.

Deltares, 2016, "Delft3D Flexible Mesh Suite," Delft, The Netherlands, available online at https://www.deltares.nl/en/software/delft3d-flexible-mesh-suite/.

Donea, J., S. Giuliani, and J-P. Halleux, 1982, "An arbitrary Lagrangian-Eulerian finite element method for transient dynamic fluid-structure interactions." *Computer Methods in Applied Mechanics and Engineering,* 33(1-3):689-723, 1982.

Ehler, C.P., J.R. Steinbeck, E.A. Laman, J.B. Hedgepeth, J.R. Skalski, and D.L. Mayer, 2002. "A Process for Evaluating Adverse Environmental Impacts by Cooling-Water System Entrainment at a California Power Plant." Research Article Defining and Assessing Adverse Environmental Impact Symposium 2001, *The Scientific World Journal*, June 2002, 2(S1), 81–105.

FEMA (Federal Emergency Management Agency), 2005. "Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States", Department of Homeland Security, January 2005, available at https://www.fema.gov/media-library-data/1389126436477-5bd6d5959718cf3f5a4b6e919f0c3b42/Guidelines_for_Coastal_Flood_Hazard_Analysis_and_Mapping_for_the_Pacific_Coast_of_the_United_States_(Jan_2005).pdf.

FEMA, 2014. "Guidance for Flood Risk Analysis and Mapping: Coastal General Study Considerations," Guidance Document 2, May 2014, available online at https://www.fema.gov/media-library-data/1481147587381-5264846ad67fbf287e1f1d46c15a1c71/Coastal_General_Study_Considerations_Guidance_May_2014.pd.pdf.

FLO-2D, 2014, "FLO-2D Pro Reference Manual," FLO-2D Software, Inc., Nutrioso, Arizona, Build No. 14.08.09, available online at www.flo-2d.com.

Google, 2016, "Google Maps" (Web site), https://www.google.com/maps.

Greene, H.G., L. Y. Murai , P. Watts, N. A. Maher , M. A. Fisher, C. E. Paull, and P. Eichhubl, "Submarine landslides in the Santa Barbara Channel as potential tsunami sources," *Natural Hazards and Earth System Sciences*, 6(1):63–88, January 2006.

Hoyt, J.C., and B.D. Wood, 1913, "Gazetteer of Surface Waters of California. Part III. Pacific Coast and Great Basin Streams," U.S. Geological Survey Water-Supply Paper 297.

Lynett, P., and P. L.-F. Liu, "A numerical study of the run-up generated by three-dimensional landslides," *Journal of Geophysical Research (Oceans)*, 110(C3), 16 p., March 2005,

Lynett, P., P.L.-F. Liu, K.I. Sitanggang, and D.H. Kim, 2008, "Modeling wave generation, evolution, and interaction with depth integrated, dispersive wave equations COULWAVE code manual." *Cornell University Long and Intermediate Wave Modeling Package,* available online at http://isec.nacse.org/models/users_guide/coulwave.pdf.

Ma, G., F. Shi, and J.T. Kirby, 2012, "Shock-capturing non-hydrostatic model for fully dispersive surface wave processes," *Ocean Modeling*, 43-44:22-35, 2012.

NEI (Nuclear Energy Institute), 2015a, "Warning Time for Local Intense Precipitation Events", Revision 6, April 8, 2015, ADAMS Accession No. ML15104A157, as endorsed by the NRC on April 23, 2015, ADAMS Accession No. ML15110A080. The white paper was subsequently issued by NEI on May 1, 2015, as NEI 15-05, "Warning Time for Local Intense Precipitation Events."

NEI, 2015b, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide", NEI-12-06 Revision 2, December 2015, ADAMS Accession No. ML16005A625.

NOAA (National Oceanic and Atmospheric Administration), 1998, "Probable Maximum Precipitation for California - Calculation Procedures," Hydrometeorological Report No. 58, National Weather Service, Silver Spring, Maryland, October 1998.

NOAA, 1999, "Probable Maximum Precipitation for California," Hydrometeorological Report No. 59, National Weather Service, Silver Spring, Maryland, February 1999.

Okada, Yoshimitsu, 1985, "Surface deformation due to shear and tensile faults in a half-space," *Bulletin of the Seismological Society of America*, 75(V4):1135-1154, August 1985.

PG&E (Pacific Gas and Electric Company), 2003, "Diablo Canyon Power Plant Units 1 and 2

Final Safety Analysis Report Update," Revision 15, September 19, 2003, ADAMS Accession No. ML032680892 (Non-Publicly Available).

PG&E, 2012, Letter from Edward D. Halpin to NRC, Subject: "Final Response to Request for information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.3 Flooding," November 27, 2012, ADAMS Accession No. ML12333A145.

PG&E, 2013a, "Diablo Canyon Creek Probable Maximum Flood (PMF) Analysis," September 6, 2013.

PG&E, 2013b, "Diablo Canyon Power Plant Units 1 and 2 Final Safety Analysis Report Update," Revision 21, September 16, 2013. Redacted version publicly available at ADAMS Accession No. ML15098A461.

PG&E, 2014, Letter from Barry S. Allen to NRC, Subject: Response to December 23, 2013 request for Additional Information Associated with Near-Term Task Force Recommendation 2.3 Flooding Walkdowns," January 29, 2014, ADAMS Accession No. ML14029A702.

PG&E, 2015a, "Diablo Canyon Power Plant, Units 1 and 2 - Flood Hazard Reevaluation Report," Revision 0, Enclosure to Letter from Barry S. Allen to the NRC, Subject: "Final Response to Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 Flooding", March 11, 2015, ADAMS Accession No. ML15071A045.

PG&E, 2015b, "Diablo Canyon Power Plant Units 1 and 2 – Updated Final Safety Analysis Report Update," Revision 22, May 6, 2015, ADAMS Accession No. ML15138A105.

PG&E, 2016a, "DCPP Local Intense Precipitation (LIP) Analysis 2D Modeling," January 26, 2016.

PG&E, 2016b, "Diablo Canyon Power Plant Units 1 and 2 Flood Hazard Reevaluation Report", Revision 1, Enclosure to Letter from L. Jearl Strickland to NRC, Subject: "Updated Response to Request for Information Pursuant to 10 CFR 50.54(f) Regarding Recommendation 2.1 Flooding," February 8, 2016, ADAMS Accession No. ML16040A009.

PG&E, 2017a, "Diablo Canyon Power Plant, Units 1 and 2, Submittal of Mitigating Strategies Assessment for Flooding Report," April 6, 2017, ADAMS Accession No. ML17096A766.

PG&E, 2017b,"Diablo Canyon Power Plant, Units 1 and 2, Plant Focused Evaluation Report for External Flooding," July 19, 2017, ADAMS Accession No. ML17200D161.

Ritter, D.F., 1986, *Process Geomorphology (2nd ed.)*, Dubuque, W. C. Brown, 1986.

SCS (Soil Conservation Service), 1986, "Urban Hydrology for Small Watersheds," Technical Release 55, Soil Conservation Service, U.S. Department of Agriculture, June 1986.

Shi, F., J.T. Kirby, and B. Tehranirad, 2012, "Tsunami Benchmark Results for Spherical Coordinate Version of FUNWAVE-TVD (Version 1.1)," University of Delaware, Newark, Center for Applied Coastal Research, Research Report No. CACR-12-02, 2012.

Synder, F.F., 1938, "Synthetic unit-graphs," *Eos, Transaction American Geophysical Union*, 19(1):447–454, August 1938.

Taylor Engineering, Inc., 2017. "Technical Evaluation Report Diablo Canyon Nuclear Power Plant Hazard Reevaluation Review," November 2017, ADAMS Accession No. ML17341A065. [Prepared for the U.S. Nuclear Regulatory Commission.]

USACE (U.S. Army Corps of Engineers), 2008, "Coastal Engineering Manual," Engineer Manual 1110-2-1100, Department of Army, 6 vols. August 2008. [Available online at http://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/u43544q/436F617374616C/.]

USACE, 2010a, *HEC-RAS River Analysis System, Hydraulic Reference Manual*, Report No. CPD-69, Version 4.1, USACE Hydrologic Engineering Center, January 2010, available online at http://www.hec.usace.army.mil/software/hec-ras/.

USACE, 2010b, *HEC-HMS Hydrologic Modeling System*, User's Manual, Version 3.5, USACE Hydrologic Engineering Center, August 2010, available online at http://www.hec.usace.army.mil/software/hec-hms/.

USACE, 2013, *HEC-GeoRAS,* Version 10.1, February 2013, available at http://www.hec.usace.army.mil/software/hec-georas/.

USACE, 2016a, "Ice Jam Database," U.S. Army Corps of Engineers, Cold Region Research and Engineering Laboratory (CRREL), available online at http://icejams.crrel.usace.army.mil/.

USACE, 2016b, "National Inventory of Dams," available online at http://nid.usace.army.mil.
USBR (U.S. Bureau of Reclamation), 1982, "Guidelines for Defining Inundated Areas Downstream from Bureau of Reclamation Dams," U.S. Department of the Interior, Denver, Colorado, June 1982.

USBR, 1983," Guidelines for Defining Inundated Areas Downstream from Bureau of Reclamation Dam," Reclamation Planning Instruction No. 83-05, U.S. Department of Interior, U.S. Bureau of Reclamation, Denver, Colorado, April 6, 1983.

USBR, 1992, "Flood Hydrology Manual A Water Resource Technical Publication," U.S. Department of the Interior, Denver, Colorado, 1992, available at https://www.usbr.gov/tsc/techreferences/mands/mands-pdfs/FloodHyd.pdf.

USGS (U.S. Geological Survey), 2016, "The National Map: Historical Topographic Map Collection," available at http://geonames.usgs.gov/apex/f?p=262:1:0.

Table 2.2-1. Flood-Causing Mechanisms and Corresponding Guidance

Flood-Causing Mechanism	SRP Section(s) and JLD-ISG
Local Intense Precipitation and Associated Drainage	SRP 2.4.2 SRP 2.4.3
Streams and Rivers	SRP 2.4.2 SRP 2.4.3
Failure of Dams and Onsite Water Control and Storage Structures	SRP 2.4.4 JLD-ISG-2013-01
Storm Surge	SRP 2.4.5 JLD-ISG-2012-06
Seiche	SRP 2.4.5 JLD-ISG-2012-06
Tsunami	SRP 2.4.6 JLD-ISG-2012-06
Ice-Induced	SRP 2.4.7
Channel Migrations or Diversions	SRP 2.4.9

Sources: NRC, 2007; NRC, 2013a; NRC 2013b

Notes:

SRP refers to the “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition”

JLD-ISG-2012-06 is the “Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment”

JLD-ISFG-2013-01 is the “Guidance for Assessment of Flooding Hazards Due to Dam Failure”

Table 3.1-1. Summary of Flood-Causing Mechanisms at the Diablo Canyon Site

Reevaluated Flood-Causing Mechanisms that May Exceed the Powerblock Elevation [87.9 ft]) [1]	Elevation[2] (NAVD88)
Local Intense Precipitation and Associated Drainage *(across powerblock yard, north to south)*	87.9 to 117.9 ft

Source: PG&E, 2016b

Notes:
[1]Average site grade. "Flood height" and "associated effects" as defined in JLD-ISG-2012-05 (NRC, 2012c).
[2] Elevation reported includes wind wave/run-up effects, if applicable to hazard.

Table 3.1-2. Current Design Basis Flood Hazard Elevations at the Diablo Canyon Site

Flood-Causing Mechanism	Stillwater Elevation (NAVD88)	Waves/ Run-up	Design Basis Hazard Elevation (NAVD88)	Reference
Local Intense Precipitation and Associated Drainage	No Impact to the Site Identified	No Impact to the Site Identified	No Impact to the Site Identified	FHRR Section 2.3.2.1
Streams and Rivers *Diablo Creek*	81.9 ft	Not Applicable	81.9 ft	FHRR Section 2.3.2.2
Failure of Dams and Onsite Water Control/ Storage Structures	No Impact to the Site Identified	No Impact to the Site Identified	No Impact to the Site Identified	FHRR Section 2.3.2.3
Storm Surge	No Impact to the Site Identified	No Impact to the Site Identified	No Impact to the Site Identified	FHRR Section 2.3.2.4
Seiche	No Impact to the Site Identified	No Impact to the Site Identified	No Impact to the Site Identified	FHRR Section 2.3.2.5
Tsunami *Distantly-Generated Tsunamis*	20.0 ft	10.3 ft	30.3 ft	FHRR Section 2.3.2.6.1 FHRR Section 2.3.2.13
Near-Shore Tsunamis	9.2 ft	25.7 ft	34.9 ft	FHRR Section 2.3.2.6.2 FHRR Section 2.3.2.13
Ice-Induced	No Impact to the Site Identified	No Impact to the Site Identified	No Impact to the Site Identified	FHRR Section 2.3.2.7
Channel Migrations or Diversions	No Impact to the Site Identified	No Impact to the Site Identified	No Impact to the Site Identified	Section 2.3.2.8

Source: NRC, 2016b

Table 3.2-1. Maximum Flood Elevations near the Access Doors within the Diablo Canyon Powerblock Area due to Local Intense Precipitation

Building Area	Door/Unit No	Grid Elevation (NAVD88)	Door Elevation (NAVD88)	Inundation Depth	Max WSE (NAVD88)[1]
Unit 1 (North)					
A-2	A2.1	87.2 ft	87.2 ft	0.2 ft	87.4 ft
	BU101	87.2 ft	87.2 ft	0.1 ft	87.3 ft
A3	BU102	87.2 ft	87.2 ft	0.2 ft	87.4 ft
	BU103	87.1 ft	87.2 ft	0.2 ft	87.3 ft
	A3.1	87.1 ft	87.2 ft	0.3 ft	87.4 ft
	A3.2	87.2 ft	87.2 ft	0.2 ft	87.4 ft
	A3.3	87.1 ft	87.2 ft	0.2 ft	87.3 ft
	BU104/5	87.2 ft	87.2 ft	0.2 ft	87.3 ft
Auxiliary Building Area	192-1	87.5 ft	87.5 ft	0.7 ft	88.2 ft
	191-1	87.5 ft	87.5 ft	0.6 ft	88.0 ft
	194-1	87.5 ft	87.5 ft	0.6 ft	88.0 ft
N/A	101-1	87.5 ft	87.5 ft	0.2 ft	87.7 ft
	102-1	87.4 ft	87.5 ft	0.3 ft	87.7 ft
	119-1	87.5 ft	87.5 ft	0.5 ft	87.9 ft
	122-1	87.5 ft	87.5 ft	0.7 ft	88.1 ft

Table 3.2-1. Maximum Flood Elevations near the Access Doors within the Diablo Canyon Powerblock Area due to Local Intense Precipitation (cont.)

Building Area	Door/Unit No	Grid Elevation (NAVD88)	Door Elevation (NAVD88)	Inundation Depth	Max WSE (NAVD88)[1]
Unit 1 (North)					
Fuel Handling Building	363-1	117.5 ft	117.5 ft	0.1 ft	117.6 ft
	361-1	117.5 ft	117.5 ft	0.4 ft	117.9 ft
	360-1	117.5 ft	117.5 ft	0.4 ft	117.9 ft
	355-1	117.5 ft	117.5 ft	0.5 ft	117.9 ft
	354-1	117.5 ft	117.5 ft	0.5 ft	117.9 ft
C	C1-1	87.5 ft	87.5 ft	0.2 ft	87.6 ft
	129	87.5 ft	87.5 ft	0.1 ft	87.6 ft
	130	87.5 ft	87.5 ft	0.1 ft	87.5 ft
Unit 2 (South)					
C	C1.2	87.5 ft	87.5 ft	0.3 ft	87.7 ft
B2	BUD108-2	87.2 ft	87.2 ft	0.2 ft	87.3 ft
	BUD105-2	87.2 ft	87.2 ft	0.1 ft	87.3 ft
	BUD106-2	87.3 ft	87.4 ft	0.2 ft	87.5 ft
	B2.1	87.5 ft	87.5 ft	0.1 ft	87.6 ft

Table 3.2-1. Maximum Flood Elevations near the Access Doors within the Diablo Canyon Powerblock Area due to Local Intense Precipitation (cont.)

Building Area	Door/Unit No	Grid Elevation (NAVD88)	Door Elevation (NAVD88)	Inundation Depth	Max WSE (NAVD88)[1]
B1	B1.1	87.5 ft	87.5 ft	0.1 ft	87.6 ft
	B1.2	87.5 ft	87.5 ft	0.1 ft	87.6 ft
Auxiliary Building Area	192-2	87.5 ft	87.5 ft	0.6 ft	88.1 ft
	191-2/191A-2	87.5 ft	87.5 ft	0.5 ft	88.0 ft
	194-2	87.4 ft	87.5 ft	0.5 ft	87.9 ft
Fuel Handling Building	360-2	117.5 ft	117.4 ft	0.5 ft	117.9 ft
	361-2	117.5 ft	117.4 ft	0.5 ft	117.9 ft
	363-2	117.5 ft	117.5 ft	0.0 ft	117.5 ft
N/A	101-2	87.5 ft	87.5 ft	0.4 ft	87.8 ft
	102-2	87.4 ft	87.5 ft	0.3 ft	87.8 ft
	119-2	87.5 ft	87.5 ft	0.5 ft	88.0 ft
	122-2	87.5 ft	87.5 ft	0.5 ft	88.0 ft

Source: PG&E, 2016b

Notes

[1] Maximum water surface elevation (WSE) is the sum of the grid elevation and inundation depth estimates. The maximum WSE reported may reflect rounding errors as a result of the summation process.

Table 3.3-1. Characteristics of Diablo Creek HEC-RAS Modeling Segments in Relation to the Diablo Canyon Nuclear Power Plant

Diablo Creek HEC-RAS Modeling Segment	Associated Site Feature	Elevation (NAVD88)	HEC-RAS Modeling Station Location
Lower Reach	Powerblock	< 105 ft	16+67 (ft)
Middle Reach	RWSRS, 230 kV switchyard	200 to 250 ft	19+29 to 26+96 (ft)
Upper Reach	500 kV switchyard	+250 ft	27+70 to 61+92 (ft)

Sources: PG&E, 2013a; PG&E 2016b

Table 3.3-2. Licensee Estimates of Freeboard on Diablo Creek in Relation to the Diablo Canyon Nuclear Power Plant Elevation Based on HEC-RAS Riverine Analysis

Diablo Creek HEC-RAS Modeling Segment	Associated Site Feature	Licensee's Relative Freeboard Estimate
Lower Reach	Powerblock	+9.3 to +200 ft
Middle Reach	RWSRs and the 230 kV switchyard	+1.6 to +91 ft (for main branch) -2.0 to +57.2 ft (for smaller branch)
Upper Reach	500 kV switchyard	+0.7 to +29 ft

Source: PG&E, 2013a: PG&E, 2016b

Table 3.4-1. Summary of Independent Analysis of a Hypothetical Dam Failure on Diablo Creek Based on Different Values of Manning's Coefficient '*n*'

HEC-RAS Cross-Section Location[1]	Associated Site Feature		Minimum HEC-RAS Channel Elevation	*n* = 0.025		*n* = 0.035	
	Description	Estimated Grade Elevation (A)		NRC Staff Estimated Elevation (B)	Estimated Freeboard (B - A)	NRC Staff Estimated Elevation (C)	Estimated Freeboard (C - A)
9+59	Warehouse 'A'[2]	105 ft	82.0 ft	107.3 ft	-2.3 ft +1.3 ft[3]	109 ft	-4.0 ft -1.0 ft[3]
7+74	Powerblock[4]	94 ft	65.0 ft	86.8 ft	+7.2 ft	88.3 ft	+5.7 ft
5+90	Powerblock	85 ft	47.3 ft	75.5 ft	+9.5 ft	77.3 ft	+7.7 ft
4+94	Powerblock	85 ft	44.0 ft	75.1 ft	+9.9 ft	77.3 ft	+7.7 ft

Notes:

[1] Station numbers refer to the HEC-RAS cross-section locations used by the licensee in the streams and rivers PMF analysis. For example, Station 14+23 refers to a horizontal location 1,423 ft upstream on the Diablo Canyon creek.

[2] Warehouse "A" structure is not considered by the licensee to be a building that is "important to safety."

[3] Elevation reflects consideration of the VBS located between the Warehouse 'A' and the Diablo Creek floodplain.

[4] Powerblock contains buildings and other structures designated "important to safety."

Table 3.7-1. Summary of Parameters Selected for the NRC Staff's Independent Probable Maximum Tsunami Assessment at the Diablo Canyon Site

Source	Location	Parameters	Expected Recurrence Period	Run-up Near Diablo Canyon ASW	
				Maximum	Minimum
Earthquake Generated (distant and local)	Aleutian Arc source produces largest tsunami at site	Earthquake Magnitude = Mw 9.6 Initial tsunami condition generated using standard Okada (1985) model	>10,000 yrs. According to published literature, the largest earthquake that could occur along this subduction zone	+34.7 ft (MSL) +37.6 ft (NAVD88)	-18.0 ft (MSL) -15.1 ft (NAVD88)
Distant Landslide	Flank collapse of Kilauea Volcano (Hawaii) produces largest tsunami at site	Subaerial landslide with an estimated displaced volume of ~1000 km^3. Slide failure and subsequent tsunami modeled using a 3D multi-material mechanics model	>100,000 yrs; Last known similar event ~120,000 yrs ago; this analysis assumes an unlikely coherent slide	+23.0 ft (MSL) +25.9 ft (NAVD88)	-10.8 ft (MSL) -7.9 ft (NAVD88)
Local Landslide	Goleta-type landslide, occurring near the site judged to produce largest tsunami	Submerged landslide with a volume of 1.5 km^3 for entire complex; note that this volume corresponds to the sum of three different landslides, or lobes, in the same complex, which have different dates. Slide failure and generated tsunami modeled with 3D multi-material mechanics model	>100,000 yrs; Ages for the different Goleta lobes range from 6,000 to 160,000 yrs. Location in the region offshore of Diablo Canyon treated stochastically; design slide corresponds to the combined Goleta volume placed in an offshore location that yields the 90^{th} percentile tsunami elevation	+44.8 ft (MSL) +47.7 ft (NAVD88)	-7.2 ft (MSL) -4.3 ft (NAVD88)

Source: Taylor Engineering, 2017

Table 3.7-2. Comparison of Diablo Canyon Design-Basis Parameters to FHRR and Independent NRC Probable Maximum Tsunami Analysis

PMT Parameter	Current Design Basis (Not to be exceeded)[1]	PG&E FHRR[1]	Independent NRC Analysis[2]
Maximum Elevation near ASW	45.6 ft MSL (48.5 ft NAVD88)	29.9 ft MSL (32.8 ft NAVD88) due to a local Goleta-like submarine mass failure	44.8 ft MSL (47.7 ft NAVD88) due to a local Goleta-like submarine mass failure
Minimum Elevation near ASW	-20.0 ft MSL (-17.1 ft NAVD88)	-18.6 ft MSL (-15.7 ft NAVD88) due to a local Goleta-like submarine mass failure	-18.0 ft MSL (-15.1 ft NAVD88) due to a distant earthquake along the Aleutian Archipelago
Maximum Speed and Duration of Tsunami Currents	Not directly applicable; proxy through debris impact loading	82 ft/s (for a few seconds) due to a local Goleta-like submarine mass failure	44.3 ft/s (for 30 seconds) due to a local Goleta-like submarine mass failure

Sources:

[1] PG&E, 2016b
[2] Taylor Engineering, 2017

Table 4.1-1. Reevaluated Hazard Elevations for Flood-Causing Mechanisms Not Bounded by the CDB: Local Intense Precipitation[1]

Building Area	Door/Unit No[2]	Stillwater Elevation (NAVD88)	Waves/ Run-up	Reevaluated Hazard Elevation (NAVD88)	Reference
Unit 1 (North)					
A-2	A2.1	87.4 ft	Minimal	87.4 ft	FHRR Enclosure 1, Table 3-5
	BU101	87.3 ft	Minimal	87.3 ft	
A3	BU102	87.4 ft	Minimal	87.4 ft	
	BU103	87.3 ft	Minimal	87.3 ft	
	A3.1	87.4 ft	Minimal	87.4 ft	
	A3.2	87.4 ft	Minimal	87.4 ft	
	A3.3	87.3 ft	Minimal	87.3 ft	
	BU104/5	87.3 ft	Minimal	87.3 ft	
Auxiliary Building Area	192-1	88.2 ft	Minimal	88.2 ft	
	191-1	88.0 ft	Minimal	88.0 ft	
	194-1	88.0 ft	Minimal	88.0 ft	
N/A	101-1	87.7 ft	Minimal	87.7 ft	
	102-1	87.7 ft	Minimal	87.7 ft	
	119-1	87.9 ft	Minimal	87.9 ft	
	122-1	88.1 ft	Minimal	88.1 ft	

Table 4.1-1. Reevaluated Hazard Elevations for Flood-Causing Mechanisms Not Bounded by the CDB: Local Intense Precipitation[1] (cont.)

Building Area	Door/Unit No[2]	Stillwater Elevation (NAVD88)	Waves/ Run-up	Reevaluated Hazard Elevation (NAVD88)	Reference
Fuel Handling Building	363-1	117.6 ft	Minimal	117.6 ft	FHRR Enclosure 1, Table 3-5
	361-1	117.9 ft	Minimal	117.9 ft	
	360-1	117.9 ft	Minimal	117.9 ft	
	355-1	117.9 ft	Minimal	117.9 ft	
	354-1	117.9 ft	Minimal	117.9 ft	
C	C1-1	87.6 ft	Minimal	87.6 ft	
	129	87.6 ft	Minimal	87.6 ft	
	130	87.5 ft	Minimal	87.5 ft	
Unit 2 (South)					
C	C1.2	87.7 ft	Minimal	87.7 ft	FHRR Enclosure 1, Table 3-5
B2	BUD108-2	87.3 ft	Minimal	87.3 ft	
	BUD105-2	87.3 ft	Minimal	87.3 ft	
	BUD106-2	87.5 ft	Minimal	87.5 ft	
	B2.1	87.6 ft	Minimal	87.6 ft	

Table 4.1-1. Reevaluated Hazard Elevations for Flood-Causing Mechanisms Not Bounded by the CDB: Local Intense Precipitation[1] (cont.)

Building Area	Door/Unit No[2]	Stillwater Elevation (NAVD88)	Waves/ Run-up	Reevaluated Hazard Elevation (NAVD88)	Reference
B1	B1.1	87.6 ft	Minimal	87.6 ft	FHRR Enclosure 1, Table 3-5
	B1.2	87.6 ft	Minimal	87.6 ft	
Auxiliary Building Area	192-2	88.1 ft	Minimal	88.1 ft	
	191-2/191A-2	88.0 ft	Minimal	88.0 ft	
	194-2	87.9 ft	Minimal	87.9 ft	
Fuel Handling Area	360-2	117.9 ft	Minimal	117.9 ft	
	361-2	117.9 ft	Minimal	117.9 ft	
	363-2	117.5 ft	Minimal	117.5 ft	
N/A	101-2	87.8 ft	Minimal	87.8 ft	
	102-2	87.8 ft	Minimal	87.8 ft	
	119-2	87.9 ft	Minimal	87.9 ft	
	122-2	88.0 ft	Minimal	88.0 ft	

Source: NRC, 2016b

Notes:

[1] Reevaluated hazard mechanisms bounded by the CDB (see Table 3.1-1) are not included in this table.

[2] Some of these locations are depicted in Figures 3.2-3 and 3.2-4

Table 4.2-1. Flood Event Duration for Flood-Causing Mechanisms Not Bounded by the CDB at the Diablo Canyon Site

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site[1]	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	Not Provided	< 7.6-h	Minimal

Source: PG&E, 2016b

Note:

[1] Reflects the maximum inundation duration (see Table 4.2-2) for those door locations identified in Table 4.1-1.

Table 4.2-2. Period of Inundation due to due to Local Intense Precipitation at the Diablo Canyon Site[1]

Building Area	Door/Unit No.	Flood Duration (h)
Unit 1 (North)		
A2	A2.1	7.6
	BU101	6.9
A3	BU102	3.3
	BU103	0.6
	A3.1	2.8
	A3.2	3.1
	A3.3	0.5
	BU104/5	3.2
Auxiliary Building Area	192-1	7.0
	191-1	6.8
	194-1	5.2
N/A	101-1	7.1
	102-1	0.6
	119-1	6.7
	122-1	5.1
Fuel Handling Building	363-1	6.5
	361-1	6.0
	360-1	7.2
	355-1	3.8
	354-1	7.1
C	C1-1	4.5
	129	6.8
	130	3.0

Table 4.2-2. Period of Inundation Due to due to Local Intense Precipitation at the Diablo Canyon Site[1] (cont.)

Building Area	Door/Unit No.	Flood Duration (h)
Unit 2 (South)		
C	C1.2	5.3
B2	BUD108-2	3.8
	BUD105-2	6.4
	BUD106-2	2.9
	B2.1	3.2
B1	B1.1	0.4
	B1.2	7.4
Auxiliary Building Area	192-2	6.9
	191-2/191A-2	6.5
	194-2	1.3
Fuel Handling Building	360-2	5.7
	361-2	5.3
	363-2	6.4
N/A	101-2	4.4
	102-2	6.8
	119-2	7.1
	122-2	6.6

Source: PG&E, 2016a

Notes:
[1] Some of these locations are depicted in Figures 3.2-3 and 3.2-4.

Table 4.3-1. Associated Effects Parameters Not Directly Associated with Total Water Surface Elevation for Flood-Causing Mechanisms Not Bounded by the CDB at the Diablo Canyon Site[1]

POWERBLOCK LOCATION	MAXIMUM FLOW DEPTH	MAXIMUM VELOCITY	MAXIMUM HYDROSTATIC LOAD	MAXIMUM HYDRODYNAMIC LOAD	DEBRIS LOADING EFFECTS	SEDIMENT LOADING EFFECTS
Local Intense Precipitation and Associated Drainage						
Unit 1 Turbine Building	< 0.58 ft	< 0.32 ft/s	< 36.10 lb/ft^2	< 0.20 lb/ft^2	Minimal	Minimal
Unit 2 Turbine Building	< 0.83 ft	< 0.64 ft/s	< 51.79 lb/ft^2	< 0.79 lb/ft^2	Minimal	Minimal
Unit 1 Auxiliary Building	< 0.48 ft	< 0.80 ft/s	< 29.95 lb/ft^2	< 1.24 lb/ft^2	Minimal	Minimal
Unit 2 Auxiliary Building	< 0.69 ft	< 1.02 ft/s	< 43.06 lb/ft^2	< 2.02 lb/ft^2	Minimal	Minimal
Unit 1 Fuel Handling Building	< 0.28 ft	< 0.32 ft/s	< 2.45 lb/ft^2	< 0.28 lb/ft^2	Minimal	Minimal
Unit 2 Fuel Handling Building	< 0.39 ft	< 0.16 ft/s	< 23.34 lb/ft^2	< 0.05 lb/ft^2	Minimal	Minimal

Source: PG&E, 2016b

Notes:
[1] Maxima reported for each parameter might not occur at the same location for a particular structure.

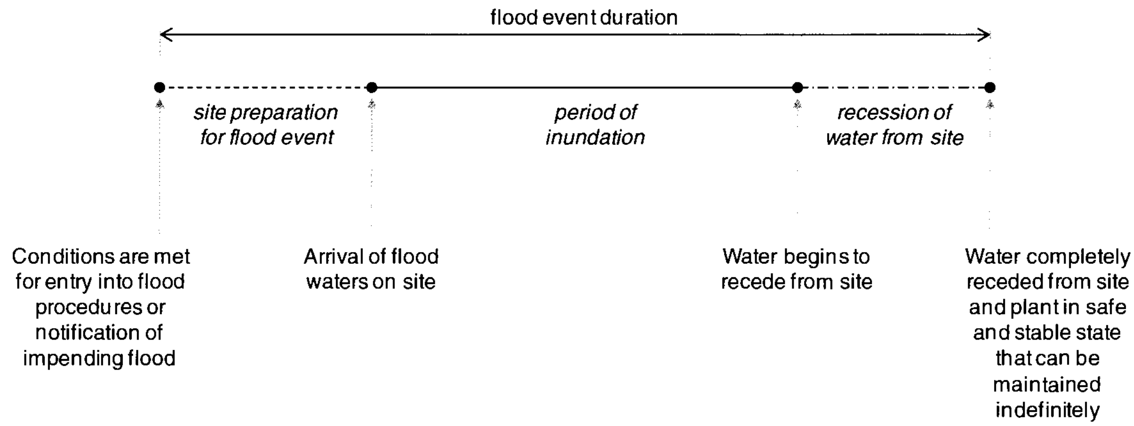

Figure 2.2-1 Flood Event Duration (NRC, 2012d)

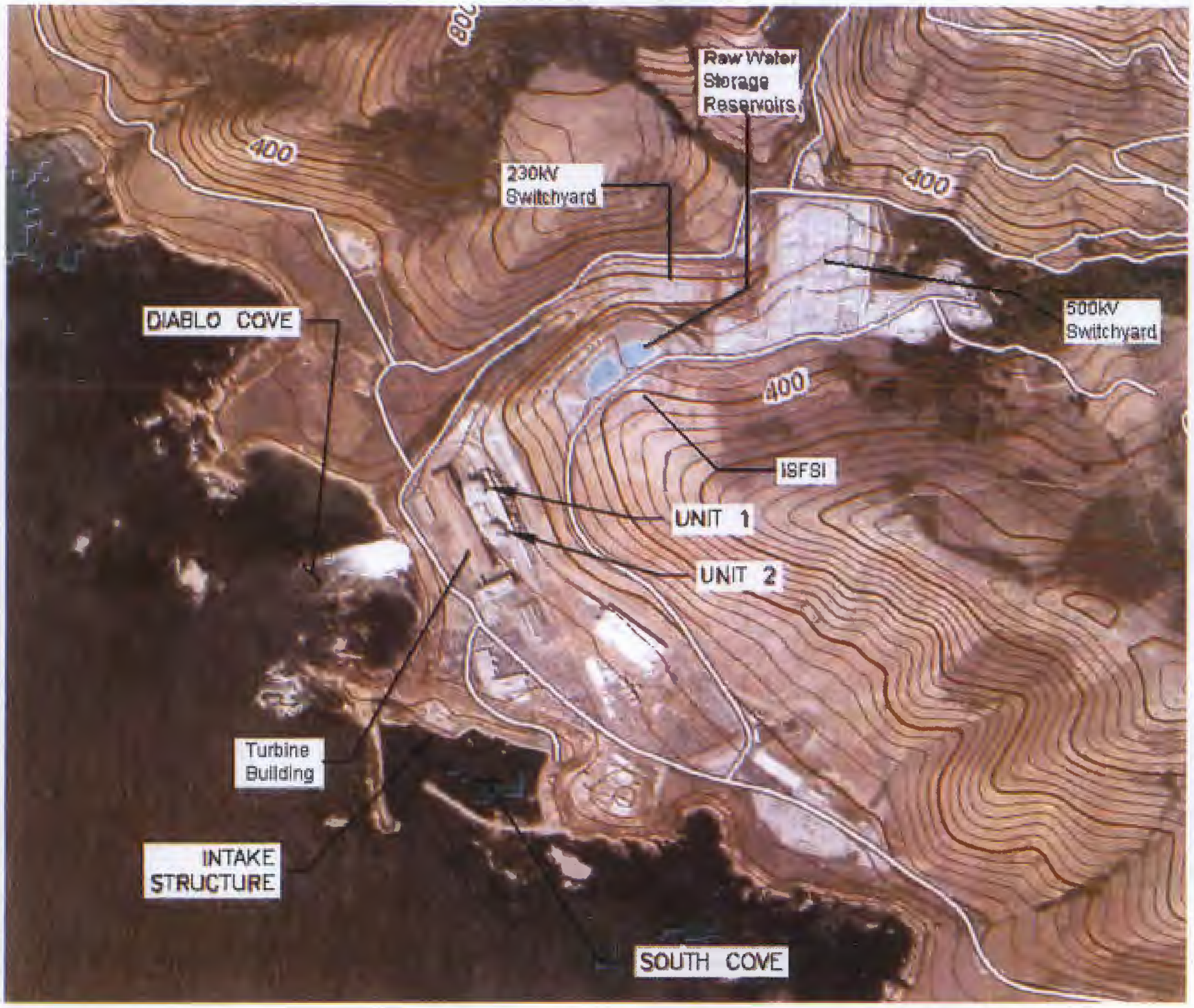

Figure 3.1-1. Key Hydrologic Features of Interest at the Diablo Canyon Site in Relation to Important Power Reactor Features and Topography (PG&E, 2016b)

Figure 3.2-1. Computational Domain for the Diablo Canyon LIP FLO-2D Analysis (PG&E, 2016a)

Figure 3.2-2. Computational Domain for the NRC Staff's Auxiliary LIP Analysis (Google, 2016)

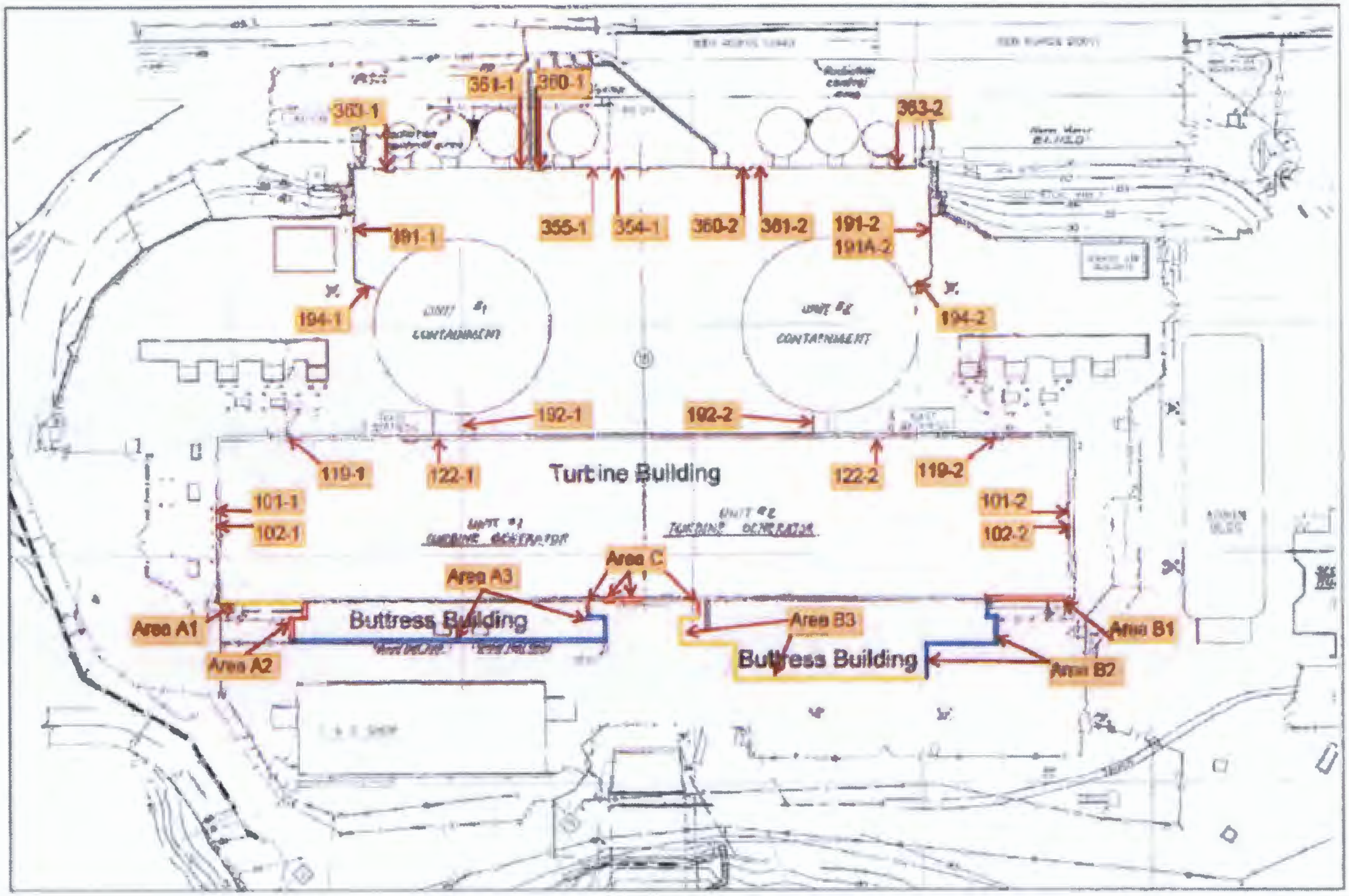

Figure 3.2-3. Location of Buildings and Facilities with Door Locations Identified for Monitoring of LIP Flood Hazards (PG&E, 2016a)

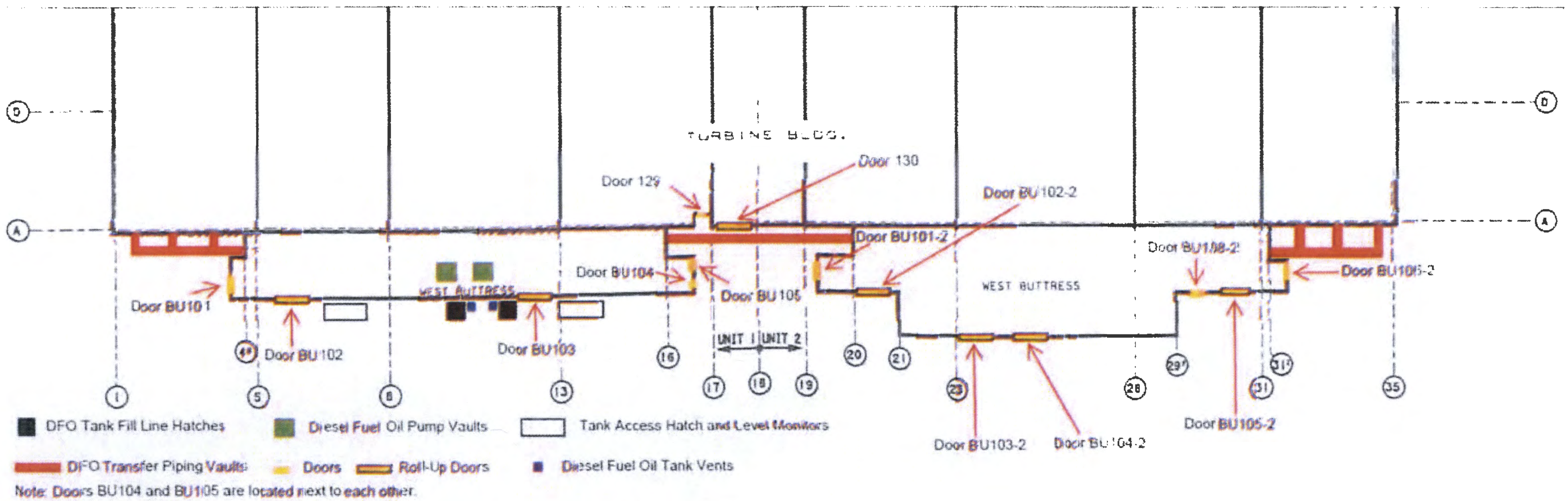

Figure 3.2-4. Turbine Building Door Locations Identified for Monitoring of LIP Flood Hazards (PG&E, 2016a)

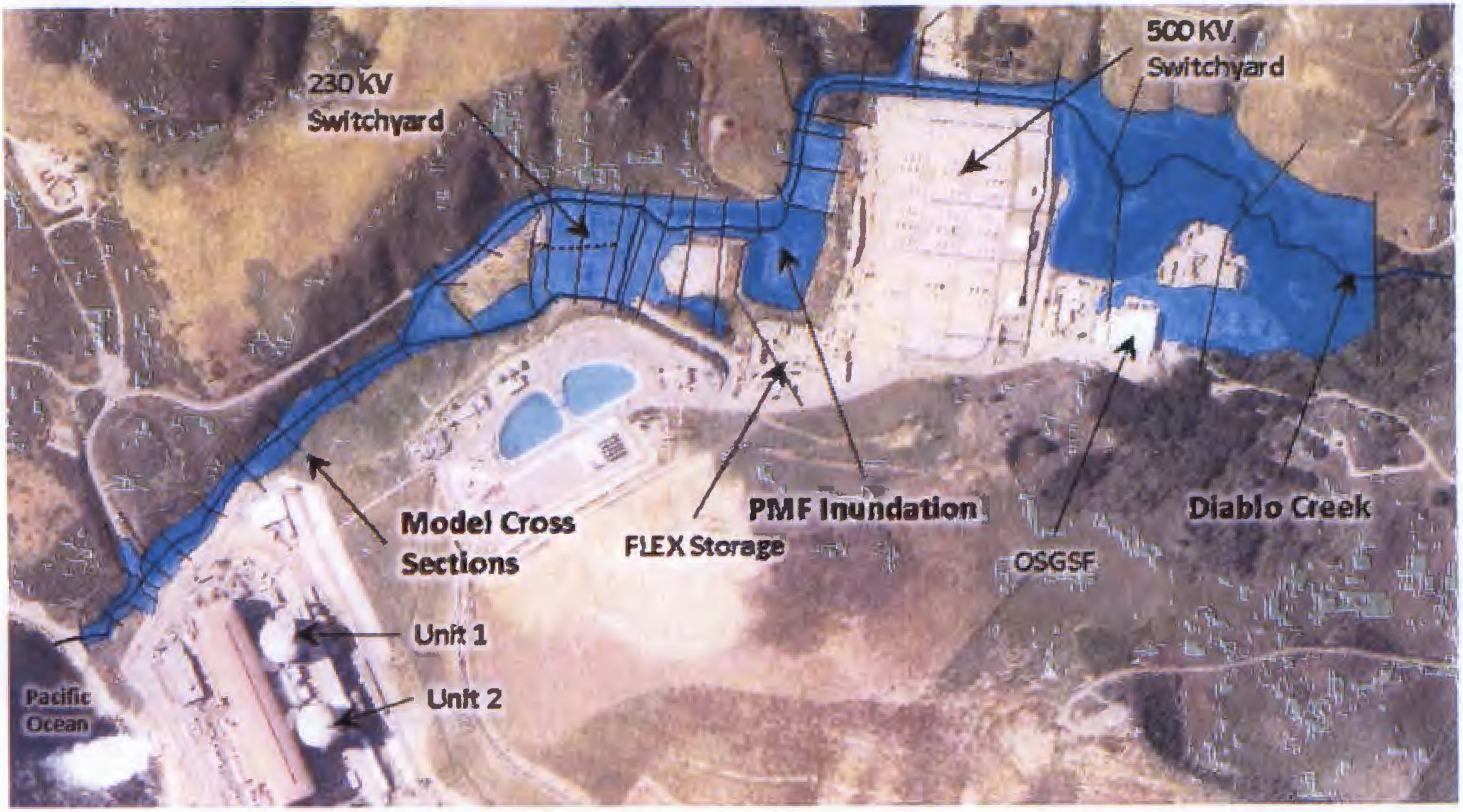

Figure 3.3-1. Extent of Inundation during the Riverine PMF (PG&E, 2016b)

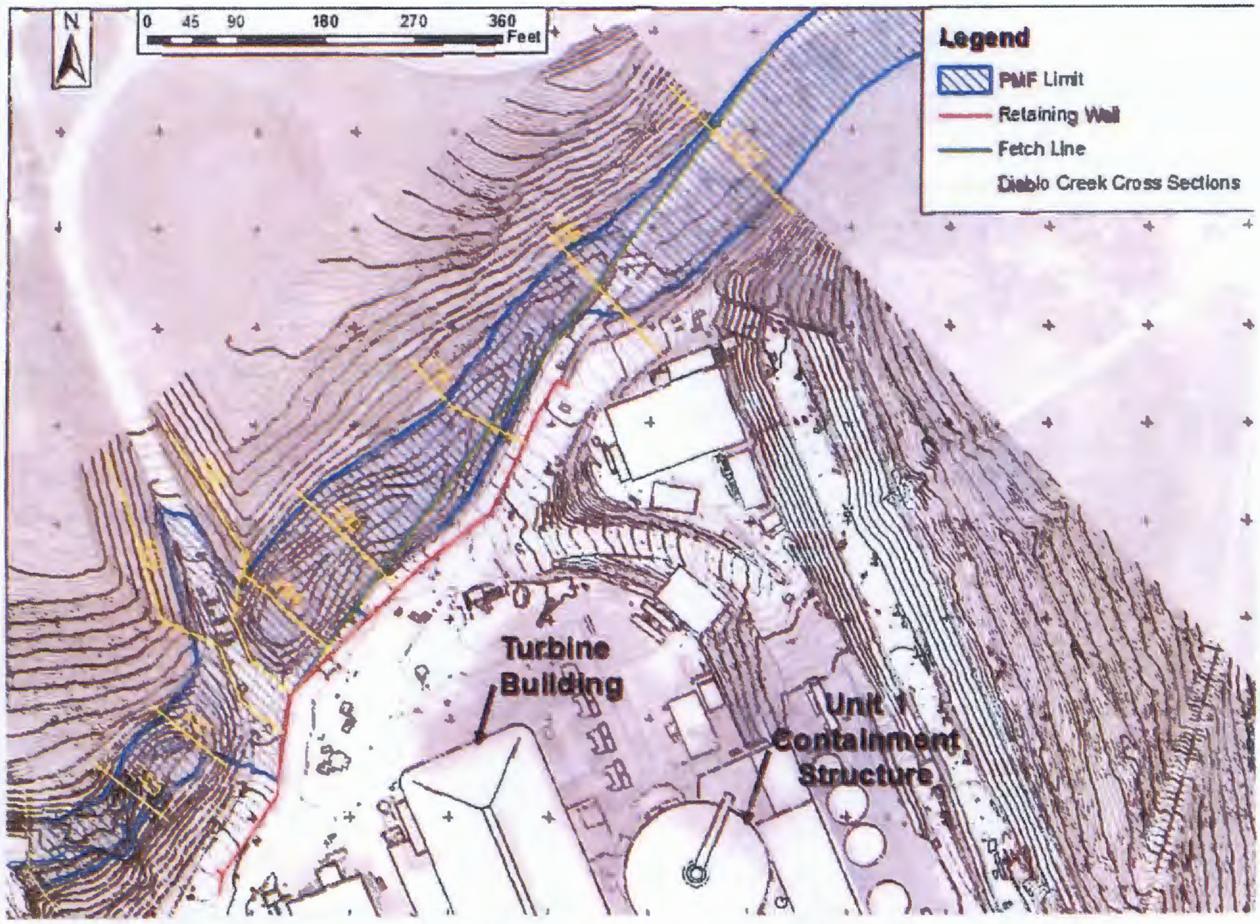

Figure 3.3-2. Critical Fetch Line for PMF Wind/Wave Analysis (PG&E, 2016b).

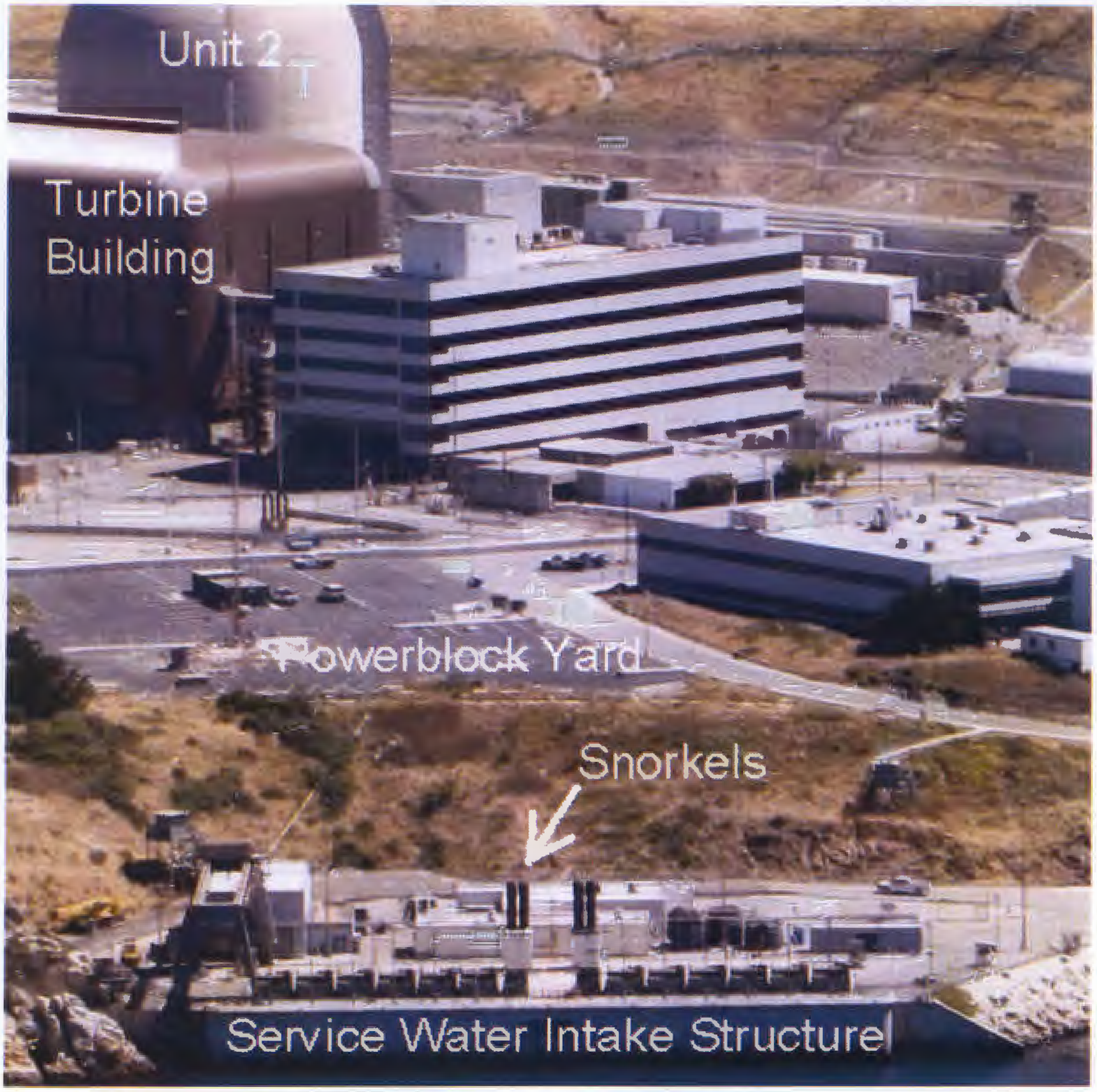

Figure 3.7-1. Key Diablo Canyon power plant structures and features shown in relation to the service water intake structure located within South Cove.

DIABLO CANYON POWER PLANT UNITS 1 AND 2 –STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION DATED December 18, 2017

DISTRIBUTION:

PUBLIC
RidsNroDsea Resource
MLee, NRO
RidsNrrPMDiabloCanyon
MShams, NRR
CCook, NRO
JThompson, NRO
RidsNrrDorlLpl4
JSebrosky, NRR
ACampbell, NRO

ADAMS Accession No.: ML17024A207 ***via email**

OFFICE	NRR/DLP/PBMB/PM	NRR/DLP/LA	NRO/DSEA/RHM/TR
NAME	JSebrosky	SLent	MLee*
DATE		1/25/17	12/12/17
OFFICE	NRO/DSEA/RHM/BC	NRR/DLP/PBMB/BC	NRR/DLP/PBMB/PM
NAME	CCook*	MShams	JSebrosky
DATE	12/13/17	12/11/17	12/18/17

OFFICIAL RECORD COPY