Pier 39 to 43.5 Sediment Remediation Project

San Francisco, San Francisco County, California

UNDERWATER NOISE MONITORING PLAN

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Introduction

Pacific Gas and Electric (PG&E) proposes to conduct a Sediment Remediation Project associated with Piers 39 to 43½. The sediment remediation area encompasses Pier 39, both the Pier 39 East and West Basins, and the intertidal and subtidal area between Pier 39 and Pier 43½, located along the margin of San Francisco Bay in the City and County of San Francisco, California (Figure 1).

The purpose of the project is to remediate (i.e., clean up) sediments impacted (i.e., contaminated) with polycyclic aromatic hydrocarbons (PAHs), likely attributable to the operations from the former Beach Street Manufactured Gas Plant, within the project area, to protect human health and the environment. The approved remedy will include a combination of dredging and capping and/or armoring the impacted sediments to minimize or reduce exposure to the impacted sediment and provide erosion protection measures to mitigate scour caused by ferry, and boat traffic and other foreseeable hydrodynamic forces, coupled with monitoring and institutional controls. In addition, the project requires the removal and installation of multiple piles and slope stabilization pins to ensure slope integrity during a seismic event.

Underwater Sound-Generating Activities

There are several noise sources associated with the project with the primary source of underwater sound being the various pile driving activities. The area of remediation at the Site is divided into the following five remedial response areas:

- Area A – Pier 43½ offshore area and western limit of the remedial response areas to the east of Pier 45.
- Area B – Pier 43 offshore area.
- Area C – Pier 41½ offshore area (Area C2) and the area under Pier 41½ (Area C1).
- Area D – Pier 39 West Basin; and
- Area E – Pier 39 East Basin and eastern limit of the remedial response areas.

Work within these response areas would include the following:

A. **Dredging** - Impacted sediment would be removed using mechanical dredges, operated primarily from water-based equipment consisting of a barge-mounted crane or excavator, typically outfitted with an environmental clamshell bucket, modified excavation bucket, or conventional excavation bucket, based on the material type being dredged. Diver-assisted micro (hydraulic) dredging, and/or manual labor could be used to perform removal in areas beneath docks, piers, or wharves that are inaccessible to water-based mechanical dredge equipment.

B. **Capping** - After debris removal and dredging is complete, impacted sediment left in place would be physically/chemically isolated through the placement of a cap and/or armor layer where necessary to protect against erosion (scour) caused by ferry and boat traffic and other foreseeable operational uses.

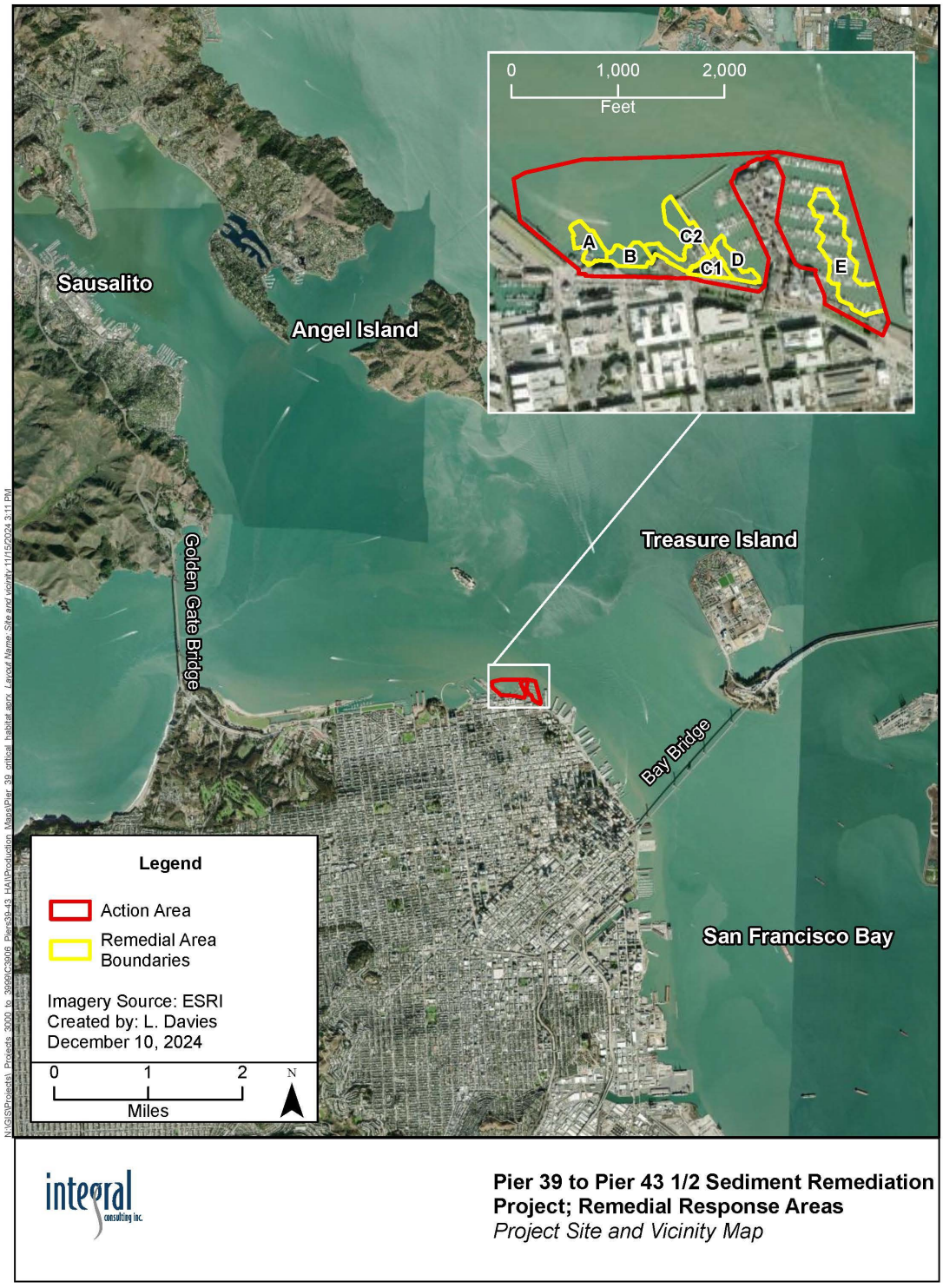

Figure 1- Project Location and Vicinity Map

Cap and armor material options include granular cap media (e.g., sand or rock), bay mud, and/or beneficial reuse of clean dredge materials from the Bay, which is generally a mixture of bay mud and coarser grained sediments (silts and sands).

Cap materials will be placed using barge-mounted cranes or excavators, using broadcasting equipment (e.g., conveyors, impellers), or by pumping as a slurry, depending on access.

C. **Pile Driving** - The primary underwater noise generation will be from the removal and installation of various pile types. There are four project components where pile driving will be required. The first is for water quality and containment where steel H-piles or up to 24-inch diameter steel shell piles are expected to be driven at key locations to facilitate turbidity curtain configurations. The piles, along with temporary anchoring locations (such as an anchor barge), would allow for shifting curtain configurations as work progresses through each Area (see Table 1). These temporary piles will be removed upon completion of work each construction season. Piles may be installed, removed, and temporarily stored for eventual reuse. The second project component involving pile driving where existing docks will need to be removed, replaced, or temporarily relocated to allow the dredging and cap installation. Thirdly, slope stabilization may be necessary in certain areas of the Project. Soil pinning will be used to promote slope stability, where necessary. Soil pinning will include the installation of an array of approximately 16-inch diameter tapered piles (e.g., timber) at approximately 6-foot centers across the face of select areas. These permanent piles will be installed vertically to a depth of approximately 25 feet below the dredge surface elevation, using impact or vibratory methods, in a uniform array across the face of select dredge slopes. Finally, 18-inch composite plastic piles will be installed with an impact hammer (and removed) to gather hydroacoustic data.

D. **Relocation of Red and White Fleet -** Relocation of the Red and White Fleet will require removal of piles and overwater structures at the current existing location. Facilities will be reconstructed, in-kind adjacent to Pier 45E, south of the USS Pampanito. Reconstruction of the temporary berthing facility will require placement of approximately 18 coated steel pipe piles (10, 36-inch diameter guide piles and 8, 24-inch diameter fender piles). Piles will be installed using vibratory methods; if an impact hammer is required to seat piles work would be restricted to occur between June 1 and October 30.

Table 1 – Summary of Pile Installation Locations and Number of Piles

Description	Remedial Response Area					
	A	**B**	**C**	**D**	**E**	**TOTAL**
Hydroacoustic Data Collection Test Piles (temporary): 18-inch composite plastic piles	10	0	10	0	0	10
Turbidity Curtain Piles (temporary): Steel H-Pile or shell piles less than 24-inches in diameter	12	8	20	9	6	55
Sediment Pin Installation (permanent): 16-inch tapered timber or composite piles	120	0	120	310	325	875
Relocation of Red and White Fleet	18	0	0	0	0	18

Dredging and Capping Underwater Noise Levels from Construction

Underwater noise generated by dredging and capping activities originates primarily from the bucket, dredge equipment mechanisms, and sounds generated by the engine and propeller of the vessel. The active waterfront within the project limits supports extensive vessel traffic including the San Francisco Ferry (from Pier 41 with up to 16 trips a day), Red and White fleet (from Pier 43½ with up to 25 trips a day), and Blue and Gold fleet (from Piers 39 (West Basin) and Pier 41 with up to 21 trips a day). In addition, multiple other commercial industries operate vessels within the project limits.

Consistent with findings within the Biological Opinion issued for the Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS), proposed dredging and capping would not generate noise that would rise to levels that would result in hearing loss, physical injury, or mortality of listed fish. Noise generated by dredging operations may result in behavioral changes including startling, avoidance of the remedial response area in which dredging is occurring, or the departure of fish (including green sturgeon) from the immediate vicinity of the activity. As such, it is not expected that dredging and capping would generate noise levels that would result in take or would produce higher than typical background noise within the project limits.

Temporary Relocation of Red and White Fleet

Relocation of the Red and White Fleet would require removal of piles and overwater structures at the current existing location. Facilities would be reconstructed, in-kind adjacent to Pier 45E, south of the USS Pampanito. Reconstruction of the temporary berthing facility would require placement of approximately 18 coated steel pipe piles (10, 36-inch diameter guide piles and 8, 24-inch diameter fender piles). Piles would be installed using vibratory methods; if an impact hammer is required to seat piles work would be restricted to occur between June 1 and October 30. Impact hammering is anticipated to occur over relatively short durations that are estimated to include up to 400 pile strikes.

Acoustic Terms

Various acoustical terms are used in this report. Sound pressure is the instantaneous absolute positive or negative pressure and is presented in this report as a decibel (dB) referenced to 1 micro-Pascal (dB re: 1 µPa). While several noise metrics are used to describe sounds in the environment, the root-mean-square (RMS) sound pressure level is an appropriate descriptor to describe measured sounds from continuous and impulsive sounds but with different averaging time constants. The RMS sound pressure level is presented in dB re: 1 µPa and is averaged over a defined time period in a stated frequency range or band. The appropriate time period to average for the RMS computation varies by the type of sound (e.g., pulsed or continuous). The average sound level during the measurement period is also computed to be the equivalent average sound pressure level measured each second over the duration of the sound (L_{eq}). Sound Exposure Level (SEL) is proportionally equivalent to the time integral of the pressure squared and is also described in this report in terms of dB re: 1 μPa^2 sec over the duration of a sound event. The Peak sound pressure is the largest absolute value of the instantaneous sound pressure. Sounds are measured over the frequency range of 20 to 20,000 hertz (Hz).

Project Area

The Project Area consists of the Piers 39 to 43½ offshore sediment remediation area (Figure 1). The Project Area is located within the San Francisco North United States (U.S.) Geological Survey 7.5' topographic quadrangle (Section 28, Township 1 South, Range 5 West) (37.809666° N, 122.411817° W). The Port of San Francisco owns and manages the waterfront. The sediment remediation area encompasses Pier 39, both the Pier 39 East Basin and West Basin, and the intertidal and subtidal area between Pier 39 and Pier 43½ along the margin of the Bay in San Francisco, California. The sediment remediation area is divided into the following five remedial response areas:

- Area A – Pier 43½ offshore area and western limit of the remedial response areas to the east of Pier 45;
- Area B – Pier 43 offshore area which includes two subareas (B1 and B2);
- Area C – Pier 41½ offshore area (Area C2) and the area under Pier 41½ (Area C1);
- Area D – Pier 39 West Basin; and
- Area E – Pier 39 East Basin and eastern limit of the remedial response areas.

Remediation is proposed to occur in phases, over a 5- to 7-year period. Construction would proceed from west to east, where each remedial response area may be constructed in one year or less, except for Area E, which could take up to two years. Figures 2a-b show the five remedial response areas discussed above.

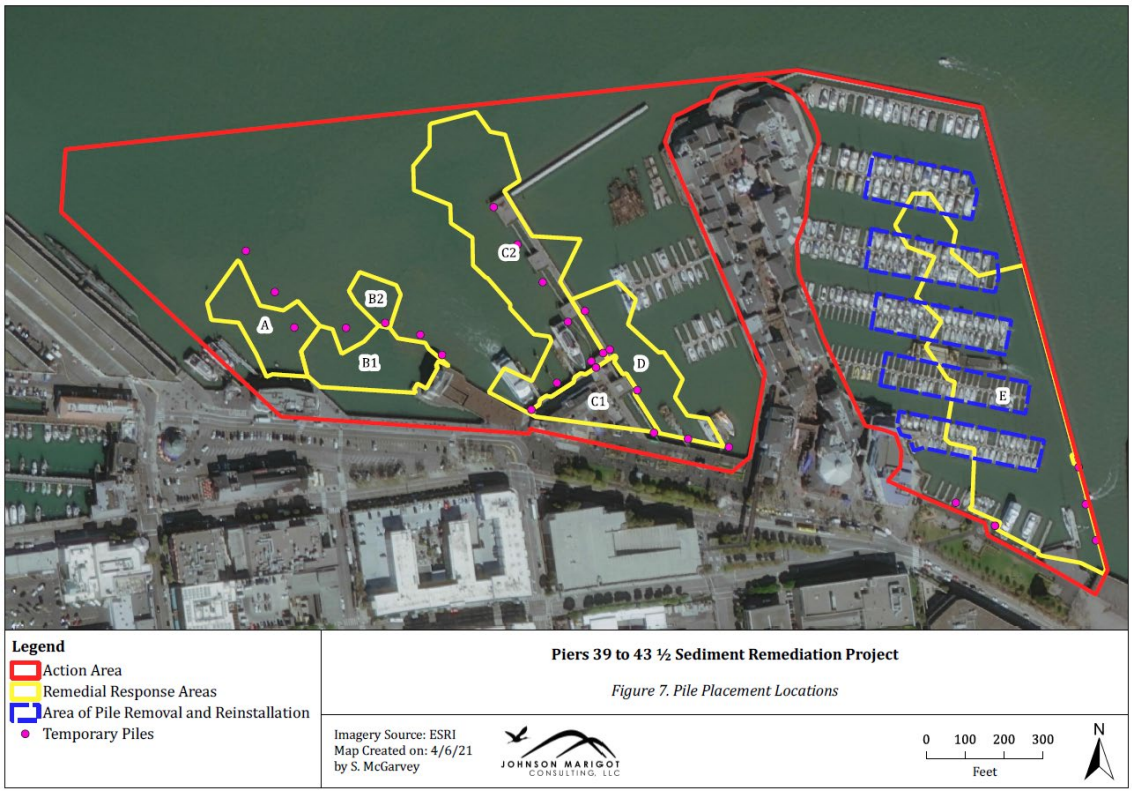

Figure 2a- Pile Placement Locations – Turbidity Curtain Piles

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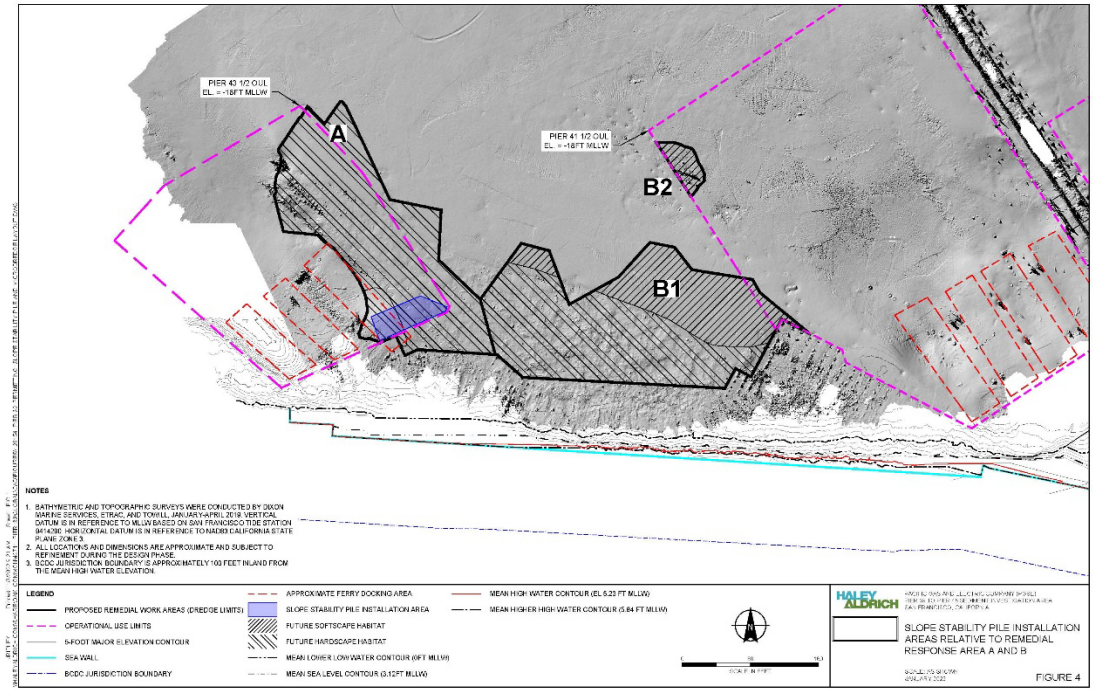

Figure 2b- Pile Placement Locations – Sediment Stabilization Pins

Hydroacoustic Monitoring Requirements

Project in-water construction activities are subject to permit conditions. Those conditions that require hydroacoustic monitoring and reporting are described in this section.

NMFS – Incidental Harassment Authorization

On January 30, 2024, NMFS issued an incidental harassment authorization (IHA) to PG&E to incidentally harass marine mammals during construction activities associated with a sediment remediation project in San Francisco Bay (89 CFR 5865). A renewal IHA was issued November 15, 2024. The Project is expected to occur over a period of 5 to 7 years, and this IHA will authorize take associated with Year 1 only. PG&E expects that Year 1 will include installation of hydroacoustic data collection piles; installation of piles to attach a turbidity curtain; dredging of impacted sediment; installation of sediment pins to promote slope stability; capping of impacted sediment to be left in place; placement of armoring as needed; and temporary relocation of the Red and White Fleet.

The project's planned activities that have the potential to take marine mammals, by Level B only, include impact installation and vibratory removal of composite piles; vibratory installation and removal of H-piles or steel shell piles less than or equal to 24 inches (61 cm) in diameter; vibratory installation and removal of 36-inch steel guide piles; vibratory and impact installation of 24-inch steel fender piles; vibratory removal of the 24-inch fender piles; and vibratory and impact installation of timber piles. In-water construction is expected to occur over 50 non-consecutive days over 1 year.

Section 5, Monitoring Requirements, require the following per the IHA:

(e) Acoustic monitoring must be conducted in accordance with the Acoustic Monitoring Plan (attached)[1].

> (i) The Holder must conduct sound source level measurements during installation of a minimum of three turbidity curtain piles (Steel H-piles or steel shell piles ≤24 inches).
>
> (ii) The Holder must conduct sound source level measurements during installation of a minimum of twelve of the 16-inch timber or composite tapered sediment pin piles.
>
> (iii) The Holder must conduct sound source level measurements during installation of a minimum of two each of the 36-inch steel shell piles and 24-inch steel shell piles required for the Red and White Fleet temporary relocation.

[1] This plan is an update to the Acoustic Monitoring Plan attached to the IHA.

(iv) The Holder must conduct sound source level measurements for installation and removal of all 18-inch composite hydroacoustic data collection test piles.

Section 6, Reporting, require the following:

(a.) The Holder must submit its draft report(s) on all monitoring conducted under this IHA within 90 calendar days of the completion of monitoring or 60 calendar days prior to the requested issuance of any subsequent IHA for construction activity at the same location, whichever comes first. A final report must be prepared and submitted within 30 calendar days following receipt of any NMFS comments on the draft report. If no comments are received from NMFS within 30 calendar days of receipt of the draft report, the report shall be considered final.

(e) The acoustic monitoring report must contain the informational elements described in the Acoustic Monitoring Plan and, at minimum, must include:

(i) Hydrophone equipment and methods: recording device, sampling rate, distance (m) from the pile where recordings were made; depth of water and recording device(s);

(ii) Type and size of pile being driven, substrate type, method of driving during recordings (e.g., hammer model and energy), and total pile driving duration;

(iii) Whether a sound attenuation device is used and, if so, a detailed description of the device used and the duration of its use per pile;

(iv) For impact pile driving: Number of strikes and strike rate; depth of substrate to penetrate; pulse duration and mean, median, and maximum sound levels (dB re: 1 µPa): root mean square sound pressure level (SPL_{rms}); cumulative sound exposure level (SEL_{cum}), peak sound pressure level (SPL_{peak}), and single-strike sound exposure level (SEL_{s-s});

(v) For vibratory driving/removal(per pile): Duration of driving per pile; mean, median, and maximum sound levels (dB re: 1 µPa): root mean square sound pressure level (SPL_{rms}), cumulative sound exposure level (SEL_{cum}) (and timeframe over which the sound is averaged);

(vi) One-third octave band spectrum and power spectral density plot.

CA Department of Fish and Wildlife - Incidental Take Permit No. 2081-2022-034-07

The California Department of Fish and Wildlife issued an Incidental Take Permit (ITP) for the project to PG&E on May 14, 2024. This permit authorization allows take of endangered, threatened, or candidate species by permit pursuant to the conditions set forth in the ITP.

Specific hydroacoustic monitoring requirements are not included in the ITP. However, Section 7, *Take Minimization Measures* includes hydroacoustic requirements that are intended to ensure the minimization of incidental take of Covered Species in the Project Area during Covered Activities.

The project is required to implement and adhere to the following applicable conditions to minimize take of Covered Species:

> 7.7 Impact Hammer Sound Decibel Limit. If the hydroacoustic monitoring show that sound pressure levels (SPL) values are exceeding or have exceeded any of the calculated distances to either the peak pressure or accumulated SEL, as specified within the ITP application or Hydroacoustic Monitoring Plan, as specified in Condition 7.9, the Permittee shall halt pile driving until the sound attenuation system is capable of meeting estimated SPL distances. The Permittee shall either take measures to increase the effectiveness of the sound attenuation system or obtain an ITP amendment from CDFW.
>
> 7.9 Hydroacoustic Monitoring Plan. Permittee shall create a hydroacoustic monitoring plan and provide CDFW with a copy for review prior to the start of Covered Activities. Note this plan serves as the requirement for this condition.

NMFS – Biological Opinion

NMFS issued a Biological Opinion (NMFS BiOp) on May 13, 2024 pursuant to Section 7 of the Endangered Species Act (ESA) and Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act for the Project (NMFS No: WCRO-2021-03500).

The NMFS BiOp acknowledges in the Project Description the commitment to conduct hydroacoustic monitoring per the draft version of this plan. Under the Terms and Conditions, the hydroacoustic data collected from the acoustic receivers are to be synthesized and compiled in a report by PG&E that will be provided to NMFS by January 31 of each year during Project activities.

U.S. Fish and Wildlife Services – Biological Opinion

The U.S. Fish and Wildlife Services, under the authority of the Endangered Species Act of 1973, also issued a Biological Opinion (USFWS BiOp) on September 4, 2024. Similar to the NMFS BiOp, the USFWS BiOp referred to Avoidance and Minimization Measures that include hydroacoustic monitoring, as described in the draft version of this plan: AMM-9. Hydroacoustic Monitoring and Reporting.

Hydroacoustic Monitoring for Pile Installation

To meet the permit conditions provided above, hydroacoustic monitoring will be conducted for each of the following activities:

- Monitor a representative sample of impact pile driving to compare with predictions for fish impact zones as specified within the ITP issued by the California Department of Fish and Wildlife. A sample size of 10 percent impact piles is considered representative.

- Turbidity Curtain Pile Installations: Steel H-piles or steel shell piles (24-inches or less in diameter) will be installed or removed using vibratory methods; and hydroacoustic monitoring will occur during installation and removal of **three** turbidity curtain anchor piles.

- Sediment Pin Installation: Hydroacoustic monitoring will occur during the installation of no less than **twelve** of the 16-inch wood or composite tapered piles. Wood or composite soil pins may require occasional use of an unattenuated impact hammer.

- In addition, test piles (18-inch diameter wood composite piles) will be installed to collect hydroacoustic data in advance of work to be completed within Remedial Response Area E. Measurements will be conducted during installation and removal of these piles.

- Red and White Fleet Temporary Relocation Piles: Hydroacoustic monitoring will occur during no less than **two of each the** 36-inch diameter guide piles and the 24-inch diameter fender piles required for the Red and White Fleet temporary relocation.

The hydroacoustic monitoring will be conducted in accordance with the requirements of the California Department of Fish and Wildlife ITP, the NMFS Marine Mammal IHA. The monitoring will be done in accordance with the methodology outlined in this Hydroacoustic Monitoring Plan. The monitoring conducted will:

- Establish field locations that will be used to document the extent of the area experiencing 206 dB peak (re: 1µPa), 187 dB cumulative SEL (SEL_{cum} re: 1µPa^2-sec) for protected fish species two grams or larger;
- Verify the SEL and RMS values corresponding to the marine mammal hearing group thresholds to establish the area of the Marine Mammal Level A Harassment shutdown zone and the Level B Harassment zone;
- Describe the methods necessary to continuously assess underwater noise on a real-time basis, including details on the number, location, distance and depth of hydrophones, and associated monitoring equipment;
- Provide a means of recording the time and number of pile strikes, the peak sound energy per strike, and interval between strikes; and
- Provide all monitoring data to the CDFW and NMFS.

At least one hydrophone system is proposed to record the sound levels at a position approximately 10 meters (33 feet) from the pile being driven. Depending on conditions and access, a second and possibly third hydrophone will be deployed at more distant positions of 50 to 100 meters from the pile with a clear line of sight between the pile and the hydrophones. The measurements from the three hydrophones will be used to compute a sound attenuation rate that can be used to predict the extent of sound that exceeds thresholds. The hydrophone may be moved either further out or closer in depending on the levels measured. Measurement positions are subject to pier access and sufficient water depth.

At PG&E's discretion, measurements of vibratory pile installation would be conducted in order to provide more accurate estimates of marine mammal impact zones. This would include a representative sampling of piles that are vibrated, which mainly result in Level B zones with quite small Level A zones. Given the potential for marine mammals to be present in the area, monitoring of these piles may be necessary to describe the affected areas more accurately.

Hydroacoustic Contractor Requirements

The acoustical monitoring contractor shall possess a minimum of a bachelor's degree in a related field,[2] with demonstrated three years of experience in noise monitoring and analysis.

Sound Monitoring Equipment Requirements

Monitoring equipment to be used shall have a measurement range in terms of amplitude (in dB) referenced to one micropascal (re: 1µPa), shall have a minimum frequency range of 20 Hz to 20 kHz and a minimum sampling rate of 48,000 Hz. Table 2 describes the minimum requirements of the equipment to be used. Calibration procedures are discussed in the methodology section.

Table 2. Proposed equipment for underwater sound monitoring (hydrophone, signal amplifier, and calibrator). All have current National Institute of Standards and Technology (NIST) traceable calibration.

Item	Specifications	Minimum Quantity	Usage
Hydrophone	Receiving Sensitivity ~200 - 210 dB ± 3 dB re 1 V/µPa OR 180 dB + 2 dB re 1 V/µPa Depending on sound source being measured	1-3	Capture underwater sound pressures for source and background levels and convert to voltages that can be recorded/analyzed by other equipment.
Signal Conditioning Amplifier	Amplifier Gain- 0.1 mV/pC to 10 V/pC Transducer Sensitivity Range- 10-12 to 103 C/MU	1-3	If necessary - Adjust signals from hydrophone to levels compatible with recording equipment. Note that Larson Davis Model 831 SLM can accommodate the range of anticipated sound levels
Calibrator (pistonphone-type)	Accuracy- IEC 942 (1988) Class 1	1	Calibration check of hydrophone in the field.
Digital Signal Analyzer	Sampling Rate- 48 kHz or greater	1-3	Larson Davis Model 831c SLM
If water velocity ~> 1m/s, Flow shield	Open cell foam cover or functional equivalent	1/hydrophone	Eliminate flow noise contamination.

[2] This can include Institute of Noise Control Engineering of the USA (INCE/USA) certification or related fields such as acoustics, physics, oceanography, geology, or other physical sciences that have required coursework in physics.

Methodology

Hydrophone placement will occur as follows:

1. One hydrophone will be placed at approximately mid-water depth at the nearest distance, which is approximately 10 meters depending on site conditions, from each pile being monitored.
2. An additional hydrophone may be placed at mid-water depth at a distance of about 50 to 100 meters from the pile, to provide two sound level readings during ambient and pile driving recording. Only one hydrophone would be placed at about 10 meters near piles expected to produce low sound levels (e.g., plastic composite piles and timber piles).
3. A third hydrophone may be placed at a position of 100 meters or further from the pile if suitable monitoring positions are available and the pile driving produces sounds that are clearly measurable at that distant position. The purpose of having three monitoring positions is to develop a sound propagation rate from the measurement data.

The 10-meter position will be monitored live to determine compliance with permit conditions. Either live or recorded sound levels would be captured at positions further than 10 meters. This allows for the deployment of autonomous underwater sound recording devices at positions that are not suitable for live monitoring.

A weighted tape measure will be used to determine the depth of the water. The hydrophones will be attached to a nylon cord or a steel chain if the current is swift enough to cause strumming of the line. One end of the nylon cord or chain will be attached to an anchor that will keep the hydrophone at the specified distance from the pile. The opposite end of the nylon cord or chain will be attached to a float or tied to a static line at the surface at the specified recording distance from the pile. The distance will be measured by a tape measure, where possible, or a range finder. To the extent practicable, there will be an unobstructed path between the pile and the hydrophones.

Ambient underwater sound levels will be measured for at least several minutes prior to initiation of pile driving, as well as in the absence of construction activities. Ambient levels will be reported as RMS and include a representative spectral analysis. The inspector/contractor will inform the hydroacoustics specialist when pile driving is about to start.

Underwater sound levels will be continuously monitored during the entire duration of each pile being driven. Peak levels of each strike will be monitored in real time. Sound levels will be measured in decibels.

Prior to and during the pile driving activity, environmental data will be gathered including, but not limited to, approximate wind speed and direction, air temperature, water depth, wave height, weather conditions, and other factors (e.g., aircraft, boats) that could contribute to influencing the underwater sound levels. Start and stop time of each pile driving event will be recorded.

Ten percent of all impact pile driving shall be monitored to determine the efficacy of any sound attenuation system and to assess whether the predicted sound pressure levels and associated distances from piles differ from the actual measurements. The construction inspector(s) will supply the hydroacoustic specialist with the substrate composition, hammer model, and size; depth the pile is driven and blows per foot for the piles monitored. Hammer energy settings will also be recorded by the construction inspector, as well as any changes made to those settings during the pile monitoring period.

Flow-Induced Noise Reduction

This area is not anticipated to experience strong currents that could cause flow-induced noise at the hydrophone that would interfere with the recording and analysis of the relevant sounds. As a rule, current speeds of 1.5 meters/second or greater are expected to generate significant flow-induced noise, which may interfere with the detection and analysis of low-level sounds such as the sounds from a distant pile driver or background sounds.

If it becomes necessary to reduce the flow-induced noise at the hydrophone, a flow shield will be installed around the hydrophone to provide a barrier between the irregular, turbulent flow and the hydrophone. If no flow shield is used in these situations, the current velocity will be measured and a correlation between the levels of the relevant sounds (background or pile driving) and current speed will be made to determine whether the data is valid and can be included in the analysis.

Calibration

Calibration of measurement systems shall be established prior to use in the field each day. An acoustical pistonphone and microphone or hydrophone coupler shall be used along with manufacturer calibration certificates to calibrate the equipment. An acoustically certified pistonphone and coupler that fits the hydrophone or microphone shall directly calibrate the measurement system. The volume correction of the coupler for each hydrophone or microphone shall be known so that the pistonphone shall produce a known signal that shall be compared against the measurement system response. The response of the measurement system shall then be noted in the field book and applied to all subsequent measurements.

Additionally, the hydrophones are calibrated to a calibration tone prior to use in the field. The tone is then measured by the hydrophone, and the results are recorded onto the beginning of the digital audio recordings. The system calibration status shall be checked by comparing the calibration tone and recorded tones. The recorded calibration tones are used for subsequent detailed analyses of recorded pile strike sounds.

Reporting

Preliminary results for daily monitoring activities will be submitted/reported to the contractor's approved designated biologist for inclusion in monthly reports. The contractor will be notified immediately via in-person, cell phone or radio if the 206 dB peak, 187 dB cumulative SEL, or 150 dB RMS fish thresholds[3] are exceeded at the estimated distances from the pile or anticipated to be exceeded during impact pile driving or pile-proofing activities. Impacts to marine mammals - Level A injury and Level B harassment thresholds will also be assessed and reported after analyzing the data collected during the construction activities conducted throughout the day. A daily hydroacoustic monitoring report, in the form of an email, will be submitted by close of business of the day following the pile driving activities that shall include real-time data regarding

[3] Popper, A., Carlson, T., Hawkins, A., Southall, B., and Gentry, R. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper. May 15.

the distance (actual or estimated using propagation models) to the thresholds (Both fish and marine mammal thresholds). Specifically, these reports would provide completed Appendix B data reporting tables that:

1. Describe the positions of hydroacoustic monitoring measurements that were used to document the extent of the underwater sound footprint during pile driving activities, including the number, location, distances, and depths of hydrophones and associated monitoring equipment.
2. Include the estimated number of pile strikes per pile (duration per pile measured for vibratory driving), the median and maximum peak pressure, RMS and SEL per strike.
3. The SEL_{cum} per day for each pile measured and for all piles.

A final hydroacoustic monitoring summary report will be submitted to NMFS 90 days following completion of monitoring. The report will provide a review of the daily monitoring data and process, as well as any problems that are encountered. The following items shall be included in these final summary reports:

1. Size and type of piles.
2. The make and model of the hammers.
3. A description of the sound monitoring equipment.
4. The distance between hydrophones and pile(s).
5. The depth of the hydrophones and depth of water at hydrophone locations.
6. The depth of water in which the pile was driven.
7. The total number of strikes for impact driving of each pile (duration per pile for vibratory driving) and all piles driven during a 24-hour period.
8. Time histories at each monitoring location.
9. Mean one-third octave band spectra and a narrowband Fast Fourier Transform (FFT) analysis of representative portions of the pile installation events to provide a power spectral density plot;
10. The results of the hydroacoustic monitoring in terms of peak pressure (dB re: 1 µPa), SEL per strike (dB re: 1 μPa^2-sec) and cumulative SEL (per Appendix A), and mean RMS (dB re: 1µPa). An example table is provided in Appendix B for reporting the results of the monitoring.
11. The distance at which SEL_{cum} and RMS values exceed the respective threshold values.
12. A description of any observable fish, marine mammal, or bird behavior in the immediate area during pile driving events will be documented and, if possible correlated to underwater sound levels occurring at that time.
13. Any problems encountered.

APPENDIX A - Calculation of Cumulative SEL

$SEL_{cumulative}$ can be measured by an SLM directly or can be estimated from a representative single-strike SEL value and the number of strikes that likely would be required to place the pile at its final depth by using the following equation (eq. 1):

$$SEL_{cumulative} = SEL_{single\ strike} + 10 \log (\#\ of\ pile\ strikes) \qquad (eq.\ 1)$$

Equation 1 assumes that all strikes have the same SEL value and that a fish would continuously be exposed to pulses with the same SEL. This is never actually the case. The equation does, however, provide a reasonable estimation of the cumulative SEL value, given a representative single-strike SEL value and an estimate of the number of strikes. Although not currently used as a criterion metric, the vector quantity particle velocity may emerge as a useful metric for evaluating the effect of underwater sound on fish. When applied to a sound wave traveling through water, particle velocity would be the physical speed of a water molecule as the wave passes by it.

APPENDIX B - Data Reporting

Date and Time	Pile ID	Hammer Type	No. of Strikes or Duration	Distance to Pile from Hydrophone (m)	Water Depth (m)		Peak (dB)			SEL (dB)				RMS (dB)			Notes
					At Pile	At H-phone	Max	Median	Mean	Max	Median	Mean	SEL_{cum}	Max	Median	Mean	