Underwater Noise Assessment

Phase II Design and Implementation Final Report

Port of Seattle

Maritime Environment and Sustainability
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Making Sustainability Happen

Revision Record

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Environmental conditions that are not apparent may exist at the site. Our professional opinions are based in part on interpretation of data from a limited number of discrete sampling locations and therefore may not be representative of the actual overall site environmental conditions.

The passage of time, manifestation of latent conditions, or occurrence of future events may require further study at the site, analysis of the data, and/or reevaluation of the findings, observations, and conclusions in the work product.

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Executive Summary

The Port of Seattle has begun implementing an Underwater Noise Assessment program to define the regional soundscape in the waters surrounding and on approach to its operational area. Two primary sources of underwater noise are expected to influence findings strongly:

1. Contributions from transiting vessels (both commercial and recreational), and
2. The development of regional in-water infrastructure (otherwise known as marine construction).

The program's overall goal is to build an acoustic database (two-years in duration) based on data collected at two separate but complementary locations. From this database (and during the data collection period), the contributions to the baseline or ambient noise level in the region will be analyzed and discussed in three categories: environmental (e.g., precipitation, waves breaking, flow noise), biological (e.g., marine mammal and fish vocalizations), and anthropogenic (e.g., vessel and marine construction-based noise).

Potential deployment sites were rigorously evaluated based on several key parameters, including ease of access, availability of power, acoustic “field of view,” security of deployed monitoring equipment, the probability of maintaining continuous monitoring over a two year period, and the likelihood of achieving the goals of the overall monitoring program.

Site inspections were conducted at four locations: the Seattle Aquarium, Pier 62, Jack Block Park, and the Seattle Water Taxi. Several parties participated in the site inspection process, ensuring a thorough understanding of the logistical and regulatory challenges associated with a multi-year deployment of a cabled monitoring station at each location. The Seattle Aquarium and Jack Block Park are the preferred locations for implementation.

The Phase II program implementation for underwater data collection efforts will commence within Elliott Bay on regulated land and waters requiring permits, consultations, reviews, certifications, licenses, and/or approvals on a local, state, and federal level. A summary of the permits anticipated to execute Phase II program implementation is presented in this report.

Currently, the primary components (smart hydrophones, mooring frames, and cabling) of the cable-to-shore systems are being manufactured and integrated before preliminary testing and subsequent deployment. To facilitate the comparison of underwater noise levels between sites, identical system components have been selected for both cable-to-shore systems.

Regular data collection and monthly equipment maintenance will occur, involving hard drive swaps, battery checks, and equipment inspections. These steps will ensure effective and continuous monitoring of underwater noise levels while safeguarding equipment from potential damage.

The ambient noise levels will be reported using the common international metrics specified and following the best practices for underwater noise measurement. The acoustic data processing aims to obtain a baseline of underwater noise at each representative site.

Finally, this report presents a timeline detailing the program’s progress and milestones achieved.

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Acronyms and Abbreviations

AC	Alternate Current
AM	Arithmetic Mean
BFE	Base Flood Elevation
CFR	Code of Federal Regulations
CZM	Coastal Zone Management
COTP	the Captain of the Port
DNR	Department of Natural Resources
DSL	Digital Subscriber Line
Ecology	Department of Ecology
ECDF	Empirical Cumulative Distribution Function
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FLAC	Free Lossless Audio Codec
ft	Foot/Feet
HAT	Highest Astronomical Tide
JARPA	Joint Aquatic Resources Permit Application
kbps	kilobits per second
kg	kilogram
kSps	kilosamples per second
lb	pound
m	meter
mm	millimeter
NAVD88	North American Datum of 1988
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
ns	Nanosecond
NWP	Nationwide Permit
O_2	Oxygen
PAM	Passive Acoustic Measurements
Park	Jack Block Park
Port	Port of Seattle
RCW	Revised Code of Washington

RMS	Root Mean Square
ROV	Remote Operated Vehicle
RUP	Revocable Use Permits
SEL	Sound Exposure Level
SEPA	State Environmental Policy Act
SFHA	Special Flood Hazard Area
SLR	SLR International Corporation
SMC	Seattle Municipal Code
SMP	Shoreline Master Programs
SPL	Sound Pressure Level
SPD	Spectral Probability Density
UNMMP	Port of Seattle Underwater Noise Mitigation and Management Plan
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USFW	US Fish and Wildlife
VDSL	Very high-speed Digital Subscriber Line
WAV	Waveform Audio file format
WDWF	Washington Department of Fish and Wildlife

1.0 Overall Program

The Port of Seattle's (Port's) mission is to promote economic opportunities and quality of life in the region by advancing trade, travel, commerce and job creation in an equitable, accountable and environmentally responsible manner. In 2012, marking the 100-year anniversary of the Port, the Port Commission adopted the Century Agenda to establish the Port's vision over the next 25 years. As part of the Century Agenda, the Port is compelled to meet international trade and cargo needs in an environmentally stable manner. This led to the Port investing in understanding their operational contribution to underwater noise in Elliott Bay. Underwater noise is an environmental concern as studies have shown that anthropogenic noise has adverse effects on marine life, including the endangered Southern Resident Killer Whale, and can impede hunting, navigation, communication, reproduction, and danger avoidance[1]. As part of its commitment to better understanding the underwater soundscape and reducing its negative effects on marine life, the Port of Seattle adopted the Green Marine framework to develop an Underwater Noise Mitigation and Management Plan (UNMMP) in 2020. A pilot study was conducted coincident with the plan development, representing Phase I of the Port's Underwater Noise Assessment Program. The goal of the program is evaluate underwater noise levels in the Port operations areas within Elliott Bay.

The UNMMP also delivers on the Port's commitment to increase its Green Marine certification level. Green Marine is a voluntary environmental certification program for the maritime industry to help participants improve their environmental performance. The Port utilizes the Green Marine framework to systematically measure program progress and provide accountability on the Port's environmental goals.

The UNMMP and Phase I of the Underwater Noise Assessment Program concluded in 2022. They identified further phases to provide baseline metrics, set noise reduction targets, and measure progress toward adaptive management of noise reduction strategies. This comprehensive program involves deploying hydrophone systems to record baseline noise levels at strategic locations. The program will collect, analyze, and report on acoustic data to establish a multi-year baseline for ambient underwater noise, assess the relative impact of various maritime activities on the underwater soundscape, and develop noise reduction targets.

The UNMMP recommendations for further Underwater Noise Assessment Program efforts will be implemented in the following phases:

- Phase II
    - Initial Design, Outreach, and Permitting
    - Final Design and Implementation
    - Equipment Mobilization
    - Year 1 Monitoring and Reporting
    - Year 2 Monitoring and Reporting
    - Final Reporting and Demobilization
- Phase III

[1] Peng C, Zhao X, Liu G. Noise in the Sea and Its Impacts on Marine Organisms. Int J Environ Res Public Health. 2015 Sep 30;12(10):12304-23. doi: 10.3390/ijerph121012304. PMID: 26437424; PMCID: PMC4626970.

- Initial Design and Outreach
- Final Design and Permitting
- Implementation of Long-term Noise Monitoring Program

The program will focus on stakeholder engagement and program design, data collection, analysis, and the establishment of long-term monitoring protocols.

1.1 Goals & Objectives

The goals and objectives of this program are to achieve the following:

- Improve understanding of underwater noise levels and sources in the Port's operations area, supporting efforts to reduce impacts of underwater noise on Southern Resident Killer Whales and other Puget Sound marine species.
- Establish a comprehensive baseline (or baselines) of ambient underwater noise levels, which is critical for identifying the sources and impacts of noise pollution.
- Develop and implement effective noise reduction strategies to mitigate the adverse effects on marine ecosystems, including sensitive species such as cetaceans. Adapt strategies based on monitoring results.
- Promote sustainable maritime operations, enhance environmental stewardship, and ensure compliance with environmental regulations.

2.0 Phase II – Program Design

2.1 Geographic Scope of the Study

The two primary port-related sources of underwater noise are vessel traffic and infrastructure development on port lands and water. The immediate and cumulative effects of underwater noise from these sources depend mainly on sound intensity, sound characteristics (i.e., frequency, range, and duration), and sound periodicity (i.e., continuous or intermittent). Vessel activities are one of two primary sources of underwater noise in and around the Port. Thousands of ocean-going vessels call on the Port each year, with various deep-sea, commercial, and recreational vessels transiting to and from the Port. The most common types of vessels active in the Port include large commercial vessels, dredging vessels, harbor tugs, harbor patrol vessels, ferries and passenger vessels, and other small commercial and recreational vessels.

Underwater noise from commercial vessels significantly influences the measurement of ambient or background underwater noise levels. This noise, primarily generated by propulsion systems, is predominantly low-frequency in nature and can dominate low-frequency bands, even well outside shipping lanes.

Underwater noise from small recreational vessels also significantly influences the measurement of ambient or background underwater noise levels. This noise is primarily generated by the rotation of the propeller and associated cavitation, the firing sequence of the engine(s), other moving parts of the propulsion system, and the release of subsurface exhausts (Erbe et al., 2016[2]).

2.2 Cable-to-Shore System

The program is designed to avoid and minimize adverse impacts on the aquatic environment of Elliott Bay:

- With a small device footprint, the mooring will be lowered to the seafloor using small anchor plates to secure its final position.
- Installation would not inhibit fishing activities.
- The deployment will use existing seafloor/ground surface infrastructure and existing pier structures to minimize or avoid shoreline impacts.
- The use of cabled-to-shore systems will reduce the need for frequent maintenance visits, thereby limiting additional vessel traffic and associated disturbance.

The cable-to-shore hydrophone system is designed for continuous coastal underwater acoustic data recording. It will be configured for a single hydrophone mooring. The output data can be used to monitor ambient noise, detect vocalizing whales and fish, and detect vessel transits.

The system is composed of a small seafloor mooring to support the hydrophone; an underwater cable to provide power to the mooring and provide data communications between the mooring and shore station; and a shore station box, which contains the power, data, time synchronization and control electronics. Options are available for alternate current (AC) mains or solar power supplies, internal data logging, or Ethernet data transmission (via radio bridge or direct Ethernet connection). The basic configuration is shown in Figure 1.

The hydrophone moorings are typically deployed within 400 meters (m) of the shore station box (shorter is better, i.e., less expensive and easier to deploy and recover). Moorings should be placed between 20 m and 30 m depth to provide immunity from surface wave pressure effects while providing easy deployment and recovery. Deployment depths of 50 m or more are possible but make the logistics of deployment and recovery more complicated. Cable lengths of more than 100 m require very high-speed digital subscriber line (VDSL) modules on the mooring and in the shore station box.

The shore station consists of a weatherproof case containing data handling and power handling electronics, as well as a small external antenna for satellite-based time synchronization to less than 10 nanosecond (ns) precision. This timing accuracy allows multiple hydrophones to work as arrays in short- or long-baseline configurations.

The shore station typically includes the necessary electronics for either AC power or solar panels. All electronics are stored in a 1660 Pelican case (Figure 2).

The weatherproof shore box has three power configurations: grid power, four lead-acid batteries, and eight lead-acid batteries. It can log data autonomously to hard drives or be configured to radio the data in real-time to a lab, where it is logged and displayed. Radio communications are typically done via line-of-sight Ethernet bridge connections.

[2] Erbe, C., Reichmuth, C., Cunningham, K., Lucke, K. and Dooling, R. 2016. Communication masking in marine mammals: A review and research strategy. Marine pollution bulletin, 103(1-2), pp. 15-38.

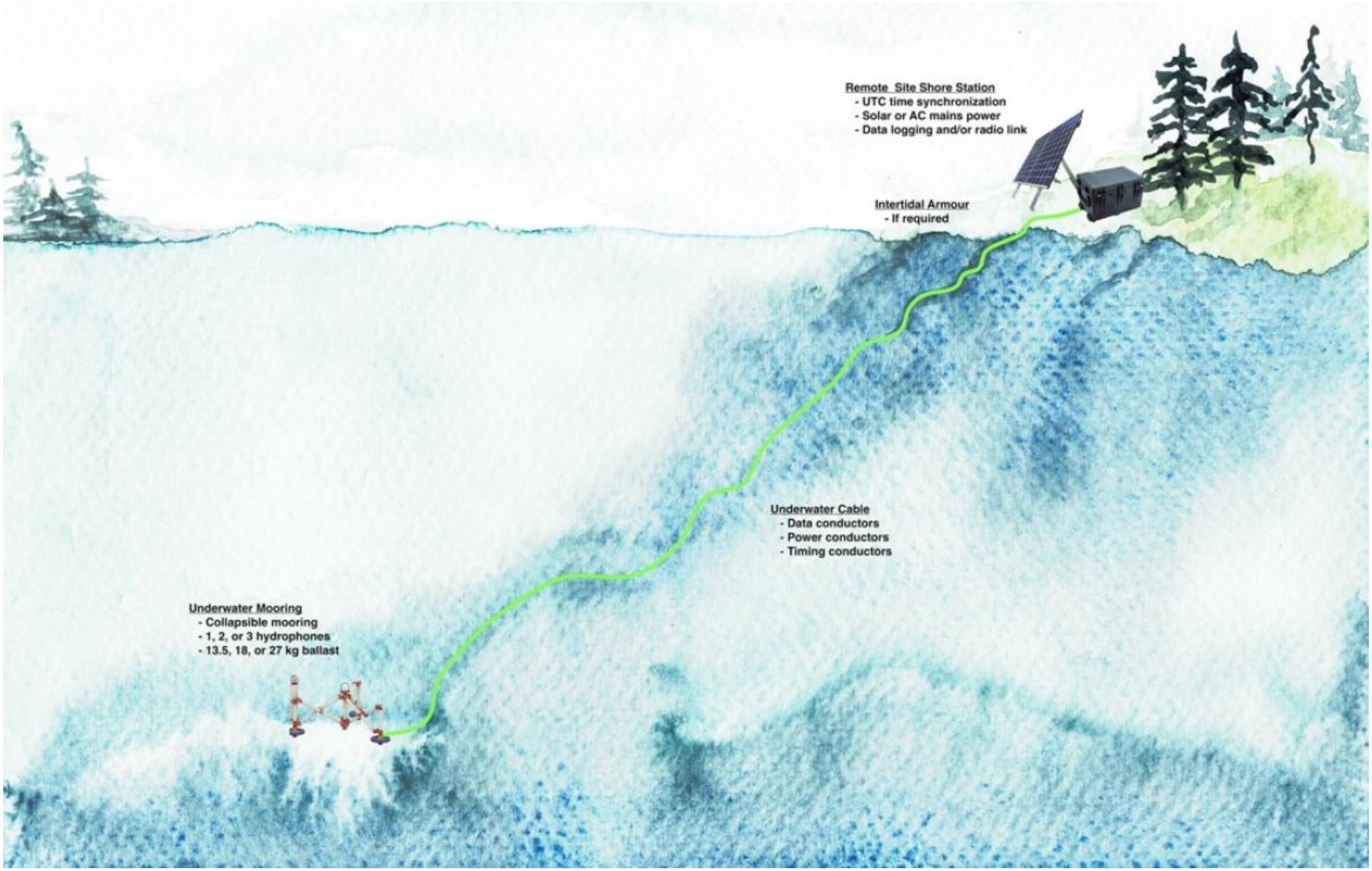

Figure 1: Basic cable-to-shore hydrophone system layout

Figure 2: Sample of the shore station box and solar panel (if required)

2.2.1 Hydrophone Specifications

Ocean Sonics' icListen SJ9 hydrophone is the system's preferred hydrophone. Special, proprietary software drivers have been developed for reliable operations, fault recovery, data parsing, error logging, and file name conventions.

Hydrophones are typically sampled at 64,000 samples per second with 24-bit resolution; however, if required, the icListen hydrophone's maximum reliable sampling rate is 128,000 samples per second or 128 kSps. The hydrophone can sample faster (e.g., up to 256 or 512 kSps); however, data packets may be occasionally dropped and lost, and data transmission at higher sample rates may be unreliable on a long cable.

Higher sampling rates improve the acoustic bandwidth at the expense of increased data storage costs. Data are collected in Waveform Audio (WAV) file format and converted daily into Free Lossless Audio Codec (FLAC) formatted files (compressed files that can be extracted) to reduce data storage and transmission costs. FLAC compression is lossless, but it is variable in compression ratio. The cleaner the data, the better the compression. The program applies a conservative compression estimate of 0.57 for disk usage estimates. For disk capacity estimates (swap out time), the disk will be kept below 80% of its rating (see Table 1).

Table 1: Recording file compression details

				Wav Files			FLAC Files		
Acoustic Bandwidth [kHz]	Sample rate [kSps]	Bit resolution	Streaming Mbits/sec	MB 5-min file	GB month	TB year	MB 5-min file	GB month	TB year
6.4	16	24	0.38	14.40	128.56	1.51	8.21	73.28	0.86
12.8	32	24	0.77	28.80	257.13	3.03	16.42	146.56	1.73
25.6	64	24	1.54	57.60	514.25	6.06	32.83	293.12	3.45
51.2	128	24	3.07	115.20	1028.51	12.12	65.66	586.25	6.91
102.4	256	24	6.14	230.40	2057.01	24.24	131.33	1172.50	13.81
204.8	512	24	12.29	460.80	4114.02	48.47	262.66	2344.99	27.63

The hydrophone will be mounted on a collapsible tripod structure at an approximate height of 714 mm or approximately 2.3 feet (ft) and will be placed in water approximately 60 feet deep (Figure 3). The tripods are connected to the shore station via underwater Cat 6 Ethernet or digital subscriber line (DSL) cables. Cable lengths between the hydrophones and shore stations will range from approximately 120 to 300 ft. Since tripods can be susceptible to tipping or current-induced noise in higher currents, the current levels at proposed sites will be assessed both prior to and during deployment.

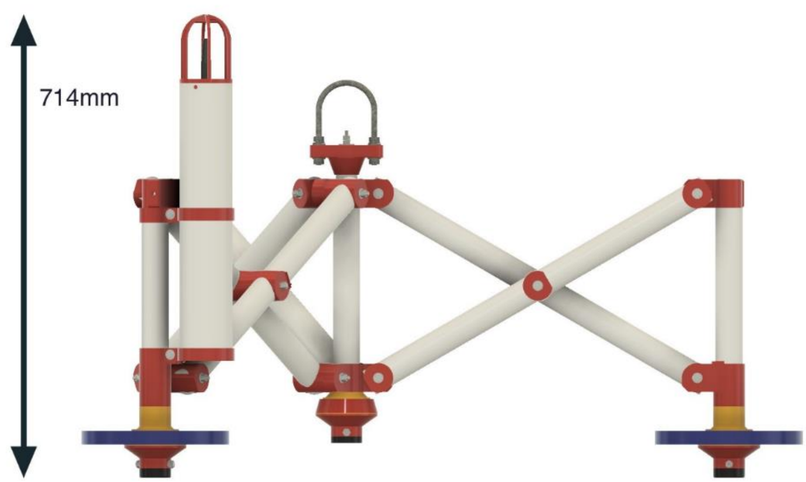

Figure 3: Sample of the hydrophone mooring mounted on a collapsible tripod

A replacement hydrophone has been included with the system design. If a hydrophone replacement is required, a spare hydrophone is ready to be installed and a data gap of approximately 1-2 weeks (assuming some cable damage requires repair) is projected for the affected site.

2.2.2 Self-Noise

The Cable-to-Shore System has vibration isolation rings inside the hydrophone tube to decouple the hydrophone from the mooring. These are designed to mitigate the noise of debris/mooring impact and Karman vortex noise[3]. They do nothing about low-frequency earthquake noise (or shore-based construction noise). This system considers:

- If noise is coupled into the water from the seafloor, it should be measured since it will impact the fauna. Known users of this system are actively pursuing shore-based noise detection, as it represents an important part of the underwater soundscape.
- Long-compliant isolation mechanisms will often induce strumming noise when exposed to currents and, therefore, should be avoided. Figure 4 is the spreadsheet plot linking strumming frequencies with a cable diameter. This chart can be used in reverse to estimate which frequencies will be generated by a known cable at various currents, such as a rope or bungee cord. The hydrophone shroud is so large to push the Karmen Street vortex frequencies well below the hydrophone's low-frequency roll-off (see Figure 4).
- Compliant line-based systems require a drogue at depth (or anchor) to prevent wave-induced heave[4] from affecting the hydrophone data. Even at a 10 m float depth, the float heave can be a few millimeters (1 mm of heave is equivalent to 139 dB). This is usually well below the hydrophone low-frequency roll-off, so the hydrophone attenuates it. Usually, it will not saturate the hydrophone, but wave noise can appear in shallow water hydrophone data. A deep drogue[5] will mitigate this, but there can be no current present in the area, or it introduces additional noise. An anchor-based line is needed for a fixed position system but this usually comes with strumming noise as well.

2.2.3 Electrical Noise

The AC-powered remote site box has internal electrical isolation designed to remove AC contamination of hydrophone data. The icListen hydrophone charges its internal battery periodically. This introduces some additional narrow-band low-intensity tones, around less than 58 dB. The icListen hydrophone also has some self-noise tonals, which are as shown inFigure 5.

[3] Karman vortex noise occurs when opposing vortices are formed behind a hydrophone that can create oscillations and vibrations that can interfere with noise monitoring.

[4] A ship up and down motion induced by wave action.

[5] A device trailing behind a boat to provide drag resistance and slow down a boat.

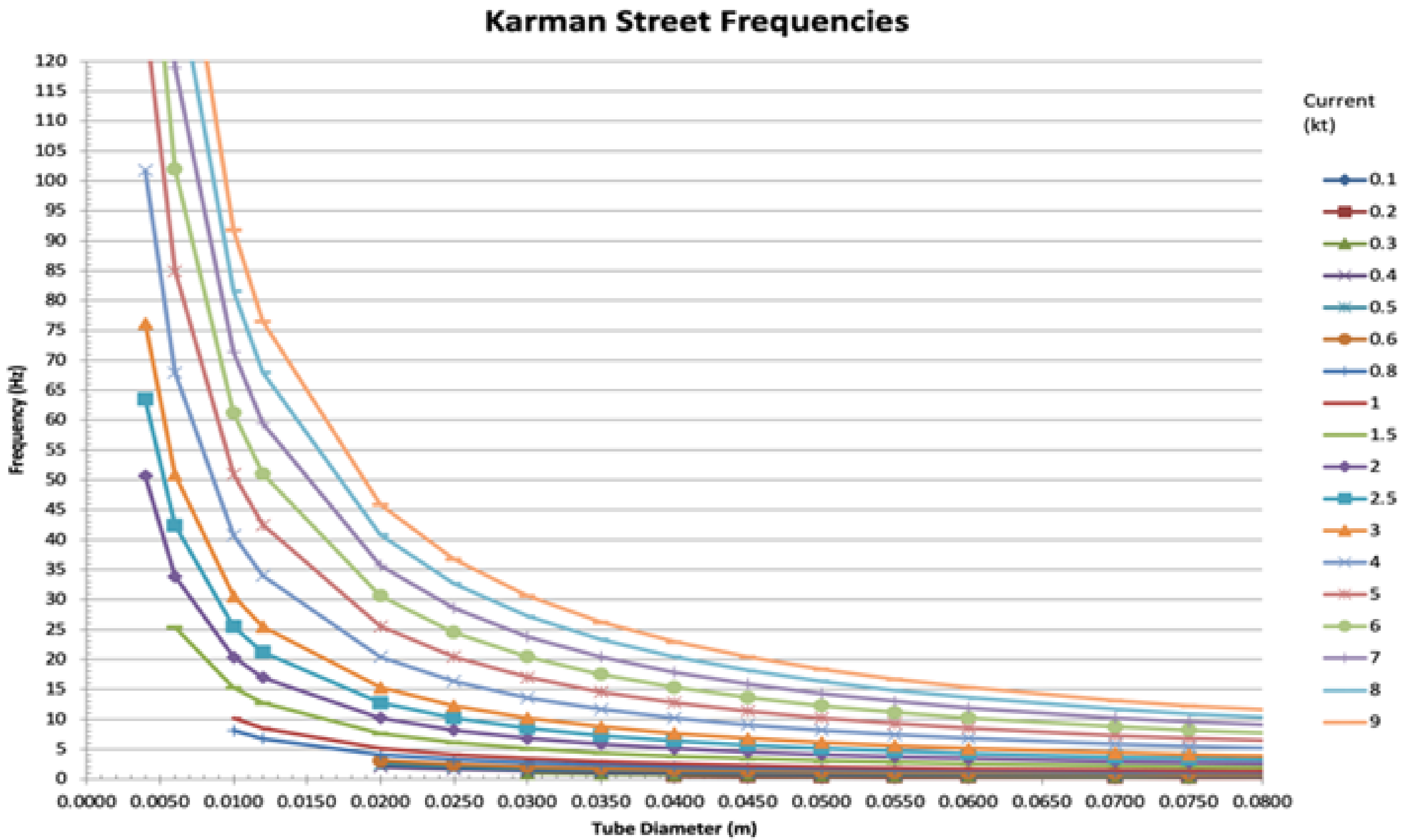

Figure 4: Karman Street Frequencies

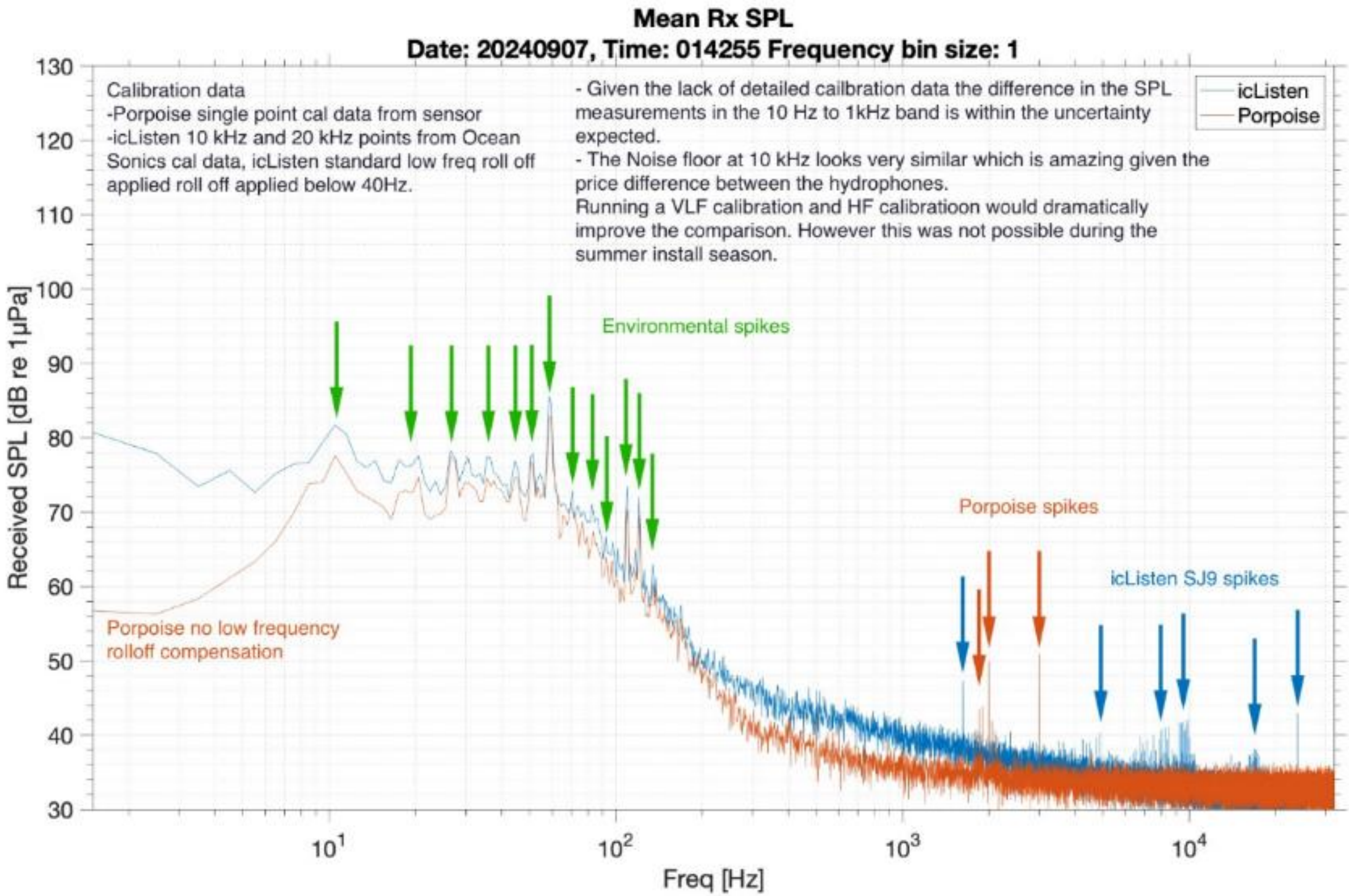

Figure 5: Typical electrical noise found within icListen hydrophone

2.3 Potential Site Locations

Sites are selected based on the program’s objectives and territorial boundaries. Factors include the following:

- Ambient noise requirements;
- Species detection requirements;
- Acoustic source localization requirements;
- Anthropogenic noise monitoring requirements;
- Choke points or travel routes for whales, vessels, currents;
- Known habitat usage zones;
- Marine protected areas;
- Shore protected areas (flora, fauna, cultural);
- Shoreline ownership;
- Solar exposure at shore site;
- Acoustic propagation to the mooring site (acoustic field of view);
- Bathymetry and seafloor type at the mooring site;
- Cable route obstructions;
- Cable protection in the intertidal zone;
- Current speeds;
- Equipment protection from wind, surf, vandalism, fishing gear, anchors; and
- Distance from natural and anthropogenic noise sources (buoys, streams, pumps, marinas, anchorages, bridges, ferry routes, etc.).

2.4 Site Visits

Based on the previous factors discussed in Section 2.3, four strategic locations have been selected as potential hydrophone deployment locations. The proposed locations are:

- Seattle Aquarium Pier,
- Jack Block View Pier,
- Pier 62, and
- West Seattle Water Taxi Pier.

The Seattle Aquarium Pier and Jack Block View Pier are the preferred locations, but all four sites are good candidates for deployment.

Below is a brief report of the evaluation of the four sites visited (Figure 6) by SLR International Corporation (SLR), the Port, and representative site staff on September 26 and 27, 2024.

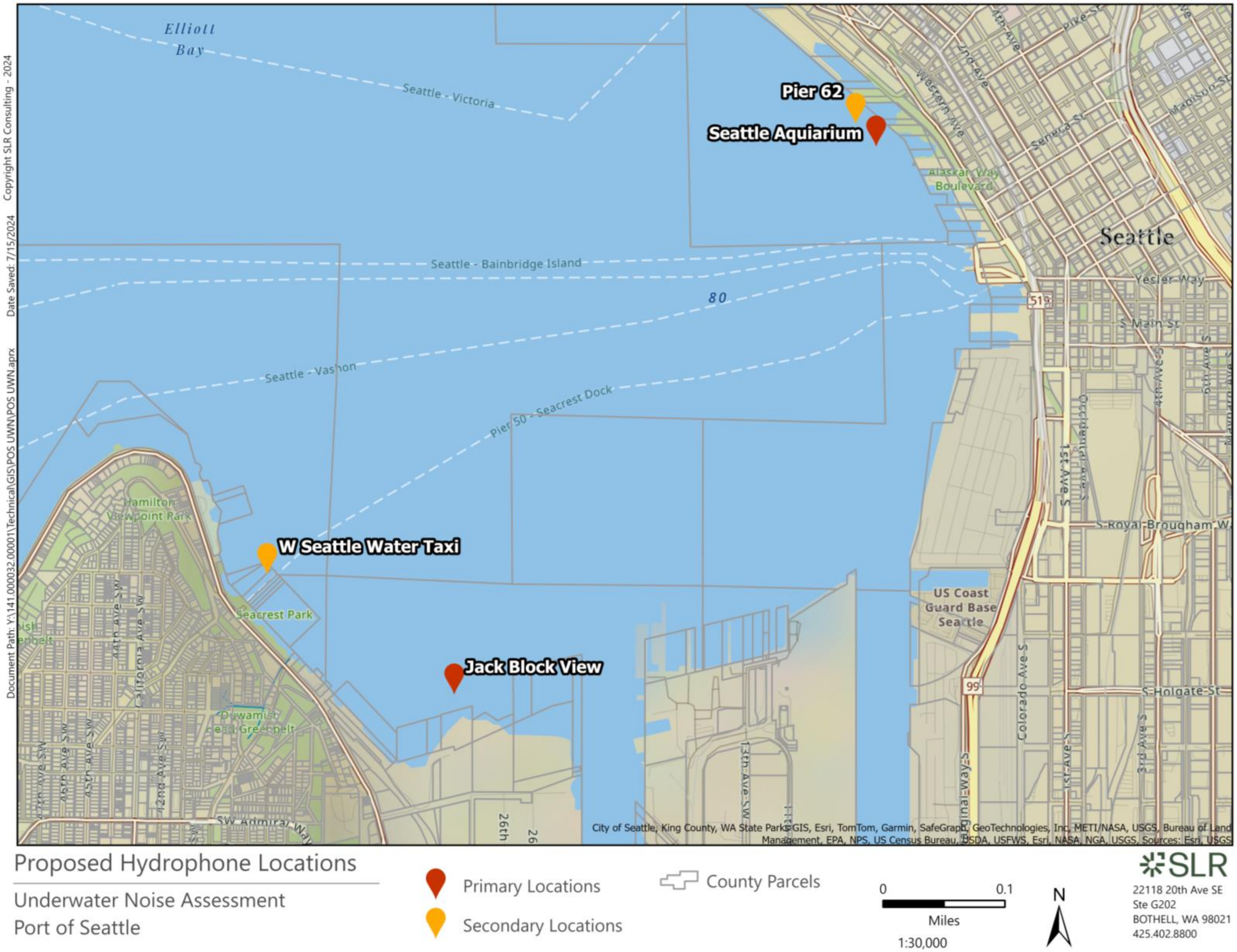

Figure 6: Strategic Site Locations within the Port of Seattle

2.4.1 Seattle Aquarium Pier

The Seattle Aquarium Pier is located at 1483 Alaskan Way Pier 59 in Seattle, Washington. The Seattle Aquarium Society manages the Aquarium, which includes the Pier 59 and Pier 60 buildings and the recently expanded Ocean Pavilion. The Aquarium is open daily to the public and has 24-hour security. SLR, the Port, and Seattle Aquarium Society personnel met onsite on September 27, 2024, to assess the site's suitability for storage and monitoring.

Figure 7 shows that the southwest corner of Pier 60 is fenced and gated to restrict access to aquarium personnel; the public is allowed to enter only during special events. The gated area has a pump house located on Pier 60 on the southwest corner, which is continuously active to support the aquarium habitats. Just outside of the pump house, there are oxygen (O_2) tanks that are stored and periodically exchanged, as shown in Figure 8. Clear access to the tanks for exchange and to the pump house must be maintained. The interior of the pump house has space available to house the hydrophone equipment, and a 120V 20A power outlet is available on the west side.

The hydrophone cable can be routed through an access hatch/window or down through the grated floor shown in Figure 9, Figure 10, and Figure 11. There are also 120V 20A power outlets along the railing to the west and south (Figure 9); however, some events use the pier, which could inadvertently cause interference if these outlets were used to power the shore station. King County uses the pump house's western access hatch for their equipment, which they periodically access (Figure 11).

SLR proposes using the gated southwest corner of Pier 60 for equipment storage, as recommended by Seattle Aquarium Society personnel. The proposed hydrophone schematic of the system setup is shown in Figure 12. The data logging equipment is stored within a 1660 Pelican case approximately 0.81 m (2.7 ft) wide, 0.59 m (1.9 ft) deep, and 0.51 m (1.7 ft) high. The case is proposed to be stored within the pump house using the existing 120V 20A power outlet inside the pump house and with no additional security or enclosure features. Cabling from the hydrophone system will be configured to work around and not impede existing equipment and access. The access hatch on the west wall of the pump house can be used to run cabling, or alternatively, the cable can be run through the grated floor.

The underwater Cat 6 Ethernet cable connected to the hydrophone is proposed to be routed through a rigid conduit from the case towards the southeastern pier outside the pump house before being diverted underwater. The hydrophone will be mounted on a collapsible tripod that will sit on the seafloor at approximate NAVD88 elevation -70 ft, using an approximate cable length of up to 100 m. The shoreline is within the Federal Emergency Management Agency's (FEMA's) coastal Special Flood Hazard Area (SFHA) Zone VE (high-hazard coastal area where wave action and fast-moving water can cause extensive damage during a base flood event with a base flood elevation (BFE) of 15 ft (North American Vertical Datum of 1988 [NAVD88]; Figure 13). The pump house is assumed to provide protection from tidal flood waters. The program team will coordinate with the Seattle Aquarium Society and King County on the hydrophone system setup, installation, permitting, design, and monitoring to ensure there is no interference with the anticipated operations.

As a future alternative option for the aquarium, an interactive listening station (e.g. an exhibit) can be set up through hardware and software upgrades to the monitoring station. It can log data autonomously to hard drives or be configured to radio the data in real-time to a lab, where it is logged and displayed. Radio communications are typically done via line-of-sight Ethernet bridge connections.

Figure 7: Seattle Aquarium Pier – Existing Site Features and Potential Location for Equipment

Figure 8: Seattle Aquarium Pier – Pump House (Looking Southeast) and O_2 Tank Storage

Figure 9: Seattle Aquarium Pier – Pump House, Facing West Interior Wall

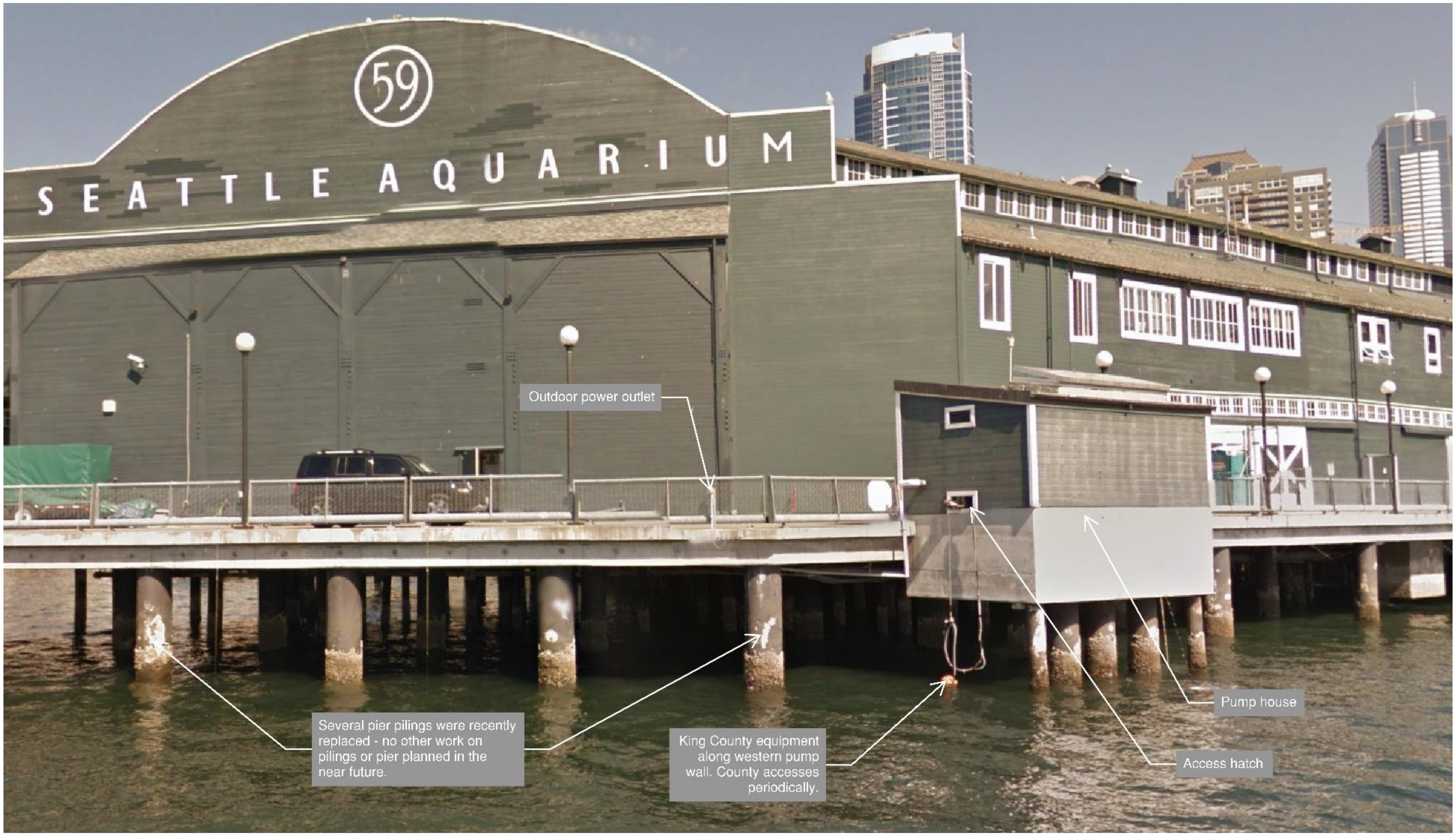

Figure 10: Seattle Aquarium Pier – Pump House, Facing West Interior Wall

Figure 11: Seattle Aquarium Pier – Pump House, Facing Exterior Wall (Looking East)

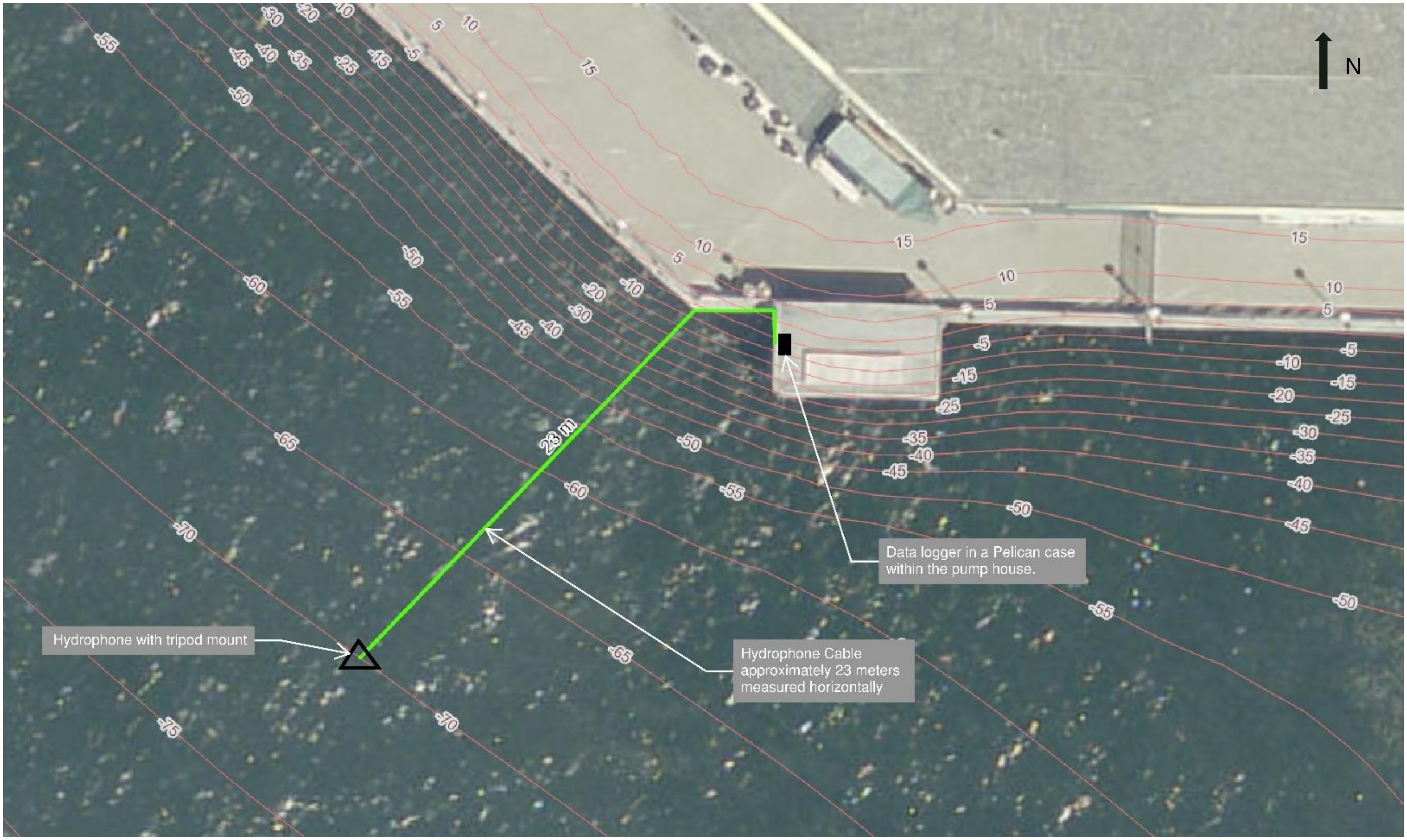

Figure 12: Seattle Aquarium Pier – Hydrophone Equipment Schematic

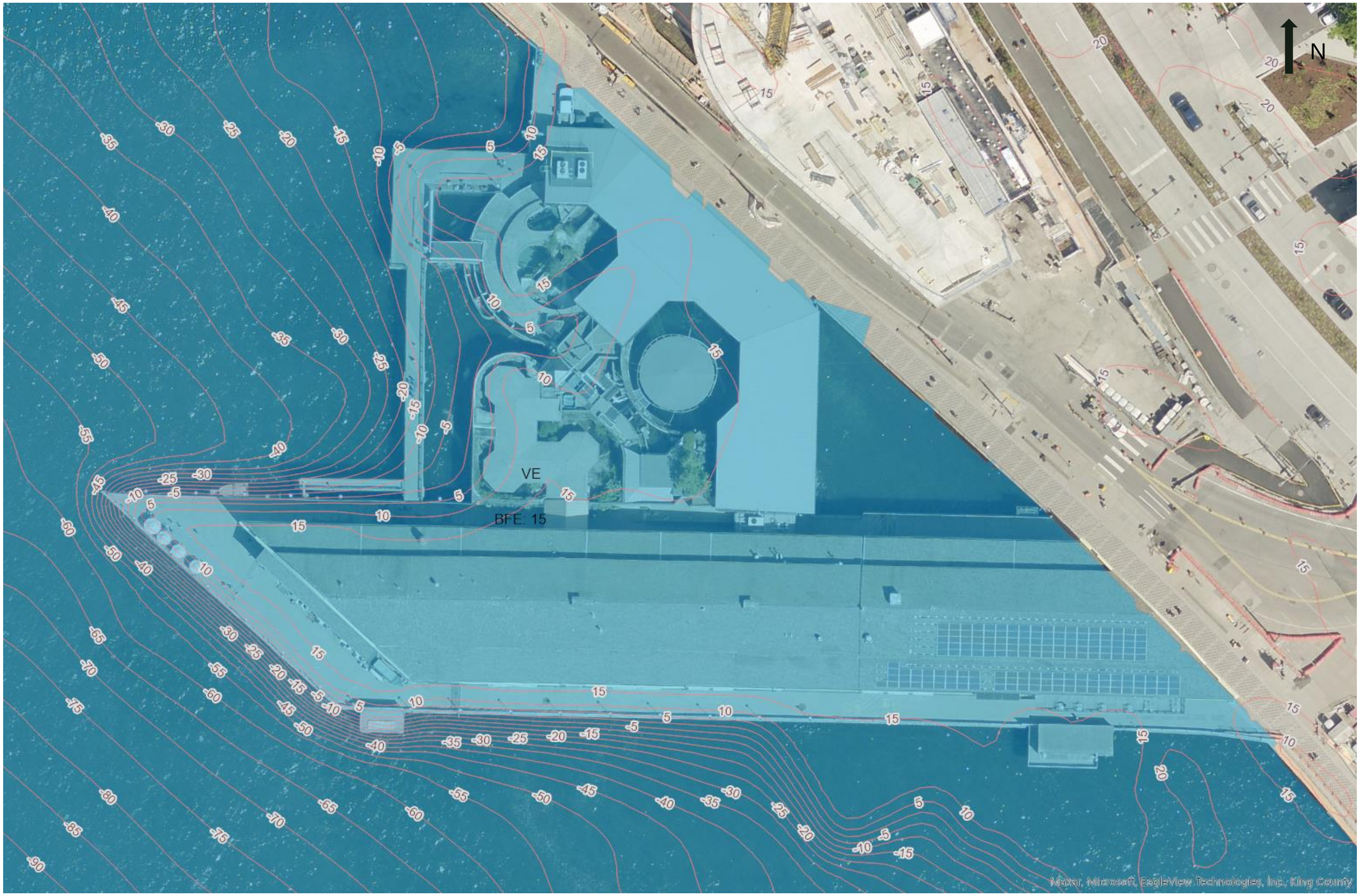

Figure 13: Seattle Aquarium Pier – FEMA SFHA Zone VE with BFE 15-Feet (Contours and Bathymetry from King County)

2.4.2 Jack Block Park Pier/Overlook

Jack Block Park (Park) is located at 2130 Harbor Ave SW in Seattle, Washington. The Park is operated through the Port of Seattle and is open to the public, with the exception of the public access pier. The Park features walking paths, beach access, a pier, and observation overlook tower. Portions of the park are within the FEMA SFHA Zone VE with a BFE of 15 ft (NAVD88; Figure 14). SLR visited the site with Port of Seattle personnel on September 27, 2024, to assess the site for suitability for long-term deployment. Upon inspection, it was determined that there may be two areas suitable for deployment: the pier and the old rail car loading area directly underneath the overlook tower walkway, as shown in Figure 15.

2.4.2.1 Jack Block View Pier

The pier is located in the northeastern portion of the Park and has been closed to the public since 2020 due to structural degradation and is tentatively scheduled for replacement in 2027. Access to the pier is currently restricted via a chain link fence gate and padlocks (Figure 15). The pier has multiple light poles and a metal railing with chain link fencing around the perimeter, though the chain link fencing has become separated from the northern pier railing (Figure 16, Figure 17, Figure 18, and Figure 19).

The pier has historically had power routed along the east side to facilitate lighting along the pier, but power has been shut off since the pier closure. During the site visit, Port personnel noted that there is limited security at the site, and despite the pier closure, there is evidence of vandalism. It was also noted that the highest astronomical tide (HAT) or king tide water surface levels have risen above the pier's decking. The National Oceanic and Atmospheric Administration (NOAA) Station 9447130 records tidal data within Elliott Bay (applicable to all sites) where the following notable tidal water levels have been recorded (Datums - NOAA Tides & Currents):

1. Mean Higher-High Water (MHHW) = 9.02 ft NAVD88 elevation.
2. Highest Astronomical Tide (HAT) or King Tide = 10.96 ft NAVD88 elevation.
3. Maximum observed tide occurred December 27, 2022, with an NAVD88 elevation of 12.78 ft.

The ideal location for storage would be along the northeastern side of the pier along the railing, as shown in Figure 16. Storing the hydrophone system at the pier would require verification of power availability, retrofitting power, strategically placing the equipment on the pier, and implementing security measures to reduce the risk of equipment failure. A schematic of the proposed hydrophone system setup is provided in Figure 20.

SLR recommends creating or obtaining an approximate 2x2x3 ft locked enclosure for the 1660 Pelican case and mounting it to the northeast railing above the BFE of 15 ft, above the HAT, or maximum observed tide to reduce the risk of flooding and vandalism. The power cable would use the existing light pole power with a rigid conduit running between decking boards or below deck to the mounted box. The underwater Cat 6 Ethernet cable connected to the hydrophone will be routed behind the pier railing through a rigid conduit for several feet before being diverted underwater. The hydrophone will be mounted on a collapsible tripod that will sit on the seafloor at approximate NAVD88 elevation -70 ft using an approximate cable length of up to 100 m. Further coordination with the Port of Seattle will be required to ensure power availability, implementation, design and the installation of equipment security measures.

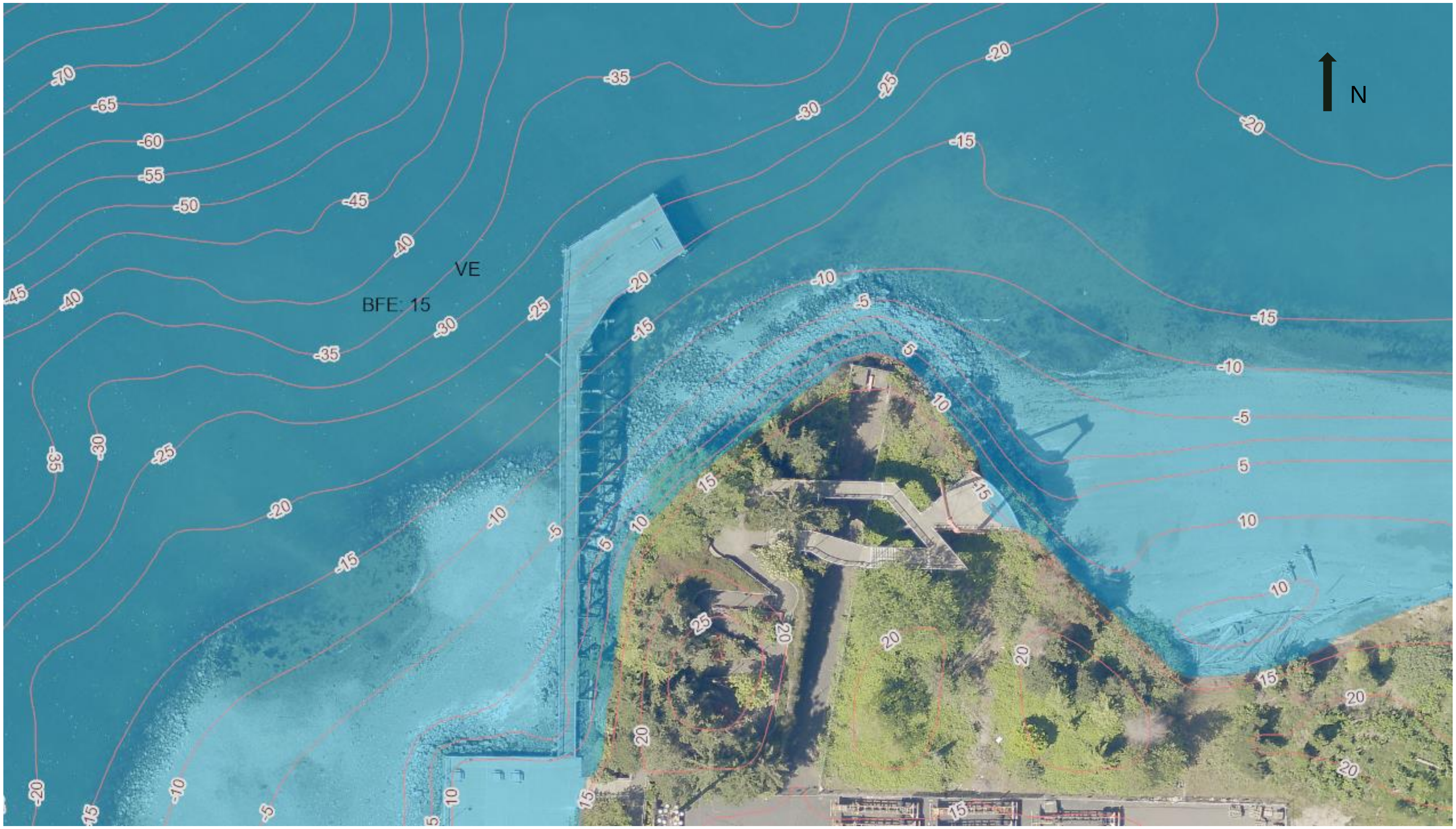

Figure 14: Jack Block Park – FEMA SFHA Zone VE with BFE 15 ft (Contours and Bathymetry from King County)

Figure 15: Jack Block Park – Plan View and Potential Data Logging Equipment Sites

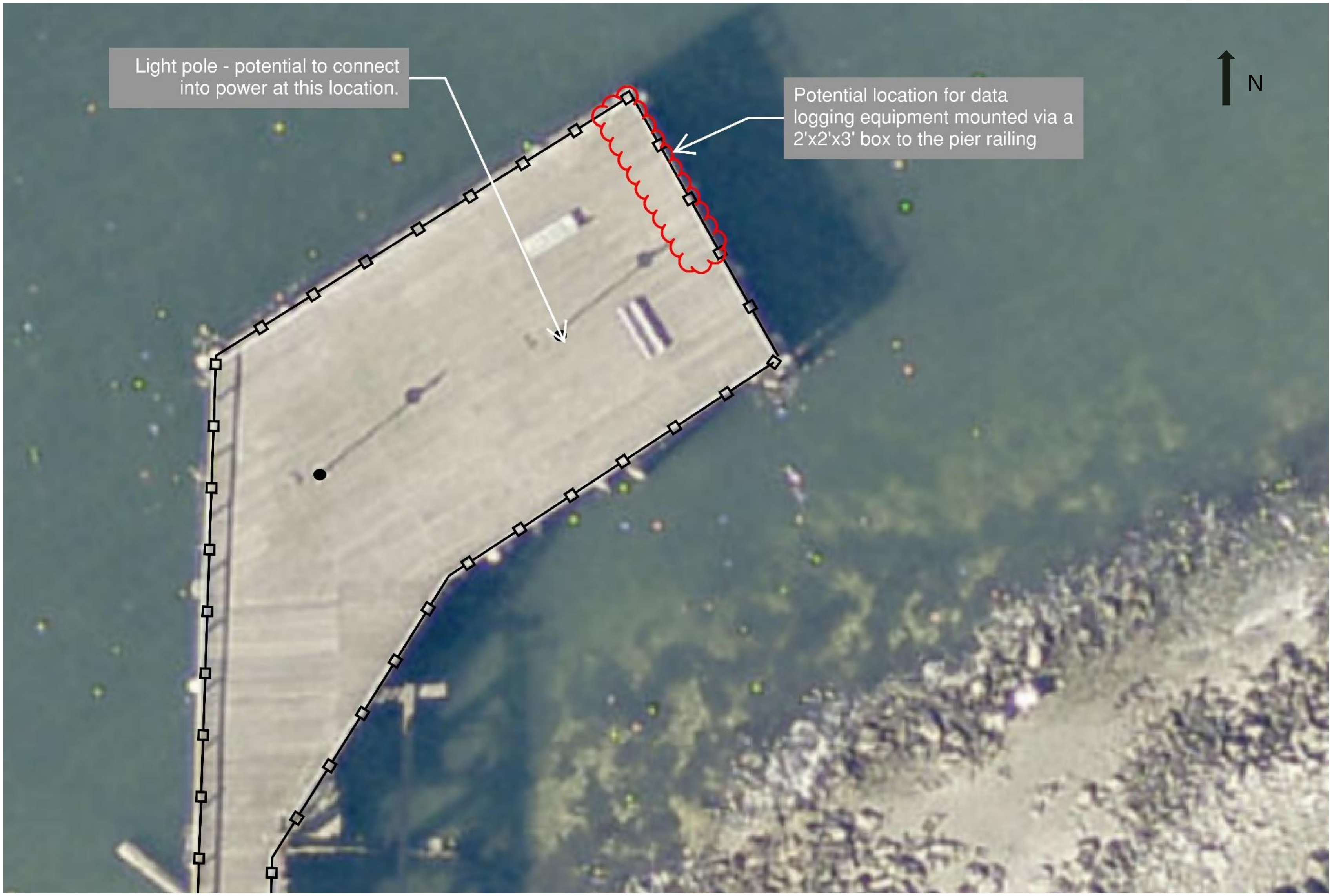

Figure 16: Jack Block Park – Pier, Existing Site Features and Potential Location for Equipment Mount at Pier

Figure 17: Jack Block Park – Pier, Looking Northeast

Figure 18: Jack Block Park – Pier, Looking Northeast from Beach

Figure 19: Jack Block Park – Pier, North Railing Separation

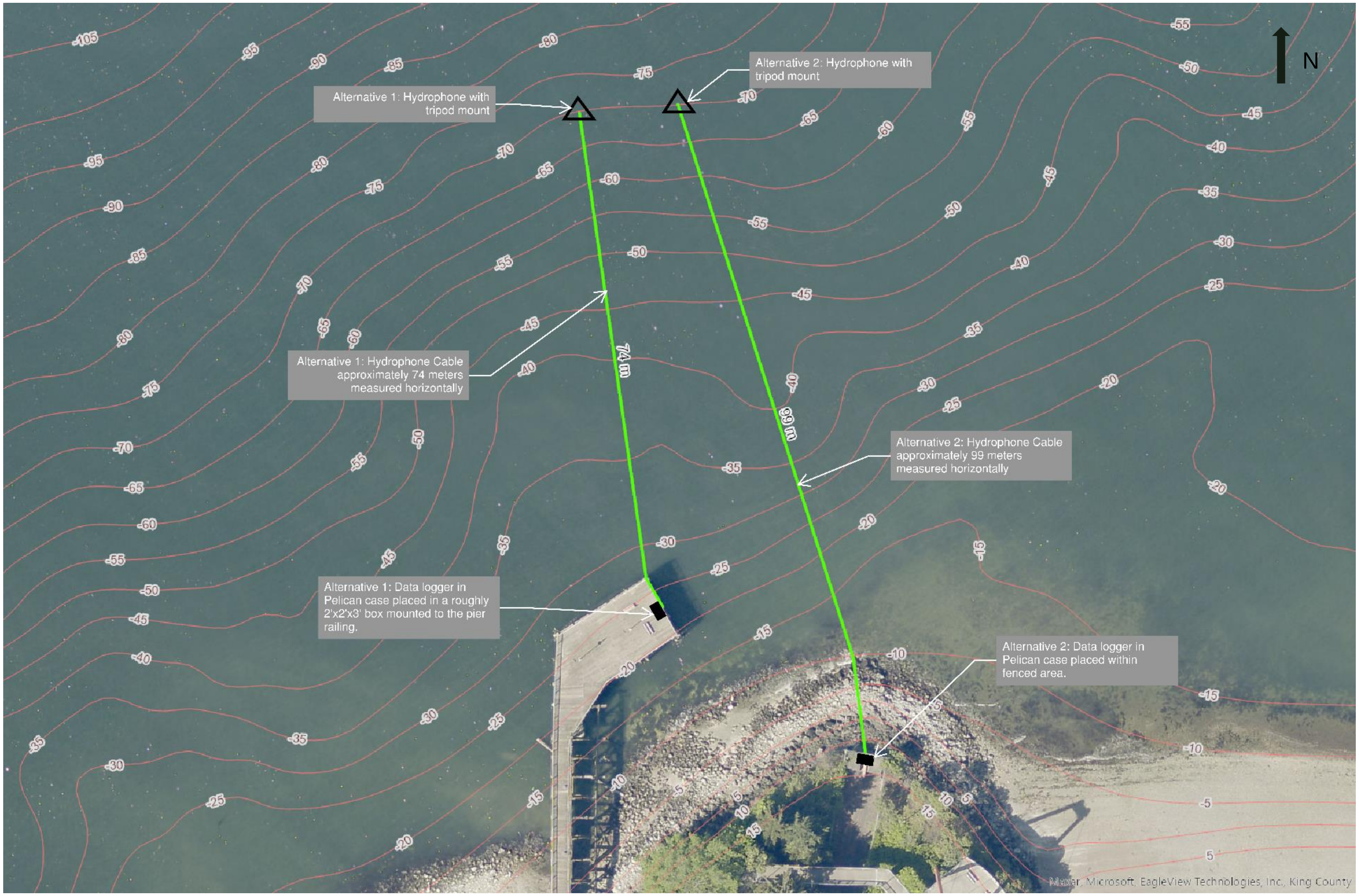

Figure 20: Jack Block Park – Hydrophone Equipment Schematics (Contours and Bathymetry from King County)

2.4.2.2 Rail Car Loading Area

There is what appears to be an old and unused rail car loading area just east of the Jack Block Park pier. The rail car loading area (Figure 21) is surrounded by a chain link fence with barbed wire and gated limited access to tenant personnel, with Port access only under emergency or specifically authorized circumstances. There is an entrance to the south, shown in Figure 15 and Figure 22, and one along the west shown in Figure 23. The west entrance leads into an area overgrown with vegetation under the overlook. There are two concrete blocks at the end of the loading area, as shown in Figure 24, presumably from remnant loading equipment. There is power alongside the overlook pier shown in Figure 25 that could feed power into the rail car loading area. Alternatively, the rail car area would be conducive to placing solar panels for hydrophone system power.

The rail car loading area is completely outside of the FEMA floodplain (Figure 14) and below mean higher high water and HAT levels. The Pelican case could be securely stored within the fenced area without additional protection. The power cable could either use the existing power located at the overlook pier with a hard conduit routed to the Pelican case or setup with solar panels.

The underwater Cat 6 Ethernet cable connected to the hydrophone will be routed behind the fencing down the beach being diverted underwater and along the sea floor. The cable can be placed in rigid conduit or buried within the riprap to avoid vandalism. The hydrophone will be mounted on a collapsible tripod that will sit on the seafloor at approximate NAVD88 elevation -70 ft. The cable length will require a cable length in excess of 100 m to facilitate this layout. A potential schematic for the hydrophone setup within the Jack Block Park rail car loading area is presented in Figure 20. The program team will continue to coordinate with the Port of Seattle on power availability, implementation, permitting, site usage, and access.

Figure 21: Jack Block Park – Existing Site Features and Potential Location for Equipment Mount at Old Rail Car Loading Area

Figure 22: Jack Block Park – Overlook, Old Rail Car Loading Area Access

Figure 23: Jack Block Park– Overlook, Rail Car Loading Area West Entrance

Figure 24: Jack Block Park – Overlook, Old Rail Car Loading Area

Figure 25: Jack Block Park – Overlook, Power along Overlook Pier

2.4.3 Pier 62

Pier 62 is managed by the Seattle Center and the City of Seattle. The pier is located at 1951 Alaskan Way in Seattle, Washington. The pier is open to the public and features a boat launch, a floating dock, an open water edge, and various maritime and public event uses. SLR, Port, and Seattle Center personnel met onsite on September 26, 2024, to discuss the potential use of the site and assess the suitability of storing the hydrophone equipment onsite over the monitoring period.

The northwesternmost point of Pier 62 is an optimal location for equipment deployment and storage. The northwestern corner has an electrical box mounted to the pier decking with 120V 20A outlets per Figure 26 and Figure 27. It was noted on site that the power along the pier's south side is not as reliable as the supply to the north. The site is public and has experienced vandalism, so consideration should be given to extra security measures to reduce the risk to the equipment. The northwest corner features a fire hydrant mounted on the outside of the west side of the railing (Figure 28) and a lock box mounted to the metal railing on the inside of the northern railing (Figure 29). Clearance and access to the lockbox, fire hydrant, and electrical box must be maintained.

SLR recommends the data logging equipment Pelican case be stored within a 2x2x3 ft locked box mounted to the pier’s metal railing, similar to the existing lockbox. The power cable would ideally use the existing electrical box’s 120V 20A power outlet with a hard conduit routed to the hydrophone’s mounted box. The underwater Cat 6 Ethernet cable connected to the hydrophone would then be routed behind the pier railing through a hard conduit for several feet before being diverted underwater. The hydrophone will be mounted on a collapsible tripod that will sit on the seafloor at approximate NAVD88 elevation -70 ft using an approximate cable length of up to 100 m. The shoreline is within the FEMA SFHA Zone VE with a BFE of 15 ft (NAVD88; Figure 30), and mounting the equipment on the railing should provide protection from tidal flood waters. The proposed hydrophone schematic of the system for Pier 62 is presented in Figure 31.

A follow-up meeting was held with the City of Seattle to further discuss the power availability and setup on October 8, 2024. Power cannot be dedicated to hydrophone equipment, but an optional pole-mounted solar panel setup may be more amenable. The program team will continue coordinating with the City of Seattle on the setup, design, permitting, installation, and monitoring. At this time, the location of equipment storage and schematic (Figure 31) has not changed; however, the power supply is likely limited to solar panels and a pole would need to be erected or retrofitted to facilitate the power needs. The pole would need to be engineered or verified to withstand the system’s weight, wind, obstructions, mounting height, and equipment security.

Figure 26: Pier 62 – Existing Site Features and Potential Location for Equipment Mount

Figure 27: Pier 62 – Electrical Box with 120V 20A Power Outlets

Figure 28: Pier 62 – Fire Hydrant

Figure 29: Pier 62 – Existing Lock Box Mounted to Railing

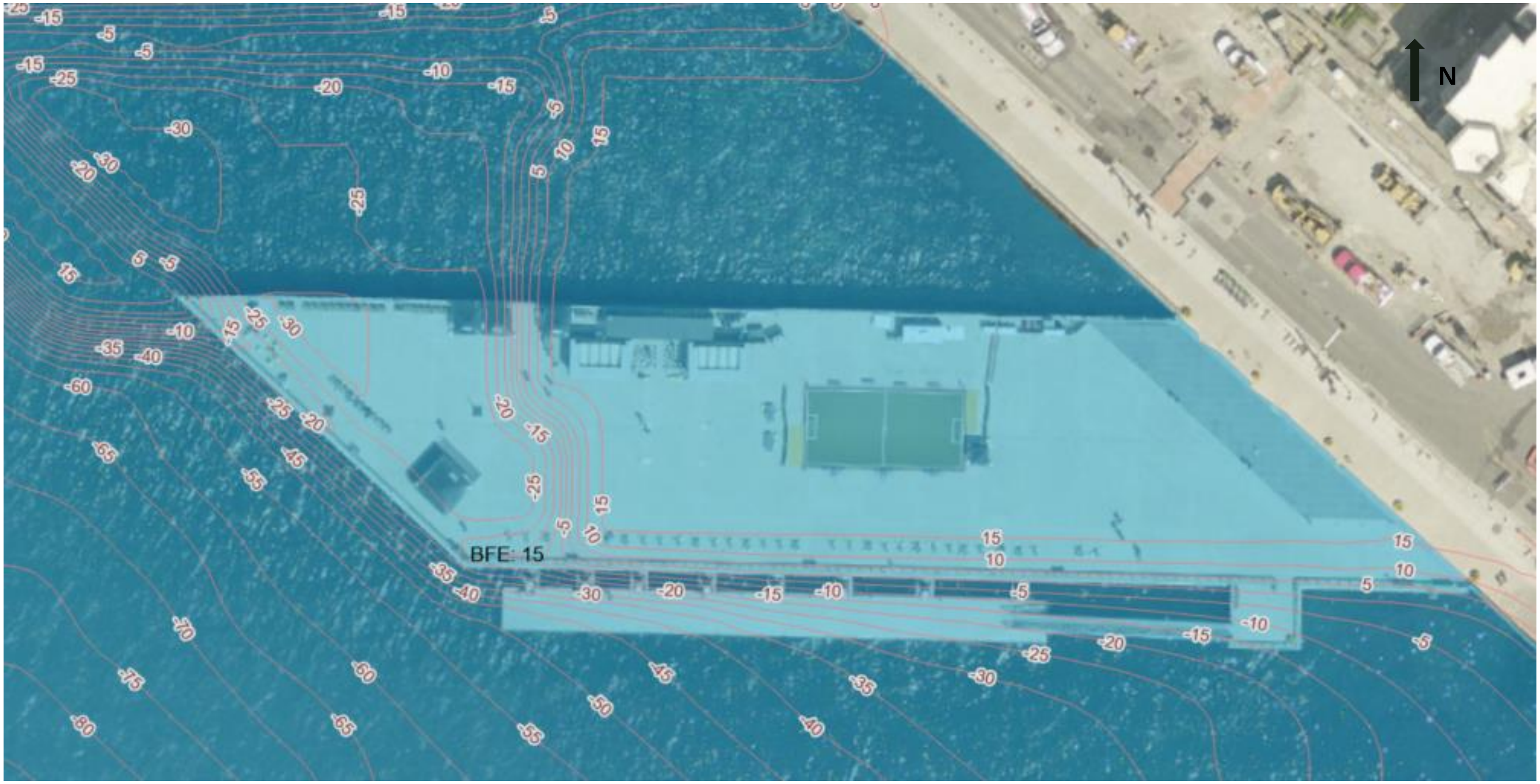

Figure 30: FEMA SFHA Zone VE with BFE 15 ft (Contours from King County)

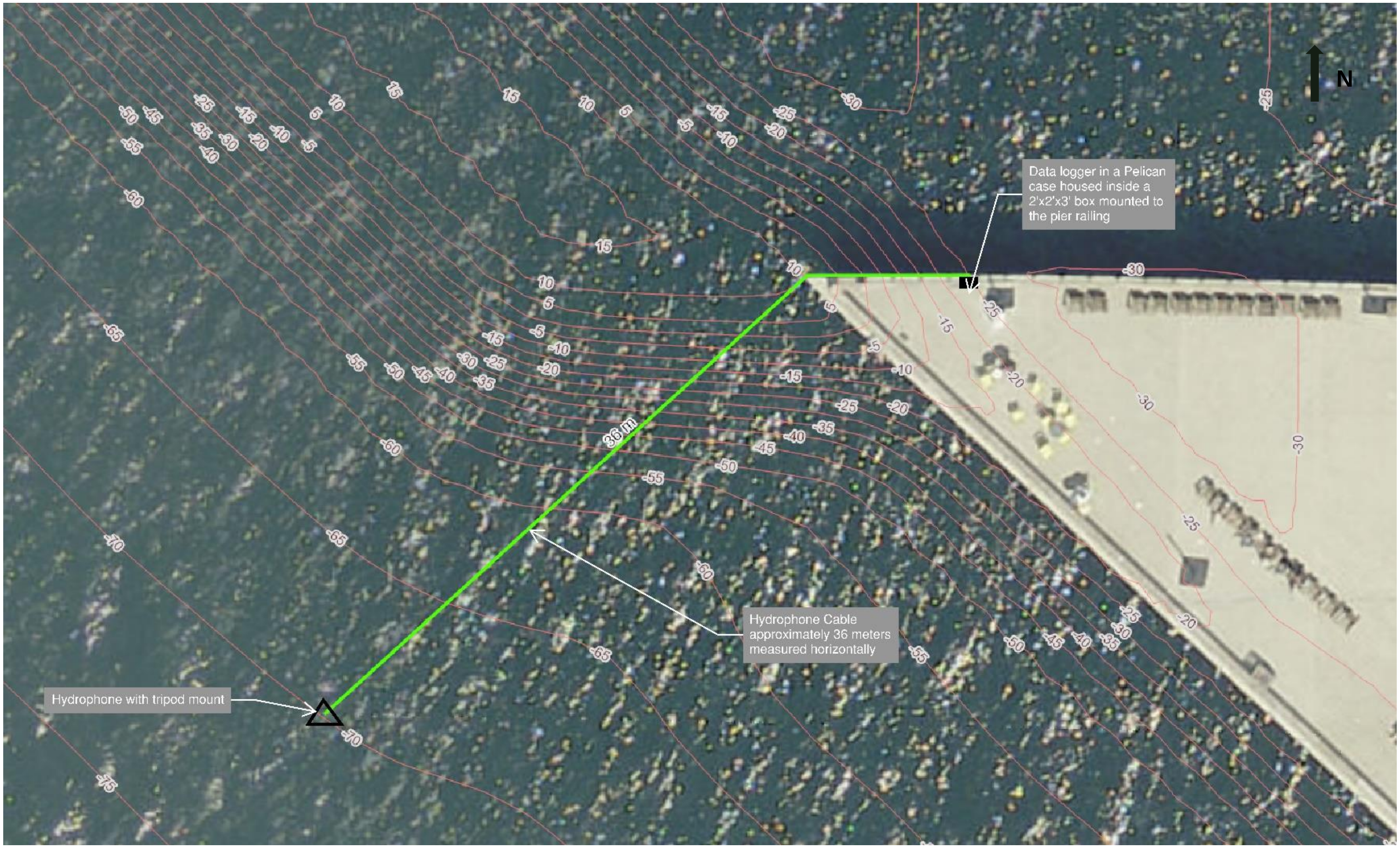

Figure 31: Pier 62 – Hydrophone Equipment Schematic

2.4.4 West Seattle Water Taxi Pier

The City of Seattle Department of Parks and Recreation manages the West Seattle Water Taxi Pier. SLR, Port of Seattle, and City of Seattle personnel visited the West Seattle Water Taxi on September 27, 2024, to determine suitability for equipment storage and monitoring. The pier is located within the City of Seattle at 1660 Harbor Ave SW in Seattle, Washington. The Water Taxi features a wooden pier, a boat launch, and a floating dock with a ramp, as shown in Figure 32. The pier is a popular fishing location and has notable vandalism. The dock has a boat launch that is restricted and gated (Figure 33 and Figure 34). Power is available at the pier within an enclosure mounted to the wooden railing on the west side of the boat launch enclosure, with power used mainly for the boat launch and the light poles (Figure 35 and Figure 36). The light poles are powered during limited times of the day and are unreliable for continuous power draw.

Because site security is a concern, SLR recommends storing the data logging equipment within a roughly 2x2x3 ft locked box mounted to the wooden pier railing within the boat enclosure area. The mounted box could be created or procured and placed in a location to maintain access and function of the boat launch area. The power cable would use the existing electrical box's 120V 20A power outlet with a rigid conduit routed to the enclosure. The underwater Cat 6 Ethernet cable connected to the hydrophone will be routed between the pier and the floating dock ramp (Figure 37) through a rigid conduit for several feet before being diverted underwater. This site has constant traffic from the Water Taxi that may dominate the soundscape and limit the data results. Therefore, should this location be the most viable, the hydrophone is recommended to be deployed as far from the Water Taxi traffic lanes as possible and is currently recommended to be deployed from the northernmost pier to deep water. The Ethernet cable is bright green and may need to be coated or concealed to prevent excessive interest from fishers. The hydrophone will be mounted on a collapsible tripod that will sit on the seafloor at approximate NAVD88 elevation -70 ft, using an approximate cable length of up to 100 m. The shoreline is within the FEMA SFHA Zone VE with a BFE of 14 ft (NAVD88; Figure 38), and mounting the equipment within the boat launch area on the railing should provide protection from tidal flood waters. A proposed hydrophone schematic of the hydrophone system set up at the West Seattle Water Taxi pier is presented in Figure 39. The program team will continue coordinating with the Seattle Department of Parks and Recreation on the availability of power, equipment setup, design, permitting, and installation of the hydrophone equipment. However, one disadvantage of this option is that since the site is close to the SeaBus, vessel noise is expected to dominate the soundscape, and very little additional knowledge can be gained.

2.4.5 Final Selection Considerations

After the final site selection, a remote-operated vehicle (ROV) or underwater camera will survey the cable route and mooring site. Crevice protection for the intertidal is needed, and cable route obstructions (for entanglements and suspensions) should be avoided. The mooring site should be flat with a 35-degree maximum slope and no nearby acoustic reflectors (boulders or cliff faces). Note that small rocks moving in the current can be very noisy.

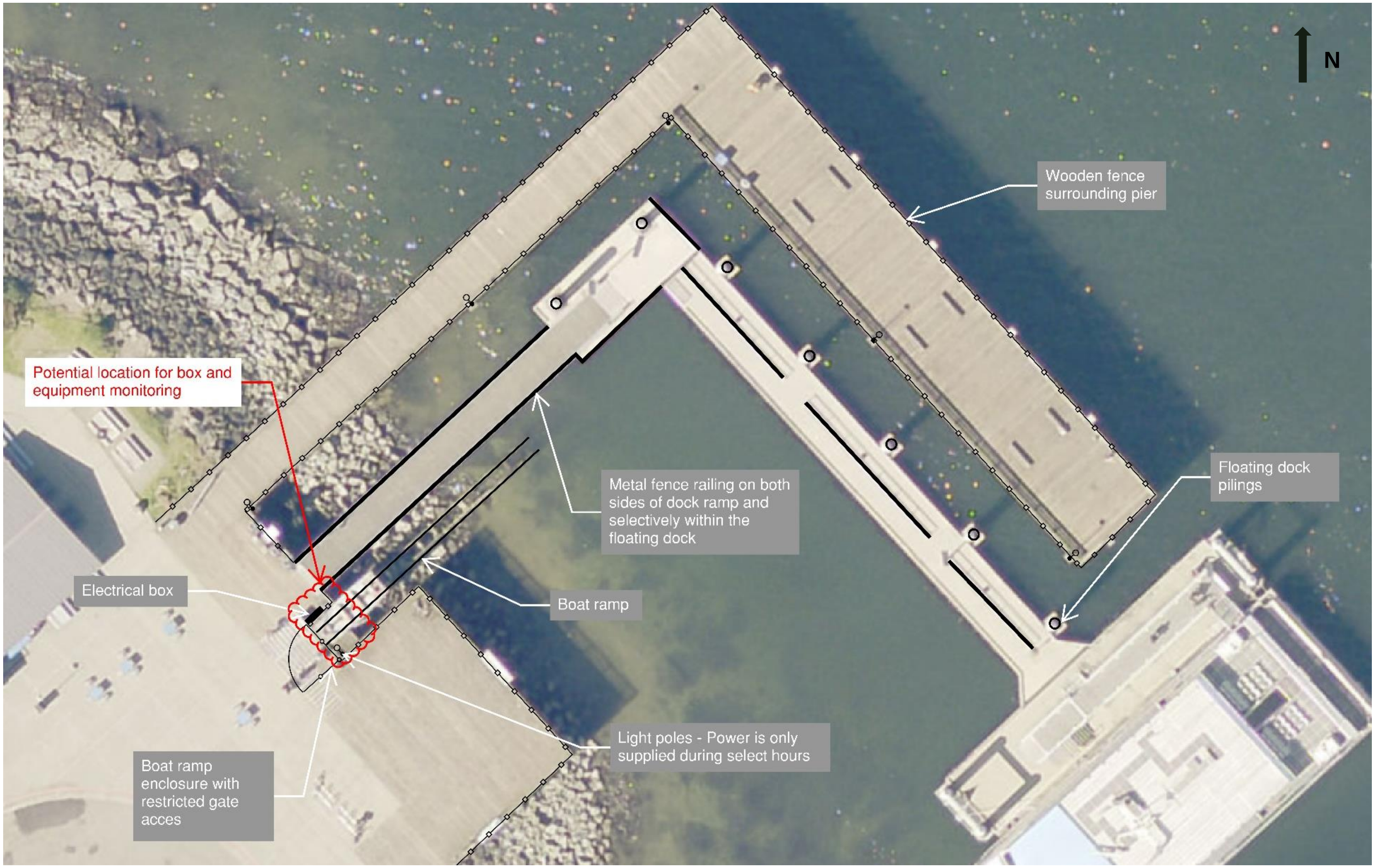

Figure 32: West Seattle Water Taxi – Existing Site Features and Potential Location for Equipment Mount

Figure 33: West Seattle Water Taxi – Boat Launch Access Area and Gate Looking Northeast)

Figure 34: West Seattle Water Taxi – Boat Launch Area Looking Northwest

Figure 35: West Seattle Water Taxi – Electrical Panel Enclosure

Figure 36: West Seattle Water Taxi – Electrical Enclosure

Figure 37: West Seattle Water Taxi – Pier, Looking Northeast Between Pier and Floating Dock Ramp

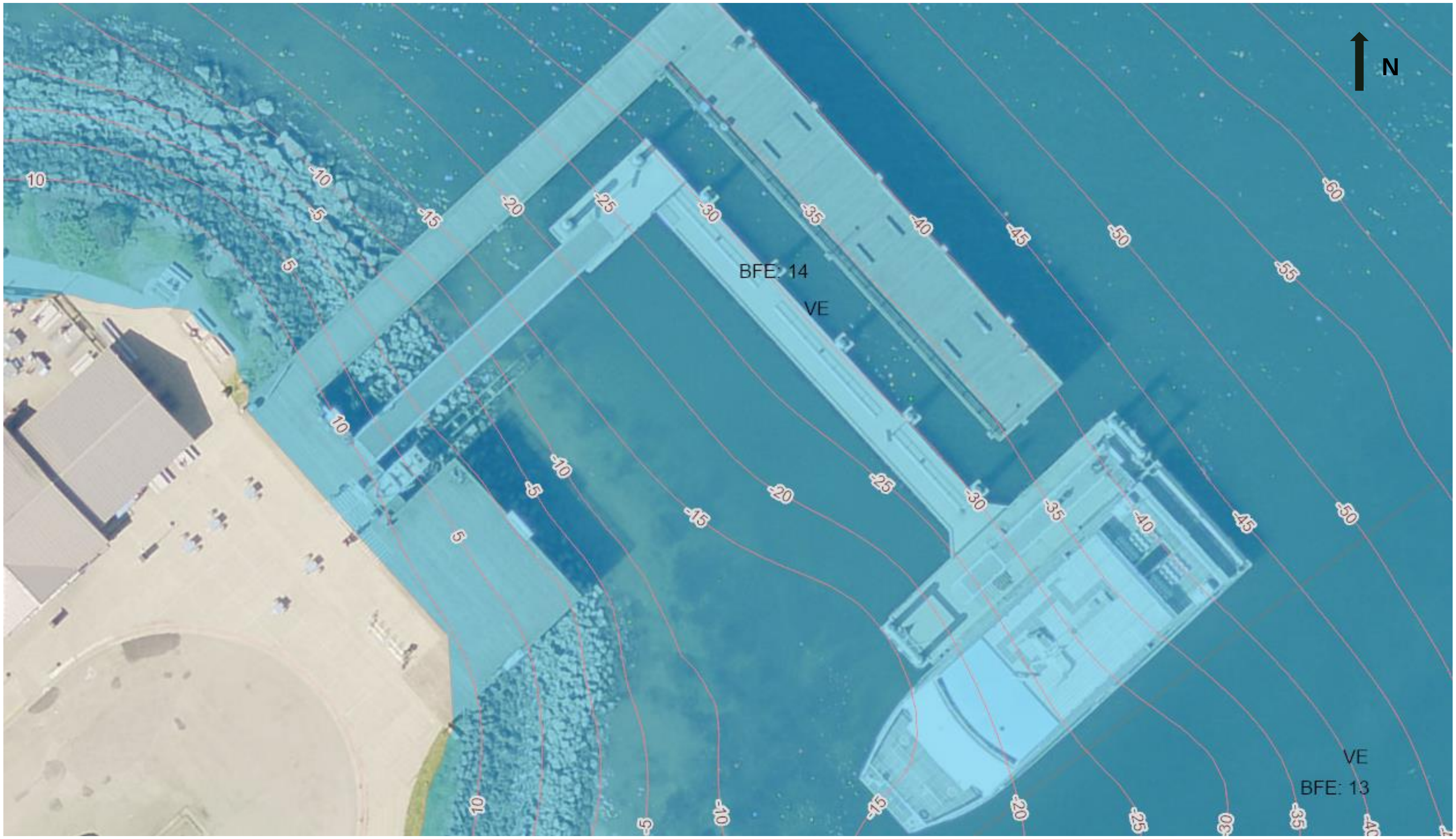

Figure 38: West Seattle Water Taxi – FEMA SFHA Zone VE with BFE 15 ft (Contours and Bathymetry from King County)

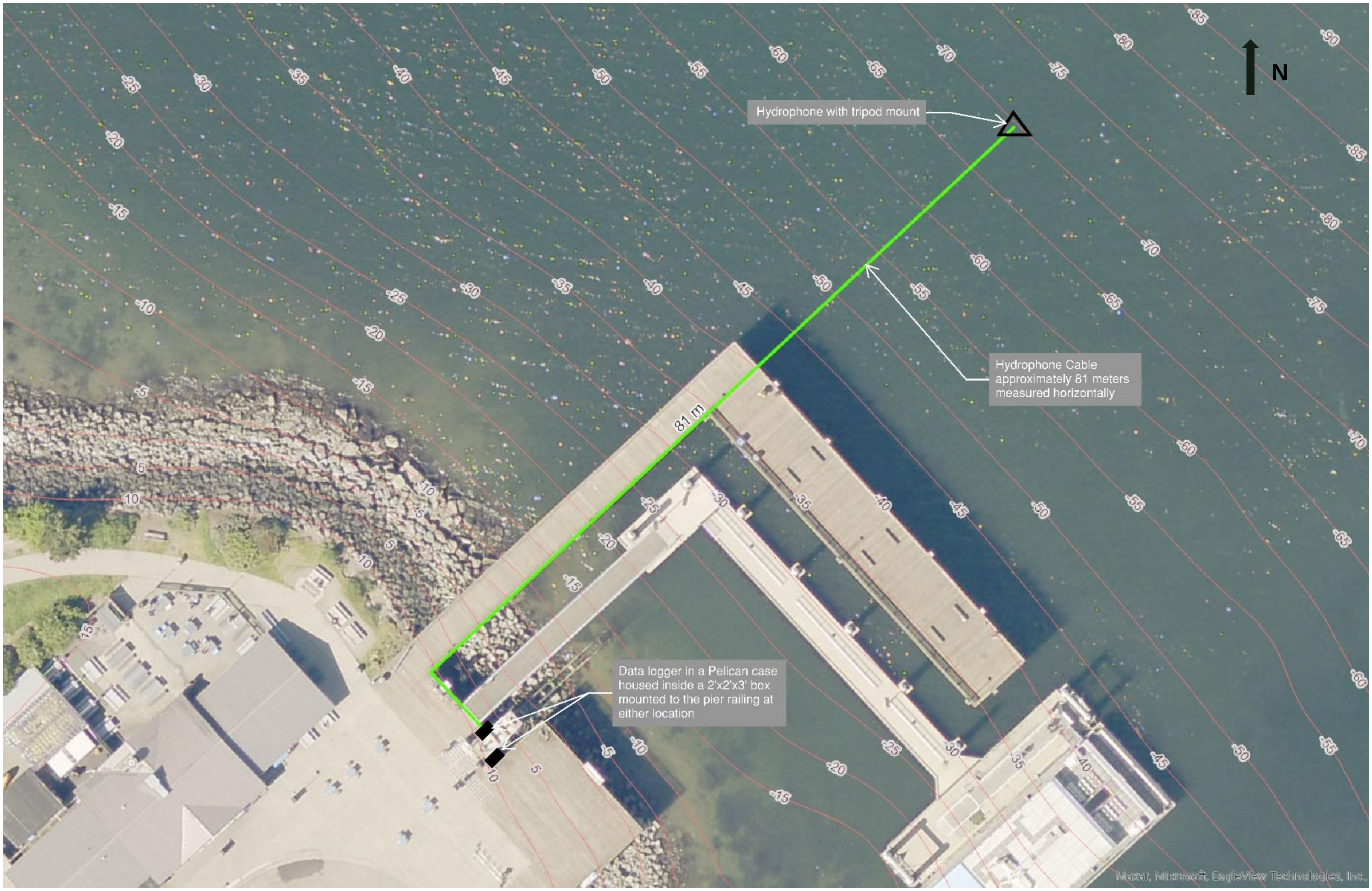

Figure 39: West Seattle Water Taxi – Hydrophone Equipment Schematic

3.0 Phase II – Program Implementation

3.1 Permits anticipated to execute Phase II Program Implementation

The Phase II program implementation for underwater data collection efforts will commence within Elliott Bay on regulated land and waters requiring permits, consultations, reviews, certifications, licenses, and/or approvals on a local, state, and federal level. The program will coordinate with the Washington State Department of Natural Resources (DNR), the Washington Department of Fish and Wildlife (WDFW), the United States Coast Guard (USCG), the United States Environmental Protection Agency (EPA), the United States Army Corps of Engineers (USACE), federally recognized Tribes with treaty-reserved Usual and Accustomed areas within the program area, Washington State Department of Ecology (Ecology), the City of Seattle, the Port of Seattle, and property owners/managers including Seattle Center, and the Seattle Aquarium Society. Several permits will be initiated through the Joint Aquatic Resources Permit Application (JARPA), which streamlines the approval process through the USACE, Ecology, DNR, USCG, WDFW, and local jurisdictions as they relate to regulated shorelines. A summary of permits being pursued as part of the Phase II program is summarized in Table 2 and outlined in the following sections.

3.1.1 Washington State Department of Natural Resources

The Washington State DNR manages state trust lands for the people of Washington with a mission to manage, sustain, and protect the health and productivity of lands and waters to meet the needs of the present and future generations. The program is proposed to include activities for scientific and/or environmental purposes on submerged land managed by the DNR. This will require an Aquatic Land Right of Entry License as per the Aquatic Land Revised Code of Washington (RCW), Chapter 79.105. DNR review periods can be highly variable and can be anywhere from one month to a year for an Aquatic Lands Right of Entry License.

3.1.2 Washington Department of Fish and Wildlife

The WDFW is a state department focused on protecting, preserving, and perpetuating fish, wildlife, and ecosystems to work in conjunction with recreation and anthropogenic influences under the Washington state hydraulic code. The phase II implementation is expected to require activities (deployment and monitoring) below the ordinary high-water mark of Elliott Bay, necessitating coordination and a Hydraulic Project Approval (HPA) through the WDFW. An HPA typically takes one to three months.

3.1.3 United States Army Corps of Engineers

The USACE regulatory program controls discharges of dredges or fill material into waters of the US and structures or work in navigable waters of the US under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. The program proposes to work in, over, under, or affect navigable waters of the United States, specifically the Puget Sound. Because Elliott Bay is home to several endangered species, the USACE will lead a consultation with the Section 7 Endangered Species Act (ESA) reviewers, including the US Fish and Wildlife (USFW) and National Marine Fisheries Service (NMFS). The work is expected to fall under a Nationwide Permit (NWP) 6 for Survey Activities. Upon receipt of the complete application, an NWP typically takes two to six months; however, this can vary depending on the complexity of the program and reviewer availability.

3.1.4 United States Coast Guard and United States Environmental Protection Agency

The program proposes to implement a hydrophone system from the Jack Block Park pier with an approximately 100 m cable and hydrophone into Elliott Bay. The proposed hydrophone system will be within the extent of the marine sediment cleanup units of the Pacific Sound Resources Superfund site. A sediment cap extends from the shoreline and under the view pier into Elliott Bay, and the marine waters encompassing the cap are designated as a Regulated Navigation Area. The 33 Code of Federal Regulations (CFR) § 165.1336 prohibits actions that would disturb the seabed, such as anchoring, dragging, trawling, spudding, or other activities that disrupt the integrity of the sediment caps installed. As the hydrophone system is anticipated to impact the sediment cap negligibly, a waiver will be requested from the Captain of the Port (COTP), an officer of the USCG. The COTP enforces vessel protection, security, and safety regulations within Elliott Bay and will consult with the EPA as necessary to make a determination. The determination is anticipated to take three to six months.

3.1.5 Washington State Department of Ecology

The program is located in King County, which is part of Washington State’s Coastal Zone Management (CZM) program, and the program requires a federal permit. Therefore, the program requires an application for certification of consistency with the Coastal Zone Management Program. The CZM consistency process is included as part of the USACE NWP determination and within the same review timeframe.

3.1.6 City of Seattle

The program will implement hydrophone systems within the City of Seattle's jurisdiction. The implementation and deployment are within 200 ft landward of the ordinary high-water mark and will require compliance with the City of Seattle’s Shoreline Master Program (SMP). The work is expected to fall under a Shoreline Exemption per Seattle Municipal Code (SMC) 23.60A.020(C)(12), which covers “site exploration and investigation activities that are prerequisite to preparation of an application for development authorization.” Environmental review in compliance with the State Environmental Policy Act (SEPA) is anticipated to be categorically exempt per SMC 25.05.800(R) “information collection and research.” The shoreline and SEPA exemption process is anticipated to complete the approval process within one to three months.

The sites within the City of Seattle Department of Parks and Recreation's purview will require Revocable Use Permits (RUPs) for non-park uses of park property. A RUP will be completed to initiate the permit process and allow agency representatives to visit the sites if needed, and another will be completed to deploy the hydrophone equipment and continuously monitor it for the two-year period. RUP issuance is anticipated to be completed between one and three months after submission.

Table 2: Potential environmental permits and supporting documentation for the Port of Seattle Underwater Noise Phase II Monitoring Program

Permit/ Review/ Certification/ License/ Consultation	Regulation	Agency	Jurisdiction	Supporting Documentation	Timing[1] (Months)	Comments
United States Army Corps of Engineers (USACE) Section 10 Nationwide Permit (NWP)	Section 10 of the Rivers and Harbors Act of 1899 Section 7 of the Endangered Species Act	USACE (Section 10) NOAA NMFS, USFWS (jointly the Services) (Section 7 ESA)	Conducting work in, over, or under navigable waters of the United States	Biological Evaluation/No effect letter SEPA Determination JARPA	2 - 6	NWP 6 for Survey Activities
Coastal Zone Management (CZM) Consistency	Coastal Zone Management Act of 1792 Washington State Coastal Zone Management Program	Washington State Department of Ecology	Activities either undertaken by a Federal agency, or that require Federal approval or use of federal funding that occur within the coastal zone which will affect a land use, water use, or natural resources of the coastal zone	JARPA Application for Certification of consistency	2 - 6	Completed as part of the JARPA process
Hydraulic Project Approval (HPA)	Washington State Hydraulic Code	WDFW	Activities affecting waters of the state	Online Application SEPA Determination Property Owner Consent	1 - 3	Coordination with WDFW is recommended prior to submitting application
State Environmental Policy Act (SEPA)	Exemption per the City of Seattle Municipal Code (SMC) 23.60A.020(C)(12)	City of Seattle Department of Construction and Inspections	Determine if a project will have significant adverse environmental impacts Agency decisions on policies, plans, or regulations; decisions to license, fund, or undertake a proposal; decisions to purchase, sell, or lease resources	SEPA Exemption JARPA	1 - 3	
Shoreline Exemption	Shoreline Management Act City of Seattle Shoreline Master Program (SMP), Chapter 23.60A Exemption under SMC 25.05.800(R) – Information Collection and Research	City of Seattle Department of Construction and Inspections	Activities occurring within shoreline jurisdiction	Shoreline Exemption JARPA	1 - 3	

Permit/ Review/ Certification/ License/ Consultation	Regulation	Agency	Jurisdiction	Supporting Documentation	Timing[1] (Months)	Comments
Revocable Use Permit (RUP)	City of Seattle Municipal Code (SMC) 18.12.042, 18.12.045, and 18.12.275	City of Seattle Department of Parks and Recreation	Non-park use of park property	RUP Application	1 - 3	RUP is required to finalize the JARPA and for deployment and monitoring
Aquatic Lands Right of Entry License	Aquatic Lands Revised Code of Washington (RCW), Chapter 79.105	Washington State Department of Natural Resources (DNR)	Activities for short term recreational, scientific, or environmental purposes on submerged land managed by DNR	JARPA	1 - 12	Coordination with WDFW is recommended prior to submitting application
Regulated Navigation Area Activities Waiver	33 Code of Federal Regulations (CFR) § 165.1336	Environmental Protection Agency (EPA) United States Coast Guard (USCG)	Activities that would disturb the seabed, such as anchoring, dragging, trawling, spudding, or other activities that involve disrupting the integrity of the sediment caps installed are prohibited.	Waiver request	3 - 6	Captain of the Port (COPT) will consult with EPA prior to determination as necessary

Notes:

1. Timing is variable depending upon agency availability and project complexity. Timing is presented as a typical range for agencies to complete their review and determination.

Acronyms:

CFR: Code of Federal Regulations
COPT: Captain of the Port, an officer of the USCG
Ecology: Washington State Department of Ecology
EPA: Environmental Protection Agency
ESA: Endangered Species Act
DNR: Washington State Department of Natural Resources
JARPA: Joint Aquatic Resource Permit Application
HPA: Hydraulic Project Approval
NMFS: National Marine Fisheries Service
NOAA: National Oceanic and Atmospheric Administration
NWP: Nationwide Permit
RCW: Revised Code of Washington
SEPA: State Environmental Policy Act
SMC: City of Seattle Municipal Code
SMP: Shoreline Master Program
USACE: Seattle District, US Army Corps of Engineers
USCG: United States Coast Guard
USFWS: United States Fish and Wildlife
WDFW: Washington Department of Fish and Wildlife

3.2 Deployment Methodology

Hydrophone deployment typically entails:

1 Selection of a site by desktop assessment using Navionics and satellite images.

2 Conduct a site survey of the shore area and use an ROV to survey the cable route and mooring site. While Navionics bathymetry is often excellent; it is heavily augmented by recreational depth sounder data, which has a wide beam angle. As a result, chart plateaus and pinnacles may actually be large boulders, and a boulder field can look like a shallow, flat area on the chart.

3 Install the shore box and power. If solar-powered, also install a seawater ground wire. Secure the cables to the shore using wedge anchor bolts and P-clamps. If cable visibility on shore needs to be reduced, one 1-inch (25 millimeter [mm]) utility-grade polypipe can be used as a conduit for the cable and seawater ground. Sometimes, a 4.5 kilogram (kg; 10-pound [lb]) cable weight just below the cable entry to the water is used to prevent the cable from moving in the waves. Set up a radio or Ethernet connection, if needed.

4 Connect the underwater cable to the box and mooring for shore testing prior to mooring deployment.

5 Deploy mooring via boat: Back the boat from shore along the cable route, paying out cable. When above the deployment site, open the mooring and lock the legs in place. Run the deployment rope through the mooring deployment eye to the halfway mark on the rope. The rope length should be greater than twice the water depth, plus 10 m, with the halfway point marked on the rope. It is helpful to mark the deployment rope with numbered depth markers at 2 m on both sides of the rope. It is also helpful to attach a cabled-camera about 1 m above the mooring and secure the cable to one side of the deployment rope with clips (or tape), ensuring slack in the cable to account for rope stretch. Lower the mooring to the sea floor. If the camera shows it is not perched on a rock and is secure, position the boat so the deployment line is vertical and document the global positioning system (GPS) point at the rope. Release the non-camera rope end and pull the camera rope up until all the rope is aboard the boat.

3.3 Data Collection Procedures and Data Collection Intervals

Regular data collection and monthly equipment maintenance will occur, involving hard drive swaps, battery checks, and equipment inspections.

- Data collection will be non-intrusive concerning the existing soundscape and marine environment, using passive acoustic measurements without introducing artificial sounds or pollutants into the environment.
- These steps will ensure effective and continuous monitoring of underwater noise levels while safeguarding equipment from potential damage.
- The data collection box and power systems will be protected in a waterproof case to avoid any damage from high tides or other inclement weather events. However, after a similar weather episode occurs, general checks and maintenance will be carried out to ensure ongoing monitoring.
- The equipment will remain in place for at least 24 months at each location.
- All in-water and onshore equipment and cables will be removed at the end of this time.

3.3.1 Environmental data

Local/NOAA tidal and weather station data will be collected as appropriate to analyze potential impacts to the soundscape. Current data may require an estimate via model until a current monitoring station (e.g., the webTide prediction model) is brought online. The potential public and available source stations for environmental data (not including current speed or direction) are:

- Seattle, WA Station ID 947130
- Station WPOW1 – West Point, WA

3.4 Data Processing and Baseline Determination

The acoustic data processing aims to obtain a multi-year baseline of underwater noise at each representative site. Following the “ingestion” of data recorded over the first recording period, high-level comparisons and examination metrics will be analyzed by calendar months and shared with stakeholders. Subsequent analysis will also include seasonal periods (e.g., May-October for cruise season, November-April for quiet season) to compare soundscapes.

The technical reports will also include acoustic artifact identification (e.g., system noise), quantification of biological vocalizations (indicative of presence, not detailed species identification), and variation in the noise floor. Evidence and detection of trends (and subsequent variations) are essential in establishing a long-term ambient noise baseline and comparing measurements collected at different measurement sites.

Sound levels can be averaged and summarized along multiple dimensions, including frequency, time, geographic location, and depth. The best averaging and summary method depends on the signals of interest and in question. Ideally, the method selected for averaging will be meaningful in a physical and biological sense. Relevant metrics for averaging and summarizing sound levels, are as described in the following sections.

3.4.1 Averaging Methods

- The arithmetic mean (AM) is the average of the squared sound pressure and is sometimes termed a root mean square (RMS) level or linear mean. The advantage of this metric is that it provides estimates independent of the choice of the temporal analysis window. The metric is sensitive to outliers.
- The median is equal to the 50th percentile. The median depends on the chosen time window. Still, it is generally less influenced by transients and is more representative of background sound levels without high-amplitude transients.
- The mode is the sound level with the greatest probability. The mode is also sensitive to the applied temporal analysis window, which needs to be constant to establish a trend.

3.4.2 Statistical Representation

- In addition to average values expressed as AM or median, it is also important to consider the distribution of ambient sound levels. Some useful ways of representing the spread of such data include percentile statistics expressed as a boxplot, showing the median, mean, and selected percentiles, or as an empirical cumulative probability distribution function (ECDF) presenting the exceedance levels or percentiles.

- The spectral probability density (SPD) illustrates the distribution of sound levels based on their empirical probability density. Basically, SPD values reveal the variation of sound levels in a given frequency band, which can also be useful for identifying the distribution of particular anthropogenic and natural sound sources and investigating the variation of sound levels between multiple sites or in different periods.

3.5 Reporting Sound and Metrics

Consistency from data collection through analysis and reporting is clearly desirable to facilitate communication, collect data of appropriate quality, and provide consistent and compatible results.

The ambient noise levels will be reported using the general metrics specified in the international ISO standard 17208-1[6] and following the best practices for underwater noise measurement[7].

3.5.1 Pulsed (impulsive) Sounds

The most appropriate metrics for use with pulsed sounds are

- Sound Exposure Level (SEL) (for single pulse),
- Cumulative SEL (for a series of pulses),
- Peak sound pressure level, and
- Peak-to-peak sound pressure level.

Calculating the peak compressional and peak rarefactional sound pressure levels, the pulse duration, and the pulse repetition frequency may also be useful.

3.5.1.1 Construction Activities

SLR and the Port of Seattle will communicate up-to-date information regarding any impulsive anthropogenic noise events, such as marine construction activities in Elliott Bay, especially those close to the PAM monitoring sites. The influence of the subsequent source level and duration of said marine construction activities will be weighed and evaluated against the effect on the short-term acoustic recordings.

3.5.2 Continuous Sounds

The metric most suitable for continuous sounds (including ambient noise) is the Sound Pressure Level (SPL). Note that this is a time-averaged quantity by convention and is most understood as an RMS value. The averaging time used to calculate the values of SPL must be stated.

Where continuous sounds also contain transient or pulsed sounds from specific events, the metrics used for pulsed sounds should be used to describe these specific events.

[6] ISO 17208-1:2016 - Underwater acoustics

[7] Robinson, S.P.; Lepper, P. A. and Hazelwood, R.A. (2014) Good Practice Guide for Underwater Noise Measurement. Teddington, England, National Measurement Office, Marine Scotland, The Crown Estate, 95pp. (NPL Good Practice Guide No. 133). DOI: http://dx.doi.org/10.25607/OBP-21

3.5.2.1 Vessel Noise

Marine Exchange of Puget Sound has terrestrial-based AIS data (as opposed to satellite-based), and VTS Puget Sound also has data regarding commercial vessels that can be shared to document vessel transits. Vessel traffic classified from AIS data will be separated and classified by vessel class, including but not limited to bulkers, tankers, containerships, cruise/passenger, vehicle carriers, tugs, research vessels and other specialty types of commercial vessels. Some smaller recreational vessels may be identifiable if equipped with a class B AIS transponder (considered optional for most small/recreational vessels). The waterways and entrances to Elliott Bay will be "geo-fenced" to track entries and exits of AIS-equipped vessels entering the program/monitoring area.

3.5.3 Marine Mammals Sounds

Among the marine mammal species expected to be recorded within the projected area are the Harbor seal, Harbor porpoise, California sea lion, Steller sea lion, Humpback whale, Gray whale, Common minke whale, Risso's dolphin, Dall's porpoise, Killer whale resident/transient pods. In order to detect marine mammal vocalizations during the recording periods, use will be made of the open-source software PAMGuard, which contains specific algorithms to scan for different types of marine mammal sounds at different frequencies, such as moans from baleen whales and whistles and clicks from toothed whale species (e.g. dolphins, porpoises). In order to cover the full spectrum range of marine mammal vocalizations, the sampling rate has to be increased to 128 kSps, making the recording files very large and limiting the recording time of the device. However, since whistles and moans typically have frequencies less than 30 kHz, the cable-to-shore hydrophone system will have the ability to record at lower sample rates while also running a high-frequency click detector using PAMGuard to pick up higher-frequency echolocation clicks such as those from porpoises or killer whale. The latter increases recording time without losing too much acoustic information.

4.0 Schedule

The program timeline is provided in Table 3. This section details the program's progress and milestones achieved, as well as anticipated completion dates for upcoming milestones. Once permitting is completed, underwater ambient noise data collection is expected to begin during the first quarter of 2025.

Table 3: Program Schedule by Milestone and Completed or Anticipated Completion Date

Milestone	Completed/Anticipated Completion Date
Phase II Initial Outreach & Permitting	
Stakeholder Engagement Meeting #1	July 31, 2024
Stakeholder Engagement Meeting #2	November 13, 2024
Phase II Equipment Mobilization	
Permitting Package	In progress
Permitting Issuance	Q1 2025
Equipment Implementation/Installation	Q1 2025*

Milestone	Completed/Anticipated Completion Date
Phase II Program Design and Implementation	
Equipment Mobilization – PO placed	Completed
Program Draft Design Report	Oct 28, 2024
Program Final Design Report	Dec 6, 2024
Phase II Underwater Ambient Noise Data Collection Reports	Q2 2025 – Q2 2027
Notes: 1. *Equipment implementation and installation is dependent upon permitting	

5.0 Closure

This document has been prepared by SLR. The material and data in this report were prepared under the supervision and direction of the undersigned.

Sincerely,

SLR International Corporation

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