APPENDIX A

Pacific Lamprey and the Columbia River Crossing Project: a White Paper

INTERSTATE 5 COLUMBIA RIVER CROSSING

Pacific Lamprey and the Columbia River Crossing Project: a White Paper

April 2011

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Cover Sheet

Interstate 5 Columbia River Crossing

Pacific Lamprey and the Columbia River Crossing Project: a White Paper

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ACRONYMS

CRITFC	Columbia River Inter-Tribal Fish Commission
CTGR	Confederated Tribes of the Grand Ronde Community of Oregon
MAX	Metropolitan Area Express
MHRR	Mount Hood Railroad
ODFW	Oregon Department of Fish and Wildlife
PAH	polycyclic aromatic hydrocarbon
PDX	Portland International Airport
PGIS	pollution-generating impervious surface
PSMFC	Pacific States Marine Fisheries Commission
RM	river mile
RKm	river kilometer
SPCC	spill prevention, control, and countermeasures
USFWS	United States Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife

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1. Introduction

Lampreys have significant cultural, spiritual, ceremonial, medicinal, subsistence, and ecological value for many Native American tribes in the Pacific Northwest (Archuleta 2005, CRITFC 2008). Lampreys play a key role in the aquatic and terrestrial food web, and are an indicator species for anthropogenic impacts to ecological systems (Close et al. 2002). Pacific lamprey (*Entosphenus tridentatus*, formerly *Lampetra tridentata*) are one of three lamprey species in the Columbia River Basin, and are the most important lamprey species to the tribes (Close et al. 2002). This species has declined in abundance due primarily to human factors, including dams for hydropower and flood control facilities, irrigation and municipal water diversions, lost and degraded habitat, poor water quality, excessive mammal, avian and fish predation, exposure to chemicals used in fish eradication programs (CRITFC 2008).

Pacific lampreys occur in the Columbia River basin and are likely to be present in the Columbia River Crossing Project area. Very little is known about this species' occurrence and use of habitat within the project area. CRC developed this white paper to summarize what is currently known and what potential project impacts may occur, and to identify research efforts that will provide additional information on this species in the lower Columbia River.

1.1 Status

Pacific lamprey and three other lamprey species were petitioned for listing under the federal Endangered Species Act in 2003 (Nawa et. al. 2003). The U.S. Fish and Wildlife Service (USFWS) determined that the petition did not adequately define the portion of the species' range that should be listed; therefore no status review was initiated. However, the USFWS's review of the petition indicated a likely decline in abundance and distribution of Pacific lamprey throughout California, Oregon, Washington, and Idaho, and acknowledged the existence of both short- and long-term threats to the species (USFWS 2008).

The Pacific lamprey is currently designated as a federal Species of Concern by USFWS. In Oregon, they are designated as Sensitive-Vulnerable, and in Washington they are proposed for the Washington Department of Fish and Wildlife (WDFW) Priority Habitat and Species List.

1.2 Life History

Pacific lampreys spend 1 to 3 years maturing in the ocean environment before migrating as adults to freshwater systems. Adults enter the mainstem Columbia River between approximately February and June (Kostow 2002). Pacific lampreys do not feed after entering freshwater, and subsist through the winter on lipid (fat) reserves (Kostow 2002). Adults are thought to overwinter in freshwater habitat for approximately one year before spawning (USFWS 2008). However, ongoing research by the Confederated Tribes of the Grand Ronde Community of Oregon (CTGR) may indicate that some adult lampreys live in freshwater habitats for up to two years before spawning (Karnosh pers. comm. 2011).

Spawning occurs between March and July in gravel-bottomed streams, at the upstream end of riffle habitat, and often near habitat suitable for ammocoetes (e.g., silty pools and banks) (Kostow 2002, Moyle 2002). After the eggs are deposited and fertilized, the adults usually die within 3 to 36 days (Kostow 2002).

Ammocoetes (larvae) drift downstream to areas of low velocity and silt or sand substrate, where they burrow and remain for 3 to 7 years. Ammocoetes are typically found in depositional areas with soft substrate near stream margins associated with pools, alcoves and glides (Graham and Brun 2007). They are relatively immobile in stream substrates and usually concentrate in areas that include many age classes (USFWS 2008). Ammocoetes are filter-feeders and feed on algae and other detritus (Kostow 2002; Moyle 2002). After reaching approximately 6 inches (15 cm) in length, ammocoetes metamorphose into macropthalmia (Moyle 2002). Downstream migrating macropthalmia have weak swimming ability (USFWS 2008) and tend to move at night (USFWS 2010). Metamorphism is reported to occur between July and November, followed by outmigration to the ocean November through June (peaking in the spring) (Kostow 2002).

Pacific lampreys migrate primarily at night, possibly in response to temperature cues or an aversion to light (Kostow 2002, USFWS 2008, USFWS 2010). Unlike most fishes, lampreys do not have swim bladders and are therefore not able to maintain neutral buoyancy; they must swim constantly or attach to objects to maintain their position in the water column (Liao 2002; Mesa et al. 2003 as cited in USFWS 2008). Lampreys may travel deeper in the water column compared to salmonids (USFWS 2008) (however, some dam passage studies have found juvenile lamprey much higher in the water column [CRITFC 2008]). Pacific lamprey adults are parasitic and feed on a variety of marine and anadromous fish. They are preyed upon by sharks, sea lions, and other marine animals (USFWS 2008).

No population estimates are available for Pacific lamprey in the Columbia River basin. Dam counts are unreliable for absolute abundance for several reasons, including lampreys migrate at night and pass counting windows when no counts are being taken; lampreys also pass via routes that bypass the counting stations; and there are large gaps in the years counts have been taken (Moser and Close 2003). However, dam passage counts can be a useful metric to describe changes in relative abundance over time, and are a clear indication of the decline of this species from historical conditions (Moser and Close 2003). For example, lamprey counts at Bonneville Dam prior to 1970 were regularly at least 50,000 adults; only about 25,000 adults have passed Bonneville Dam in recent annual counts (Kostow 2002). Passage counts show an even sharper decline at the furthest upstream dams: two hundred lampreys have been observed annually at the upper Snake River dams (Kostow 2002). Tribal and commercial harvest data at Willamette Falls also show a sharp decline in abundance of this species since the early 1900's (Close et al. 1995).

1.3 Threats

Causes of decline and threats to Pacific lamprey include the following (USFWS 2008):

- Artificial barriers to juvenile downstream migration, including culverts and water diversions. Outmigrating macropthalmia can be entrained in water diversions or turbine intakes, and impinged on vertical bar screens and trash racks.
- Artificial barriers to adult upstream migration. Many fish ladders and culverts designed to pass salmonids do not effectively pass lampreys due to sharp angles and high water velocities that are difficult for lampreys to navigate.
- Poor water quality—water temperatures above 72ºF (22ºC) may cause significant death or deformation of eggs or ammocoetes.
- Chemical poisoning (accidental spills as well as intentional chemical treatments such as rotenone).
- Predation by nonnative species (e.g., bass, sunfish, walleye).

- Stream and floodplain degradation, and consequent loss of side channel habitat, reduces areas for spawning and ammocoetes rearing.
- Poor ocean conditions affect prey species such as salmon, hake, and other host species.
- Dredging for channel maintenance and mining has significant impacts on ammocoetes in the substrate.
- Harvest may alter distribution and population structure.
- Dewatering and flow management in reservoirs and water diversions can strand ammocoetes present in the substrate.

The reduction in distribution and abundance of Pacific lampreys is a result of a combination of these threats. Many of these factors (e.g., dewatering and flow management, dredging and other channel alterations, chemical poisoning) may affect several age classes of ammocoetes in one event. Because ammocoetes are filter feeders and remain in the substrate of river systems for 3-7 years, they accumulate PCBs, mercury, and other heavy metals (USFWS 2008). Juvenile life stages of Pacific lamprey are vulnerable to exposure to 'legacy contaminants' that were released before regulation of toxic chemicals took effect, but that are still present in surface water and sediments.

1.4 Distribution and Abundance

Historically, Pacific lampreys are thought to have been distributed wherever salmon and steelhead once occurred (USFWS 2008). Their range extends around the Pacific Rim from Japan, through Alaska and the West Coast of the U.S., down to Mexico. Pacific lampreys are the most widely distributed lamprey species on the west coast, and occur in major river systems including the Fraser, Columbia-Snake, Klamath-Trinity, Eel, and Sacramento-San Joaquin Rivers (USFWS 2008).

Pacific lamprey populations are known to have declined or been extirpated in significant portions of their previous distribution from Alaska to California (USFWS 2008). Their decline has been noted in coastal streams as well as in large rivers, including the Columbia River basin. They have been extirpated above dams and other impassable barriers in several waterways, including the upper Snake and Columbia Rivers (USFWS 2008).

The mainstem Columbia River is used as a migration corridor for returning adult lamprey and outmigrating juveniles (macropthalmia), but the mainstem river contains relatively little spawning habitat (Silver et al. 2008). Knowledge of larval lamprey presence in mainstem habitats has been largely based on anecdotal observations at hydropower facilities or in downstream bypass reaches (CRITFC 2008). In general, lamprey in the ammocoete and macrophthalmia life stages are known to be present in the lower mainstem Columbia River, but their distribution and abundance have not been extensively studied, and are not well documented. Likewise, their timing, duration, and habitat use of the lower Columbia River basin are poorly understood (Jolley et al. 2010). Despite the apparent abundance of presumably suitable rearing habitat in the mainstem Columbia River (Silver et al. 2008), the extent to which ammocoetes rear in the mainstem is also unknown (Jolley et al. 2010).

However, recent USFWS research in the mainstem Columbia River has begun to address these data gaps. Studies conducted in 2010 in the Bonneville reservoir and tailwater, and in the lower Columbia River estuary near the river's mouth (up to RM 38), have focused on documenting presence/absence, age distribution, and species composition of larval lamprey (Jolley et al. 2011a, 2011b). Low abundance was documented in 2010 above Bonneville, and no larval lamprey were documented below Bonneville or in the estuary; however, this research is ongoing and will include additional portions of the mainstem Columbia River both above and below Bonneville Dam in 2011.

These Columbia River mainstem studies build on surveys conducted in the Willamette River in 2009 (Jolley et al. 2010), which documented the first quantitative information on larval Pacific lamprey and *Lampetra* spp. occupancy in mainstem river habitats. These studies applied a statistically robust and rigorous sampling methodology to describe patterns of larval lamprey distribution, occupancy, and detection, and have created a foundation for comparisons of lamprey occupancy and detection in other mainstem areas (Jolley et al. 2011a). The Willamette River surveys documented rearing ammocoetes in the Portland Harbor area of the Lower Willamette River, which drains into the Lower Columbia River approximately five river miles downstream of the project site. Differences in substrate types between the Willamette and Lower Columbia Rivers preclude direct extrapolation of survey results; however, the Willamette River study highlights the importance of mainstem areas as rearing habitat and not just as migration corridors (Jolley et al. 2011a). Research in the Columbia River is expected to continue through at least 2011, and may provide valuable new insights into lamprey use of habitat in this system.

Studies done on European lamprey (which have similar substrate requirements to Pacific lamprey) indicate that juvenile lamprey populations may have disparate distributions with a wide range of presence and population size, and that dispersal is commonly unrelated to presence of suitable habitat (King et al. 2008). Jolley et al. (2010) bears this out, having sampled for ammocoetes in the Multnomah Channel but finding none, despite the presence of apparently suitable habitat. Because relatively little sampling has been done in the mainstem Columbia River and its side channels, data are not available at a fine resolution to indicate what depths and substrates are preferred by larval and juvenile lamprey in mainstem habitats (Jolley pers. comm. 2010).

1.4.1 Distribution and Abundance in the Project Area

Although there have been no studies specifically of lamprey of any age class within the project area, ammocoetes have been documented in the mainstem Columbia River and in the North Portland Harbor[1]. These observations confirm the presence of ammocoetes in the project area, but because the data are limited and in some cases the observations were incidental to other projects, no inferences can be made regarding ammocoete abundance or distribution in the project area.

In March 2011, lamprey ammocoetes were incidentally observed in the project area during the course of a sediment sampling and characterization project for CRC. Sediment grab samples were taken at a total of 15 sites, 11 in the Columbia River and 4 in North Portland Harbor. Lamprey ammocoetes were found at four of these sites. Three detections occurred in North Portland Harbor and one in the Columbia River mainstem (see map in Appendix A). One lamprey was found at each site, at depths ranging from 7.0 to 29.5 feet, ranging in length from 2.5 to 6.0 inches. Each of the lamprey ammocoetes occurred where water velocities were slow in loose, silty sediments, as opposed to the coarse sands of the Columbia River mainstem navigational channel (Parametrix 2011). These ammocoetes were not identified to the species level. Sampling equipment used was not optimal for capturing larval lamprey (i.e., a power grab sampler vs. an electrofisher), and this project was not designed to study lamprey; therefore, few inferences can be made beyond confirming ammocoete presence in the project area at the time of sampling.

[1] The I-5 bridge that crosses the Oregon Slough, a side channel of the Columbia River, is known by title as the North Portland Harbor Bridge. In this paper, the term “Portland Harbor” is interchangeable with Oregon Slough.

In July 2010, biologists from USFWS testing lamprey sampling gear (e.g., deepwater electrofishers) in the mainstem Columbia River near Portland International Airport (PDX) documented larval lamprey in sediment in approximately 12 feet of water (Jolley pers. comm. 2010). This site is approximately four miles upstream of the I-5 bridge.

A 2007 USFWS study of Pacific lamprey and western brook lamprey use of mainstem habitat in the Columbia River documented Pacific lamprey and western brook lamprey in nearshore (less than 1 meter (m) deep) areas. Of 21 sites sampled in the mainstem Columbia River, ammocoetes were detected at only three sites: the Cowlitz River delta, the Government Island area, and the Cottonwood Island area. Of these sites, Government Island is the nearest to the CRC project area and is approximately 8 miles upriver of the I-5 bridge. Sites where ammocoetes were found were typically a mix of sand, small gravel and silt, and organic matter (Silver et al. 2008).The study detected lamprey ammocoetes along underwater ledges near drop-offs to deeper water (referred to in this study as water over 1 m deep), but did not find ammocoetes in many shallow, sandy areas that appeared to provide suitable habitat. The authors of the study posited that ammocoetes may be more likely present in deeper areas because such habitat is not subject to drying during summer months (Silver et al. 2008). Sampling of ammocoetes in deeper water has not been done on a large scale due to specialized gear requirements (i.e., the difficulty associated with using deepwater electrofishers).

North Portland Harbor has not been sampled for adult or larval lamprey (Jolley pers. comm. 2010).Timing of adult lamprey upstream migration through the project area may be expected from approximately February through June (Kostow 2002). After entering fresh water, Pacific lamprey may overwinter in some habitats before spawning the following season. It is possible that adult lamprey may overwinter in the project area, although this habitat use has not been well documented in this area and the extent to which adults overwinter in the mainstem Columbia River is unknown.

Lampreys are known to occur in Burnt Bridge Creek (PSMFC 2003) and the Columbia Slough (BES 2005); however, no data are available on distribution, abundance, timing, or habitat use for these waterways.

The primary method used to sample the mainstem Columbia River for ammocoetes has been backpack electrofishing (Silver et al. 2008). This method has also been used to sample mainstem Columbia River tributaries (e.g., the John Day, Umatilla, and Walla Walla Rivers) (Moser and Close 2003). Deepwater electroshocking gear has been used to sample the Willamette River (Jolley et al. 2010), and will be necessary to sample any deep water areas of the Columbia River. Radio telemetry and trapping at dam fishways has also been used to assess lamprey presence and passage success higher in the Columbia River basin (e.g., at Bonneville, the Dalles, and John Day dams) (Kostow 2002, Moser and Close 2003). Researchers have noted the need for standardized larval lamprey monitoring that provides both abundance and size distributions (Moser and Close 2003).

2. Columbia River Crossing Project Overview

The following discussion is a brief overview of the proposed Columbia River Crossing project. The discussion below focuses on project components that may directly or indirectly affect Pacific lamprey in the project area.

The I-5 CRC project is a multimodal transportation project focused on improving safety, reducing congestion, and increasing mobility of motorists, freight, bicyclists, and pedestrians along a 5-mile section of the I-5 corridor connecting Vancouver, Washington and Portland, Oregon, and extending the Yellow Line Metropolitan Area Express (MAX) from Delta Park in Portland to Clark College in Vancouver. The project area stretches from SR 500 in northern Vancouver, south through downtown Vancouver and over the I-5 bridges across the Columbia River to just north of Columbia Boulevard in north Portland (Figure 1).

The project proposes to:

- Replace the existing Columbia River bridges with two new structures.
- Widen the existing North Portland Harbor bridge and construct three additional structures across the harbor.
- Improve seven interchanges along I-5 in Portland and Vancouver.
- Improve highway safety and mobility along I-5 in Portland and Vancouver.
- Extend light rail transit from north Portland to downtown Vancouver.
- Add improved bike/pedestrian access on the new bridges and surrounding areas.
- Construct three new park and ride facilities in Vancouver.
- Expand the Ruby Junction Maintenance Facility to accommodate additional light rail transit vehicles.
- Demolish existing Columbia River bridges.

The ODFW- and WDFW-specified in-water work window for this portion of the Columbia River and North Portland Harbor is November 1 through February 28. Because of the large amount of in-water work involved, this project would not be able to complete the in-water work during this time period. Therefore, the project would request a variance to the published in water work window. Some in-water construction activities are proposed to occur year-round (e.g., installation and extraction of piles ≤48”; installation of drilled shaft casings ≥72”; installation and removal of cofferdams; superstructure construction). Activities taking place outside of the normal in-water work would occur in coordination with ODFW, WDFW, NMFS, and USFWS and in compliance with the terms and conditions of all regulatory permits obtained for this project.

Figure 1. Project Location

Columbia River CROSSING

2.1 Project Area

The aquatic portion of the project area encompasses the Columbia River from approximately RM 101 to 118 (RKm 163 to 190), and North Portland Harbor 3.5 miles downstream and 1.9 miles upstream of the existing bridge. In Burnt Bridge Creek and the Columbia Slough, the extent of the project area is based on the distance to where stormwater pollutants are expected to dilute to background levels. In Burnt Bridge Creek, based on proposed treatment and infiltration methods, pollutant levels in stormwater runoff would outflow only in infrequent storm events, and pollutants entering the creek are expected to dilute to background levels in close proximity to the stormwater outfall. In the Columbia Slough watershed, stormwater runoff from the project travels through open ditches before being pumped to the Columbia Slough. Based on stormwater treatment, pollutant levels are expected to dilute to background levels at or close to the Columbia Slough outfall, prior to reaching the salmon-bearing portion of the slough.

3. Project Activities Potentially Affecting Lamprey

Given that the current state of knowledge of larval, juvenile, and adult lamprey use of the mainstem Columbia River, North Portland Harbor, Burnt Bridge Creek, and the Columbia Slough in the project area is essentially lacking, we cannot analyze or quantify project impacts to Pacific lamprey with any level of certainty. However, because the following project activities have potential impacts to salmonids and other native fish, and in the interest of erring on the side of being over-protective rather than under-protective in the face of uncertainty, these activities merit discussion in the context of potential impacts to Pacific lamprey.

3.1 Bridge Construction

The project would construct two new bridges across the mainstem Columbia River downstream (to the west) of the existing interstate bridges. The existing North Portland Harbor bridges would be widened, and three new bridges would be constructed across North Portland Harbor. General sequencing of the bridge construction appears below.

- Install temporary cofferdam.
- Install temporary piles to moor barges and to support temporary work platforms and work bridges.
- Install drilled shafts for each pier complex.
- Remove work platform or work bridge and associated piles.
- Install shaft caps at the water level.
- Remove cofferdam.
- Erect tower crane.
- Construct columns on the shaft caps.
- Build bridge superstructure spanning the columns.
- Remove tower crane.

- Connect superstructure spans with mid-span closures.
- Remove barge moorings.

The existing Columbia River bridges would then be demolished.

3.2 Roadway Improvements

The proposed project includes improvements to seven interchanges along a 5-mile segment of I-5 between Victory Boulevard in Portland and SR 500 in Vancouver. These improvements include some reconfiguration of adjacent local streets to complement the new interchange designs, as well as new facilities for bicyclists and pedestrians. The proposed project would increase the total impervious area by approximately 42 acres, which would result in increased stormwater runoff rates and volumes. Stormwater from roadways is known to convey pollutant loads of suspended sediments, nutrients, polycyclic aromatic hydrocarbons (PAHs), oils and grease, antifreeze from leaks, cadmium and zinc from tire wear, and copper from wear and tear from brake pads, bearings, metal plating, and engine parts. However, with the construction of new conveyance systems and water quality facilities, untreated PGIS would be reduced from the current 219 acres to approximately 8 acres. Improvements to stormwater treatment on new and resurfaced impervious surfaces, including the I-5 and North Portland Harbor bridges, would result in a net improvement for water quality in the Columbia River, North Portland Harbor, Burnt Bridge Creek, and the Columbia Slough.

4. Analysis of Potential Project Effects to Pacific Lamprey

The following discussion addresses known or potential project impacts in the context of their effects to Pacific lamprey.

4.1 Hydroacoustics

The following discussion is an overview of what is currently known about hydroacoustic impacts to fish, based on laboratory studies as well as field observations.

Hydroacoustic impacts from impact pile driving are the farthest reaching extent of project aquatic impacts in the Columbia River and North Portland Harbor. Due to the curvature of the river and islands present, underwater noise from impact pile driving is expected to encounter land before it reaches ambient levels. Noise from impact pile driving is not expected to extend beyond Sauvie Island, approximately 5.5 miles downstream, and Lady Island, 12.5 miles upstream. This distance encompasses the Columbia River from approximately RM 101 to 118 (RKm 163 to 190). Within North Portland Harbor, underwater noise is expected to extend 3.5 miles downstream and 1.9 miles upstream.

Direct injury, mortality, or behavioral disturbance to fish species may result from sound levels associated with impact pile driving and other in-water construction techniques associated with the installation of temporary steel piles necessary for the construction of the bridges over the Columbia River and North Portland Harbor. Impacts associated with pile driving may include physical injury (particularly to air-filled spaces such as swim bladders), auditory tissue damage, temporary or permanent hearing loss, behavioral effects, and immediate and delayed mortality.

The amount of energy and the resulting sound pressure from pile driving depend on the size and type of pile, type of hammer, energy of the hammer, depth of the water column, and substrate. Impacts to individual fish depend on sound pressure levels, fish species, fish size, fish condition, and depth of the water column (Popper et al. 2006). Use of bubble curtains or other noise attenuation devices during impact pile driving may reduce the level of noise impacts to fish (Caltrans 2009).

It is well documented that hydroacoustic impacts can be significant, causing injury or mortality, for fish with swimbladders. Lampreys do not have swimbladders and it is therefore difficult to determine the extent of this impact. Fish species without swimbladders are thought to be at lower risk from underwater sound than fishes with swimbladders (Stadler pers. comm. 2010, Hastings and Popper 2005, Coker and Hollis 1952, Gaspin 1975, Baxter et al. 1982, Goertner 1994). No thresholds for disturbance or injury have been established for such fish (Stadler pers. comm. 2010). Therefore, hydroacoustic impacts to lamprey should not be discounted, but they cannot be quantified or analyzed with any level of certainty.

Data on hydroacoustic effects to fish eggs and larvae, particularly hydroacoustics of pile driving, are lacking (Hastings and Popper 2005); in addition, there is next to no information on distribution, abundance, and timing of ammocoetes in the project area. Therefore, we cannot speculate on the potential hydroacoustic project impacts to lamprey ammocoetes in the project area.

Despite the uncertainties surrounding hydroacoustic impacts to lamprey, it should be noted that a test pile project conducted by CRC in February, 2011, to evaluate the geotechnical and sound propagation characteristics of the project area found that hydroacoustic impacts from pile driving were less than anticipated (i.e., transmission loss was slightly greater than what had been expected due to lower source values). Hydroacoustic data collected during the test pile project were still being analyzed in April 2011; however, preliminary results indicate that effects to fish will be less than what was modeled for the ESA Section 7 consultation.

4.2 Temporary Effects to Water Quality

The project will implement BMPs during in-water and upland construction activities to avoid and minimize impacts to water quality. Although there are several potential sources of chemical contaminants, there is a low risk that chemicals would actually enter the Columbia River and North Portland Harbor. A Spill Prevention, Control, and Countermeasures (SPCC) plan would be implemented to completely contain sources of chemical contamination such as equipment leaks, uncured concrete, and other pollutants. All project activities that release water would meet state water quality standards.

The project is likely to generate temporary, localized turbidity during the in-water work in the Columbia River and North Portland Harbor. Turbidity would pose fairly limited impacts to habitat, as the project would restrict the extent of turbidity to distances specified by regulatory permits (anticipated to be no more than 300 feet). In actuality, many of the activities would restrict the turbidity plume to far shorter distances than the anticipated 300 foot mixing zone. Permits would also restrict the duration of each turbidity plume to approximately 4 to 6 hours.

Minimization measures would limit effects to water quality. Some level of turbidity may actually contribute to juvenile lamprey survival by concealing macropthalmia from predation (CRITFC 2008). Temporary effects to water quality are not likely to measurably affect any life stages of lamprey.

4.3 Contaminated Sediments

State and federal databases have identified upland sites in the project area or immediate vicinity that are known or suspected to contain contaminated media (Parcel Insight 2009). These include two former marine repair facilities, a former landfill, and a former lumber mill. The CRC project completed sediment evaluation testing in the immediate project area for North Portland Harbor and Columbia River in March, 2011. As of mid-April, 2011, the lab results from the sediment evaluation are pending.

The project would implement several measures to prevent the mobilization of contaminated sediments in the project area, including Phase I and II environmental site assessments (as necessary) for each property. The project would implement BMPs to ensure that the project either: 1) avoids areas of contaminated sediment or 2) enables responsible parties to initiate cleanup activities for contaminated sediments occurring within the project construction areas. This aspect of the project is not likely to measurably affect any life stages of lamprey.

4.4 Stormwater

Improvements to stormwater treatment on new and resurfaced impervious surfaces, including the I-5 and North Portland Harbor bridges, would result in a net improvement for water quality in the Columbia River, North Portland Harbor, Burnt Bridge Creek, and the Columbia Slough. Most of the runoff generated by the existing highway corridor is not treated before being discharged. All new and rebuilt impervious surfaces, as well as some resurfaced and existing pavement, would be treated in accordance with current stormwater treatment standards before being discharged to project area receiving streams. On the Washington side of the alignment, the project would exceed state stormwater treatment standards.

In Burnt Bridge Creek, based on proposed treatment and infiltration methods, pollutant levels in stormwater runoff would outflow only in infrequent storm events. Therefore, any pollutants entering the creek are expected to dilute to background levels in close proximity to the outfall, and most definitely by the confluence with Vancouver Lake.

In the Columbia Slough watershed, stormwater runoff from the project travels through open ditches before being pumped to the Columbia Slough. Based on the enhanced treatment proposed and some infiltration that would occur prior to the outfall to the Columbia Slough, pollutant levels are expected to dilute to background levels at or close to the Columbia Slough outfall, prior to reaching the salmon-bearing portion of the slough.

In the Columbia River and North Portland Harbor, lampreys may potentially be exposed to degraded water quality within a short distance of the outfalls during periods when lampreys are present, and when there is an event that exceeds the design storm design. Exposure would be minimal due to the high dilution capacity of these large water bodies. During events that do not exceed the design storm, the project is expected to discharge runoff that has less pollutant content than the pre-project condition due to the high level of stormwater treatment relative to the net new PGIS. While it is inconclusive whether this constitutes a benefit to lamprey, the high level of treatment makes it improbable that the runoff would degrade the baseline or cause higher levels of exposure during these events.

In the Columbia Slough, there is a minimal chance that lampreys would be exposed to degraded water quality. Stormwater outfalls discharge directly into water bodies that do not contain listed fish, and by association, are unlikely to contain lampreys. Stormwater discharging into these water bodies would travel through several thousand linear feet of a vegetated open conveyance system before entering the Columbia Slough. Given the distance between stormwater outfalls and the nearest locations where listed fish and lamprey are present, and given the high levels of dilution likely to occur, pollutants would likely dissipate to ambient levels before discharging to fish bearing waters.

In Burnt Bridge Creek, lampreys may be exposed to degraded water quality and flow regime during periods when lamprey are present and when there is an event that exceeds the design storm. The abundance and distribution of lampreys in Burnt Bridge Creek are unknown, and the level of exposure cannot be quantified at this time.

4.5 Effects to Shallow Water Habitat

The project would have both temporary and permanent effects to shallow-water habitat (water less than 20 feet deep) in the Columbia River and North Portland Harbor. Project elements responsible for temporary physical loss include the footprint of the numerous temporary piles associated with in-water work platforms, work bridges, tower cranes, oscillator support piles, cofferdams, and barge moorings in the Columbia River and North Portland Harbor. Permanent impacts include the addition of in-water and overwater bridge elements and the removal of existing in water and overwater structures.

The project would lead to temporary physical loss of approximately 20,700 sq. ft. of shallow-water habitat. Pier 7 is located in shallow water on the Vancouver side of the Columbia River (Figure 2); in-water portions of the new structures at this pier would result in the permanent physical loss of approximately 250 sq. ft. of shallow-water habitat. Demolition of the existing Columbia River structures would permanently restore about 6,000 sq. ft. of shallow-water habitat, and removal of a large overwater structure at the Quay, also on the Vancouver side of the Columbia River, would permanently restore about 600 sq. ft. of shallow water habitat. Overall, there would be a net permanent gain of about 5,345 sq. ft. of shallow-water habitat in the Columbia River. At North Portland Harbor, there would be a permanent net loss of about 2,435 sq. ft. of shallow water habitat at all of the new in water bridge bents. Exact pier locations in North Portland Harbor have not yet been determined; however, because the harbor is shallow in general, all North Portland Harbor impacts are expected to be in shallow water (Figure 3).

In-water portions of the structures would not pose a complete blockage to migration anywhere in the action area. Although these structures would cover potential nearshore migration areas for lamprey, the habitat is not rare and is not of particularly high quality. Adult and juvenile lamprey would still be able to use the abundant shallow water habitat available for miles in either direction. Information on ammocoete use of shallow water habitat in or near the project area may be extrapolated from Silver et al. (2008)—in this study, ammocoetes were found in shallow water on the north bank of Government Island. As discussed above, ammocoetes have also been documented in the mainstem Columbia River near PDX (Jolley pers. comm. 2010). These results indicate potential ammocoete presence in shallow water habitat within the project area. The work discussed above would remove or disturb substrate that may contain ammocoetes. Therefore, ammocoetes may be injured or killed by the temporary work done at the sites discussed above. Potential project impacts to this life stage should not be discounted, but because abundance and distribution data are so limited, impacts cannot be quantified at this time.

Pier # / Location	Min. Depth	Max. Depth	Average Depth
P-2	15	30	23
P-3	24	29	27
P-4	24	27	25
P-5	28	31	30
P-6	28	30	29
P-7	6	31	20
N. Portland Harbor	6	20	13

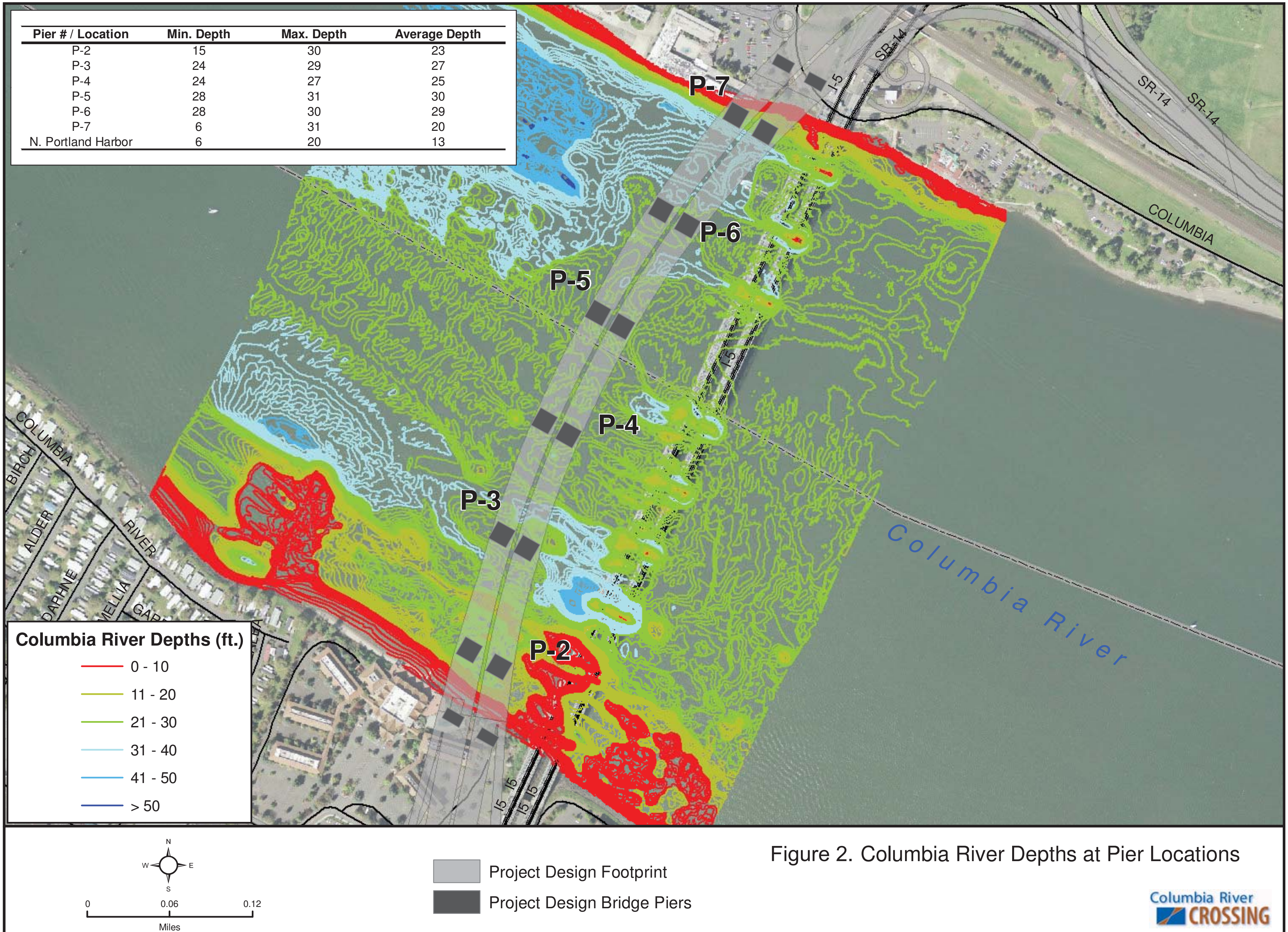

Figure 2. Columbia River Depths at Pier Locations

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Aug. 19. 2010; File Name: Bathym_JL081810.mxd

Pier # / Location	Min. Depth	Max. Depth	Average Depth
P-2	15	30	23
P-3	24	29	27
P-4	24	27	25
P-5	28	31	30
P-6	28	30	29
P-7	6	31	20
N. Portland Harbor	6	20	13

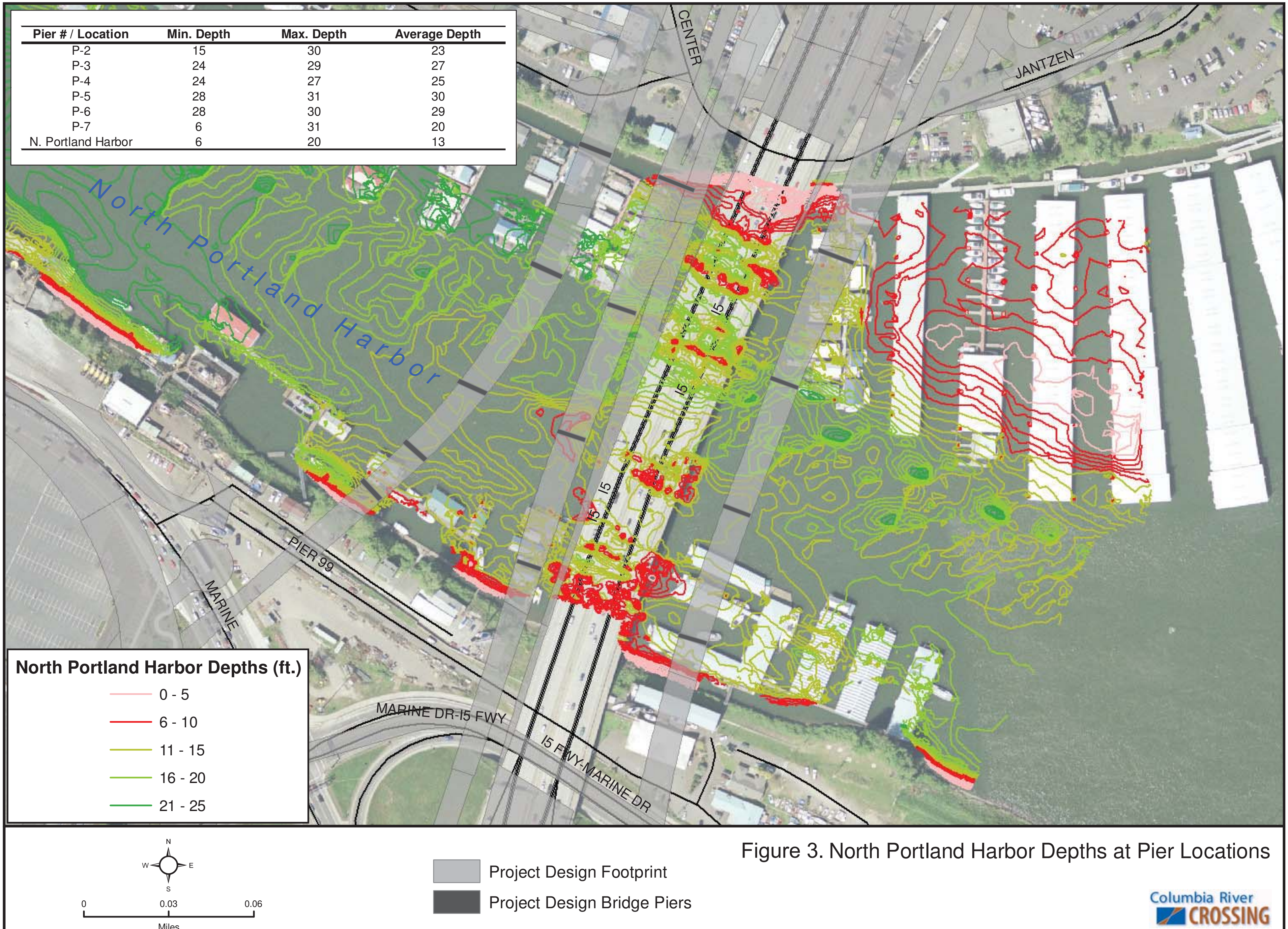

Figure 3. North Portland Harbor Depths at Pier Locations

Columbia River CROSSING

Analysis by J. Koloszar; Analysis Date: Aug. 19. 2010; File Name: Bathym_JL081810.mxd

4.6 Effects to Deep Water Habitat

Deep-water habitat (defined generally as water greater than 20 feet deep) occurs only in the Columbia River and not in the other waterways in the project area. Project elements responsible for temporary physical loss include the cofferdams and numerous temporary piles associated with in-water work platforms and moorings. Project elements responsible for permanent physical loss include the presence of new bridge piers in the river.

The project would lead to temporary physical loss of approximately 16,635 sq. ft. of deep-water habitat, consisting chiefly of coarse sand with a small proportion of gravel. Project elements responsible for temporary physical loss include the cofferdams and numerous temporary piles associated with in-water work platforms and moorings. The in-water portions of the new structures would result in the permanent physical loss of approximately 6,300 sq. ft. of deep-water habitat at pier complex 2 (on the Oregon side of the river) through pier complex 7 in the Columbia River. Demolition of the existing Columbia River piers would permanently restore about 21,000 sq. ft. of deep-water habitat. Overall there would be a net permanent gain of about 15,000 sq. ft. of deep water habitat in the Columbia River.

The lost habitat is not rare or of particularly high quality, and there is abundant similar habitat in immediately adjacent areas of the Columbia River and for many miles both upstream and downstream. The lost habitat would represent a very small fraction of the remaining habitat available. The structures would not pose a physical barrier to adult and juvenile lamprey migration.

Other than serving as migration habitat, no data are available on larval, juvenile, or adult lamprey use of deep water in the mainstem Columbia River. Larval Pacific lampreys and western brook lampreys have been documented in the lower Willamette River at depths up to 16 m (Jolley et al. 2010). A rough assumption could be made that lamprey may also occur in the Columbia River at such depths; however, extrapolating these results to the Columbia River may be problematic due to differences in substrate between the two rivers (Jolley pers. comm. 2010). In the Willamette study, distribution of ammocoetes was not associated with a particular depth. Other studies indicate that various species of lamprey can occur in deep water habitats: larval sea lamprey (*Petromyzon marinus*) and American brook lamprey (*Lethenteron appendix*) have been found in lentic areas of the Great Lakes (Hansen and Hayne 1962) and in deepwater tributaries (Bergstedt and Genovese 1994; Fodale et al. 2003, as cited in Jolley et al. 2010).

The work discussed above would remove or disturb substrate that may contain ammocoetes. Therefore, ammocoetes may be injured or killed by the temporary work done at the sites discussed above. Potential project impacts to larval, juvenile, or adult lamprey in deep water portions of the project area should not be discounted, but because data are lacking, impacts cannot be quantified at this time.

4.7 Effects to Prey Species

Adult lampreys prey on many species of fish, including salmon and steelhead, when in a marine environment. Adult and juvenile Pacific lampreys do not feed during freshwater migration, and subsist on lipid reserves during this life stage (Kostow 2002). The project would have no impact on the marine life stages of lamprey prey species. Project activities are anticipated to impact a very small portion of the salmon and steelhead runs in the Columbia River (depending on the ESU/DPS, this impact is expected to be less than 1% of the mean cumulative run; for many ESUs/DPSs, this would be less than 0.4%) (refer to section 6 and Appendix K of the Biological Assessment for a full analysis [CRC 2010]). The project is therefore expected to have insignificant effects to salmon and steelhead as the lamprey prey base. Ammocoetes are filter-feeders and feed on algae and other detritus (Kostow 2002; Moyle 2002). Project activities are not expected to impact the food base for ammocoetes.

5. Minimization and Mitigation Measures

5.1 Minimization

The CRC project's efforts at minimization and design refinements have reduced the acreage of the project footprint in the river by approximately one-half from initial designs. Specific design modifications to minimize the project footprint include:

- The original bridge crossing design was for 3 bridge spans (2 bridges for roadway and a separate bridge crossing for transit and bike/ped crossing). Using a Stacked Transit Highway Bridge (STHB) has reduced the design to 2 bridge spans and minimized the permanent in-water impact by over 40% (from 3.04 acres to 1.58 acres).
- The North Portland Harbor bridge will not be replaced, thereby reducing in-water impacts in North Portland Harbor.
- The number of piers in the Columbia River has been reduced from 21 to 12. Further design refinements on the bridge piers reduced the permanent footprint of the bridge an additional 10 percent, and reduced hydraulic effects in the river.
- Removal of the existing I-5 Bridge will restore 0.43 acre of aquatic habitat in the river bed.
- Providing a high level of stormwater treatment will minimize impacts to water quality and may provide a net improvement in water quality associated with the bridges.

All project work would be performed according to the requirements and conditions of the regulatory permits issued by federal, state, and local governments. Additional minimization measures that would be employed to limit project impacts to aquatic species and habitat include:

- Seasonal restrictions, such as in-water work windows.
- A Water Quality Sampling Plan would be developed and implemented for conducting water quality monitoring.
- A Spill Pollution and Prevention Control Plan would be developed and implemented in accordance with ODOT and WSDOT standard specifications.
- A Site Erosion and Sediment Control Plan would be developed and implemented in accordance with ODOT and WSDOT standard specifications.

- If work occurs at night, temporary lighting should be used in the night work zones. Directional lighting with shielded luminaries would be used to control glare and direct light onto work area; not surface waters.
- Hydroacoustic impacts would be minimized by the following measures:
  - Permanent foundations would be installed by means of drilled shafts, which would significantly reduce the amount of impact pile driving, the size of piles, and amount of in-water noise.
  - Installation of piles using impact driving may only occur between September 15 and April 15 of the following year.
  - In waters with depths more than 0.67 meters (2 feet), a bubble curtain or other sound attenuation measure would be implemented for impact driving of pilings.
  - Hydroacoustic levels would be monitored to limit exposure to migrating fish and to test the effectiveness of noise attenuation devices.
  - One 12-hour rest period would occur each work day in which no impact pile driving would occur.
  - A qualified biologist would be present during all impact pile driving operations to observe and report any indications of dead, injured, or distressed fishes, including direct observations of these fishes or increases in bird foraging activity.
  - Temporary piles shall be removed with a vibratory hammer and shall never be intentionally broken by twisting or bending. Except when piles are hollow and were placed in clean, sand-dominated substrate, the holes left by the removed pile shall be filled with clean native sediments immediately following removal. No filling of holes shall be required when hollow piles are removed from clean, sand-dominated substrates. At locations where hazardous materials are present or adjacent to utilities, temporary piles may be cut off at the mud line with underwater torches.

5.2 Mitigation

To offset project impacts to aquatic habitat in the Columbia River and North Portland Harbor, CRC will provide compensatory mitigation at two sites (one in Oregon and one in Washington) in compliance with the statutory requirements of each state. The mitigation designs have not yet been developed, but the mitigation sites will comply fully with all regulatory permit terms and conditions.

CRC coordinated with NMFS, USFWS, ODFW, and WDFW to develop mitigation goals used to select the two mitigation sites. The goals are:

- To restore habitat types or aspects that have been lost or greatly reduced over the last approximately 75 years.
- To restore access to historical habitats for anadromous and resident aquatic species.
- To provide connectivity and not be physically isolated from other habitat areas.
- To address impaired watershed processes that affect the aquatic system, water quality, and related ecosystem services.
- To preserve, enhance, and protect natural processes in order to maintain the habitat restored.
- To help implement adopted recovery plans or develop information to help advance the science.

In Oregon, CRC selected the Hood River Off-Channel Reconnection because it will provide high-value off-channel rearing habitat for juvenile salmonids and some spawning habitat for adult salmonids. Lampreys are known to occur in the Hood River and its tributaries. No ammocoetes were observed at the mitigation site during an ODFW/Confederated Tribes of the Warm Springs survey in September 2010 (Seals pers. comm. 2010); however, ammocoetes were documented in the mainstem river near the mitigation areas in October 2009 (Graham pers. comm. 2010).

The restoration site is part of a 400-acre parcel owned by Columbia Land Trust. CRC is providing funding for design and implementation of restoring a historic side channel of the Hood River. Columbia Land Trust and Hood River Watershed Council would be responsible for establishing the restoration site. CRC is proposing off-site compensatory mitigation on the lower Hood River located between RM 1.0 and 2.0 where the Mount Hood Railroad (MHRR) has cut off and isolated a historic side channel and associated wetland. The purpose of the mitigation project is to restore connectivity of the side channel and associated 21 acre wetland to the mainstem Hood River, greatly improving aquatic habitat complexity for migrating and rearing salmonids. The final design and construction sequence of the reconnected side channel and wetland will be based upon construction and staging methods, site topography, groundwater levels, and stream flow.

In Washington, CRC selected the Lewis River Confluence Side Channel Restoration project because the restored shallow water off channel habitats will provide high-value tidal rearing habitat for juvenile salmonids. Pacific lampreys are known to occur in the Lewis River and its tributaries, although specific data regarding abundance and habitat use in the mainstem portion of the river are lacking (Hallock pers. comm. 2010). USFWS has conducted a multi-year study of Pacific lamprey in Cedar Creek, a tributary to the mainstem Lewis River, and anecdotal records exist of adults spawning in the lower mainstem portion of the river (Silver pers. comm. 2010).

Mitigation will occur on the east bank of the Lewis River at its confluence with the Columbia River. This site is located downriver and approximately 10 miles northwest of the CRC project in the Lewis River watershed in Clark County. The restoration site is a 640-acre privately owned site managed by Wildlands of Washington, Inc. The CRC project is providing funding to buy a conservation easement on approximately 80 acres of the property, of which 18.1 acres is proposed restoration of historic side channels to mitigate for the CRC project's waterway impacts. The remaining 60+ acres of the easement would be re-creation and restoration of a riparian corridor along the restored side channels, enhancement of the existing riparian corridor along the Lewis River and shoreline enhancement and floodplain re-connection by removal of remnant levee along the east bank of the Lewis River. Historically, the east bank of the Lewis River at the confluence of the Columbia River had multiple side channels with an open hydraulic connection to the Columbia River. Those side channels were filled in and blocked by deposition of dredge spoils by USACE between the years 1965 to 1973. Restoration of the side channels will consist of removal of the dredge spoils to restore the channels and reconnect to the Lewis and Columbia Rivers. The mitigation project would restore over 21,100 linear feet of historic side channels of the Lewis River totaling 18.1 acres.

5.3 Best Management Practices Specific to Pacific Lamprey

CRC acknowledges that instream activities associated with aquatic habitat restoration for salmonids can impact habitat for Pacific lamprey (USFWS 2010), however the goals for the mitigation projects for salmonids are consistent with those for lamprey habitat restoration—i.e., to restore access to, and ecological function of, degraded historical habitat. USFWS (2010) has identified the following specific characteristics of desirable lamprey habitat:

- Stream and river reaches that have relatively stable flow conditions and that are not extreme or flashy.
- Large substrates (i.e. very large cobble and boulders) submerged in low or no flow areas of rivers and streams that provide high quality adult overwintering habitat.
- Areas of small to medium cobbles, free of fine sediment, that serve as spawning habitats.
- Depositional areas, including alcoves, side channels, backwater areas, pools, and low velocity stream and river margins that recruit fine sands and silts, downstream of spawning areas, that provide ammocoete rearing habitat.
- A combination of habitat components to serve all life stages, including deep pools, low velocity rearing areas with fine sand or silt, silt-free cobble areas upstream of rearing areas, and summer temperatures at or below 20^{o} C (68^{o} F).

USFWS (2010) has also identified the following "BMPs for Instream Activities to Avoid Adverse Effects to Pacific Lampreys":

- Consult with local federal, state and tribal biologists to obtain information on known lamprey populations in the drainage. Perform a site reconnaissance with nest surveys or other appropriate methods to identify locations of lamprey spawning and rearing habitat, and if possible, lamprey presence.

- Avoid working in stream or river channels from March 1 to July 1 in low to mid elevation reaches (<5,000 ft). In high elevation reaches (>5,000 feet), avoid working in stream or river channels from March 1 to August 1.

- Avoid dewatering stream reaches where lampreys are known to exist; survey to determine ammocoete presence, preferably at the project planning stage and when the project is implemented. Ramping flows, particularly during hours of darkness, can be effective in encouraging ammocoetes to move out of areas of impact.

- If dewatering is necessary in reaches with known lamprey presence, attempt salvage and move ammocoetes to a safe area. Dewater slowly over several days or at a minimum overnight. Identify areas adjacent to ammocoete habitat outside of the disturbance area but within the channel, and dig holes (e.g., few scoops with a backhoe) where ammocoetes may take refuge as dewatering occurs; cover these 'refuge' holes to protect them from predators. Anecdotal information suggests ammocoetes will move into areas that retain water—placing straw bales in habitats where ammocoetes are present may encourage them to move into the straw as dewatering occurs. Bales and ammocoetes can be safely removed the next day. If successful, document and provide this information to the USFWS.

- Avoid instream channel reconstruction, re-routing, dredging, and other activities that disturb or remove substrate materials where ammocoetes are known to exist. Where avoidance is not possible, salvage efforts should be attempted prior to activity. Sift through the removed substrate—salvaging any ammocoetes—and return them to the stream away from the construction activity.

The project will consider the specific habitat requirements of lamprey, the life history traits of lamprey, and the BMPs in the implementation of the mitigation projects discussed above. The dredge spoils to be removed at the mouth of the Lewis River are dry and are not suitable habitat for any life stage of lamprey.

CRC feels that the restoration projects in the Hood River and Lewis River will provide significant benefit to all native fish, especially lamprey. Both restoration projects will provide side channels, backwater areas, pools, and lower velocity stream flow and lower stream temperatures that will provide ideal ammocoete rearing areas (USFWS 2010). Studies in Ireland (King et al.) show that lamprey can rapidly colonize new habitat. In these studies, new habitat areas on the River Nore in Kilkenny, Ireland were terrestrial dry-land habitats prior to excavation for channel widening. Following restoration work, new lamprey populations colonized the sites via downstream drift, facilitated by displacement of upstream lamprey by flooding or torrential flow events. Both the Hood River and Lewis River projects will restore upland areas to their historic status as side channels of the river.

6. On-going Research and Data Needs

Pilot studies have been conducted in the mainstem Columbia River (Silver et al. 2008) and in the lower Willamette River (Jolley et al. 2010) that provide a starting point for assessing larval, juvenile, and adult lamprey presence and distribution in and near the project area. More research is needed to fully understand lamprey population dynamics in the project area and to allow project impact analysis with any level of certainty. As of August 2010, the following studies are currently underway or will be soon, and are anticipated to provide valuable information:

- USFWS will be continuing research in the mainstem Columbia River to examine occupancy and habitat use above and below Bonneville Dam, as well as in the tidally influenced portion of the river near and below Skamokawa (Jolley pers. comm. 2010). These studies are not being conducted within the CRC project area, but may have results useful for identifying lamprey use of mainstem habitats.
- The Columbia River Basin Lamprey Technical Workgroup has a subgroup that is developing a project to sample dredge spoils at various sites in the mainstem Columbia River for ammocoetes. The intent of this project is to help describe ammocoete distribution and impacts from dredging (Luzier pers. comm. 2010). Depending on the sampling locations, results from this project could help identify where ammocoetes are likely to occur in the mainstem Columbia River. Data on preferred depths, substrate characteristics, distribution patterns, and other parameters may help fill in existing data gaps for lamprey in the mainstem river.
- The U.S. Fish and Wildlife Service Pacific Lamprey Conservation Plan is in the process of being revised to include other existing restoration plans (e.g., the CRITFC restoration plan [2008]) nested within one document. Incorporating all existing plans into one document will minimize the duplicative nature and volume of existing management, conservation, and restoration plans. The revised document went out for internal review in mid-August 2010. This document, once finalized, will be a useful source of the most up-to-date lamprey conservation guidance.
- The Portland Harbor Natural Resources Trustee Council is conducting a study which began in 2009 to evaluate impacts of contaminated sediment on lamprey ammocoetes.
- CTGR is conducting an adult lamprey tracking study which began in 2006 to evaluate movements of adult lampreys in the Willamette River and its tributaries. While this study does not include the Lower Columbia River, it may provide valuable insights into the behavior of adult lamprey, which is largely unknown at this point.

Additional research needs include developing standardized methodologies designed to accurately sample all lamprey life stages to assess the status of this species (Moser and Close 2003), and studies of larval lamprey mainstem habitat to provide quantitative assessments of larval abundance, distribution and habitat parameter (Silver et al. 2008). Quantifying physical and chemical parameters may also aid development of tools for predicting larval distribution in large river systems (Silver et al. 2008).

7. Conclusions

Significantly more information is needed on lamprey distribution, abundance, and habitat use in the project area in order for CRC to complete a full project impacts analysis. It is well known that Pacific lamprey larvae, juveniles, and adults are present in the Columbia River, and impacts to all life stages cannot be wholly discounted. However, given the current paucity of existing data, as well as the lack of research on hydroacoustic impacts to lamprey, the extent of impacts is unknown, and an impact analysis is largely speculative. Lamprey ammocoetes may be impacted by in-water construction at each bridge pier site; however, ammocoete distribution and use of mainstem substrate is unknown and impacts cannot be quantified.

Project impacts to lamprey may be minimized by the following points:

- Adult lampreys are nocturnal and migrate at night. Lamprey movement through the project area would be expected to be at night, when impact pile driving would not occur and reduced construction activity is likely. It is unknown whether lampreys attach to manmade or natural in-water structures in the project area, such as bridge piers, dock pilings, rip rap, or boats, and therefore could be present in the project area during daytime.
- Major threats to lamprey in the mainstem Columbia River include barriers to migration, poor water quality, loss of floodplain and side channel habitat, dredging, and dewatering. The CRC project would not pose any of these threats to lamprey. Some habitat parameters are expected to improve over existing conditions due to enhanced stormwater treatment and improved side channel habitat at the two mitigation sites described above.

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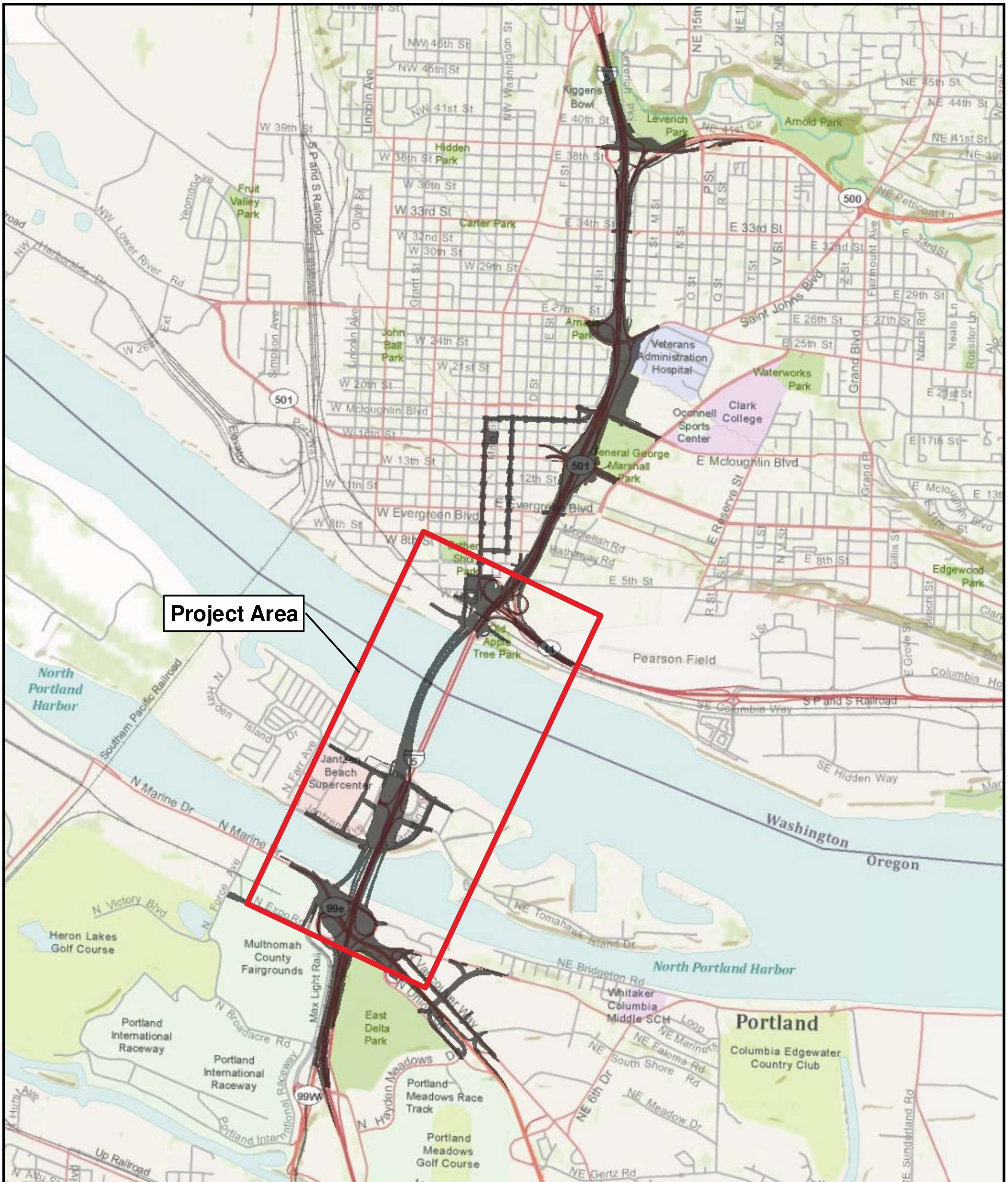
APPENDIX A

Sediment Sampling Map



N
W E
S

0 2,000 4,000
Feet

Project Footprint

Figure A-1. Project Location Map

Columbia River CROSSING

Analysis by MS Marshall; Analysis Date: January 7, 2011; File Name: 1-1_SedimentSampling_ER_PDXHarbor.mxd

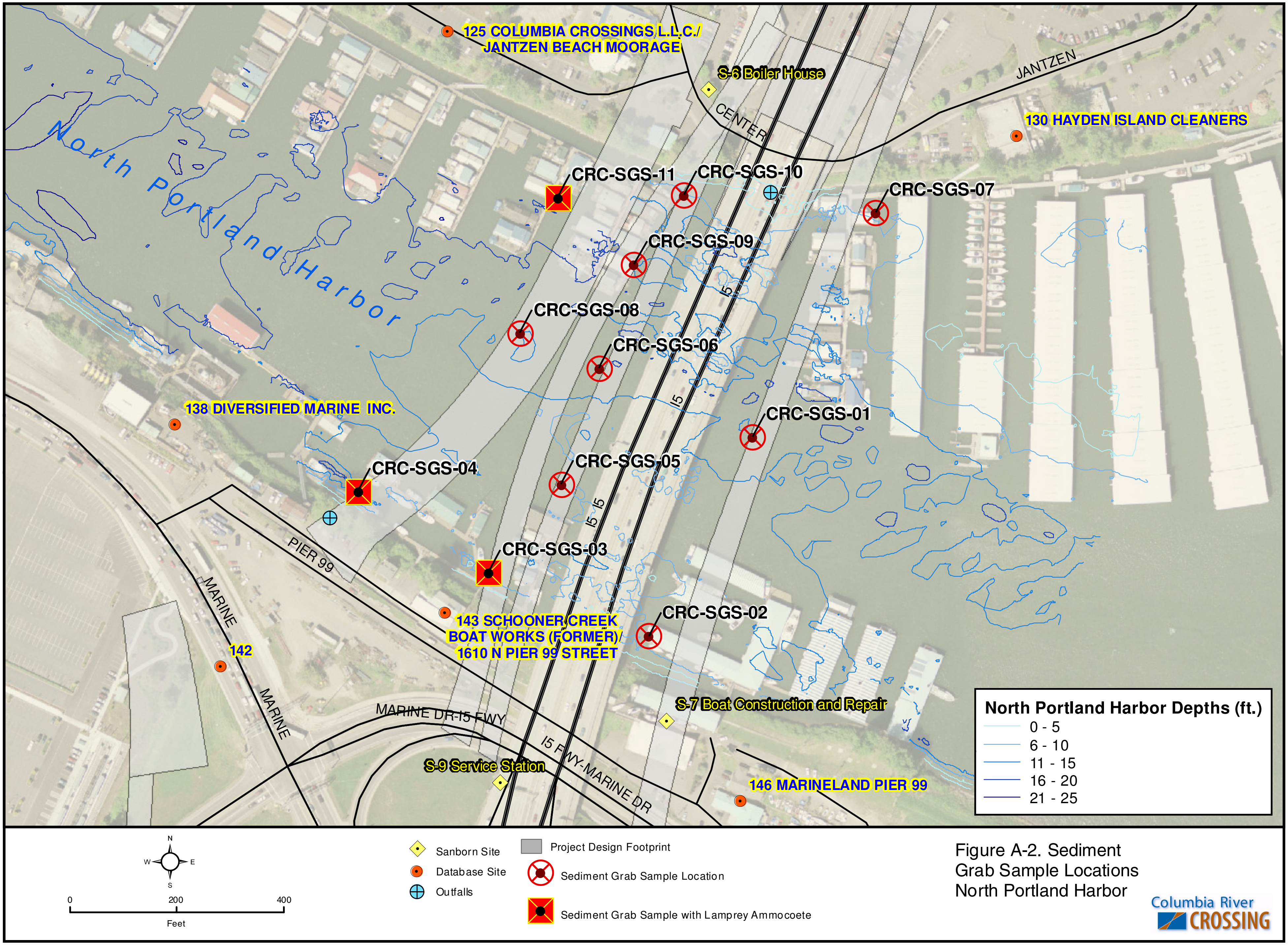
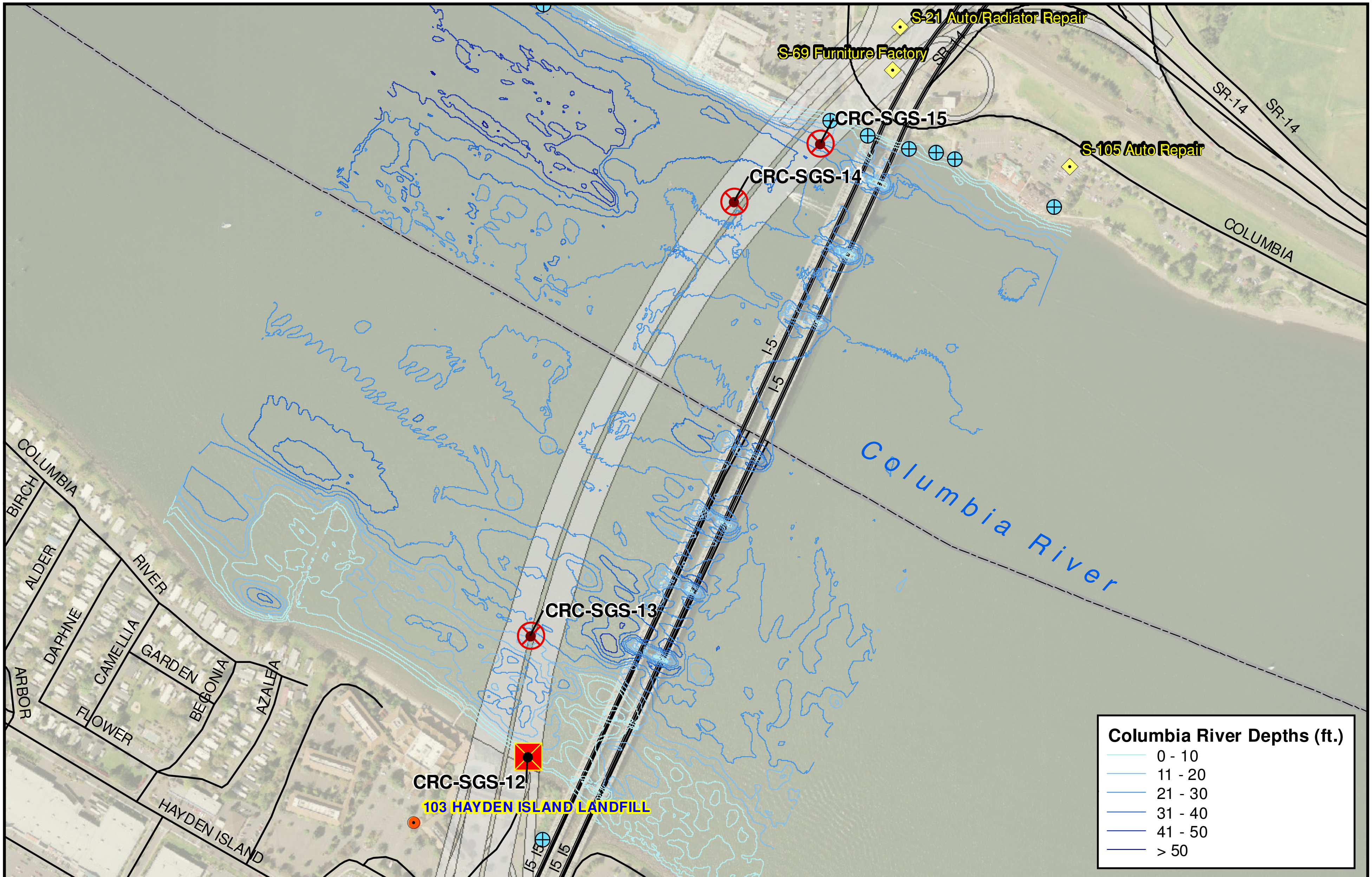


Figure A-2. Sediment Grab Sample Locations North Portland Harbor

Analysis by MS Marshall; Analysis Date: April 7, 2011; File Name: 1-2_SedimentSampling_ER_PDXHarbor.mxd



Sanborn Site
Database Site
Outfalls
Project Design Footprint
Sediment Grab Sample Location
Sediment Grab Sample with Lamprey Ammocoete

Figure A-3. Sediment Grab Sample Locations Columbia River

Columbia River CROSSING

Analysis by MS Marshall; Analysis Date: April 2011; File Name: 1-3_SedimentSampling_ER_PDXHarbor.mxd

APPENDIX B

Columbia River Crossing Test Pile Project Hydroacoustic Monitoring Final Report

Columbia River Crossing Test Pile Project Hydroacoustic Monitoring Final Report

July 2011

Columbia River
CROSSING

Title VI

The Columbia River Crossing project team ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin or sex in the provision of benefits and services resulting from its federally assisted programs and activities. For questions regarding WSDOT's Title VI Program, you may contact the Department's Title VI Coordinator at (360) 705-7098. For questions regarding ODOT's Title VI Program, you may contact the Department's Civil Rights Office at (503) 986-4350.

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Cover Sheet

Report Title

Final Report: Columbia River Crossing Test Pile Project Hydroacoustic Monitoring

Submitted By: James Coleman, David Evans and Associates, Inc.

Cooperating Agencies: None

Abstract:

This report presents the results of hydroacoustic and turbidity monitoring during the driving of test piles near two proposed pier locations for the new Interstate 5 Bridge between Vancouver, Washington, and Portland, Oregon. Hydroacoustic monitoring included analysis of background sound levels, noise levels associated with vibratory installation, noise levels associated with impact driving under different attenuation conditions, and the determination of transmission loss associated with both vibratory and impact driving. Six test piles were driven between 11 and 21 February, 2011 at two sites in the Columbia River. These sites were monitored by five separate hydrophones at different locations within the river. Attenuation methods during impact driving included both an open and confined bubble curtain.

Signature	8/1/11 Date
Signature	8/1/11 Date

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ACRONYMS

BC	Bubble Curtain
CDF	Cumulative Distribution Function
CFM	Cubic Feet per Minute
CRC	Columbia River Crossing
DAS	Sound-data acquisition system
GPS	Global Positioning System
PMF	Probability Mass Function
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Units
PSD	Power Spectral Density
RMS	Root Mean Square
RTK	Real-time Kinematic
SEL	Sound Exposure Level
SPL	Sound Pressure Level
WSDOT	Washington State Department of Transportation

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1. Introduction

This report presents the results of hydroacoustic and turbidity monitoring during the driving of test piles near two proposed pier locations for the new Interstate 5 Bridge between Vancouver, Washington, and Portland, Oregon. Hydroacoustic monitoring included analysis of background sound levels, noise levels associated with vibratory installation, noise levels associated with impact driving under different attenuation conditions, and the determination of transmission loss associated with both vibratory and impact driving. Six test piles were driven between 11 and 21 February, 2011 at two sites in the Columbia River. These sites were monitored by five separate hydrophones at different locations within the river. Attenuation methods during impact driving included both an open and confined bubble curtain.

David Evans and Associates, Inc (DEA) Marine Services Division was tasked to conduct hydroacoustic monitoring for the Columbia River Crossing (CRC) Project as stated in *Columbia River Crossing Agreement Number Y-9245, Task AH, Amendment No.7*, dated May 25, 2011. Additional work was approved by CRC in the statement of work *CRC Test Pile Project – Updated Draft Scope of Work for Acoustic Monitoring Status, Modifications and Additions 02/10/2011.*

1.1 Test Pile Operations

Test pile operations consisted of impact driving or vibropiling at six pile locations using 24-inch and 48-inch piles. Twenty-four (24) inch piles were impact driven using the APE Model D19-42 single-acting diesel impact hammer. The Model D19-42 has a rated energy range of 22,721 ft-lbs to 47,335ft-lbs with a stroke of 135 inches at maximum energy in 34-52 blows per minute. Forty-eight (48) inch piles were impact driven using the APE Model D80-42 single-acting diesel impact hammer. The Model D80-42 has a rated energy range of 127,206 ft-lbs to 198,450 ft-lbs with a stroke of 135 inches at maximum energy in 34-53 blows per minute. The APE King Kong model 400 vibratory pile driver/extractor was used to stabilize piles for pile driving events. The APE Model 400 is a variable frequency vibratory pile driver designed for use in difficult soil conditions including clay. It operates in a frequency range of up to 1,400 cycles per minute depending on the hydraulic flow and on the hydraulic motors fitted to the gear train.

A confined or unconfined bubble curtain was tested during each pile installation. Either a confined or unconfined bubble curtain is required by the NMFS Biological Opinion to be used when water velocity is 1.6 feet per second or less. If the water velocity is greater than 1.6 feet per second a confined bubble curtain is required. Bubble curtains are required to distribute air bubbles around 100 percent of the piling perimeter for the full depth of the water column. Bubble curtains used for the test pile project were designed and fabricated according to the specifications listed in the *I-5 Columbia River Bridge Temporary Pile Test Program 10x314 Document, Division 6 Structures, Piling, Bubble Curtain*, found in Appendix III.

1.2 Hydroacoustic Monitoring Operations

Hydroacoustic and turbidity monitoring was carried out by a DEA team. Section 11.2.5 of the *Columbia River Crossing Request for Marine Mammal Protection Act Letter of Authorization* required one hydrophone to be placed at mid-depth and 10 meters from the pile being driven and an additional hydrophone placed at mid-depth and at a distance from the pile being driven. As requested by Columbia River Crossing (CRC), additional monitoring was conducted at specific distances from pile driving to determine site-specific transmission loss and directionality of noise to help establish the radii of safety and disturbance zones for marine mammals. Data were collected at a total of five sites during pile driving. While all reasonable efforts were made to capture data during both impact piling and vibropiling construction, all events were not captured at all five sites due to a variety of factors, including equipment failures, timing limitations in remote station deployment, and duties related to marine mammal observation.

2. Equipment

2.1 Vessels

Two (2) DEA vessels were used to conduct sound monitoring: R/V *Preston* and a DIB inflatable boat (figure 2-1). The R/V *Preston* conducted continuous sound monitoring operations including daily deployment and retrieval of unmanned remotely operated platforms and served as the DEA primary survey vessel. The DIB inflatable boat conducted turbidity, conductivity, temperature, and pressure (depth) profiling and supported biological monitoring throughout the project. It also assisted in the deployment and recovery of unmanned platforms.

FIGURE 2-1. R/V PRESTON ON STATION FOR DEPLOYMENT (LEFT) AND DIB INFLATABLE BOAT (RIGHT)

2.2 Sound Monitoring Equipment

2.1.1 Ten-meter Sound Monitoring Station

FIGURE 2-2. TEN-METER ACQUISITION SYSTEM

The 10-meter monitoring system onboard the R/V *Preston* consisted of a Cetacean Research Technology (CRT) model CR1 hydrophone with -198 dB (re: 1V/µPa) transducer sensitivity with a Sound Technology, Inc ST1400 low distortion audio oscillator digital acquisition system (DAS) connected to a computer interface (figure 2-2). The system is capable of collecting 4 channels at 96 kHz sample rate and 24 bit samples.

2.1.2 Remote Sound Monitoring Stations

Three (3) remotely operated unmanned sound monitoring stations (figure 2-3) were deployed upstream or downstream of the test pile project at 200, 400 and 800 meter distances. The three monitoring stations (COHO, SOCKEYE, SUPERCUBE) contained a CRT CR1 hydrophone with -198 dB (re: 1V/µPa) sensitivity. A fourth monitoring station was deployed at 800 meters in the opposite direction of the other three remote systems (i.e. upstream if the other three were downstream). The fourth 800-meter station (KOKANEE) consisted of a more sensitive CRT CR55 hydrophone with -165 dB (re: 1V/µPa) sensitivity.

Sound Technology, Inc ST191 and ST219 sound DAS interfaces capable of recording 24-bit samples at a rate of 44 kHz over 2 channels were connected to a laptop computer with cellular modems. The cellular modems were used to connect to and monitor the remote stations with the "master" 10-meter station from the primary vessel. Factory calibrations for the CR1 hydrophones include the specific cable length associated with each instrument. Table 2-1 shows the setup for hydrophones and DAS at each station.

Table 2-1. Systems setups for monitoring stations

Station	Hydrophone Type	DAS	Cable Length (m)	Gain (dB)
KOKANEE	CR55 563	ST191	61	0
COHO	CR1-10247-01	ST191	61	+30
SOCKEYE	CR1-10247-02	ST191	61	+30
SUPERCUBE	CR1-10181-01	ST219	30	+40
10-METER	CR1-10246-03	ST191	30	0

FIGURE 2-3. UNMANNED REMOTELY OPERATED SOUND MONITORING PLATFORMS

2.3 CTD/Turbidity Equipment

A SeaBird SBE-19 SEACAT Profiler CTD (SN: 3036) with a D&A Instruments OBS-3 Turbidity Monitor encased in a stainless steel protective cage (figure 2-4) was used to acquire turbidity profiles at various locations from onboard the DIB inflatable boat. The Seabird SBE-19 acquires conductivity, temperature, and pressure measurements up to 3500m with a 5 centimeter resolution. It contains 8 MB of internal memory and internal and external recording options. The OBS-3 Turbidity Monitor acquires turbidity measurements in the range of 0 to 4000 Nephelometric Turbidity Units (NTU).

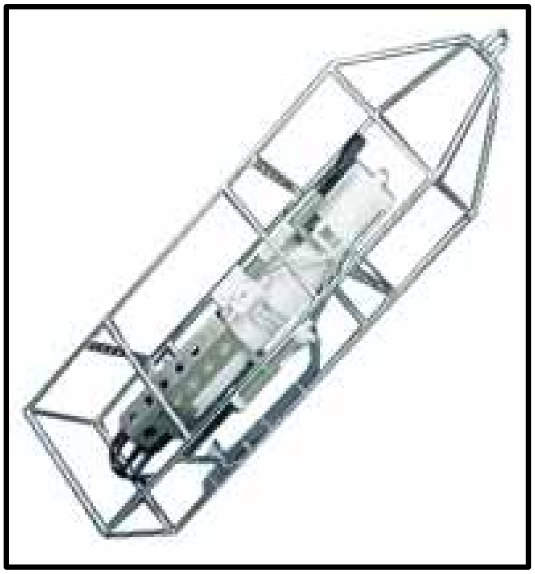

FIGURE 2-4. SEABIRD SBE-19 CTD

2.4 Current Meter Equipment

An InterOcean Systems, Inc. S4 current meter was used to monitor river flow rates at two background monitoring sites to correlate river velocity with changes in background noise levels. The S4 current meter has a measurement accuracy of 2 percent of reading ±1 cm/sec, a resolution of 2 Hz at 0.03 to 0.35 cm/sec depending on range, and 5 Hz at 0.037 to 0.43 cm/sec depending on range. The S4 maintains low threshold and noise levels ideal for low current and sound sensitive studies. It has a memory capacity of 128KB that allows acquisition for approximately 20 days.

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3. Methods and Systems Checks

Sound monitoring site geometry was recommended by a team of acoustic experts contracted by the CRC. The objective of the deployment configuration was to place the remote monitoring systems in a geometry (10, 200, 400, 800 and -800 meters) that would allow for fairly direct indications of the observed sound attenuation. A fifth system (KOKANEE) was placed in the opposite 800 meter direction from the primary array to help confirm the consistency of attenuation in the upstream vs. downstream directions. In addition, the array geometry was reversed between each side of the river (three downstream and one upstream on the south side versus three upstream and one downstream on the north side). The objective of the reversal in geometry was also to help characterize any differences in observed propagation loss between the upstream and downstream directions within the river. The site diagram depicts the locations of all the stations occupied for the length of the project (figure 3-1 and table 3-1).

Prior to sound monitoring operations, background sound and river flow data were collected at two (2) locations to provide baseline sound levels. Background Site #1 was located near the City of Vancouver dock on the north side of the river, and Background Site #2 was located near the dolphins on the south side of the river approximately 600 meters downstream of the Test Pile Site "A", as shown in figure 3-1. Monitoring for Background Site #1 occurred 27-30 January, and monitoring for Background Site #2 occurred 31 January through 03 February. Background data were required to be logged continuously for at least 72 hours at each location; actual data logging was 94 hours at Background Site #1, and 89 hours at Background Site #2. During construction activity, sound monitoring was conducted daily, and accompanied by CTD and turbidity profiling and intermittent marine mammal observer support. Pre-deployment system checks were performed on all hydroacoustic gear daily to ensure proper function and are detailed in section 3.1 of this report.

3.1 Systems Checks

To confirm accurate measurement of sound levels, DEA utilized state-of-the-art, NIST calibrated data acquisition systems for the primary and two of the remote monitoring locations. The other two remote systems were built by the same manufacturer utilizing the same methods, but did not have the extra documentation associated with the NIST certification. Four (4) of these digital acquisition systems were connected to CR1 hydrophones and one was connected to a C55 hydrophone. The capacitance of each CR1 hydrophone is documented during the factory calibration, and remains fixed as long as the cable is not altered. The stability and repeatability of using this system architecture is believed to be beneficial to both overall data quality and project logistics. This equipment configuration was specifically designed to avoid the use of charge amplifiers. Although charge amplifiers allow a variety of cable lengths to be used, they are prone to drift when used in non-laboratory conditions and require frequent calibration when used in the field. Instead, these hydrophones were calibrated with specific cables at predetermined lengths, and always operated using those cables.

Daily checks made of the acquisition systems included:

- Confirmation of hydrophone "cal" value in acquisition software
- Confirmation of proper DAQ "full scale" percentage for each channel

- Verification of adequate hard drive space for full day recording
- Verification of cellular modem connection for each remote system

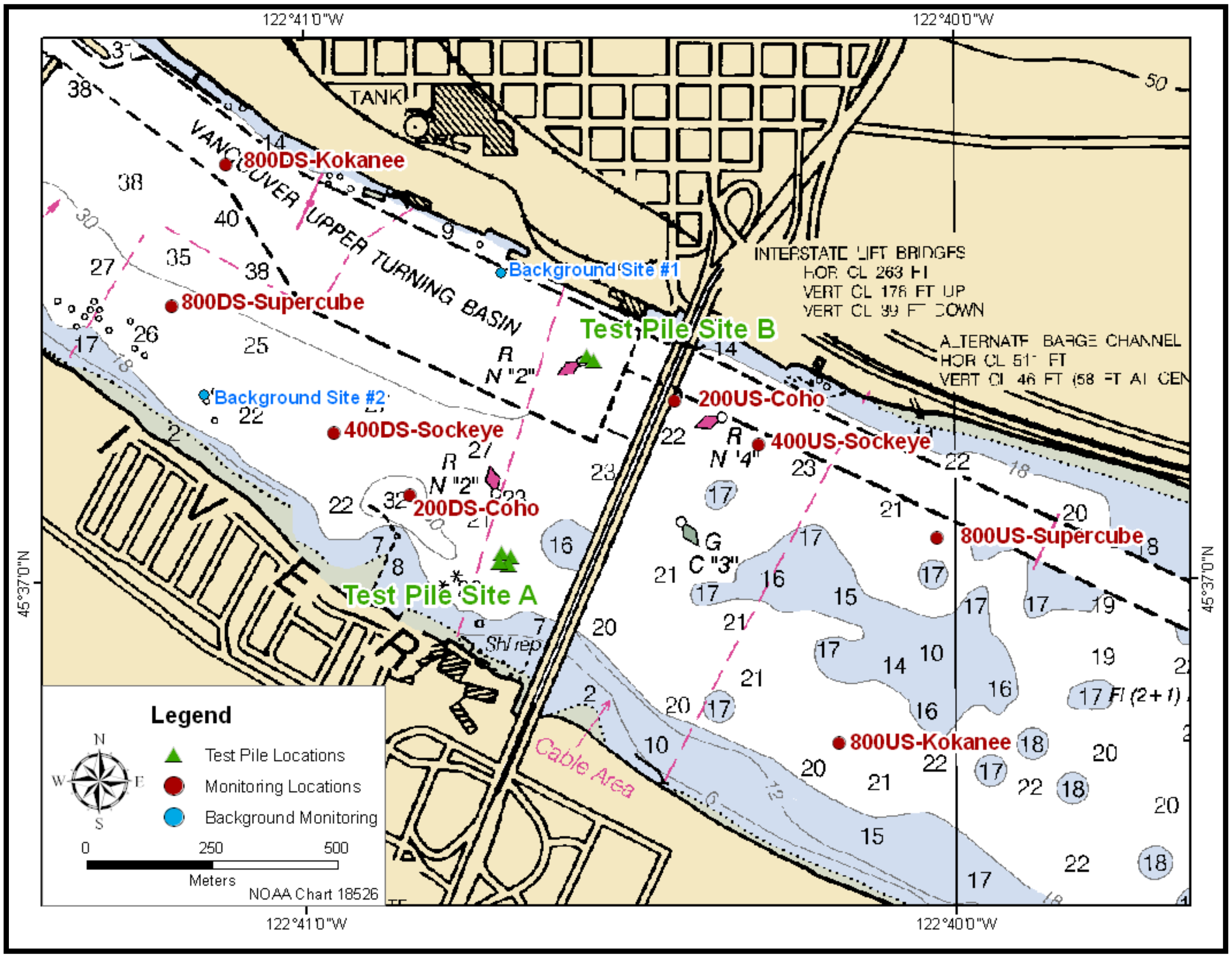

FIGURE 3-1. SITE CONFIGURATION

Table 3-1. Remote station deployment sites. Positions reported are calculated from the center of the error ellipse calculated from all deployments for that site.

Station	Station Name	Latitude (N)	Longitude(W)	Position Variance (m)	No. Deploy-ments	Approximate Water Column Depth (m)
Pile Site A						
200 DS	COHO	45° 37' 05.53"	122° 40' 50.31"	7.0	5	10.4
400 DS	SOCKEYE	45° 37' 09.68"	122° 40' 57.45"	10.4	5	9.1
800 DS	SUPERCUBE	45° 37' 17.86"	122° 41' 12.31"	21.9	5	10.4
800 US	KOKANEE	45° 36' 49.42"	122° 40' 10.75"	21.7	5	6.1
Pile Site B						
200 US	COHO	45° 37' 11.54"	122° 40' 25.76"	15.3	3	8.8
400 US	SOCKEYE	45° 37' 08.74"	122° 40' 18.05"	6.9	3	8.7
800 US	SUPERCUBE	45° 37' 02.70"	122° 40' 01.63"	9.4	3	6.5
800 DS	KOKANEE	45° 37' 27.08"	122° 41' 07.24"	39.5	3	15.3

In addition, in-water system checks of each system to a known reference source were conducted as often as allowed by project schedule and logistics and when any equipment settings were altered or otherwise adjusted (i.e., fixed gain steps changed). These checks were intended to confirm that the systems were detecting reasonable sound levels; they were not used to adjust any factory or NIST calibration values. This process is described in section 3.1.1 below.

Upon conclusion of the CRC field operations, DEA sent all hydrophones back for "post-mission" calibration. All post hydrophone calibrations agreed with original calibration values with the exception of one. The discrepancy was attributed to an early factory calibration offset related to incorrect impedance matching in the initial factory setup and not due to hydrophone damage. The post-calibration values were applied to all acquired sound data.

3.1.1 In-water "Open Field" Method

In-water checks were conducted during monitoring operations to verify proper system operation and that the factory calibration was still valid (figure 3-2). Prior to survey, DEA had two CR1 hydrophones sent to an acoustic testing facility for additional calibration data. The calibrations provided detailed transmit voltage response (TVR) and open circuit voltage (OCV) graphs. The TVR shows the sound level produced at 1 meter when a 1-volt Root Mean Square (RMS) signal is injected into the hydrophone. The calibration values are determined for a range of frequencies. These two hydrophones were used in the field as "reference" hydrophones producing a "known" sound level as provided by the TVR or OCV graphs, against which the other DAS systems could be checked.

The field procedure for the in-water checks consisted of attaching a "reference" hydrophone and a "receiving" hydrophone to the DEA fabricated 1-meter reference bracket (figure 3-3). The "reference" and the "receiving" hydrophones used were those mentioned above with associated TVR and OCV graphs. The other three hydrophones without calibrated TVR and OCV graphs were attached to the reference bracket in line with the "receiving" hydrophone. Accuracy measurements of the one meter reference bracket where 1 cm, resulting in a possible error of ± 0.09 dB (figure 3-3). A BK Precision 4040A 20 MHz Sweep/Function Generator was used to inject a 1-volt RMS ± 0.02V sine wave signal at 20 kHz into the "reference" hydrophone. The RMS voltage was simultaneously monitored with a Leader LMV-185A 2 Channel AC RMS Millivoltmeter and ST1400 DAS for quality assurance. The "receiving" hydrophone received the transmitted signal and sent it to the A/D Convertor (i.e. DAS) being checked. The received signal was band pass filtered at ±500 Hz centered around 20 kHz to eliminate background noise. The final RMS signal level output in decibels was verified against the initial signal output from the signal generator in decibels as determined by the TVR graph. TVR graphs are located in Appendix I *Instrument Calibration Documents,* of this document.

The majority of in-water checks were conducted using a 20 kHz signal at 1 volt RMS which resulted in RMS output levels of 124.57 dB and 123.14 dB for hydrophones 247-02 and 246-03, respectively. In most cases the observed values from the open field tests fell within +/- 1 dB of the reference. In some instances, system hardware errors were detected where an accidental switch placement caused the system to be grossly in error (i.e. > 10 dB). No data were used from the systems while in the incorrect settings. High background noise levels resulted in low signal to noise (SNR) ratios for some of the open-field checks; to mitigate this, it is recommended on future operations that separation of the transmit and receive hydrophones be reduced from 1 meter to 0.5 meters to gain an additional 6 dB and improve the SNR during the open-field checks.

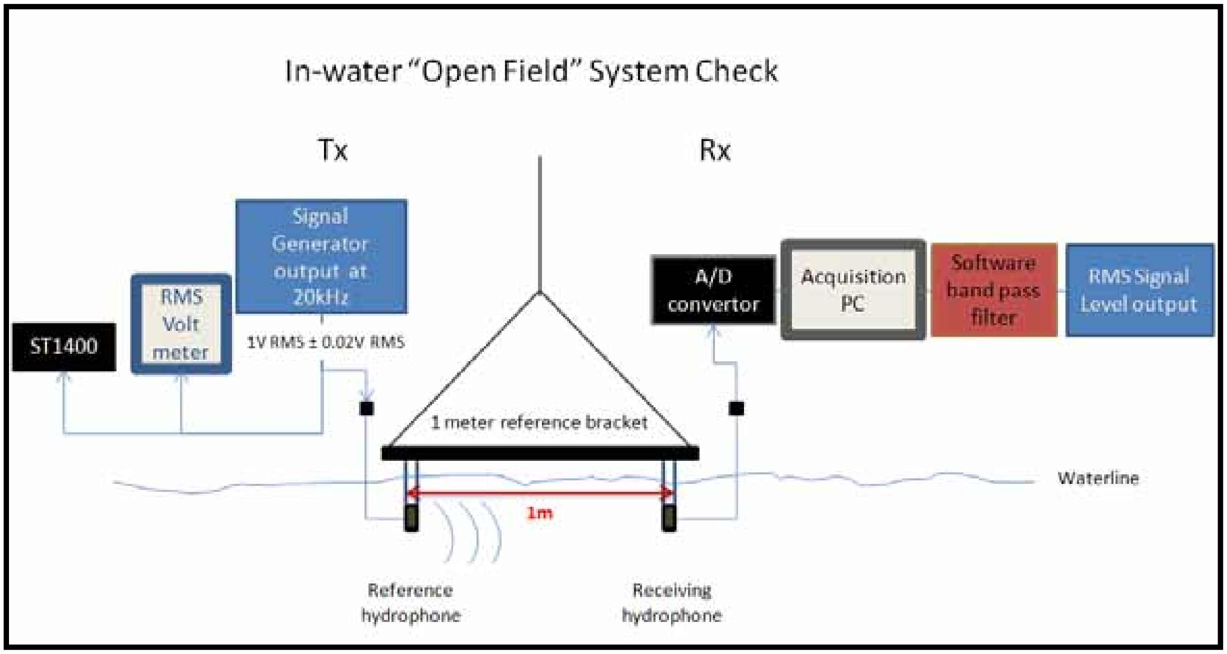

FIGURE 3-2. SYSTEMS CHECK DIAGRAM.

FIGURE 3-3. ONE METER REFERENCE BRACKET WITH HYDROPHONES

3.1.2 CTD and Turbidity System Checks

Checks were completed for the SEACAT Conductivity Temperature Depth (CTD) and OBS3 turbidity monitor prior to any field monitoring. The SEACAT CTD was checked by a direct comparison to an Odom Digibar sound velocity probe to validate data accuracy. The two instruments were fixed together to acquire a check cast at the same time, area, and position. Sound velocity was calculated from measurements made by the CTD and compared to the direct measurement made by the Digibar. Both instruments reported measurement accuracies within 0.5 meter per second, verifying the SEACAT CTD data quality. An operational check of the turbidity sensor was completed by suspending the OBS3 monitor in the river for a baseline sample and then disturbing the bottom sediment up to create a temporary area of highly dense suspended sediments. Differences between clear water and highly dense sediments were readily evident in comparisons.

3.2 Background Monitoring Methods

Background sound and river flow data were collected to determine baseline conditions prior to test pile activities at two sites. Site #1 was located approximately 100 meters downstream of the I-5 Bridge near the middle of the river. Collection of data at Site #1 began on 27 January and lasted approximately 94 hours. Site #2 was located approximately 600 meters downstream of the I-5 Bridge and toward the Oregon (south) side of the river. Collection of data at Site #2 began on 31 January and lasted approximately 89 hours.

High flows of debris were observed while preparing to deploy the monitoring instrumentation at Site #1. As the debris flows presented a physical risk to the instrument, authorization was given by CRC to shift Site #1 from the original position to a new position (45°37’12.055”N, 122°41’09.335”W) approximately 400 meters downstream of the I-5 Bridge toward the north side of the channel. The new position was approximately 10 meters downstream of a dolphin to provide protection from debris.

3.2.1 Sound Monitoring Data

A system check was performed prior to background monitoring. Background sound monitoring at both sites used the CR55 hydrophone with a ST191 DAS. A three-point mooring (one port side bow, one starboard side bow and one stern) was used to minimize movement of the platform during shifting tides and currents. SpectraPro Version 3.32.18d acquisition software was used to acquire data.

3.2.2 Current Meter Data

An InterOcean Systems, Inc. S4A current meter was used to monitor river flow rates to correlate river velocity with changes in background noise levels. The current meter was deployed in the vicinity of the background noise monitoring sites, including the revised Site #1 location, on both sides of the river. A one-minute average current measurement was recorded every 3 minutes. Data were processed with S4 Application Software version 5.1.0.

3.3 Monitoring Methods during Pile Driving

Pile driving operations were conducted from 11 to 21, February with the R/V *Preston* serving as the primary vessel and operations control center for hydroacoustic monitoring. All sound monitoring sites were monitored remotely from onboard the R/V *Preston*. Data collected by each vessel and sound monitoring station were backed up at the end of each day to an onboard portable hard drive used to transfer data to a server located at the DEA Marine Services office in Vancouver, WA. Figure 3.4 is a summary of operations for the duration of the pile events as documented in field logs.

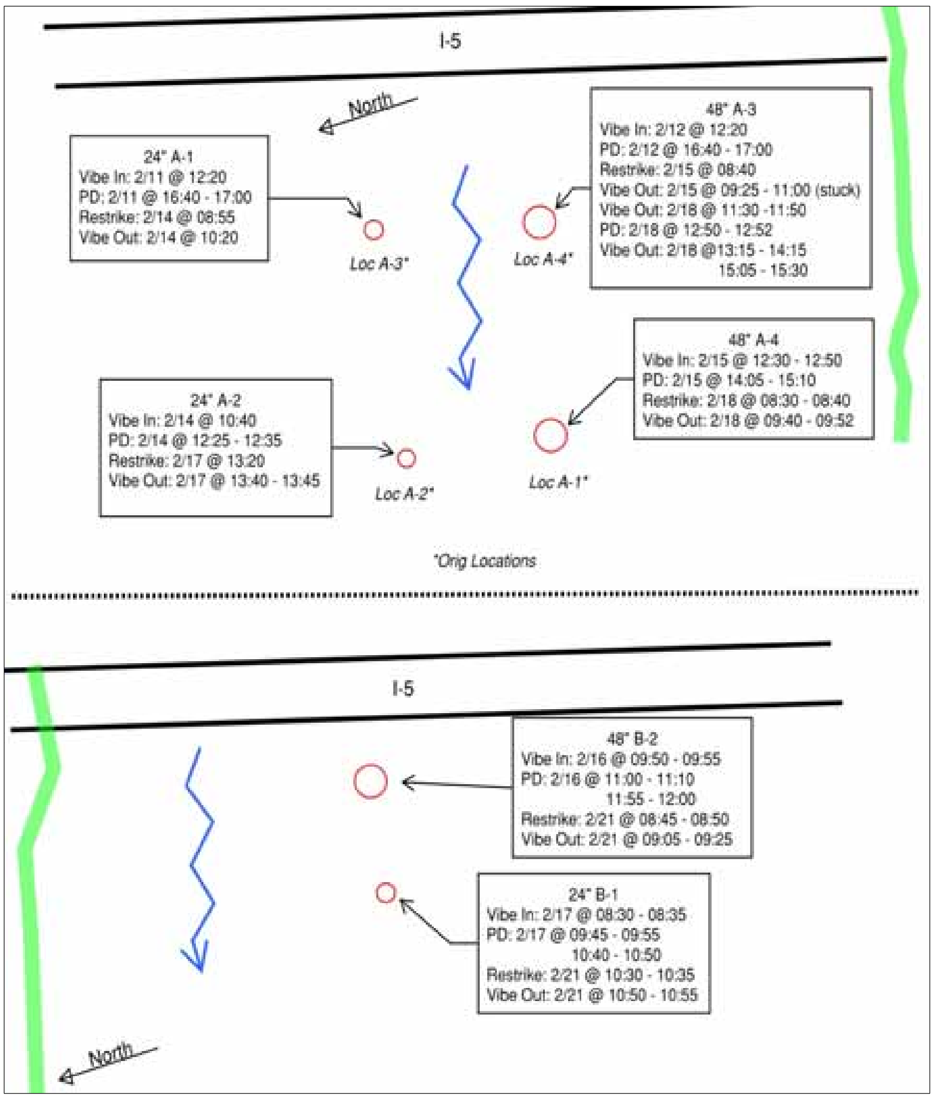

FIGURE 3-4. PILE OPERATIONS

3.3.1 Positioning of Piles and Sound Monitoring Remote Stations

Piles and sound monitoring stations were positioned by the crew of the DIB inflatable boat using an RTK GPS antenna. The RTK GPS received kinematic correctors from a base station located on the roof at the DEA Marine Services office upstream from the operations site. The DIB inflatable boat pulled alongside each pile and remote station and recorded position of the pile.

The pile positions were then imported into ArcGIS V. 9.3. Error ellipses were calculated for each remote station from all positions recorded at that station to derive a mean center location value. The mean center location was used to calculate the distance between pile locations and sound monitoring locations.

3.3.2 Sound Data

Remote monitoring stations were recovered at the end of each day and redeployed each morning of operations. Remote stations were anchored at approximately 200, 400, and 800 meters upstream (US) and or downstream (DS) from each pile during pile driving operations (figure 3-1). After remote station deployment the R/V *Preston* moored alongside the construction barge or moored to one of the driven piles in order to continuously monitor the 10-meter station. Two-point anchor systems were used for remote stations while operations took place on the Oregon side of the river. A one-point mooring system was used on the Washington side of the river due to time constraints created by removal and deployment from within the navigation channel.

Sound data were continuously collected and monitored at each station. Remote stations were monitored via a cellular modem connection from the primary vessel. Any station that was not responding to the cellular call was checked by personnel. The 10-meter station sound data were acquired using ST1400 ENV Software and the remote station data were acquired using SpectraPro Version 3.32.18D.

The remote station acquisition system settings were configured dependent upon their distance from the construction site. All hydrophones used a fixed cable length with a known decibel loss. Gain was adjusted in fixed increments on hydrophones to obtain optimum signal values for the designated distance. The same stations were used for the same distances for the duration of the project. Per the Washington State Department of Transportation (WSDOT) protocol, the 10 m station remained at mid-water depth for the duration of the project as water depth always exceeded 5 m at this station. Variable water column depths at other stations required adjustment of the height above the bottom to acquire quality data. Specifications for monitoring depth were based on recommendations in the Dahl and Rienhall Review of the Underwater Noise Monitoring Plan for the Columbia River Crossing Test Pile Project. In that review, a nominal model for transmission loss in a channel showed that sound levels were expected to be significantly reduced near the surface when compared to sound levels near the bottom. The review also raised concerns about potential masking of sound levels by soft mud and sediments near the river floor. To account for these potential issues, the hydrophones were lowered to as close as possible to mid-water column while adhering to the depth specifications of "…*either greater than 5 m, or placed 1-3 m above the bottom.*"[1] Most times hydrophones were lowered to a depth of one-half the water column unless the specification would indicate otherwise (table 3-

[1] Dahl and Reinhall, Review of the Underwater Noise Monitoring Plan for the Columbia River Crossing Test Pile Project

1). In areas where the mid-water column depth was less than 5 meters, the hydrophone cables were marked with 5-meter reference points to ensure that they were always deployed at a minimum depth of 5 meters. Unmanned remote systems are shown in figure 2-3. Site geometry is shown in figure 3-1. Once deployed for operations, hydrophones remained in the water and acquiring data until the end of construction activity for the day.

3.3.3 Baseline CTD and Turbidity Data

Baseline turbidity profiles were acquired the day before the commencement of pile driving activities at the 10-meter and 800-meter stations. Additional turbidity baselines were acquired each day prior to the day's pile driving operations at the other remote stations. While pile operations were occurring, the DIB inflatable boat team continued to monitor conductivity, temperature, pressure and turbidity at the sound monitoring station locations at timed 15-minute intervals or at times when turbidity changes were expected to occur (i.e. after a pile strike, or upon starting the bubble curtain). To account for the time required for currents to advect turbid water, the DIB inflatable boat did a drift timing measurement to determine the time it would take for surface currents to reach each remote station location. Cast timing was adjusted accordingly to increase the probability of detecting suspended sediments.

3.3.4 Bathymetric Data

Single-beam data were acquired in Hypack using the Odom CV-100 along the sound monitoring station transects to provide depth measurements for remote station monitoring deployments. Vertical offset and sound velocity measurements were accounted for during acquisition. Data were processed in Hypack Max 2009a using the Single Beam Editor to remove erroneous data points caused by noise in the water column in accordance with standard hydrographic processing techniques[2]. The depth data were then exported in feet as a 4-foot sort and overlaid in ArcGIS 9.3 to provide a correlation between the remote stations and the transects. The remote station depth reported was determined by choosing the depth closest to the mean center of all deployments. These depths are listed in table 3-1.

3.3.5 Marine Mammal Monitoring

At various times throughout pile operations the DIB inflatable boat was called to do marine mammal observations. Operators maintained sufficient distance so as not to harass the mammals.

3.3.6 Weather Data Collection during Operations

Water depth, sea state and wind conditions were monitored coincident to pile driving operations and recorded in vessel logs.

3.4 Acoustic Data Processing Methodology

Accurate processing of the data required development of custom programs to process and represent data in a quantifiable and easily visualized format. The majority of data processing and analysis was accomplished using DEA custom designed programming scripts written in the Python programming language. These Python scripts were used to compute all derived

[2] NOAA Field Procedures Manual, NOAA Office of Coast Survey, 2011

quantities, including Root Mean Square (RMS) pressure, Sound Exposure Level (SEL), and Strike Time. Spectra Pro software was used for rapid visualization of time series data during field work and system checks. Periodically, quantities derived by the Python scripts were compared to quantities calculated by Spectra Pro to verify the accuracy of the Python scripts.

1.1.1. Definitions of Derived Quantities

A significant number of calculated quantities are presented throughout this report and warrant explicit definition. In addition, shortened notation has been used for many quantities for efficiency. For example, Peak $Strike_{Maximum}$ is used to indicate the maximum magnitude of the peak strike amplitudes for an entire strike series. Various statistical quantities are indicated through the use of subscripts as identified below (using RMS as an example), followed by an alphabetical listing of the other major quantities. As the variability in sound levels between strikes appeared lognormal, population mean and standard deviations were calculated from the underlying quantities in decibel, not linear, units.

RMS_{Mean}: The average in decibel space of a range of RMS values, expressed in dB (re: 1μPa).

$RMS_{1\sigma}$: The standard deviation in decibel of a range of RMS values, expressed in dB (re: 1μPa).

$RMS_{Maximum}$: The maximum of a range of RMS values, expressed in dB (re: 1μPa).

$RMS_{(5\text{-}95\%)}$: The RMS pressure in decibels calculated using 5-95 percent of an impact strike waveform, expressed in dB (re: 1μPa).

$RMS_{PeakStrike}$: The RMS value corresponding to the strike with the highest instantaneous magnitude within a strike series, expressed in dB (re: 1μPa).

Cumulative $SEL_{Analyzed}$: The summation of the time integral of all of the analyzed strikes in a series. In this definition, the background level in between strikes is not included in the computation. Expressed in dB (re: $1\mu Pa^2$*sec). This quantity represents a direct measurement of the total energy of the analyzed strikes, and is useful when calculating propagation loss. These measurements are reported in the Appendix II.

Cumulative SEL: The Cumulative SEL derived from the analyzed strikes proportionally increased to represent the Cumulative SEL of an entire strike series, assuming the remaining strikes exhibited the same behavior as the analyzed strikes. This is calculated by taking 10 times the logarithm of the ratio of total strikes to analyzed strikes and adding it to the Cumulative SEL of the analyzed strikes. Expressed in dB (re: $1\mu Pa^2$*sec). As Cumulative SEL derived in this manner includes data from a large number of strikes, this measure was given preference over single strike SEL when evaluating transmission loss and attenuation effectiveness.

Peak Strike: The maximum instantaneous pressure magnitude of a strike waveform in decibels, expressed in dB (re: 1μPa).

RMS: The root mean square sound pressure level over a specified interval. For background and vibratory monitoring, the interval is 30 seconds, for impact driving, it is 90 percent of the total energy. Expressed in dB (re: 1μPa).

SEL: Sound Exposure Level – The time integrated sound pressure squared over a specific interval, expressed in dB (re: 1μPa^2*sec). When applied to a single strike, the SEL was defined as the time integrated sound pressure squared over 90 percent of the total energy of the strike.

Series RMS: The RMS pressure over 90 percent of the strike energy for all the analyzed strikes in a strike series, expressed in dB (re: 1μPa).

Strike Time: The time elapsed from the start of the strike, or from a specific minimum energy point within the strike (e.g. 5 percent), to a designated ending energy point of the strike (e.g. 90 percent or 95 percent), expressed in milliseconds.

Time to Peak: Two interpretations exist; the first is the time from a change in background levels to the peak of a strike wave form, the second is equivalent to rise time, or the time from the zero pressure crossing immediately preceding the peak to the peak of the waveform. The former definition was used in this study, expressed in milliseconds.

Waveform envelope: the average of all of the analyzed waveforms in a strike series, plus and minus 2 standard deviations. Ninety-five (95) percent of all component waveform pressures fall within the waveform envelope. An example envelope and single strike waveform is shown in figure 3-5.

Transmission Loss coefficient: Transmission loss is defined as the accumulated decrease in acoustic intensity as an acoustic pressure wave propagates outwards from a source[3]. The coefficient of transmission loss is used in this report, which represents the geometric factor of spreading. A value of 20 is spherical spreading, while 10 represents cylindrical spreading. This quantity is always calculated across the total distance to a particular station. For example, the Transmission Loss coefficient for the 400 meter station is based on the change from the 10 meter sound level, not the value recorded at 200 meters.

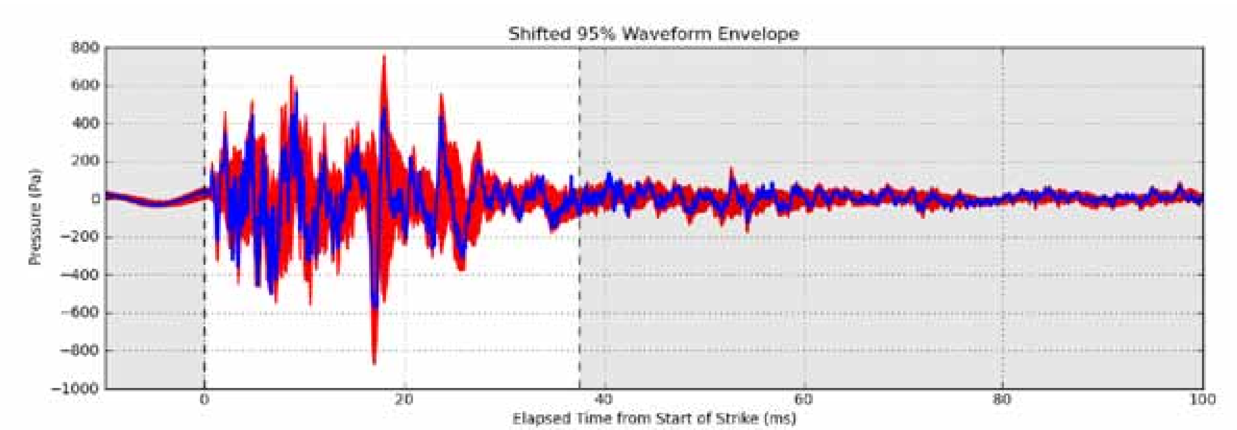

FIGURE 3-5. 95 PERCENT WAVEFORM ENVELOPE (RED) WITH SINGLE COMPONENT STRIKE WAVEFORM (BLUE). 90 PERCENT OF THE ENERGY OF THE STRIKE LIES BETWEEN THE SHADED REGIONS.

[3] Principles of Underwater Sound, 3[rd] Edition, Robert Urick, 1983

1.1.2. Processing of Background Data

Background data were segmented into 30-second blocks for analysis. An RMS pressure was calculated for each 30-second block. The power spectral density (PSD) function for each 30-second block was calculated using standard signal processing methodology, namely the Welch method with a 4096-point window (roughly 100ms), Hann filter and corresponding correction factor, and 50 percent window overlap. Power spectral densities for an entire day are the result of averaging each 30-second PSD.

When reviewing the background data, noise artifacts, likely electronic noise caused by the bus of the collection computer, could be seen in the spectral data during a couple hours of very low background noise. These artifacts occurred at exact intervals of 1000Hz. The spectral signature of the artifact was defined based on several low-noise samples, and then subtracted from the background spectra. This eliminated the artifact, as shown in figure 3-6.

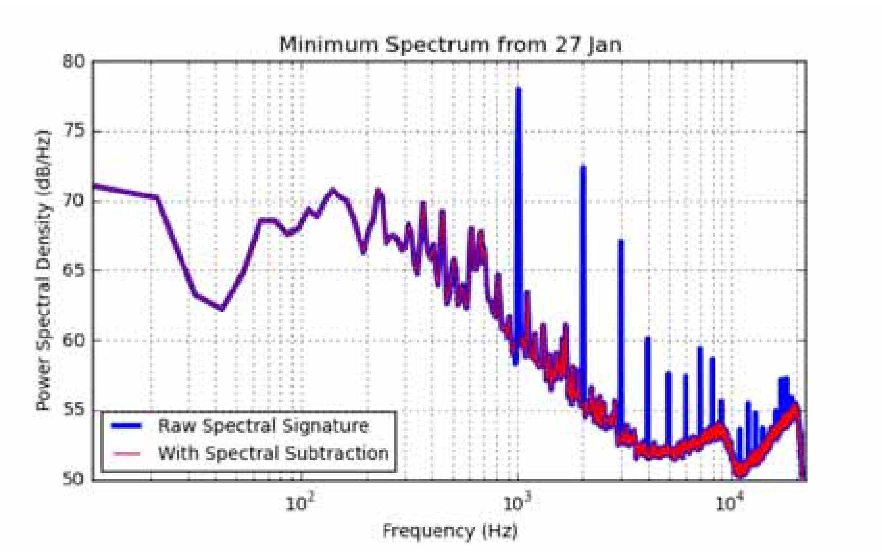

FIGURE 3-6. SUBTRACTION OF ELECTRONIC NOISE ARTIFACT FROM THE SPECTRAL DENSITY.

A histogram was generated from the final 30-second RMS data using one decibel bins, and then normalized to produce a probability mass function and cumulative distribution function.

1.1.3. Processing of Vibratory Driving Data

Similar to background data, time series containing vibrodrive data were divided into 30-second blocks for analysis. An RMS pressure was calculated for each 30-second block. Those values were then graphically reviewed, and a subset of 30-second RMS values corresponding to the approximate steady-state portion of the vibratory drive were extracted and averaged to produce a single RMS value. The spectral densities corresponding to the same subset of 30-second values were also averaged to produce a single estimate of power spectral density. For vibration periods less than one minute, an RMS value and spectral density was derived directly from the time series, not by averaging 30-second values

1.1.4. Processing of Impact Driving Data

Analysis of impact driving was done on a strike-by-strike basis. A strike detection algorithm using a simple detection threshold with time-blanking was passed over an impact-driving time-series to locate individual strikes within the time series. These individual strikes were then graphically reviewed to ensure accurate selection. If both air-on and air-off conditions occurred during the strike series, the subset of strikes corresponding to a single condition was extracted for further analysis. Analysis was then conducted on each individual identified strike, and statistics were compiled for the strike series.

Each individual strike was passed through an additional algorithm to detect the start point of the strike based on a departure of the time-rate of change of the accumulated energy, or the SEL, when compared to the local background sound level. The picks from this algorithm were then graphically reviewed to ensure accuracy. The total energy of the strike was then defined as the accumulated energy 500 milliseconds (ms) following the start of the strike.

Statistics were then compiled on the series of strikes. Simple statistics for the strike series, such as mean and standard deviation, were generated using the decibel values of the underlying quantities, not the pressure values.

Every quantity was also derived after passing the time series through a 75 Hz high-pass filter to mimic the range of frequencies of interest for marine mammal (specifically pinniped) hearing. Following standard signal processing techniques, a third-order Butterworth filter was used, which was run in both the forward and reverse direction and then combined to generate the filtered result.

1.1.5. Determining Total Strike Energy

Several quantities, including RMS, SEL, and Strike Time, are calculated over 90 percent of the total energy of a strike. Specifically, these quantities are often defined from 5-95 percent of the energy of the strike. The challenge in calculating these quantities lies in determining the total energy of the strike. As shown in figure 3-7, it is difficult to ascertain whether the total energy of the strike has completely dissipated prior to the next strike one and a half seconds later. For computational simplicity, a simple time window is typically used to derive the total energy of a strike; for this study, a 500-millisecond time window was used. The total energy of the strike was therefore defined as the time integrated sound pressure squared over the first 500-milliseconds of the strike. The energy levels corresponding to the 5 and 95 percentiles were subsequently derived based on that total energy.

Additional analysis was done to determine the bias that the somewhat arbitrary selection of the time window adds to the determination to the calculated quantities. To assess the induced bias, strike times were calculated using two definitions and using two time windows for total energy. Strike times defined as 0-90 percent total energy and times defined as 5-95 percent total energy were calculated for each strike in one strike series using a 750-millisecond window and a 250-millisecond window and then compared to one another. The mean strike time using the 0-90 percent definition changed by 5 milliseconds when calculated using a 750-millisecond total energy window as opposed to a 350-millisecond total energy window. The mean strike time using the 5-95 percent definition changed by 37 milliseconds over the same two time windows. The cause for this significant difference is apparent when looking at the strike waveform envelope. As shown in figure 3-8, the 95 percent energy point occurs in the tail of the strike, once the majority of the strike energy has subsided. As a result, larger changes in strike time are required to accommodate differing definitions of total energy.

Both 0-90 percent and 5-95 percent quantities were calculated throughout the study, though 0-90 percent quantities were given preference during the analysis due to their relative insensitivity to the selection of the total energy time window.

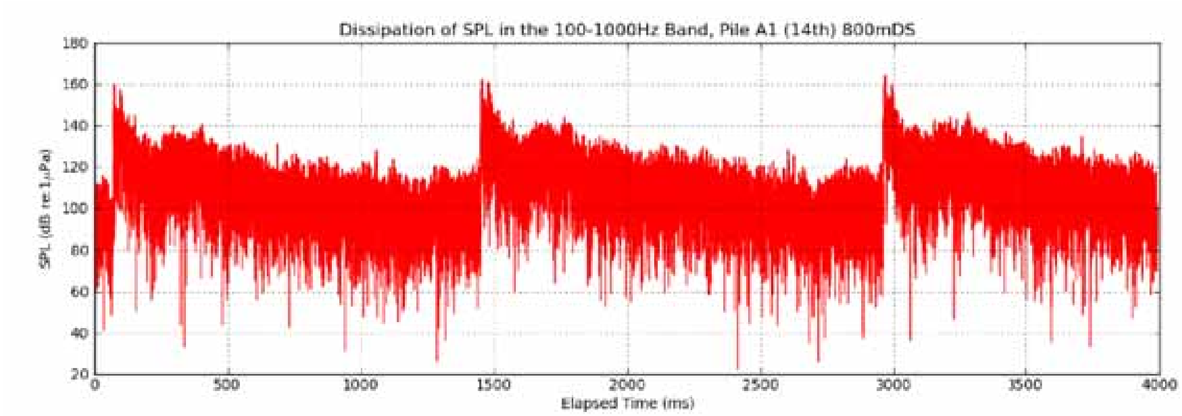

FIGURE 3-7. STRIKE ENERGY AT 800 METERS DOES NOT APPEAR TO FULLY DISSIPATE UNTIL JUST PRIOR TO THE NEXT STRIKE.

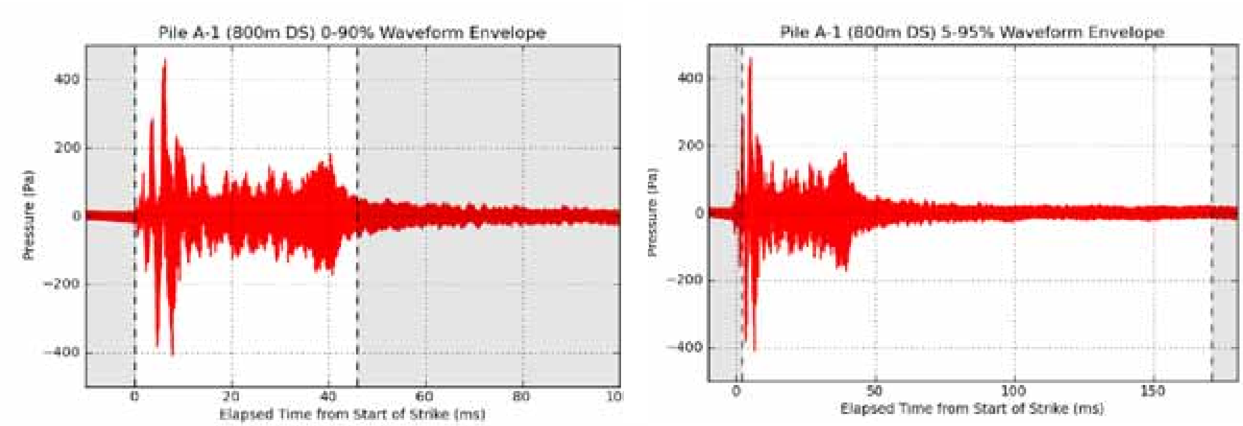

FIGURE 3-8. 0-90 PERCENT ENCLOSES STRIKE, WHILE 5-95 PERCENT INCLUDES THE TAIL OF THE STRIKE.

1.1.6. Analysis Methodology for Impact Driving Data

Results of the analysis of impact drives are located in Appendix II. Analysis included the computation of quantities outlined in section 3.4.1, along with graphics of specific quantities pertaining to the strike series. While analysis was conducted on a strike-by-strike basis, the quantities pertaining to individual strikes were always averaged or otherwise combined as appropriate (e.g. summed) across all of the analyzed strikes for a strike series. With the exception of the example strike shown in figure 3-5, no single strike results are depicted in this report.

The standard analysis of a strike series was conducted as follows. For strike series including both air-on and air-off conditions, strikes not matching the condition of interest (e.g. air-on) were excluded from the analysis, as shown by the gray regions in figure 3-9.

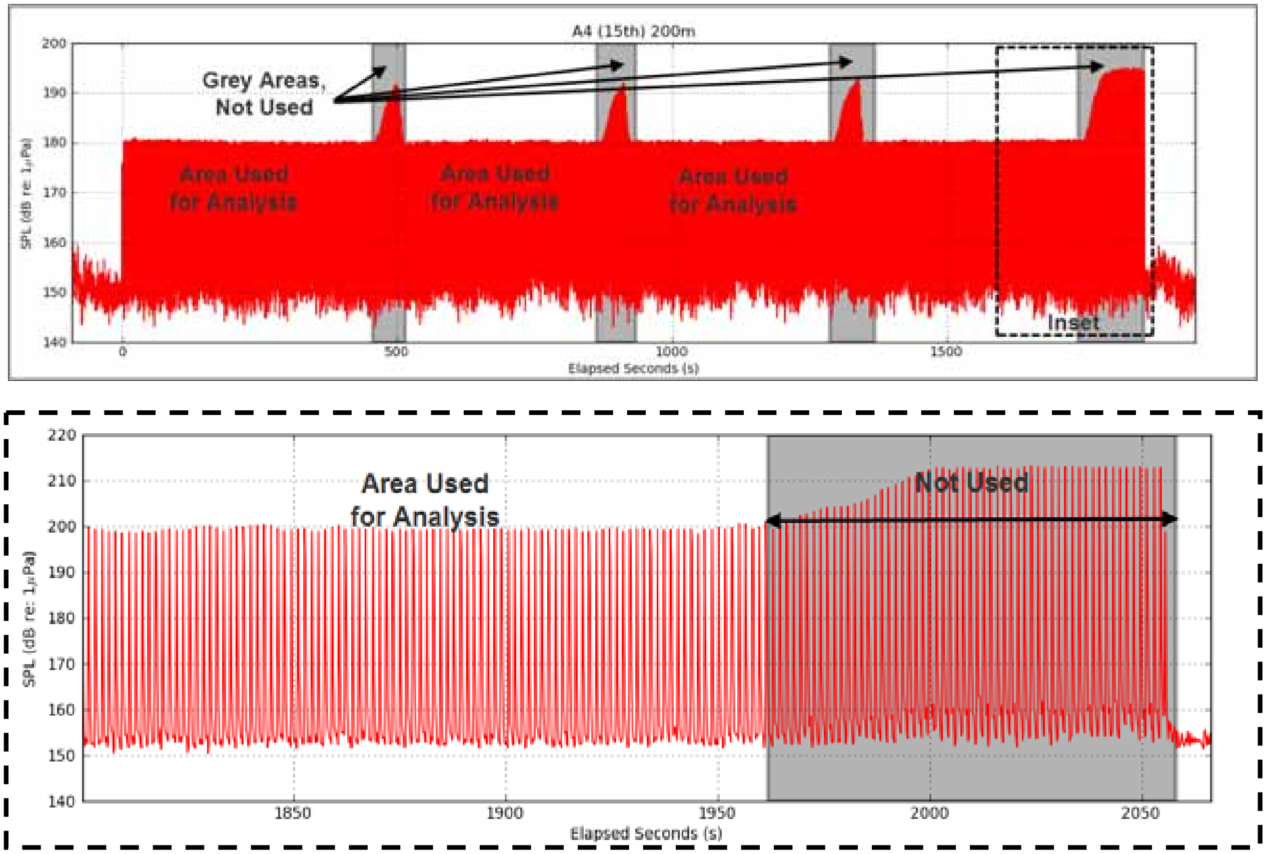

Figure 3-9. Strike series for Pile A-4 showing areas not used in the analysis of the air-on condition.A power spectral density for the remaining strikes was then computed using standard methodologies for calculating spectral density. Spectral densities for a strike series were ensemble averaged using a 2048-point window with 50 percent overlap on the portion of each strike corresponding to 0-90 percent of the total strike energy. The resulting density for each strike was then averaged across all of the analyzed strikes of a series to produce a single estimate of spectral density for a strike series under the condition of interest (e.g. air-on) (Figure 3-10).

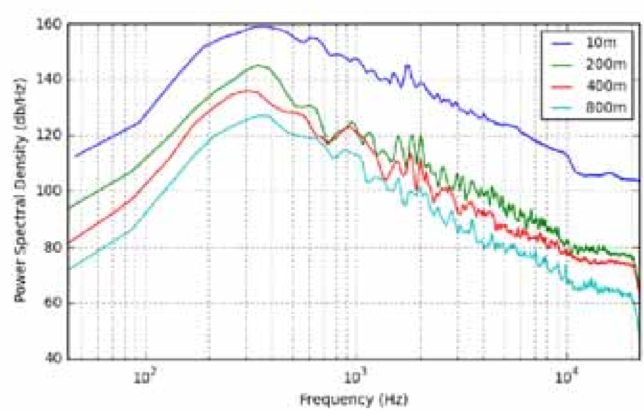

FIGURE 3-10. EXAMPLE POWER SPECTRAL DENSITY OF A STRIKE SERIES AT ALL RANGES

The accumulated energy, or SEL, for each of the analyzed strikes was also computed across the 500-millisecond time-window used to determine total energy. These results are depicted graphically in Appendix II for each strike series at each monitored range. An example is shown in figure 3-11. In the graphic, the average of the time-integrated SEL for all of the analyzed strikes is shown, as well the envelope corresponding to the maximum and minimum single-strike SEL levels within the strike series. The final SEL value for a single strike was defined as 90 percent of the SEL at 500ms. Final single strike SELs were combined across and entire strike series to produce an average and cumulative SEL value for the strike series.

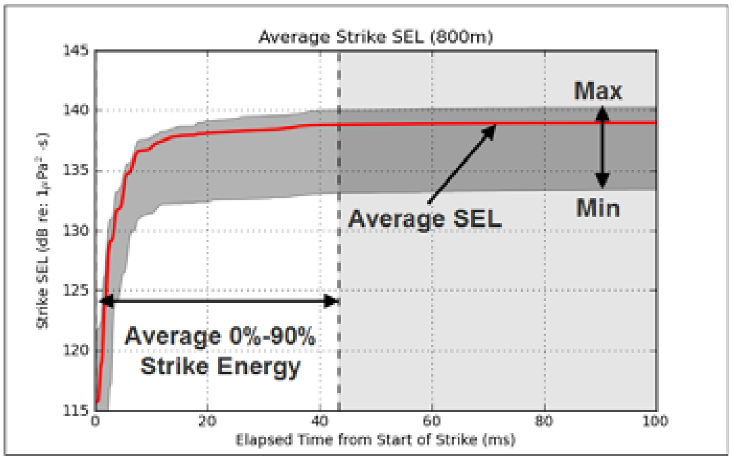

FIGURE 3-11. EXAMPLE SEL GRAPHIC SHOWING AVERAGE, MAXIMUM, AND MINIMUM SEL OF A STRIKE SERIES ALONG WITH AVERAGE STRIKE END TIME.

The waveforms for each of the analyzed strikes were then averaged across the entire strike series. Two standard deviations were added and subtracted from the average to calculate a 95 percent waveform envelope. An example is shown in figure 3-12.

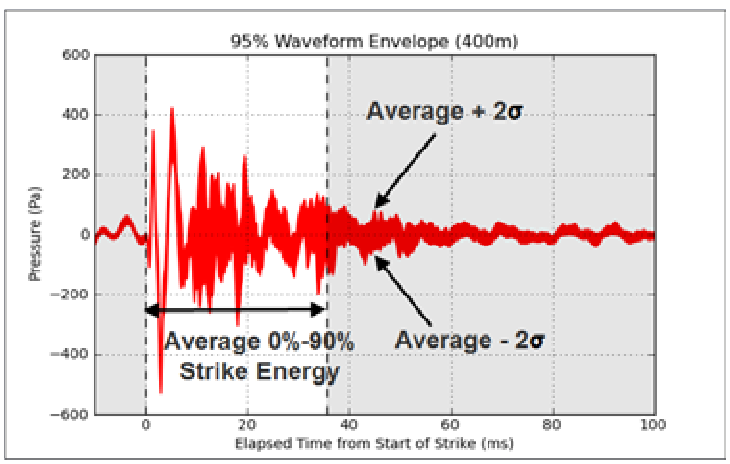

FIGURE 3-12. EXAMPLE STRIKE WAVEFORM ENVELOPE WITH THE STRIKE START AND AVERAGE END TIME.

Some strike series may include quiet periods in between strikes within the series. Though these quiet periods will not have gray regions similar to figure 3-9, their presence does not impact the results of the analysis. As discussed previously, all analysis was conducted on a strike-by-strike basis, and then individual strike results were combined across a strike series. As no strikes occur during the quiet periods, their presence does not impact the calculated quantities.

In all, 3986 individual strikes over 17 different strike series were analyzed at all available ranges. Several of these strike series included multiple attenuation conditions (i.e. air-on and air-on) within the same series, and as a result were analyzed twice (once for each condition). This resulted in a total of 21 different analyses for the 17 recorded strike series. The results for each analysis are located in Appendix II. In comparing each of the 21 different strike series analyses, it was apparent that variability in every quantity between different strike series was far greater than the variability between individual strikes with any given strike series. Therefore, the results for each strike series were considered and as an individual sample when compared to other strike series, and not weighted by the number of analyzed strikes comprising the series. For example, the average Peak Strike amplitude for a 24-inch pile restrike on the Oregon side of the river would be determined by directly averaging the Peak $Strike_{Mean}$ for both pile A-1 and A-2, not by combining the 311 strikes from A-1 with the 471 strikes from A-2 and taking the average of the set of all 788 individual component strikes.

The results from the 21 different strike series where combined to provide average values and corresponding uncertainty. Complicating this effort, the 21 different strike series included a wide range of conditions which may affect hydroacoustic sound levels and propagation. Specifically, the strike series include 24-inch and 48-inch piles, Oregon and Washington sides of the river, upstream and downstream attenuation, open bubble curtain attenuation, confined bubble curtain attenuation with air on and off and with varying air levels, unattenuated driving strikes and restrikes. While each of these different conditions has the potential to impact both sound levels and propagation, there were an insufficient number of strike series samples to distinguish the effects of all of these conditions.

In order to guide how best to combine results without masking potentially important distinctions, Student's *t*-tests were conducted between different populations of strike series. This test was intended to determine if it was more likely than not two samples were from the same population. The level of significance to conclude that populations were distinct was set to 0.05. However, if the probabilities returned by the test were much less than 50% ($p<<0.5$), it was inferred that a difference in populations may exist, though cannot be concluded. In these instances, additional qualitative analysis was performed to present potential differences, though the existence of a clear distinction cannot be concluded.

The Student's *t*-test assumes the underlying population is normally distributed. Though the sample numbers are generally low within each category, the hydroacoustic results do not indicate that this is an inappropriate assumption. All *t*-tests were 2-tailed and assumed unequal variance due to the differing sample sizes. For consistency, *t*-test results are always depicted as the *p*-value that the two samples belong to the same population. These tests were always conducted separately on 24-inch and 48-inch piles, due to the clear difference in strike intensity associated with each pile size. Results for *t*-tests are often presented in tables in this report, with *p*-values reported as probabilities to facilitate their use in inference as discussed above.

4. Results

4.1 Positioning

Results from the RTK derived positioning for both the driven pile position and remote station position are shown in tables 4-1 through 4-3.

Table 4-1. Pile positions.

Pile	Latitude (N)	Longitude(W)	Size (in)	Depth (m)
Pile A				
1	45.61710858	-122.6780767	24	10.8
2	45.61696328	-122.6781121	48	10.8
3	45.61715326	-122.6783028	24	10.3
4 [a]	45.61700131	-122.6783586	48	--
Pile B				
1	45.62062203	-122.6759064	48	10.7
2	45.62068725	-122.6760911	24	10.9

[a] *Position estimated*

Table 4-2. Distance in meters from driven pile to remote monitoring stations (piles A1-A4).

Date	Pile Name	Distance (m)			
		P3-800 US	P3-200 DS	P3-400 DS	P3-800 DS
2/11/2011	A-1 (24")	753	231	430	844
2/12/2011	A-3 (48")[b]	770	214	413	827
2/14/2011	A-1 (24")	750	237	433	851
2/14/2011	A-2 (24")	768	219	415	834
2/15/2011	A-3 (48")	744	244	442	860
2/15/2011	A-4 (48")[a]	761	227	425	844
2/17/2011	A-2 (24")	780	213	411	815
2/18/2011	A-4 (48")[a]	774	224	415	822
2/18/2011	A-3 (48")	757	240	431	838

[a] *Position estimated*
[b] *No positions. February 11, 2011 positions used.*

Table 4-3. Distance in meters from driven pile to remote monitoring stations (piles B1-B2).

Date	Pile Name	Distance (m)			
		P6-800DS	P6-200US	P6-400US	P6-800US
2/16/2011	B-2 (48") Pile 5	860	180	369	773
2/17/2011	B-1 (24") Pile 6	805	205	388	789
2/21/2011	B-2 (48") Pile 5	821	174	370	768
2/21/2011	B-1 (24") Pile 6	805	190	386	784

4.2 Background Monitoring

Background levels were analyzed and reported as RMS levels (dB re: 1µPa), shown in spectral frequency graphs, a daily probability plot, and an overall cumulative distribution plot (figure 4-2). A typical time series is depicted in figure 4-1.

Site #1 was located near the city dock on the north side of the river approximately 400 meters downstream of the I-5 Bridge. This site was monitored from 26 to 30 January. River flow levels were monitored concurrently. Background noise levels for Site #1 were similar for each day, with noise levels averaging 111dB (re: 1µPa). On 27 January, higher than expected sound levels occurred between approximately 14:00 to 16:00 and 19:00 to 21:00 local time, resulting in a non-normal probability mass function (PMF). The cause of this increased noise is unknown. Because Site #1 was moved to an alternate site behind a dolphin near a public dock, noise levels may be attributed to a recreational boat docking with the engine remaining at idle for several hours. Background data also included clear noise spikes attributable to passing vessels. The spectral signature of these vessels is evident in frequencies above 1 kHz on 28 to 30 January (figure 4-2).

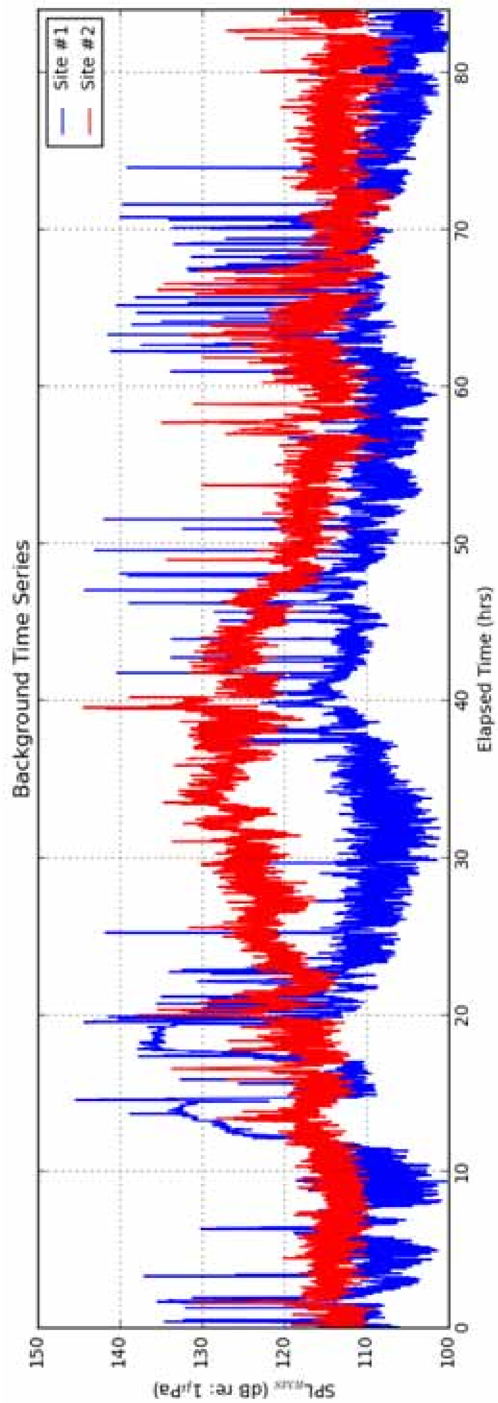

FIGURE 4-1. TYPICAL RMS TIME SERIES FOR ONE DAY AT EACH SITE. SPIKES ARE ATTRIBUTABLE TO PASSING VESSELS.

Site #2 was located near the dolphins on the south side of the river approximately 600 meters downstream of the test pile site. This site was monitored from 31 January to 03 February. River flow levels were monitored concurrently. With the exception of 01 February, background noise levels were similar for each day, averaging 118dB (re: 1µPa). On 01 February, noise levels were roughly 10dB higher than on other days. This increase in noise correlated to a high wind event, with wind speed averaging 10 m/s over a 15-hour period.

Current speeds for both sites averaged 47 cm/s, and did not exceed 1m/s for the entire deployment. To verify that recorded sound levels were not contaminated by flow noise, sound levels were regressed against current speed to ensure no correlation exists. The greatest variability in current speed of all monitoring days occurred on 02 February, which was used for the analysis. Since current speeds were recorded as three-minute averages, three-minute RMS levels were derived to compare to the current meter measurements. Flow noise does not appear to bias the results as there is no correlation between current speed and recorded sound level (figure 4-3).

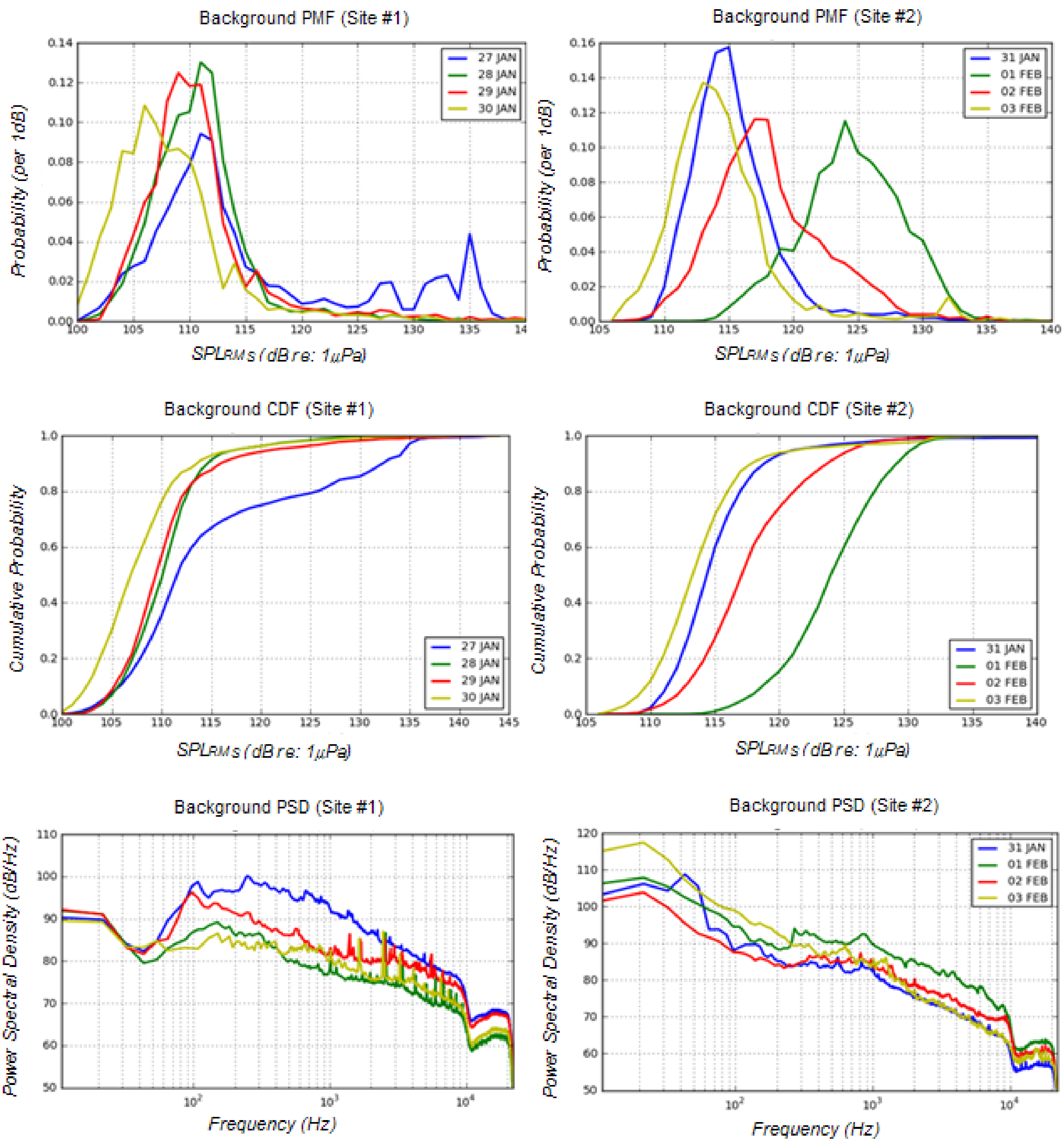

FIGURE 4-2. PROBABILITY MASS FUNCTIONS, CUMULATIVE DISTRIBUTION FUNCTIONS, AND POWER SPECTRAL DENSITY FUNCTIONS FOR BACKGROUND SITES #1 AND #2. ENGINE NOISE FROM PASSING VESSELS IS EVIDENT AS DISTINCT SPECTRAL SPIKES AT SITE #1.

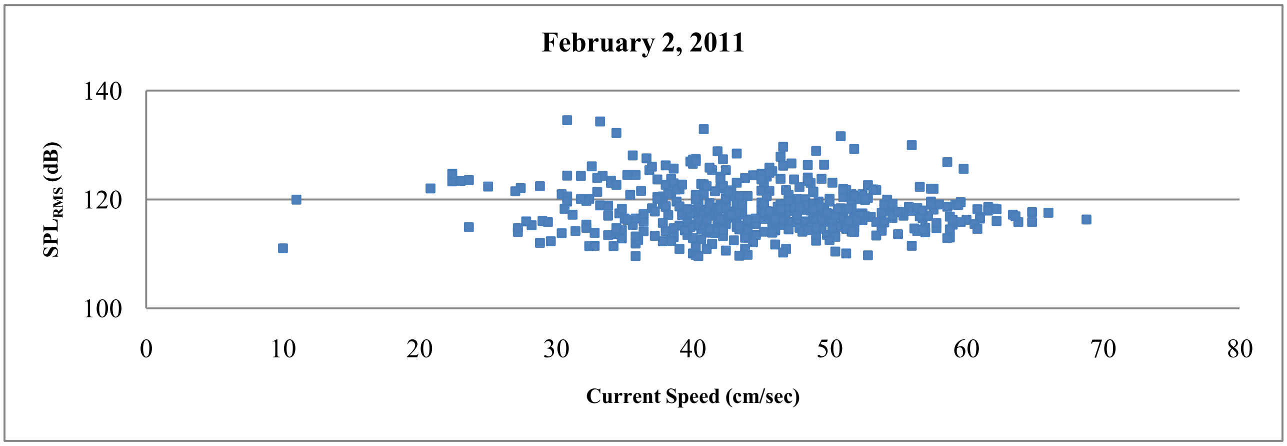

FIGURE 4-3. REGRESSION OF SPL AGAINST CURRENT SPEED SHOWING NO CLEAR CORRELATION.

For comparison between sites, a probability mass function, cumulative distribution function, and power spectral density were calculated for the entire deployment at each site. Site #2 was found to be slightly louder than Site #1, but with very similar spectral characteristics (figure 4-4). Cumulative statistics are shown in the table 4-4, and figures 4-4 and 4-5.

Table 4-4. Cumulative background sound levels at Site #1 and Site #2

Background Sound Levels by Site				
	Mean (dB)	50% CDF (dB)	Maximum (dB)	1σ (dB)
Site #1	111	110	145	7
Site #2	118	117	157	6
Delta	7	7	12	

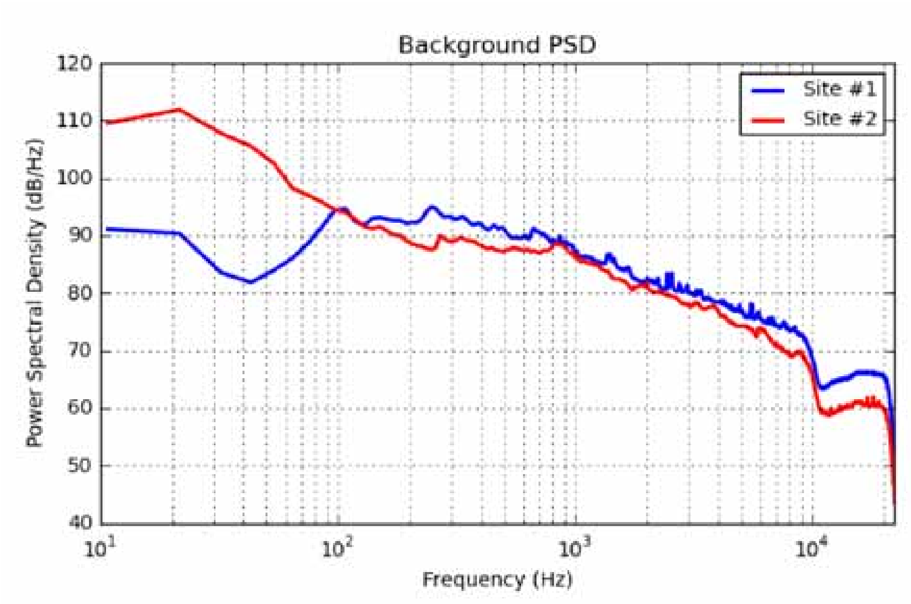

FIGURE 4-4. SPECTRAL DENSITY FOR EACH SITE.

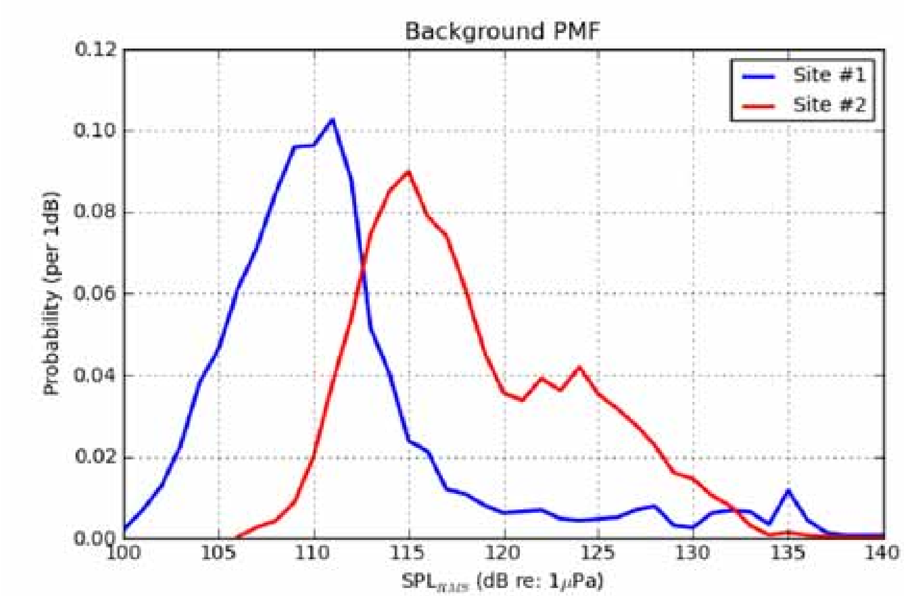

FIGURE 4-5. PMF FOR EACH SITE.

4.3 Vibration Monitoring

There were six separate vibration drives, one for each pile. Sound levels generated by vibration driving varied widely from pile to pile. Vibration times needed to drive the pile to the desired depth also varied, and appear to correlate to the generated sound level.

Vibratory drives typically begin with a ramp-up in vibration energy, a period of quiet, then a period of vibration driving at high energy (figure 4-6), following procedures outlined in the *Columbia River Crossing Request for Marine Mammal Protection Act Letter of Authorization*. For the calculation of RMS pressure level, only the time period when driving at maximum energy was used; the ramp up was not analyzed. A summary of the average RMS pressure level of the driving vibration at 10 meters is shown in table 4-5 for each pile. An error in data logging at the 10-meter station for pile A1 prevented calculation of the 10-meter RMS level for that pile. No information was available regarding the vibratory drive depth of pile A4.

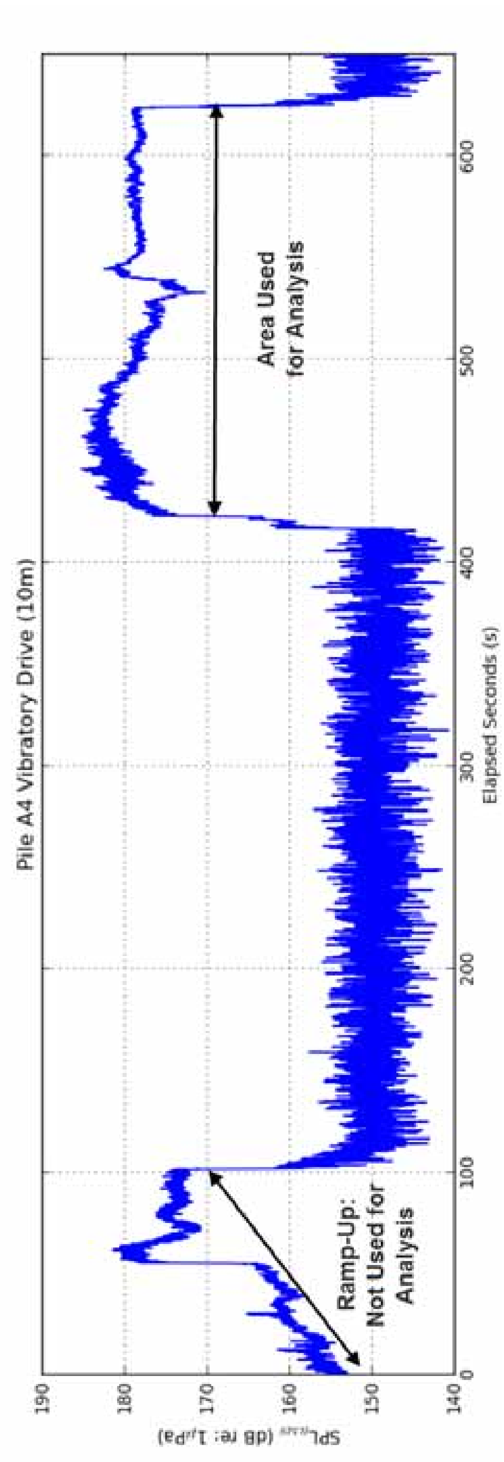

Figure 4-6. Vibratory drive RMS time series for Pile A4, showing the ramp up and subsequent drive.

Table 4-5. RMS Pressure levels for vibrodriving.

Pile	Size (inches)	SPL_{RMS} (dB) (10m)	Total Time (min)	Driven Depth
A1 (24”)	24			30
A2 (24”)	24	157	<1	16
A3 (48”)	48	181	9	61
A4 (48”)	48	179	4	
B1 (24”)	24	162	<1	24
B2 (48”)	48	161	<1	27

As represented in figures 4-6 and 4-7 and table 4-5, vibration noise levels were markedly different at piles A2, B1, and B2, from piles A3 and A4. The quiet drives associated with piles A2, B1, and B2 were short-duration drives, suggesting the piles were easily driven to the desired depth. It is likely that the ease with which the pile is driven is correlated to the relative quiet of the drive.

The low sound levels associated with the vibropiling drives adversely affected calculations for transmission loss, however. For piles B2 and B3, by 200 meters the vibratory signal could not be clearly distinguished from

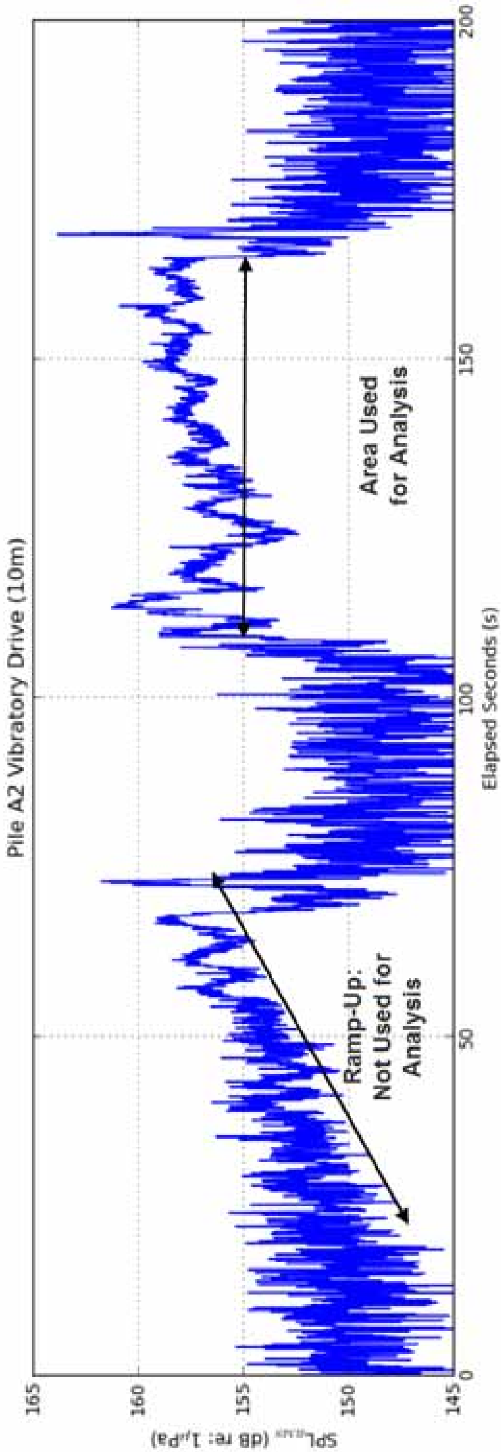

FIGURE 4-7. VIBRATORY DRIVE RMS TIME SERIES FOR PILE A2, SHOWING THE RAMP UP, SUBSEQUENT DRIVE, AND LOW OVERALL SOUND LEVEL.

the background noise, so the transmission loss coefficient could not be calculated for these piles. Similarly, for pile A2 the signal could not be distinguished at 800 meters. Equipment failures further complicated the analysis of vibratory transmission loss. During the vibratory drive of pile A3, the recording device at 400 meters suffered a battery failure, and the sound levels at the 800-meter station were clipped and could not be used. A complete dataset was available for the vibratory drive at pile A-4, and the signal was of sufficient strength to be clearly measured at 800 meters. The resulting derived transmission loss coefficients, relative to the 10-meter signal, are shown in the table 4-6 below.

Table 4-6. Transmission Loss for Vibrodriving, Pile A4.

Pile A4 (48") Vibratory Drive	
Range	Transmission Loss Coefficient
200	15.7
400	15.4
800	15.5

The spectral signature of pile A-4 was derived at each station (figure 4-8). For the derivation of spectral density, only the time period when driving at maximum energy was used; the ramp up was not analyzed. The 10-meter station shows considerable broadband energy, particularly between 100 and 300 Hz, which is attenuated rapidly with distance.

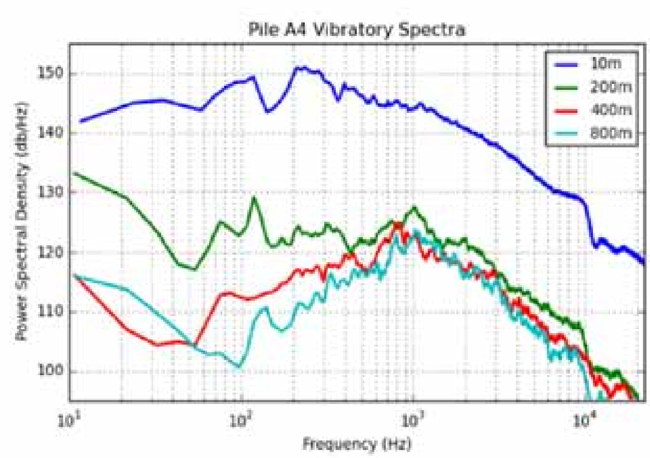

FIGURE 4-8. VIBRATORY DRIVE PSD

4.4 Impact Driving

1.1.7. Sound Levels for Unattenuated Strikes

For the test pile program, hydroacoustic monitoring was also conducted on pile restrikes. These strikes occurred a minimum of 24-hours (though usually 48 hours) after the driving strikes to allow time for the sediment to consolidate. It was anticipated that restrikes may possess different sound levels than unattenuated driving strikes, and the intent of monitoring the restrikes was to quantify that difference. Review of the data, however, does not suggest they are statistically different from one another. A Student's *t*-test analysis was done on each population of strikes, separated by pile size, for mean Peak Strike, RMS, and SEL. All *p*-values exceeded 0.5.

Since the restrikes and unattenuated driving strikes were statistically similar, monitoring results for these drives were combined to provide a more robust analysis of transmission loss and sound levels for unattenuated strikes. All restrikes and unattenuated driving strikes were combined to compute an average sound level for both a 24-inch and 48-inch pile, as shown in table 4-7. The resulting standard deviations are also shown.

Table 4-7. Average impact driving sound levels for 24-inch and 48-inch piles.

Average Unattenuated Strike Characteristics (10m)					
	24" Pile	48" Pile		24" Pile	48" Pile
Peak Strike$_{Mean}$ (dB)	205	214	Time to Peak$_{Mean}$ (ms)	13	15
Peak Strikes$_{1\sigma}$	1	2	Time to Peak$_{1\sigma}$ (ms)	3	2
RMS$_{(0\text{-}90\%)\ Mean}$ (dB)	189	200	Strike Time$_{(0\text{-}90\%)\ Mean}$ (ms)	33	27
RMS$_{(5\text{-}95\%)\ Mean}$ (dB)	190	201	Strike Time$_{1\sigma}$ (ms)	3	3
RMS$_{1\sigma}$	1	2			
SEL$_{Mean}$ (dB)	175	184			
SEL$_{1\sigma}$	1	2			

Unattenuated strike characteristics were also compiled with high-pass filtered data using a cutoff frequency of 75 Hz. As most of the spectral strike energy is in frequencies greater than 100 Hz, there is minimal overall reduction in sound levels due to the high pass filter when compared to unfiltered results (table 4-8).

Table 4-8. Impact driving sound levels after high pass filtering.

Highpass Filter at 75 Hz		
Average Unattenuated Strike Characteristics (10m)		
	24" Pile	48" Pile
Peak Strike$_{Mean}$ (dB)	205	214
RMS$_{(0\text{-}90\%)\ Mean}$ (dB)	189	198
RMS$_{(5\text{-}95\%)\ Mean}$ (dB)	189	200
SEL$_{Mean}$ (dB)	174	183

1.1.8. Summary of Activity by Pile

Impact driving for pile A1 occurred on 11 February and was intended to use the confined bubble curtain. However, upon activation of the confined bubble curtain, the high volume of air flow created an effect similar to a fountain, with water pouring out over the top of the confined curtain. As a result, the sleeve for the curtain began to dig itself into the sediment. The confined curtain was replaced with an open bubble curtain. The open bubble curtain was configured to use 700 cubic feet per minute (CFM) in the bottom two rings, and between 620 and 680CFM on the remaining three rings. Pile A1, a 24-inch pile, was driven 8 feet using between 311 and 315 strikes. The air to the bubble curtain was turned off twice during the drive, providing a direct measurement of the unattenuated sound level during the drive (table 4-9).

Table 4-9. Sound levels during impact drive of pile A1.

	Pile A1 (24”)	
	No Attenuation	**Open BC, Air On**
Number of Strikes: Total	311	
Number of Strikes: Analyzed	26	241
Series RMS $_{(0\text{-}90\%)}$	185	176
Cumulative SEL	197	188
Peak Strike$_{Maximum}$	203	195
Peak Strike$_{Mean}$	200	190
SEL$_{Mean}$	172	163

Impact driving for A2 occurred on 14 February and used the confined bubble curtain. The pile was driven in two separate series of strikes, the first with the confined curtain in place, the second with it removed to drive the final 3 feet. The pile was driven a total of 16 feet using between 461 and 471 strikes. The confined curtain was set to 490CFM at the bottom ring, and the top rings were off. The air was turned off twice during the driving to provide sound levels, however the amount of time the air was turned off was insufficient to allow all of the bubbles to clear. Therefore, no analysis could be done on the attenuation of the sleeve alone without air for this pile. The confined curtain was removed for the last 3 feet of driving to provide space for the dynamic testing sensors. This final 3 feet of driving was used as the no attenuation condition for this pile (table 4-10).

Table 4-10. Sound levels during impact drive of pile A2.

	Pile A2 (24")	
	No Attenuation	Confined BC, Air On
Number of Strikes: Total	471	
Number of Strikes: Analyzed	121	293
Series RMS $_{(0\text{-}90\%)}$	191	183
Cumulative SEL	202	196
Peak Strike$_{Maximum}$	207	200
Peak Strike$_{Mean}$	206	197
SEL$_{Mean}$	175	169

Impact driving for pile A3 occurred on 12 February. The unconfined bubble ring was used for attenuation on this pile. The curtain was set to use 700CFM for the bottom two rings and 620-680CFM for the remaining three. The pile was driven a total of 26 feet using between 1242 and 1279 strikes. Strikes were counted manually by the inspector on this drive. The air was shut off three times for less than one minute, and then for several minutes at the end of the drive. The air-off condition did not reach steady state for the three times when the air was off for less than one minute. However, the final set of strikes with the air off did reach steady state and were used to determine the unattenuated sound level (table 4-11).

Table 4-11. Sound levels during impact drive of pile A3.

	Pile A3 (48")	
	No Attenuation	Open BC, Air On
Number of Strikes: Total	1242	
Number of Strikes: Analyzed	33	1006
Series RMS $_{(0\text{-}90\%)}$	198	187
Cumulative SEL	214	204
Peak Strike$_{Maximum}$	213	206
Peak Strike$_{Mean}$	212	199
SEL$_{Mean}$	183	173

Impact driving for pile A4 occurred on 15 February. The pile was driven in two series of strikes, with approximately a 20-minute break between strikes to remove the dynamic testing sensors. The confined bubble ring was used for attenuation on this pile. The confined curtain was set to use 125CFM for the bottom ring, with the top ring off. The pile was driven a total of 26 feet using between 1429 and 1473 strikes. The air was shut off three times for less than one minute, and then for several minutes at the end of the drive. The air-off condition did not reach steady state for the three times where the air was off for less than one minute. However, the final set of strikes with the air off did reach steady state and were used to determine the sound level associated with the sleeve, but no air.

No air was used during the second series of strikes, though the confined sleeve was still in place. There were no unattenuated driving strikes on this pile. In order to provide a measure of the attenuation effectiveness on this pile, measured values from the restrike on pile A4 were used as the sound levels for the no attenuation condition. These values are italicized in table 4-12. The use of restrike data in lieu of unattenuated driving strike data for the determination of sound levels is based on the statistical equivalence as discussed previously.

Table 4-12. Sound levels during impact drive of pile A4.

	Pile A4 (48”)		
	No Attenuation	**Confined BC, Air Off**	**Confined BC, Air On**
Number of Strikes: Total	1429		
Number of Strikes: Analyzed	*36*	31	1210
Series RMS $_{(0-90\%)}$	*201*	197	186
Cumulative SEL	*216*	214	205
Peak Strike$_{Maximum}$	*216*	214	201
Peak Strike$_{Mean}$	*214*	213	199
SEL$_{Mean}$	*184*	182	173

Impact driving for pile B1 occurred on 17 February. The pile was driven in two series of strikes, with approximately a 45-minute break between strikes to remove the dynamic testing sensors and bubble curtain. The pile was driven 17 feet using between 462 and 463 strikes. The configuration of the confined curtain was altered to use both the top and bottom rings at 150CFM.

In addition, due to high current in the channel, the confined curtain was leaning against the pile. Lines were attached to the curtain and to pile B2 to pull the sleeve off of the pile. The air was shut off for less than one minute, three times during the drive; however the sound level did not reach steady state after the change in air level. Approximately 322 strikes were driven with the attenuation in place, then the sleeve was removed for the second strike series of 140 strikes (table 4-13).

Table 4-13. Sound levels during impact drive of pile B1.

	Pile B1 (24")	
	No Attenuation	Confined BC, Air On
Number of Strikes: Total	462	
Number of Strikes: Analyzed	140	245
Series RMS $_{(0-90\%)}$	190	181
Cumulative SEL	201	192
Peak Strike$_{Maximum}$	207	197
Peak Strike$_{Mean}$	206	195
SEL$_{Mean}$	174	165

Impact driving on pile B2 occurred on 16 February. The pile was driven in two series of strikes, with approximately a 40-minute break between strikes to remove the dynamic testing sensors and bubble curtain. The pile was driven 27 feet using between 496 and 503 strikes. The air was left off for the first half of pile driving, then both rings were turned on just enough not to make a fountain. The air was then turned off again twice for less than one minute each time. Approximately 380 strikes were with the confined curtain in place, and the final 113 were with no attenuation in place (table 4-14).

Table 4-14. Sound levels during impact drive of pile B2.

	Pile B2 (48")		
	No Attenuation	Confined BC, Air Off	Confined BC, Air On
Number of Strikes: Total	496		
Number of Strikes: Analyzed	112	207	81
Series RMS $_{(0-90\%)}$	201	196	190
Cumulative SEL	213	209	202
Peak Strike$_{Maximum}$	217	211	201
Peak Strike$_{Mean}$	214	207	200
SEL$_{Mean}$	185	182	175

1.1.9. Impact Driving Sound Levels

Impact driving was conducted on one pile per day of operations. Cumulative SEL values from impact driving for each day are shown in table 4-15. These cumulative values represent the actual observed levels, and include both the attenuated and unattenuated configurations used during the pile drive. All six piles exceeded 187dB in Cumulative SEL. The maximum peak strike associated with each day always occurred when attenuation measures were not in place.

Table 4-15. Sound levels for each day of impact driving.

Impact Driving Sound Levels by Day						
Day	11-Feb	12-Feb	14-Feb	15-Feb	16-Feb	17-Feb
Pile	A1	A3	A2	A4	B2	B1
Cumulative SEL (dB)	190	205	199	205	210	197
Peak $Strike_{Maximum}$ (dB)	203	213	207	201	211	207

For unattenuated strikes, on average, 50 percent of the 24-inch pile strikes within a strike series exceeded a peak amplitude of 206dB at 10 meters, and nearly 100 percent of the 48-inch pile strikes exceeded 206dB at 10 meters. No single unattenuated 24-inch strike exceeded 183 SEL at 10 meters. For individual unattenuated 48-inch strikes, on average, 80 percent exceeded 183dB SEL, with only 10 percent exceeding 187dB SEL. All of the unattenuated 24-inch and 48-inch strikes exceeded 150dB $RMS_{(0\text{-}90\%)}$ at 10 meters.

With attenuation in place and air on, no individual 48-inch or 24-inch strike exceeded 206dB in peak amplitude at 10 meters, or 183dB in individual strike SEL. All strikes and strikes series continued to exceed 150dB $RMS_{(0\text{-}90\%)}$ at 10 meters and 187dB in Cumulative SEL at 10 meters when attenuation was in place.

1.1.10. Effectiveness of the Bubble Curtain

Part of the test methodology included shutting off the air of the attenuation curtain for roughly 30 seconds to provide a sound level from which to derive the attenuation effectiveness of the bubble curtain (BC). Unfortunately, in every instance where this was attempted, the data in the air off condition could not be used to determine the unattenuated level. Once the air was shut off, the amplitude of the observed strikes would steadily increase, as shown in figure 4-9 below, but could not reach a steady state condition within the short time that the air was shut off (typically 30 to 45 seconds). These results match with DEA's experience using sonars in rough sea states. While large bubbles will very rapidly rise to the surface, smaller bubbles, which are very effective at sound attenuation, rise much more slowly and may take a significant amount of time to clear the water column. While the time to clear will depend upon water depth, for the test piles it required roughly 45 seconds once the air was shut off to reach steady state.

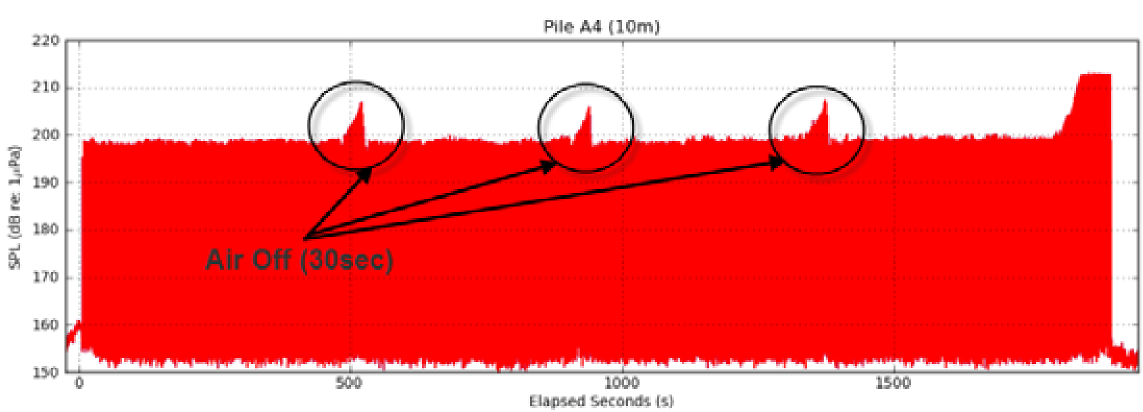

FIGURE 4-9. STRIKE TIME SERIES WITH SHORT-DURATION AIR OFF CONDITIONS

To assess the effectiveness of the various attenuation methods, data were reorganized by attenuation method, and each strike series averaged to generate nominal attenuation values. Of the various quantities measured within a strike series, three values were used to represent the attenuation capability of the bubble curtain. The attenuation of the mean Peak Strike amplitude (Peak $Strike_{Mean}$), the attenuation of the mean strike RMS ($RMS_{(0\text{-}90\%)Mean}$), and the attenuation of the accumulated sound energy (Cumulative SEL). As air bubbles in water are very effective sound scatterers, it is anticipated that bubble-based attenuation methods will affect each of these quantities in differing degrees. Peak Strike amplitude is generally indicative of the magnitude of the initial pressure pulse leaving the pile. The presence of scatterers in the water column will disrupt this pulse by redirecting the energy in the initial plane wave. RMS is reflective of the time averaged pressure magnitude, which will be less sensitive to changes in the initial wavefront. SEL and Cumulative SEL are measures of total energy, and of the three quantities will likely be the least impacted by scatterers.

Pile A4 and B2 both included strikes which occurred with the sleeve for the confined bubble curtain in place, but without air and at steady state. The presence of the sleeve comprising the confined curtain, in the absence of air, provides approximately 3-4 dB of attenuation across total energy, RMS, and Peak Strike amplitude (table 4-16), when compared to the unattenuated condition on those piles. The uncertainty in these numbers is higher due in part to a relatively low number of samples comprising each condition.

Table 4-16. Attenuation effectiveness of the confined bubble curtain sleeve (no air) in decibels.

	Confined BC Attenuation (Sleeve Only, No Air)		
Pile	A4 (48“)	B2 (48”)	Mean
Series RMS $_{(0\text{-}90\%)}$ (dB)	3	5	4
Cumulative SEL (dB)	2	4	3
Peak $Strikes_{Mean}$ (dB)	2	7	4

The total attenuation values for the confined bubble curtain, with both the sleeve in place and the air on, are provided in table 4-17. The confined bubble curtain was considerably more effective on the 48-inch pile when compared to the 24-inch pile. As expected, peak strike amplitude is most effectively attenuated, and Cumulative SEL is least effectively attenuated. Reflective of this, plots of the waveform envelop show that the strike-to-strike variability increases in the attenuated condition, and that the energy content of the strike is spread over a longer period of time, thereby lowering both peak strike amplitude and strike RMS pressure through time stretching (figures 4-10 and 4-11).

The design for the confined curtain intended to use 490CFM of air at both rings. That volume of air, however, resulted in a fountain effect on the first pile which caused the confined curtain sleeve to dig into the sediment. Several configurations were attempted to maximize the volume of air within the sleeve while preventing the fountain effect. For both A2 and A4, the top rings were off and the bottom rings were at 490CFM and 125CFM, respectively. For B1 and B2, both rings were on, with both at 125CFM. However, no clear pattern exists between the air configuration used and the attenuation effectiveness.

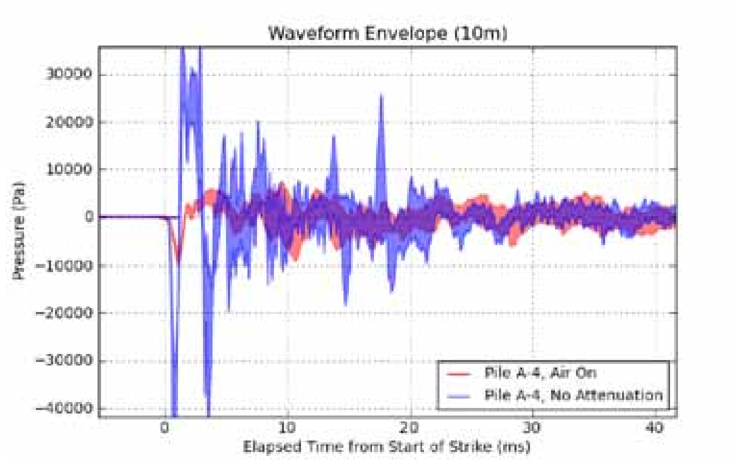

FIGURE 4-10. WAVEFORM ENVELOPE FOR AIR ON AND UNATTENUATED STRIKES

Table 4-17. Attenuation effectiveness of the confined bubble curtain (air on) in decibels.

	Confined BC Attenuation (With Air)					
Pile	A4 (48”)	B2 (48”)	B1 (24”)	A2 (24”)	48" Mean	24" Mean
Series RMS $_{(0\text{-}90\%)}$ (dB)	14	11	9	8	13	8
Cumulative SEL (dB)	11	11	8	6	11	7
Peak Strikes$_{Mean}$ (dB)	15	14	11	9	15	10

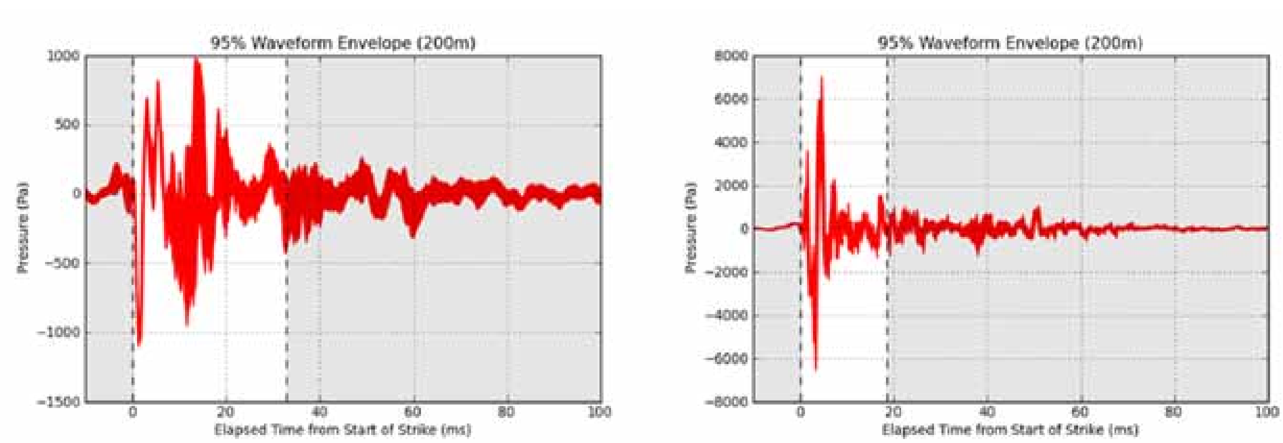

FIGURE 4-11. WAVEFORM ENVELOPE WITH CONFINED BUBBLE CURTAIN ATTENUATION (LEFT) AND NO ATTENUATION (RIGHT).

The open bubble curtain attenuation values are provided in table 4-18. The open bubble curtain was more effective on the 48-inch pile than the 24-inch pile, although to a lesser degree than in the case of the confined pile. As expected, peak strike amplitude attenuation was the highest, and the total energy content attenuated the least. Similar to the confined BC, plots of the waveform envelope show that the strike to strike variability increases in the air-on condition, and that the strike energy is spread over a longer period of time, lowering both peak strike amplitude and RMS pressure through time stretching (figures 4-12 and 4-13).

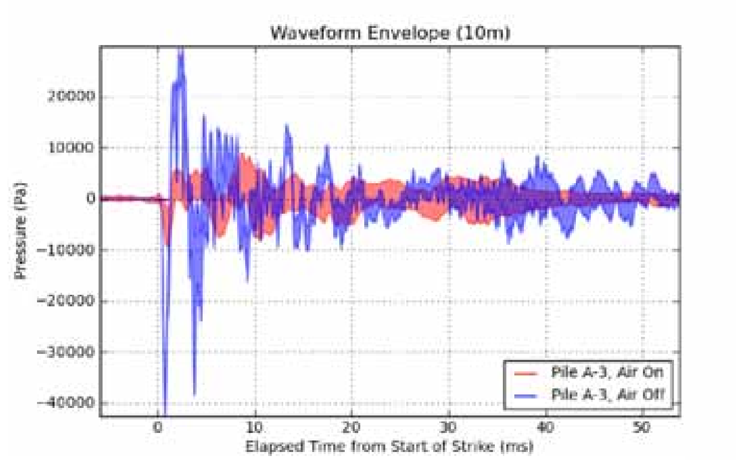

FIGURE 4-12. WAVEFORM ENVELOPE FOR THE OPEN BUBBLE CURTAIN AND UNATTENUATED STRIKES

Table 4-18. Attenuation effectiveness of the open bubble curtain in decibels

	Open BC Effectiveness		
Pile	A1 (24")	A3 (48")	Mean
Series RMS $_{(0-90\%)}$ (dB)	9	11	10
Cumulative SEL (dB)	9	10	9
Peak Strikes$_{Mean}$ (dB)	10	13	12

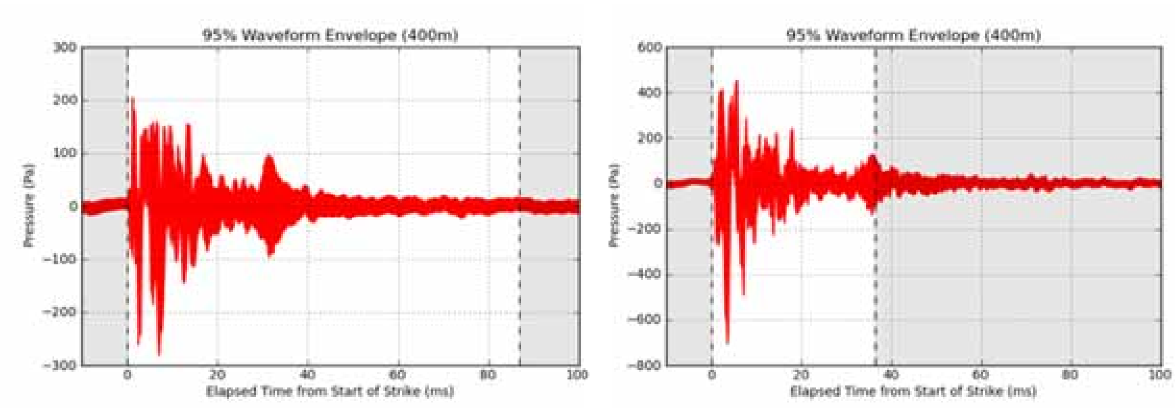

FIGURE 4-13. WAVEFORM ENVELOPE WITH OPEN BUBBLE CURTAIN ATTENUATION (LEFT) AND NO ATTENUATION (RIGHT).

For both the confined and unconfined BC, the attenuation was spectrally flat, as shown in figure 4-14. In comparing the performance of the open bubble curtain to the confined bubble curtain, the open bubble curtain performed similarly to the confined bubble curtain. However, there are two significant areas where the confined curtain outperforms the open bubble curtain. While the open bubble curtain attenuation of the average peak strike amplitude is considerable, the variability in peak strikes is twice as large as in the confined bubble curtain. As a result, the attenuation in the maximum peak strike is only 7dB, significantly less than the 12dB attenuation of the average peak strike. The principle concern in using the bubble curtain, however, is the effect of river current on the attenuation capabilities of the curtain. Unfortunately, only "A" side piles used the open curtain, leaving only one 800-meter station on the upstream side of the pile. The sound levels in that station were clipped during the drive of pile A3, leaving only the transmission loss at 800 meters on pile A2 to judge the upstream attenuation effectiveness of the open bubble curtain. The transmission loss coefficient for pile A2 at 800 meters upstream was less than 13 in all three quantities. Those were the lowest 800-meter values recorded during the study, and suggest that the attenuation effectiveness of the open bubble curtain on the upstream side was much less than that measured downstream. This is consistent with the anticipated effect of current on the open bubble curtain.

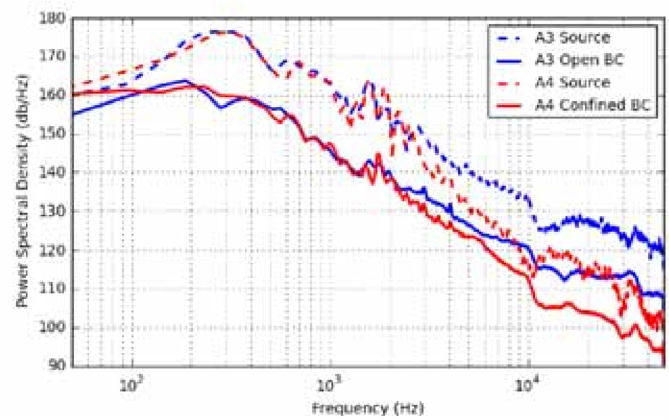

FIGURE 4-14. ATTENUATED AND UNATTENUATED SPECTRAL DENSITY

1.1.11. Transmission Loss

Unattenuated strikes, both driving strikes and restrikes, represented the largest sample size in a similar condition. To provide the most robust statistics, therefore, transmission loss analysis was conducted on all the unattenuated strikes. Similar to the evaluation of bubble curtain effectiveness, Peak Strike, RMS, and Cumulative SEL were used to evaluate transmission loss. Transmission loss in all quantities consistently increases with increasing range from the source, moving from a practical spreading model toward a spherical spreading model (table 4-19). Similar to the expectation with bubble curtain attenuation, transmission loss is highest with peak strike amplitude, and lowest in Cumulative SEL.

Table 4-19. Transmission loss coefficient

Transmission Loss Coefficient with Range			
Range	200	400	800
Peak Strikes$_{Mean}$	15.7	17.2	19.2
RMS$_{(0\text{-}90\%)\ Mean}$	15.2	16.5	18.2
Cumulative SEL	14.9	15.4	17.0

When looking at the strike waveform envelope, the energy of the strike can be seen to spread over time with distance (figure 4-16), though the loss of strike to strike coherence is less than that caused by the presence of an attenuation curtain. The strike time for 90 percent of the pulse energy tends to increase with distance as well. This time stretching of the pulse is likely due to multipath propagation, and contributes to the increased transmission loss of peak strike amplitude and RMS pressure level. The transmission loss appears spectrally flat with no unique spectral characteristics (figure 4-15).

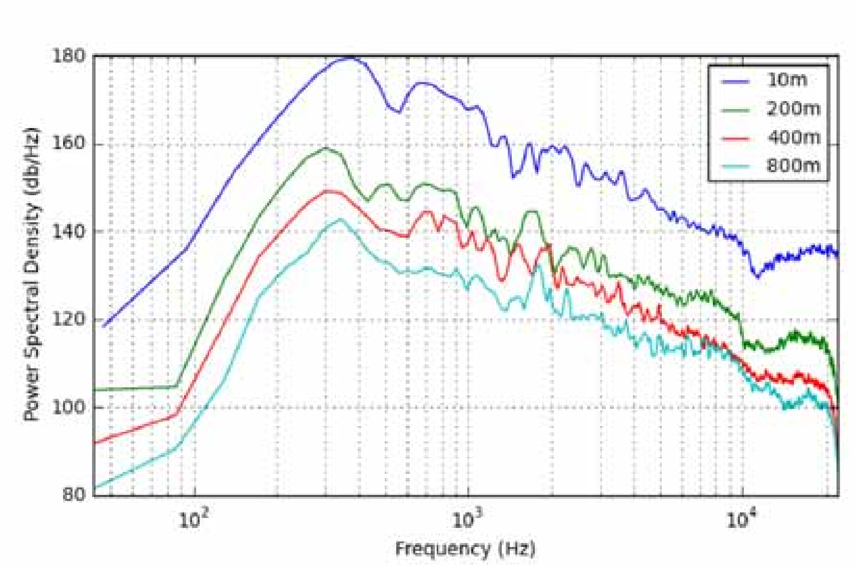

FIGURE 4-15. SPECTRAL DENSITY FOR PILE B2 RESTRIKE WITH INCREASING RANGE.

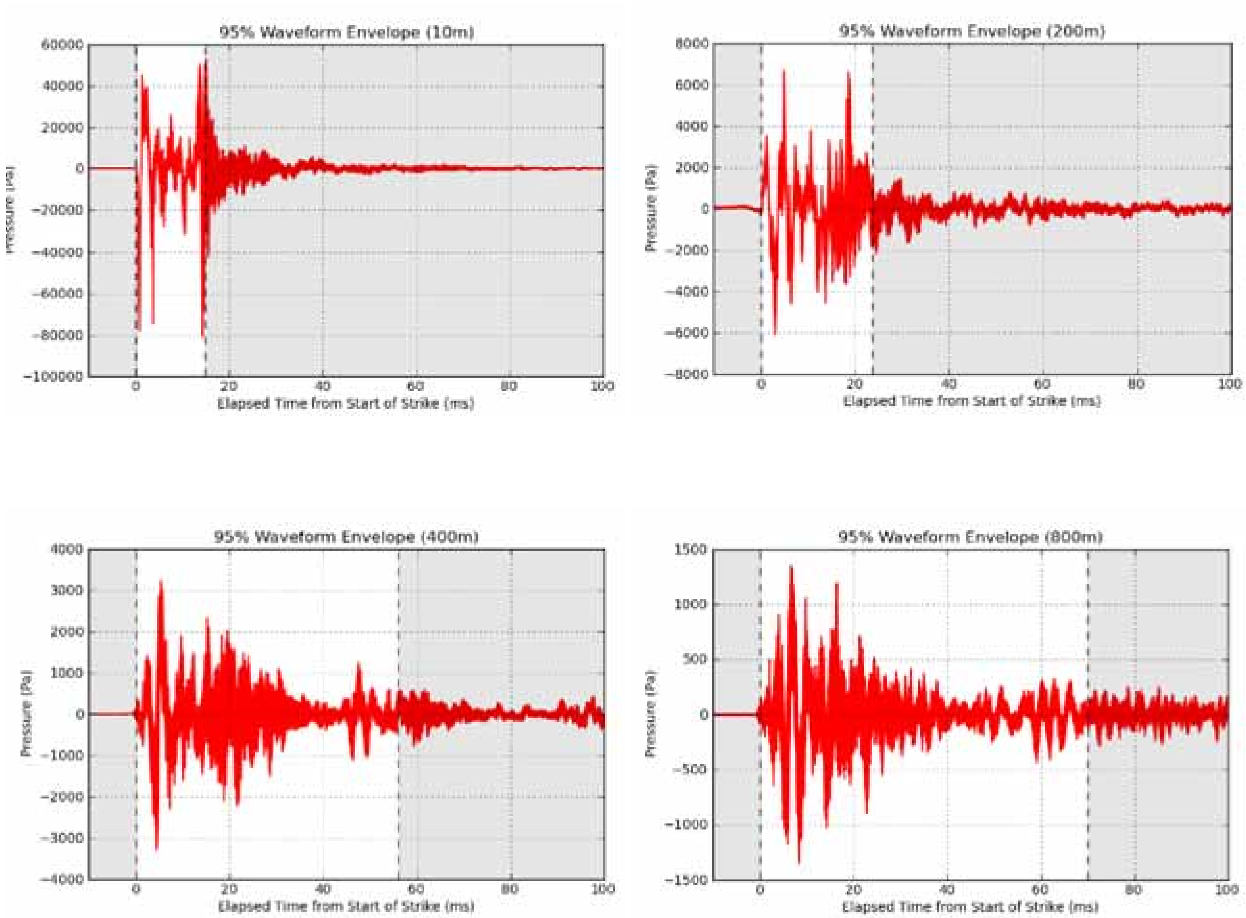

FIGURE 4-16. WAVEFORMS WITH INCREASING RANGE FOR PILE B2 RESTRIKE. NOTICE THE INCREASE IN STRIKE TIME WITH RANGE.

4.5 Potential Factors Affecting Impact Driving Sound Levels

1.1.12. Comparison of Sound Levels at Site A and B

The data suggest there may be a difference in sound levels between sites A and B. A Student's *t*-test on 24 and 48-inch piles results in probabilities much less than 50 percent, however the results are not significant enough to conclude that a difference sound levels at sites A and B are different (table 4-20). The average sound levels at Site B are approximately 2.5 dB louder in both RMS pressure level and peak strike amplitude (table 4-21), though the standard deviations in each quantity overlap. In reviewing the waveform envelope, there is significant energy present at site B between 10-15 milliseconds into the strike that is not present at site A. This is particularly evident in the 48-inch piles, where the 10-15 millisecond pulse is actually louder in some instances than the initial pulse (figure 4-17). This suggests differences in geomorphology, where site B may have a shallow, highly reflective layer.

Table 4-20. Student's *t*-test at Site A and Site B.

Site A vs. Site B		
Student's t-Test for the Same Population		
	24" Piles	48" Piles
Peak $Strikes_{Mean}$	19%	35%
$RMS_{(0-90\%)\ Mean}$	20%	14%
SEL_{Mean}	60%	7%

Table 4-21. Difference in sound levels at Site A and Site B.

Site A vs. Site B	
Increase in Sound Level at Site B (dB)	
Peak $Strikes_{Mean}$	2.6
$RMS_{(0-90\%)\ Mean}$	2.6
SEL_{Mean}	1.7

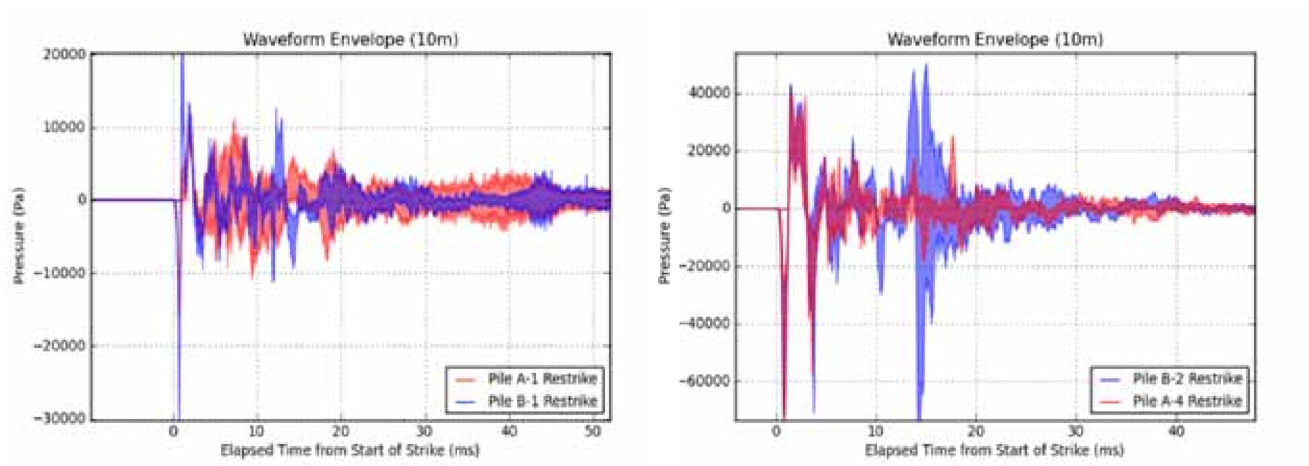

FIGURE 4-17. ATTENUATED AND UNATTENUATED WAVEFORM ENVELOPE

The PSD shows tightly correlated spectral composition between the 48 inch piles at both sites, and even similar spectral structure with the 24 inch pile A1 (figure 4-18). The cause of the different spectral behavior at B1 is unknown.

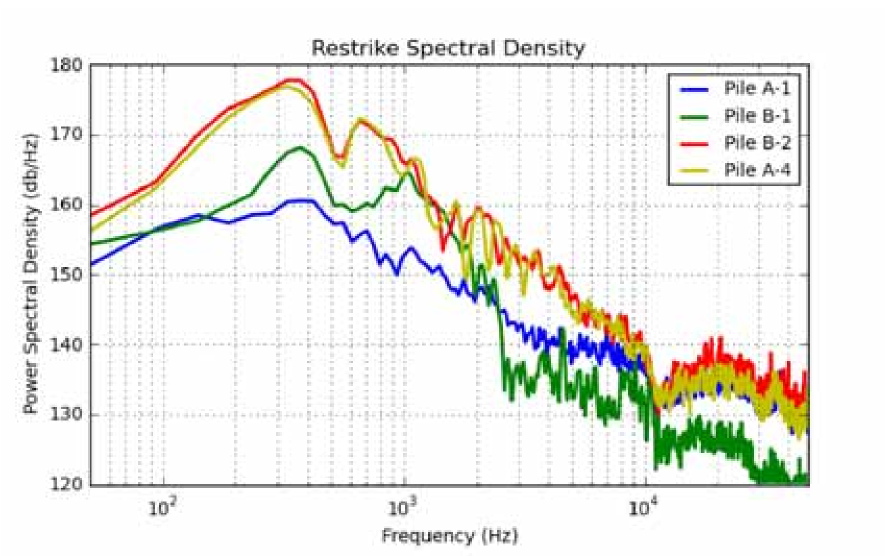

FIGURE 4-18. SPECTRAL DENSITY AT 10-METERS FOR SITE A AND B, 24-INCH AND 48-INCH PILES.

These results are consistent with the findings of geotechnical investigations of the area conducted by DEA in support of the Columbia River Crossing. Figure 4-19 shows the results and corresponding interpretation of a seismic profile run approximately 3000 meters upstream of the test pile area. The Troutdale formation, a layer of compacted gravelly sediments formed by the ancestral Columbia River, is shallow on the Washington side of the river, where site B piles were driven, and much deeper on the Oregon side of the river. In reviewing the seismic profile, the highly reflective layer associated with the Troutdale formation occurs roughly 15 milliseconds following the first return off the seabed on the northwest, or Washington, side of the profile. This coincides well with the 10-15 millisecond pulse seen in the waveform envelope for Site B piles (Figure 4-17).

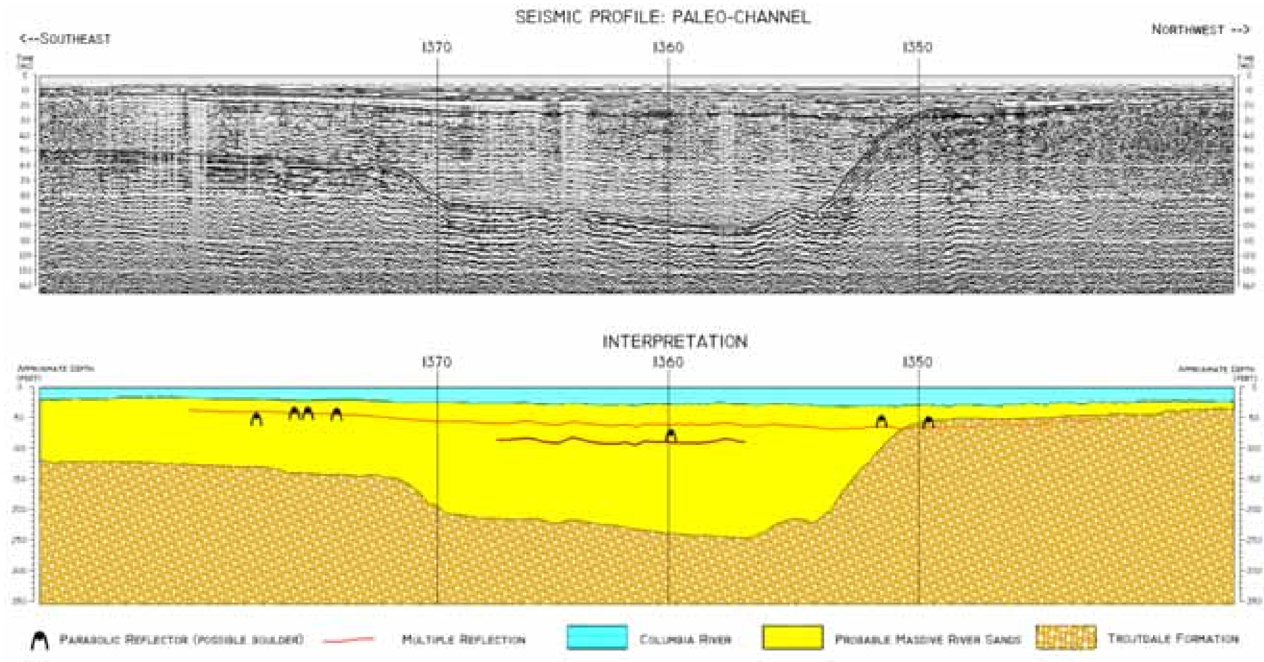

FIGURE 4-19. SEISMIC PROFILING RESULTS SHOWING THE TROUTDALE FORMATION NEAR THE SURFACE ON THE WASHINGTON SIDE OF THE RIVER.

1.1.13. Comparison of 24-inch and 48-inch Piles

The average unattenuated sound levels for the 24-inch and 48-inch piles were compared for the same primary sound level parameters to provide values for the increase in sound level associated with the 48-inch pile (table 4-22). A comparison of typical waveform envelopes shows a significant difference in the amount of energy in the 48-inch strike, and more strike to strike coherence when compared to the 24-inch strike (figure 4-20).

Table 4-22. Comparison of 48-inch and 24-inch sound levels

48" Pile Increase Over 24" Pile	
All Unattenuated Strikes	
Peak Strikes$_{Mean}$	9
RMS $_{(0-90\%)\ Mean}$	10
SEL$_{Mean}$	10

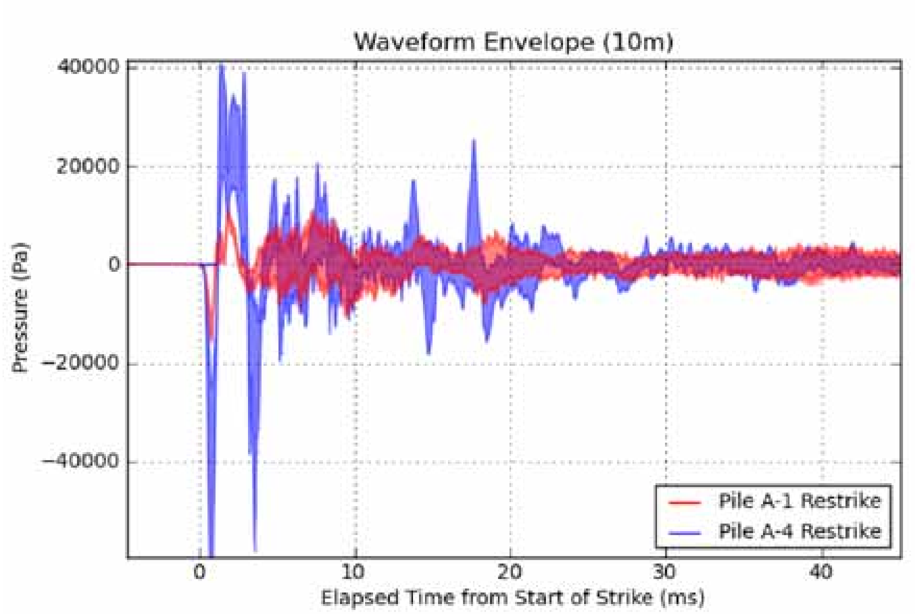

FIGURE 4-20. WAVEFORM ENVELOPES FOR 24-INCH AND 48-INCH PILES

Review of the transmission loss coefficients suggested a consistent difference in transmission loss between the 24-inch piles and the 48-inch piles at near ranges (200 and 400 meters). A *t*-test was conducted on the 400 meter transmission loss values. The results of the test show low probabilities, however the results are only significant in average RMS (table 4-23). This suggests that there may be a distinction in transmission loss at near ranges, so separate transmission loss values were derived for the 48-inch and 24-inch piles. Transmission loss is slightly greater on the 24-inch piles when compared to the 48-inch piles and near ranges (table 4-24).

Table 4-23. 48-inch vs. 24-inch impact driving transmission loss

48" vs. 24" Impact Driving Transmission Loss	
Student's t-Test for the Same Population	
Peak $Strikes_{Mean}$	8%
$RMS_{(0-90\%)\ Mean}$	2%
SEL_{Mean}	22%

Table 4-24. Transmission Loss Coefficient

Transmission Loss Coefficient with Range: 24" Piles			
Range	200	400	800
Peak Strikes$_{Mean}$	16.4	18.0	19.5
RMS $_{(0-90\%)\ Mean}$	16.0	17.1	18.5
Cumulative SEL	15.6	15.9	17.2
Transmission Loss Coefficient with Range, 48" Piles			
Range	200	400	800
Peak Strikes$_{Mean}$	14.9	16.1	19.0
RMS $_{(0-90\%)\ Mean}$	14.3	15.9	18.0
Cumulative SEL	14.0	14.8	16.9

1.1.14. Upstream and Downstream Propagation

Transmission loss coefficients were investigated to determine if there was a significant difference in transmission loss between upstream and downstream propagation. While investigating individual strike series suggested the possibility of a difference between upstream and downstream propagation, in aggregate there was no clear pattern distinguishing the two (table 4-25). For example, in looking at the 800-meter downstream and 800-meter upstream propagation, for which there are the most samples, the upstream transmission loss coefficient averages approximately one less than the downstream in Cumulative SEL, indicating faster attenuation downstream. The corresponding standard deviation, however, is 1.5, meaning the result is not significantly different than zero. Similar to previous analysis, a Student's *t*-test was conducted to determine if there was a meaningful difference between the upstream and downstream propagation. The Student's *t*-test results show no statistically significant differences, and *p*-values were approximately 0.5. Though the possibility that propagation loss is different upstream and downstream cannot be excluded, these results suggest any potential difference is less than the variability in transmission loss caused by other factors, such as site location, pile size, and placement of recording devices.

Table 4-25. Transmission Loss Coefficient

Transmission Loss Coefficient with Range			
Upstream minus Downstream Propagation			
Range	200	400	800
Peak Strikes$_{Mean}$	-0.2	2.6	0.5
RMS $_{(0-90\%)\ Mean}$	-0.6	2.4	0.1
Cumulative SEL	-1.2	-0.2	-1.1

4.6 Turbidity Monitoring

Over 130 separate turbidity casts were taken under both background and pile driving conditions and at various ranges from the construction activity. Analysis of the turbidity data showed no significant impact to turbidity due to pile driving activities. Any increase in turbidity due to pile driving is masked by more significant changes in background levels over time. Figure 4-21 shows an example of this for all turbidity monitoring on pile A-1, where there is no discernable difference between turbidity under driving conditions, and any possible variation is far less than the change in ambient conditions over time.

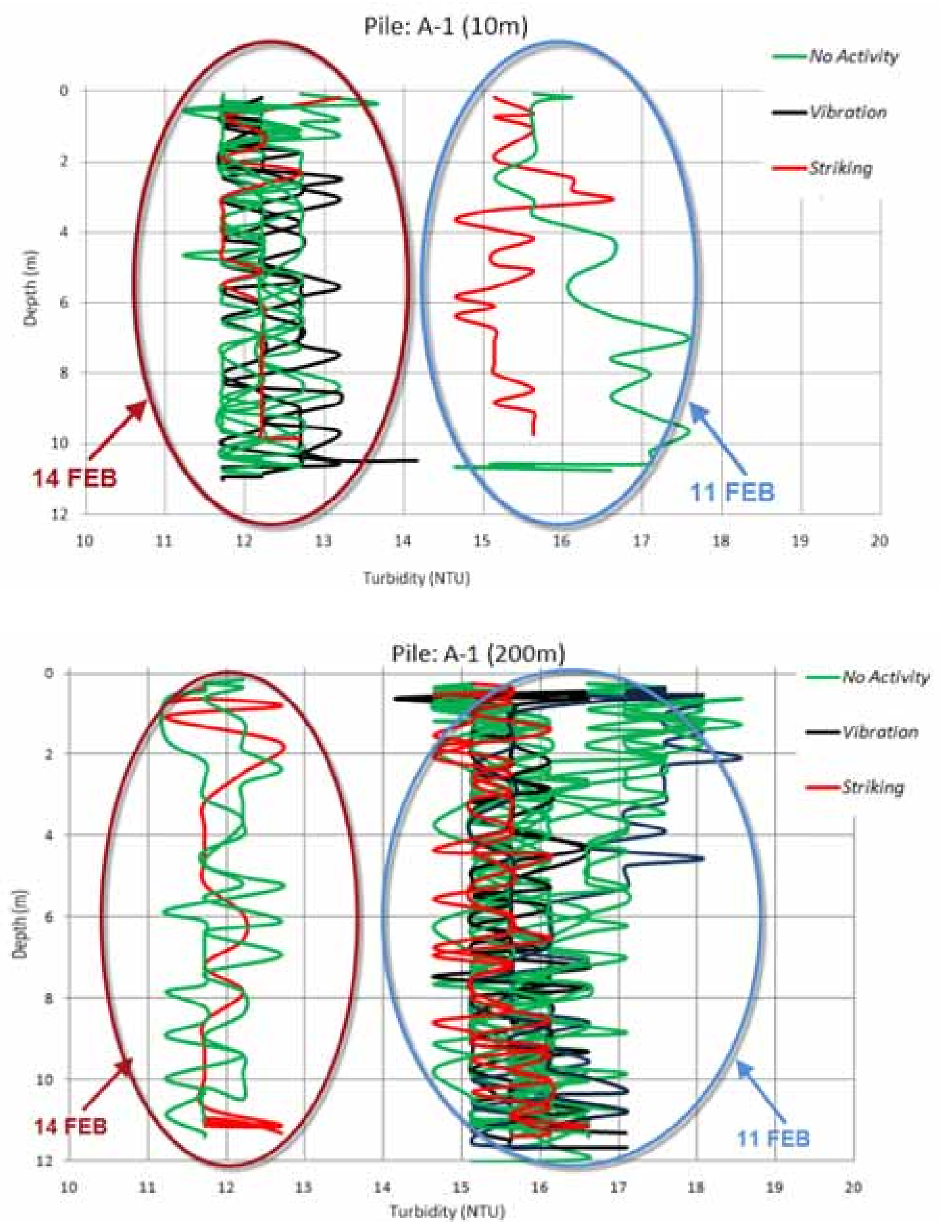

FIGURE 4-21. PROFILES OF TURBIDITY UNDER PILE DRIVING AND BACKGROUND CONDITIONS FOR A-1 (24") AT 10 METER AND 200 METER RANGES

4.7 Marine Mammal Monitoring

Sea lions were seen traversing the project area on several occasions as reported by marine mammal observers on shore. Observations were radioed to the onboard inspector for logging. The table below (table 4-26) indicates when inspector's notes indicated marine mammal activity or the DIB inflatable boat observed marine mammal activities. At these times CTD and turbidity profiling requirements were not always met due to observations requested by WSDOT.

Table 4-26. Marine mammal sightings as recorded by DEA logs and Inspector logs.

Sighting	Date and Time Sited	Action	Result	Log
Birds	2/16/2011 11:21am	Inspected by DIB inflatable boat	Retrieved debris being eaten for WSDOT inspection	D
	2/18/2011 8:56am	Inspected by DIB inflatable boat	Birds just floating, nothing found	D
	2/18/2011 2:14pm	Inspected by DIB inflatable boat	Birds just floating, nothing found	D
Sea lions	2/11/2011 12:35pm	Operations on hold	Wait 30 min before resuming work, no operations delay, lunch break called	I
	2/11/2011 1:50pm	Operations on hold	Wait 11 min	I
	2/17/2011 9:30am	Operations on hold	Wait 15 min	I
	2/17/2011 11:15am	Not affecting work area	Continued operations	I
	2/17/2011 12:55pm	Operations on hold	All clear at 1:20pm	I
	2/18/2011 2:15pm	Stopped operations, DIB inflatable boat tracking sea lion through project area	All clear. Restart at 3:05pm	I, D
Fish	2/17/2011 1:30pm	Retrieved for inspection by DIB inflatable boat	Reported to WSDOT by DIB inflatable boat. Specimen was very aged half eaten sturgeon	I, D

I = Inspector's Notes; D = DIB inflatable boat Vessel Log

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5. Conclusions

Background sound level monitoring was successfully conducted between 27 January and 03 February, 2011. The background sound level at 50 percent CDF on the Washington side of the river was found to be 110dB. The background level at 50 percent CDF on the Oregon side of the river was slightly higher at 117dB.

Hydroacoustic monitoring was successfully conducted during test pile construction activities between 11 and 21 February, 2011. RMS Pressure levels associated with vibropiling varied widely pile to pile, with a maximum value of 181dB. For impact driving, average sound levels were derived for both 24-inch and 48-inch piles. Impact driving on 48-inch piles was, on average, 10dB louder than driving on 24-inch piles. On average, 50 percent of the unattenuated 24-inch pile strikes within a strike series exceeded a peak amplitude of 206dB at 10 meters. None of the 24-inch strikes exceeded 183 SEL at 10 meters. All of the 24-inch strikes exceeded 150dB $RMS_{(0\text{-}90\%)}$. Nearly 100 percent the unattenuated 48-inch strikes exceeded a peak amplitude of 206dB. On average, 80 percent of the 48-inch strikes within a strike series exceeded 183dB SEL, with only 10 percent exceeding 187dB SEL. All of the unattenuated 48-inch strikes exceeded 150dB $RMS_{(0\text{-}90\%)}$. All strike series exceeded 187dB in Cumulative SEL.

Measured sound levels for both vibropiling and impact driving were similar to those expected as outlined in the *Columbia River Crossing Request for Marine Mammal Protection Act Letter of Authorization, Appendix B*. For vibropiling, the observed maximum sound level (181dB) was only slightly louder than the anticipated maximum sound level (180dB). For impact driving, observed unattenuated RMS sound levels for 24-inch piles (190dB) were slightly louder than anticipated (189dB). Unattenuated RMS sound levels for 48-inch piles (201dB) were as anticipated.

Open curtain attenuation methods reduced the sound levels for 48-inch piles 11dB on average, and 9dB on average for 24-inch piles. Confined curtain attenuation methods reduced the sound levels for 48-inch piles 13dB on average, and 8dB on average for 24-inch piles. Open bubble curtain attenuation was similar to confined curtain attenuation at 10 meters downstream, however, the effectiveness of the open bubble curtain appeared to be significantly less upstream when compared to downstream, likely due to the effect of current on the open bubble curtain. The effectiveness of both open and confined bubble curtains at attenuating peak amplitudes (10-15dB) was equal or greater than anticipated (10dB) in the *Columbia River Crossing Request for Marine Mammal Protection Act Letter of Authorization*. With attenuation in place and air on, no strikes exceeded 206dB in peak amplitude or 183dB in individual strike SEL.

Transmission loss was analyzed for both vibropiling and impact driving. Transmission loss for vibropiling was in line with the practical spreading model, as anticipated. Transmission loss for impact driving was in line with the practical spreading model at the 200-meter range, but steadily increased toward spherical spreading with increasing range, resulting in greater than anticipated transmission loss. Time stretching of the pulse with range was evident in the majority of strikes, which contributed to increased transmission loss with range for both RMS pressure and peak strike amplitude.

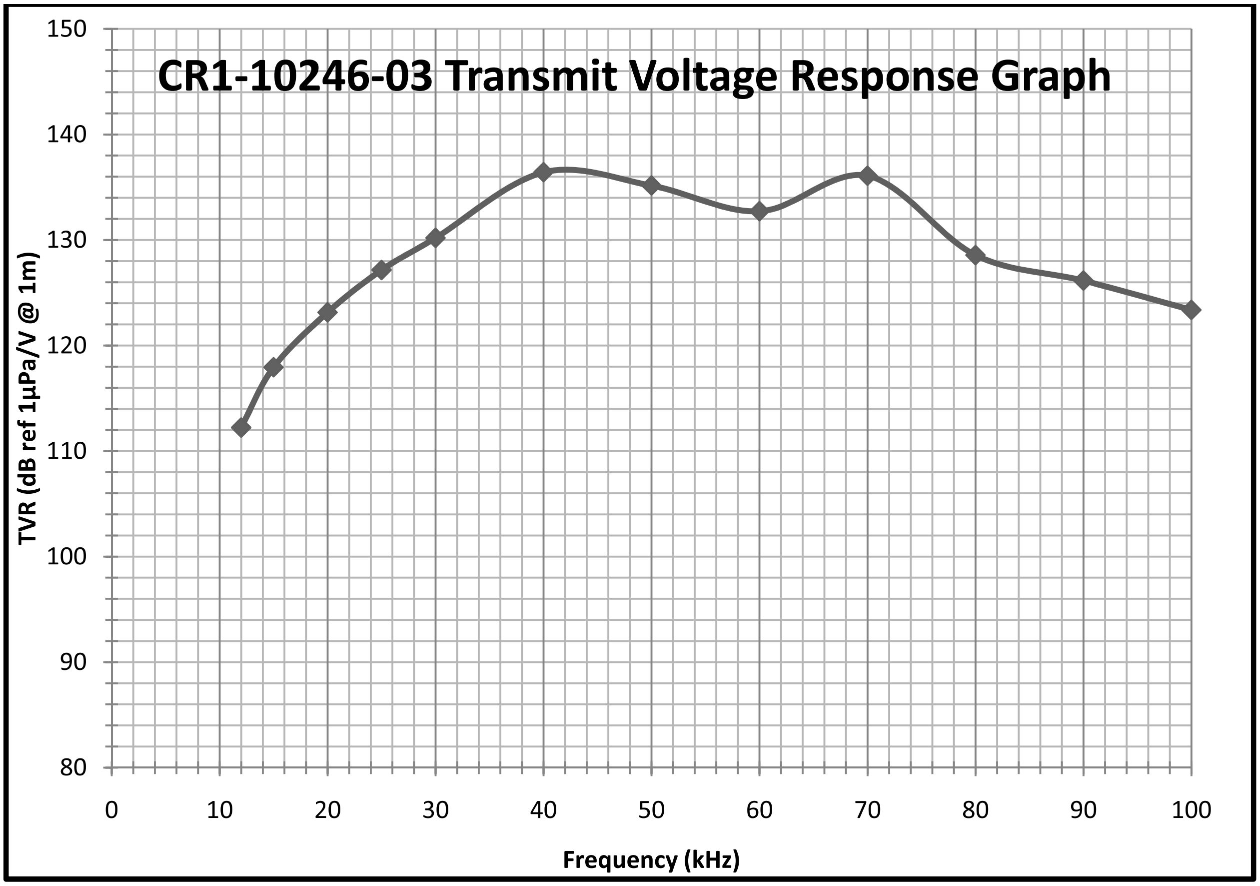
Turbidity was monitored throughout the test pile program. Very little discernable impact from pile driving activities was observed, and any potential impact was significantly less than changes in ambient water clarity with time.

Appendix I

Equipment Calibration Documentation

Preliminary Calibrations:

CR-10246-03 Calibrated on 12/24/2010



CR1-10246-03			
Frequency (kHz)	TVR (dB re uP*m/volt)	Frequency (kHz)	OCV (dB re V/uPa)
12	112.227	10	-200.191
15	117.941	12	-200.625
20	123.143	15	-199.989
25	127.156	17.5	-199.618
30	130.193	20	-199.369
40	136.418	25	-199.045
50	135.152	30	-197.01
60	132.724	35	-195.02
70	136.084	40	-192.275
80	128.565	45	-203.384
90	126.147	50	-215.199
100	123.369	55	-215.193
		60	-214.114
		65	-221.142
		70	-226.256
		75	-226.209
		80	-222.056
		85	-221.826
		90	-219.865
		95	-216.655
		100	-214.535

CR-10247-01 and CR-10247-02 Calibrated on 09/16/2010

SENSOR TECHNOLOGY LIMITED

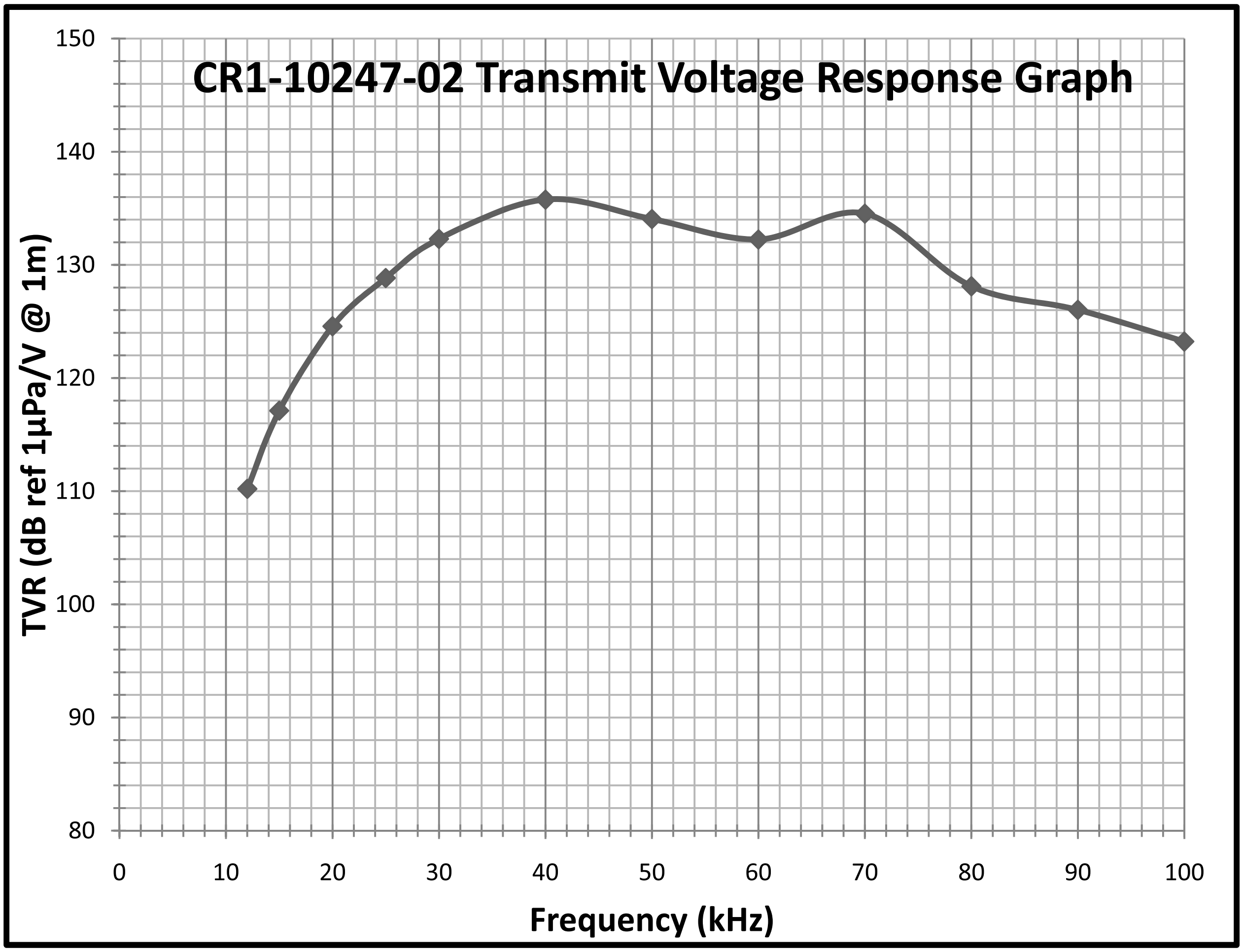
Test Report

Work Order # **10247**
Date **16-Sep-10**

Tested in air at 30Hz

Part # **CR1 with 60m cable**

Serial #	Sensitivity (dB)	Capacitance (nF)	Dissipation (%)
CR1-10247-01	-199.86	13.28	1.415
CR1-10247-02	-200.16	13.81	1.34


CR1-10247-02 Transmit Voltage Response Graph
TVR (dB ref 1µPa/V @ 1m)
Frequency (kHz)
150
140
130
120
110
100
90
80
0
10
20
30
40
50
60
70
80
90
100

CR1-10247-02			
Frequency (kHz)	TVR (dB re uP*m/volt)	Frequency (kHz)	OCV (dB re V/uPa)
12	110.199	10	-200.585
15	117.111	12	-200.188
20	124.572	15	-200.213
25	128.842	17.5	-199.454
30	132.299	20	-200.401
40	135.773	25	-199.441
50	134.053	30	-198.752
60	132.247	35	-197.091
70	134.532	40	-193.135
80	128.112	45	-204.017
90	126.027	50	-212.418
100	123.227	55	-209.016
		60	-208.201
		65	-213.099
		70	-220.684
		75	-225.078
		80	-226.0321
		85	-226.214
		90	-222.542
		95	-215.014
		100	-209.27

CR-10181-01 Calibrated on 5/18/2010

SENSOR TECHNOLOGY LIMITED

Test Report

Page 1 of 1

Work Order # **10181**
Date **18-May-10**

Part # **CR1 with 30m cable**

Serial #	Sensitivity (dB)	Capacitance (nF)	Dissipation (%)
CR1-10181-01	-202.3	12.13	0.016
CR1-10181-02	-201.5	11.29	0.015
CR1-10181-03	-201.6	12.3	0.016
CR1-10181-04	-201.8	12.15	0.017
CR1-10181-05	-202.1	11.5	0.016

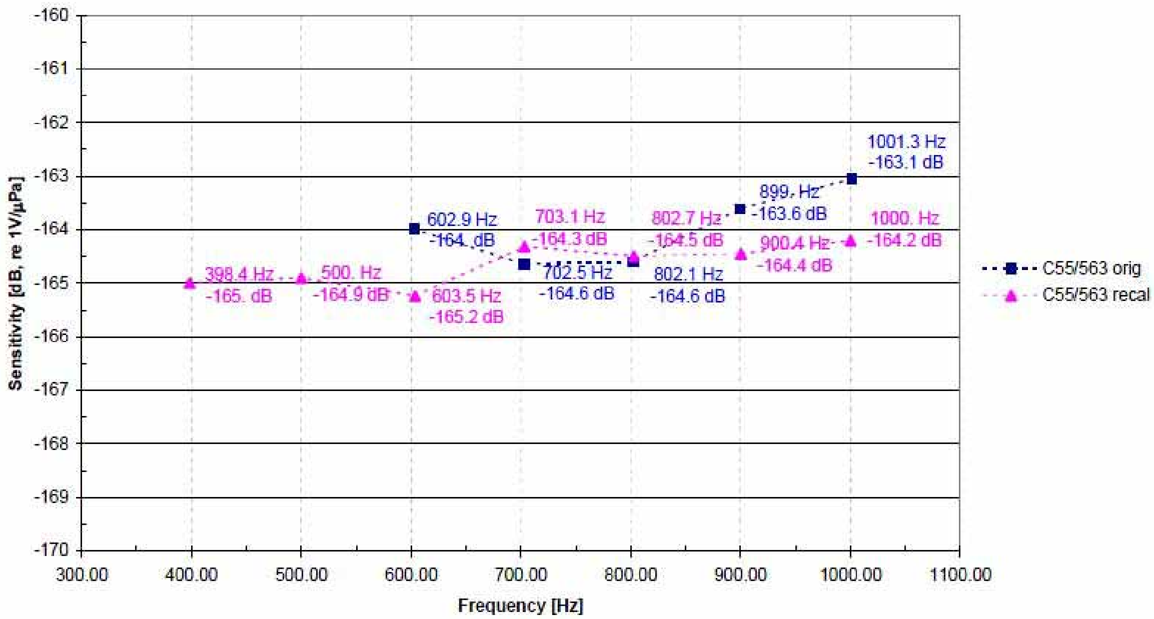
Part # **CR1 with 15m cable**

Serial #	Sensitivity (dB)	Capacitance (nF)	Dissipation (%)
CR1-10181-06	-198.3	10.47	0.016

CR55/563 Pre-calibration (Blue) Calibrated on 01/21/2011

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com

C55/563 Mean Sensitivity = -164.0dB
Recal C55/563 Mean Sensitivity = -164.7dB



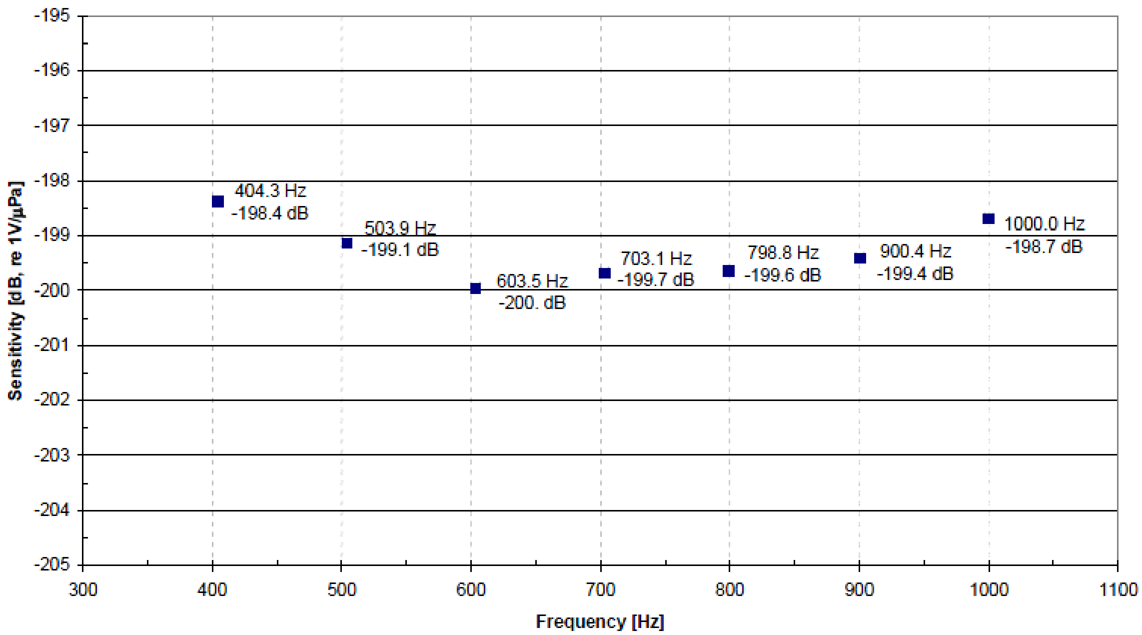
Method: USRD C100 Hydrophone Calibrator + NIST certified ST191 DSA (for 2nd measurement).
Measurement Date: 21 January 2011
Remeasurement Date: 21 March 2011

Post Operation Calibrations:

CR-10246-03 Calibrated on 03/21/2011

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com

CR1-10246-03 Mean Sensitivity = -199.3dB

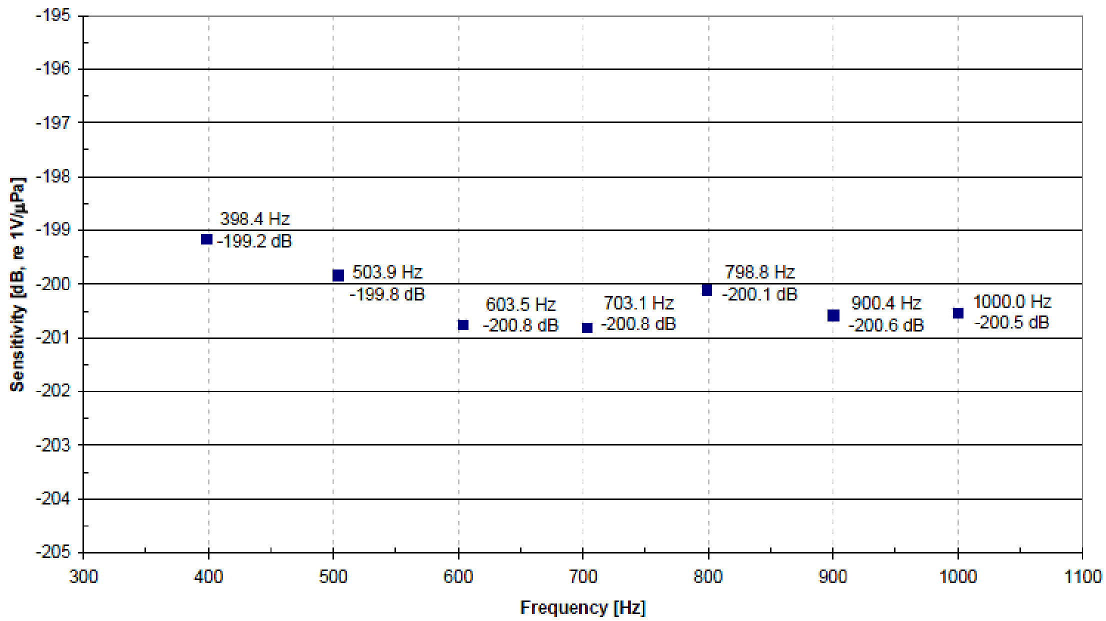


Method: USRD C100 Hydrophone Calibrator + NIST certified ST191 DSA.
Measurement Date: 21 March 2011

CR-10247-01 Calibrated on 03/21/2011

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com

CR1-10247-01 Mean Sensitivity = -200.3dB

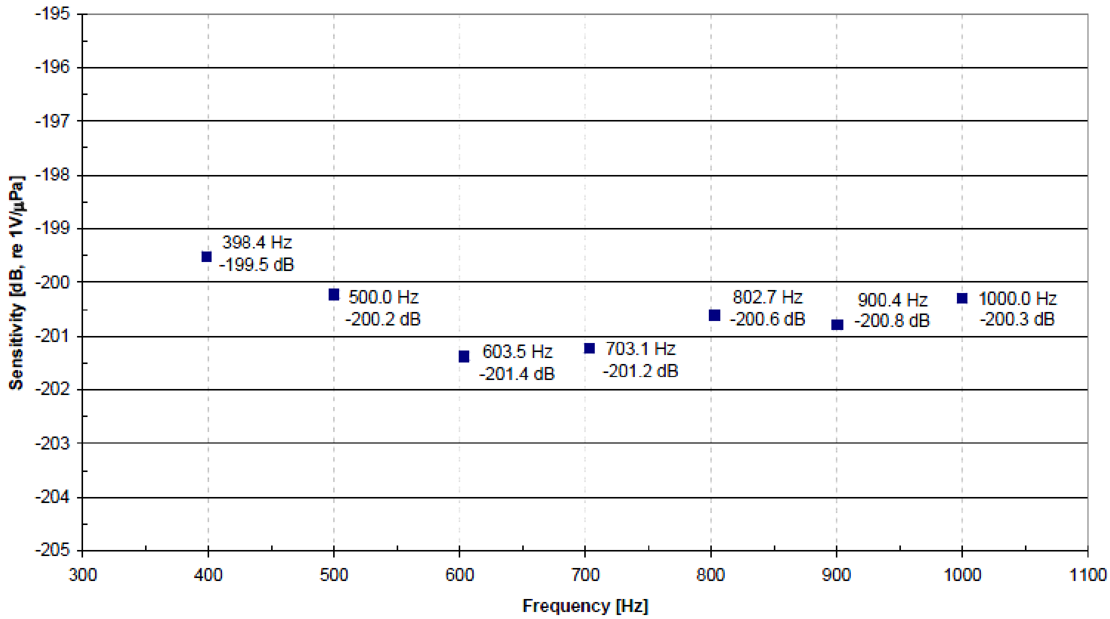


Method: USRD C100 Hydrophone Calibrator + NIST certified ST191 DSA.
Measurement Date: 21 March 2011

CR-10247-02 Calibrated on 03/21/2011

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com

CR1-10247-02 Mean Sensitivity = -200.6dB

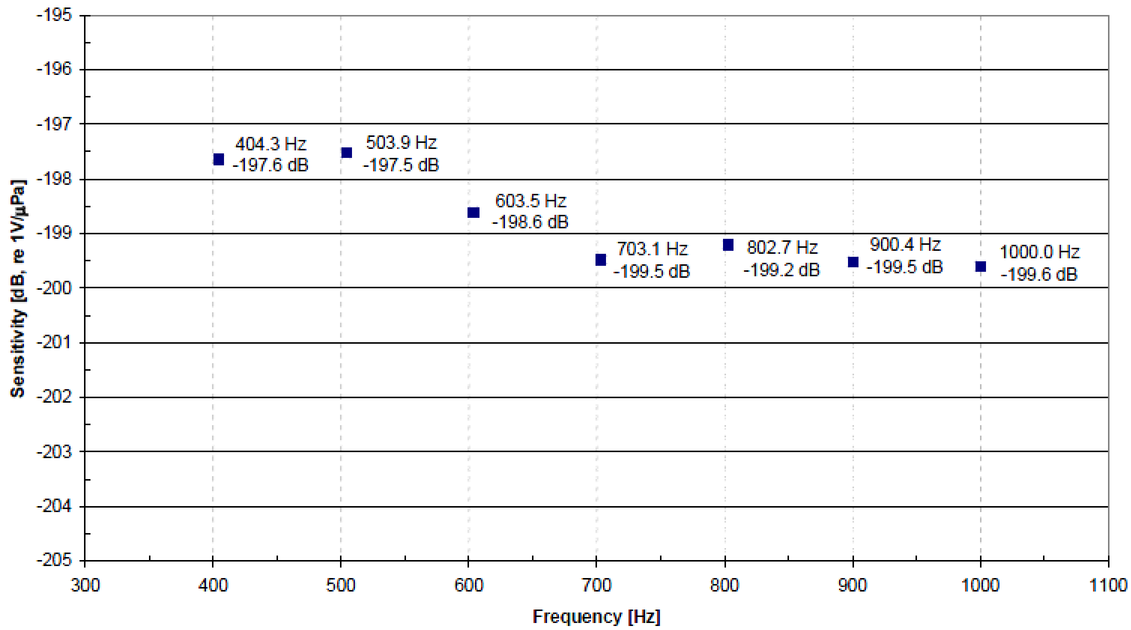


Method: USRD C100 Hydrophone Calibrator + NIST certified ST191 DSA.
Measurement Date: 21 March 2011

CR-10181-01 Calibrated on 03/21/2011

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com

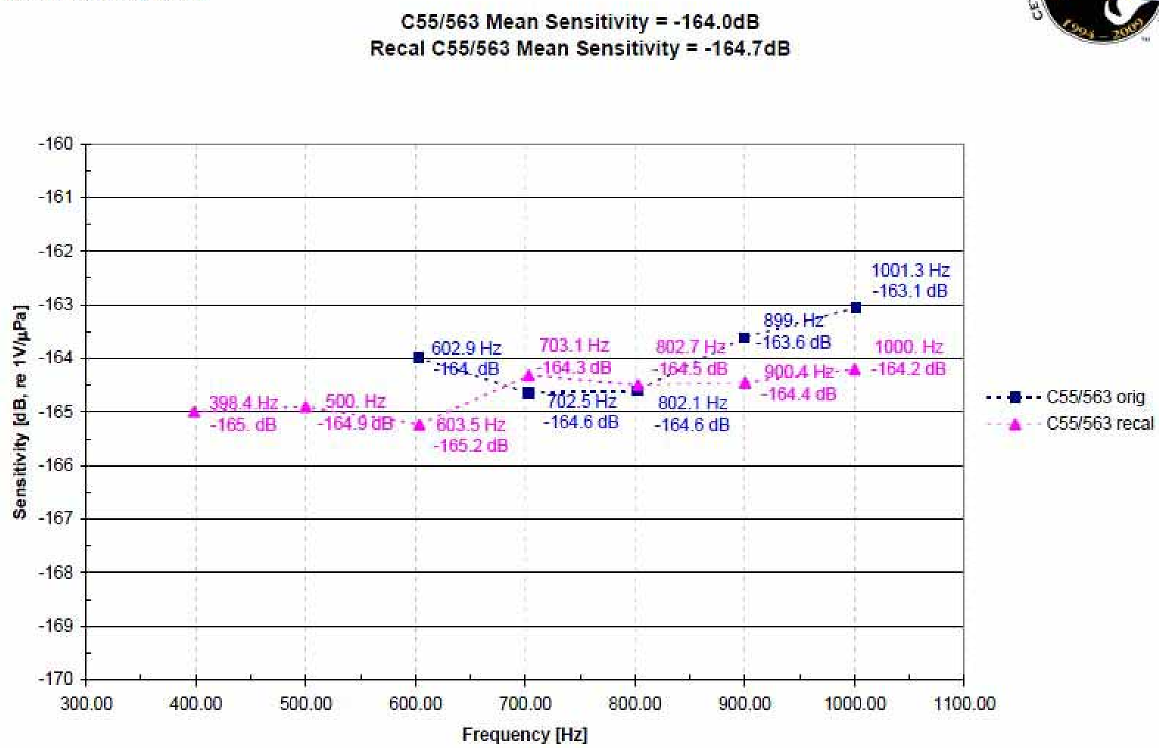
CR1-10181-01 Mean Sensitivity = -198.8dB



Method: USRD C100 Hydrophone Calibrator + NIST certified ST191 DSA.
Measurement Date: 21 March 2011

CR55/563 Post-calibration (Pink)Calibrated on 03/21/2011

Cetacean Research Technology
4728 12th Ave. NE
Seattle, WA 98105
www.cetaceanresearch.com



Method: USRD C100 Hydrophone Calibrator + NIST certified ST191 DSA (for 2nd measurement).
Measurement Date: 21 January 2011
Remeasurement Date: 21 March 2011

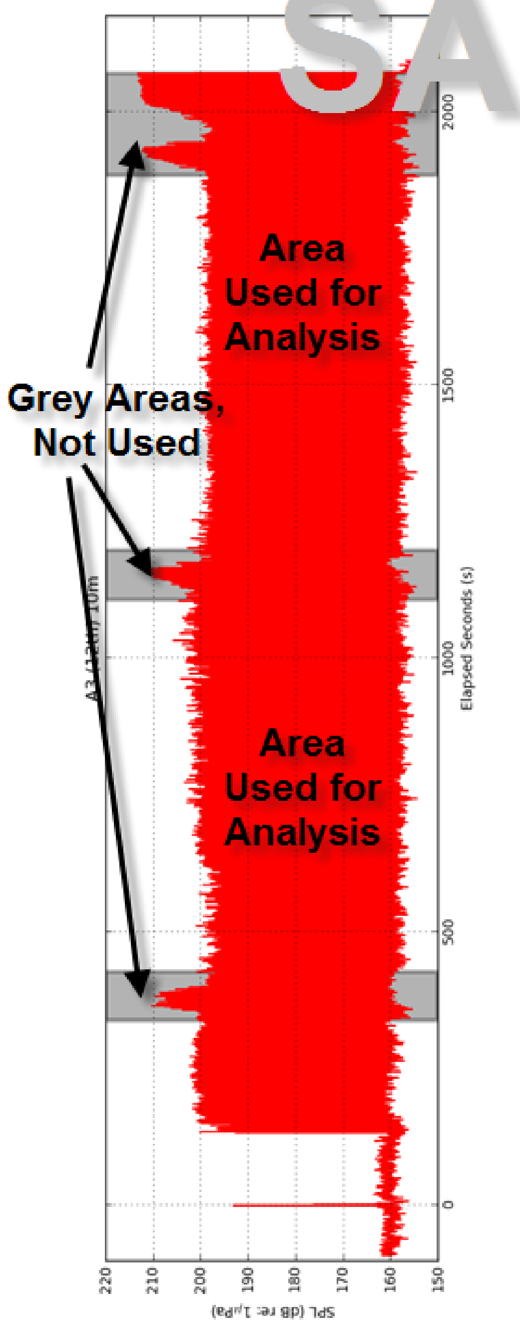
Appendix II

Analysis of Impact Pile Driving Strikes

STRIKE SERIES ANALYSIS EXAMPLE:

Strike Series Analysis: Pile A-3, Air On, February 12, 2011 16:40 (pg 1 of 3)

Time Series of Strikes at 10 meters

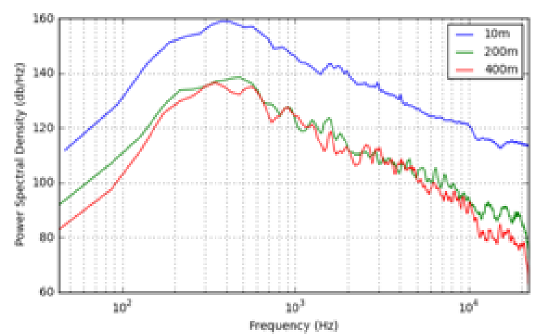


Pile A-3, 48" diameter

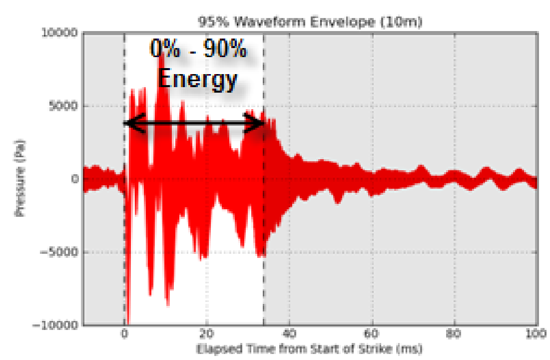
Da : eb ary 1 20 Time: :40

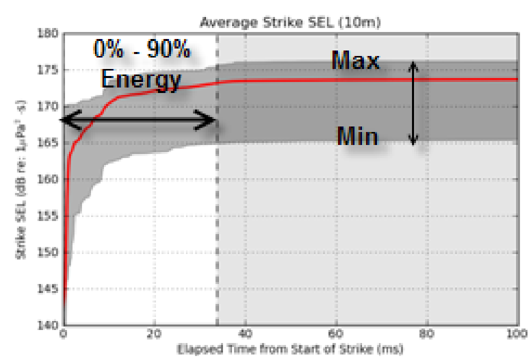
er atic Unconfir l Bubble rtain
um er o trikes: 12
Number of Strikes Analyzed: 1006
Air: On

Spectral Density



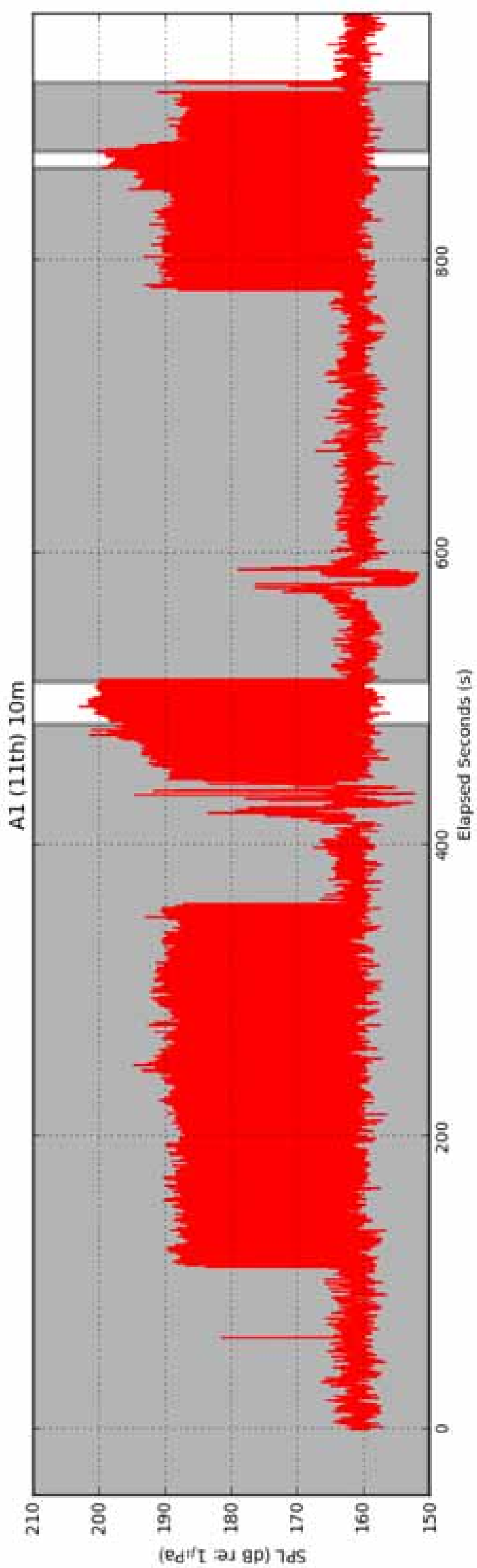
ST1400 – 10 meters





Strike Series Analysis: Pile A-1, Air Off, February 11, 2011 16:40 (pg 1 of 3)

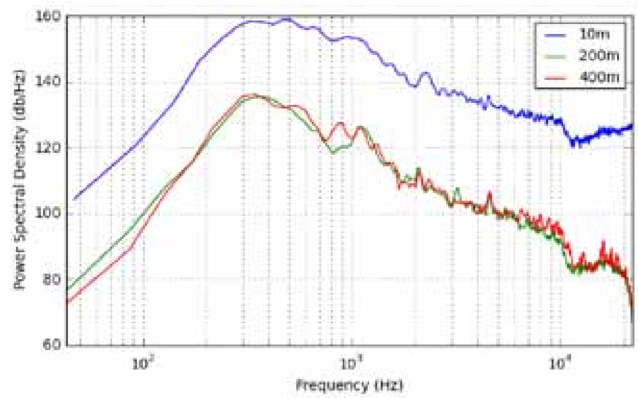
Time Series of Strikes at 10 meters



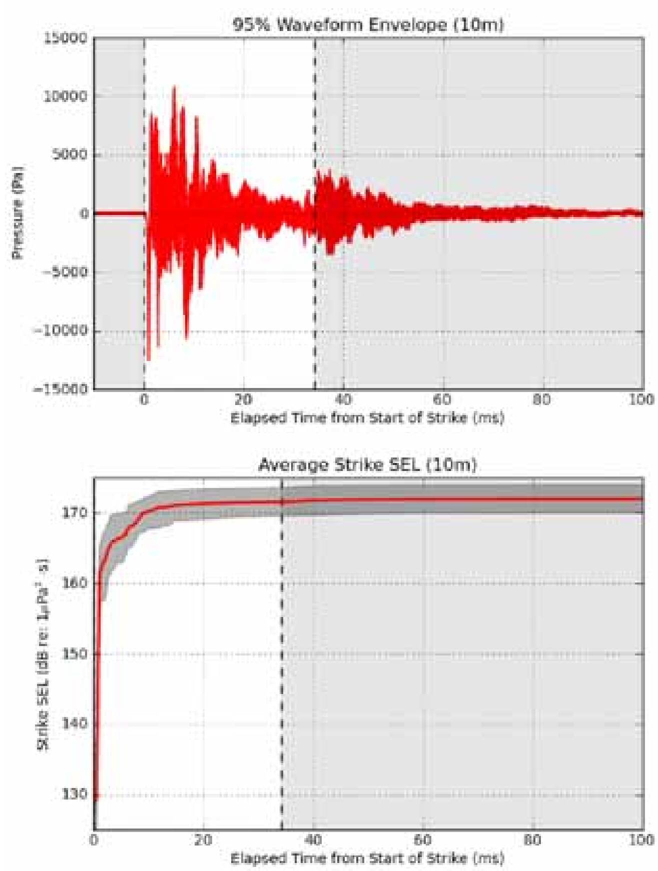
Pile A-1, 24" diameter

Date: February 11, 2011   Time: 16:40

Attenuation: Unconfined Bubble Curtain
Number of Strikes: 311
Number of Strikes Analyzed: 33
Air: Off



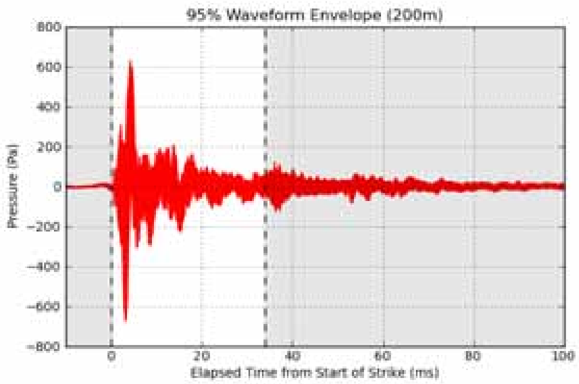
Spectral Density

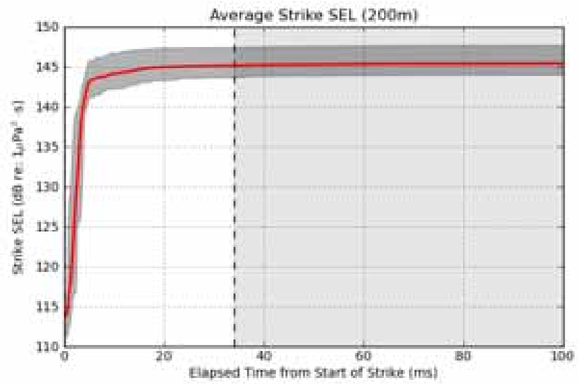


ST1400 – 10 meters

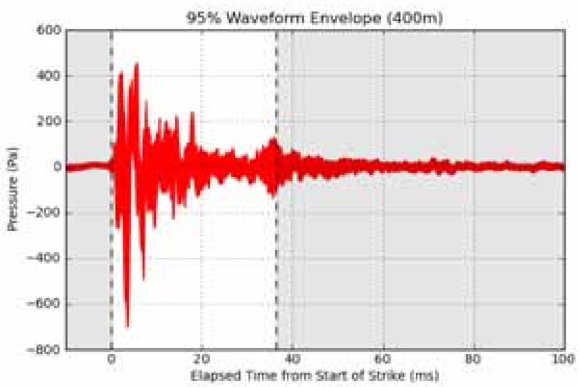
Strike Series Analysis: Pile A-1, Air Off, February 11, 2011 16:40 (pg 2 of 3)

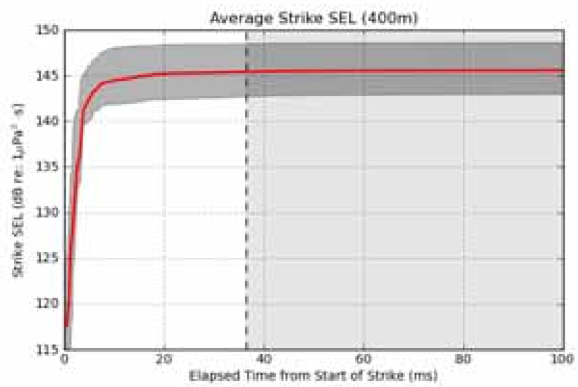
Waveforms | **SELs**





COHO – 200 meter s



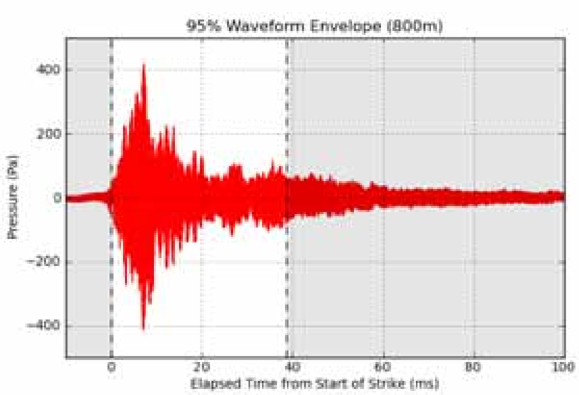


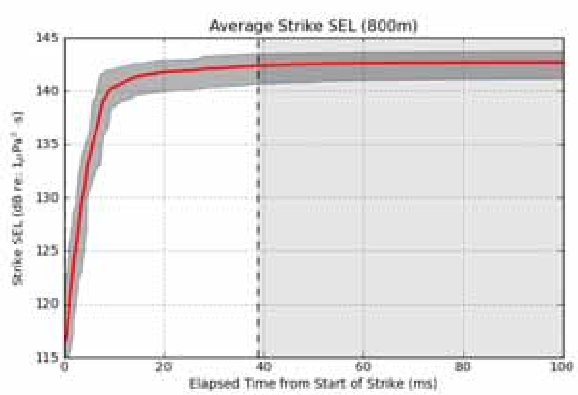
SOCKEYE – 400 meters

No data

No data

SUPERCUBE – 800 meters





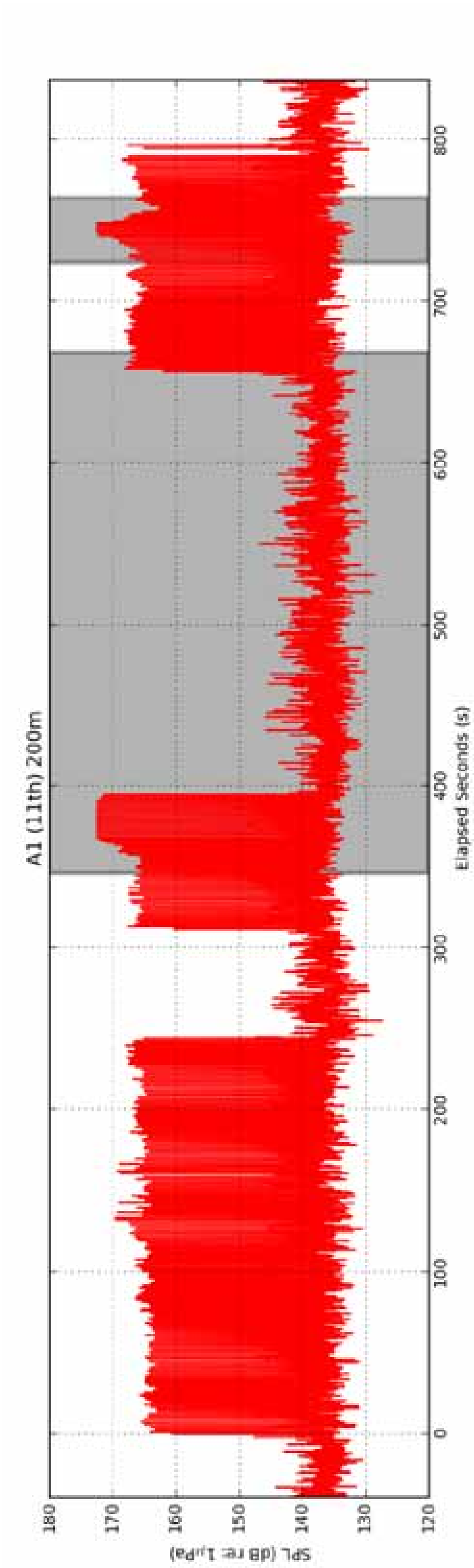
KOKANEE – 800 meters

Strike Series Analysis: Pile A-1, Air Off, February 11, 2011 16:40 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	231	430	No Data	753	10	231	430	No Data	753
	Number of Strikes: Total	311	311	311		311	311	311	311		311
	Number of Strikes: Analyzed	26	26	26		26	26	26	26		26
	Series RMS $_{(0\text{-}90\%)}$	185.3	158.8	158.9		155.5	184.1	157.2	157.4		154.5
	Series RMS $_{(5\text{-}95\%)}$	185.7	157.7	154.2		155.7	184.5	156.0	152.5		154.7
	Cumulative SEL$_{Analyzed}$	185.9	159.4	159.7		156.5	184.8	157.9	158.4		155.6
	Cumulative SEL	196.7	170.2	170.5		167.3	195.5	168.7	169.2		166.4
	Peak Strikes$_{Maximum}$	203.0	172.5	176.0		171.3	203.0	172.5	176.0		171.3
	Peak Strikes$_{Mean}$	199.7	172.3	173.1		169.9	199.7	172.3	173.1		169.9
	Peak Strikes$_{1\sigma}$	1.5	0.5	1.3		1.1	1.5	0.5	1.3		1.1
	Maximum Overpressure$_{Mean}$	8195.1	410.8	315.8		300.8	7402.8	308.6	298.8		280.4
	Maximum Overpressure$_{1\sigma}$	1177.8	23.2	61.2		33.3	934.3	33.9	79.1		33.2
	Maximum Underpressure$_{Mean}$	-9484.4	-395.2	-458.2		-300.2	-8671.0	-374.1	-394.7		-271.2
	Maximum Underpressure$_{1\sigma}$	1840.1	40.9	72.4		45.6	1974.9	49.4	69.0		45.3
	RMS $_{(0\text{-}90\%)\ Maximum}$	188.1	161.9	163.8		157.2	187.3	160.6	162.8		156.2
	RMS $_{(5\text{-}95\%)\ Maximum}$	187.6	161.4	163.0		157.2	186.9	160.1	162.0		156.3
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	186.9	158.5	162.7		155.1	186.0	156.6	161.7		154.1
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	187.3	157.4	161.4		155.3	186.4	155.4	160.1		154.4
	RMS $_{(0\text{-}90\%)\ Mean}$	185.2	158.8	158.8		155.5	184.0	157.1	157.3		154.5
	RMS $_{(5\text{-}95\%)\ Mean}$	185.5	157.7	154.7		155.6	184.4	155.9	153.0		154.7
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	1.2	1.1	2.0		0.8	1.4	1.2	2.2		0.8
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	1.1	1.4	3.8		0.7	1.3	1.6	3.9		0.8
	SEL$_{Maximum}$	173.6	147.3	148.3		143.3	172.7	146.2	147.3		142.6
	SEL$_{Peak\ Strike}$	173.2	145.0	147.0		142.2	172.3	143.2	145.9		141.3
	SEL$_{Mean}$	171.6	145.2	145.4		142.4	170.4	143.6	144.1		141.4
	SEL$_{1\sigma}$	1.1	0.8	1.2		0.6	1.2	0.9	1.3		0.6
Time Strike Series Statistics	Time to Peak$_{Minimum}$	11.0	12.7	12.1		13.3	11.0	12.1	11.8		13.1
	Time to Peak$_{Mean}$	14.7	13.5	13.4		16.2	14.1	13.4	13.5		15.3
	Time to Peak$_{1\sigma}$	3.3	0.6	0.4		1.6	3.4	0.6	0.9		1.5
	Strike Time $_{(0\text{-}90\%)\ Mean}$	44.2	44.0	46.4		48.8	44.3	45.2	49.0		49.4
	Strike Time $_{(5\text{-}95\%)\ Mean}$	40.4	57.8	142.5		47.2	40.5	60.1	151.6		47.7
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	4.1	4.5	8.6		2.7	4.1	4.0	10.7		2.8
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	2.4	10.0	70.5		2.4	2.4	11.1	68.7		2.6
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%		0%	0%	0%	0%		0%
	Pct Exceeding 187dB SEL	0%	0%	0%		0%	0%	0%	0%		0%
	Pct Exceeding 183dB SEL	0%	0%	0%		0%	0%	0%	0%		0%
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	96%		100%	100%	100%	69%		100%
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	100%		100%	100%	100%	100%		100%
Transmission Loss Coefficients	Peak Strike$_{Mean}$		20.1	16.2		15.8		20.1	16.2		15.8
	Cumulative SEL		19.4	16.0		15.6		20.5	16.8		16.1
	Series RMS $_{(0\text{-}90\%)}$		19.4	16.1		15.9		20.6	17.1		16.4
	Series RMS $_{(5\text{-}95\%)}$		20.5	19.3		16.0		21.8	20.3		16.5

Strike Series Analysis: Pile A-1, Air On, February 11, 2011 16:40 (pg 1 of 3)

Time Series of Strikes at 200 meters

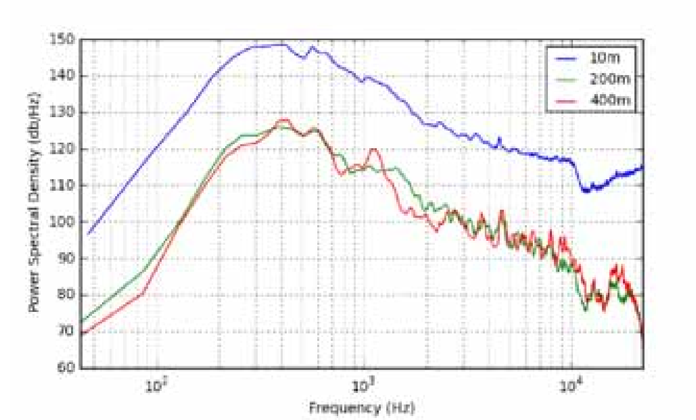


Pile A-1, 24" diameter

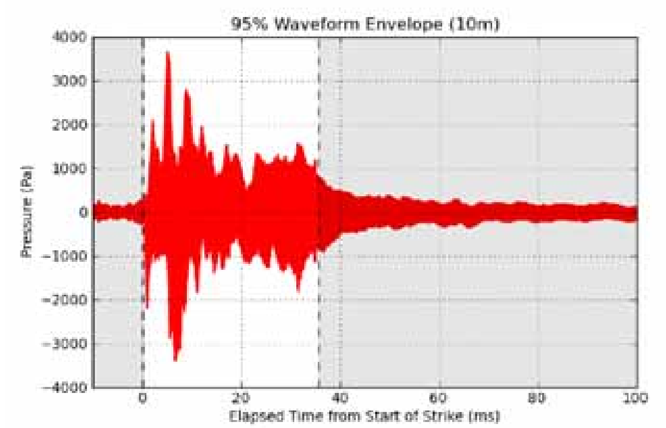
Date: February 11, 2011   Time: 16:40

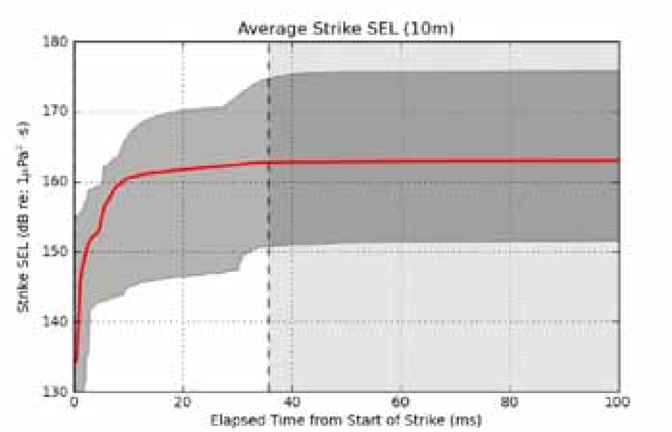
Attenuation: Unconfined Bubble Curtain
Number of Strikes: 311
Number of Strikes Analyzed: 241
Air: On

Spectral Density

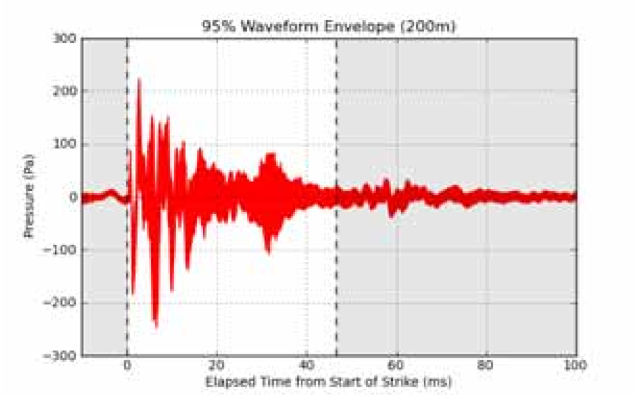
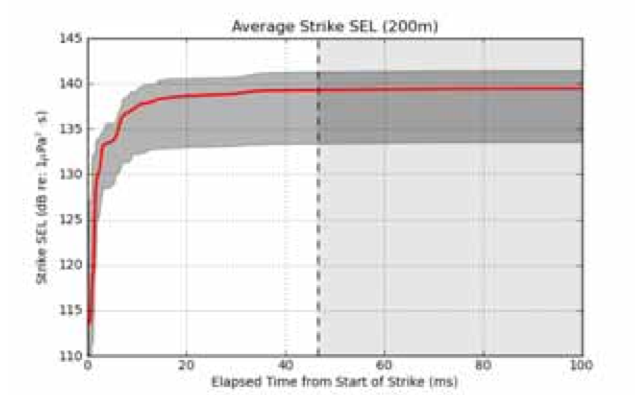
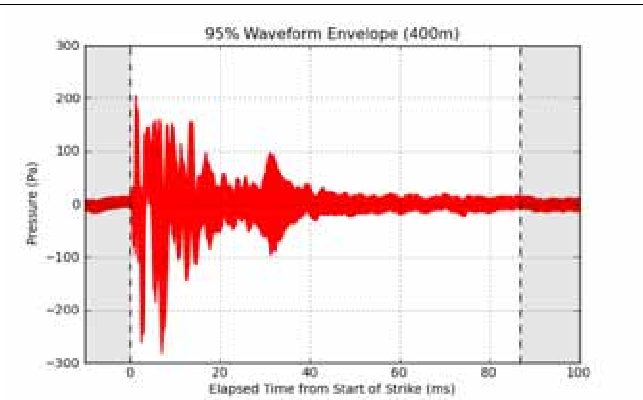
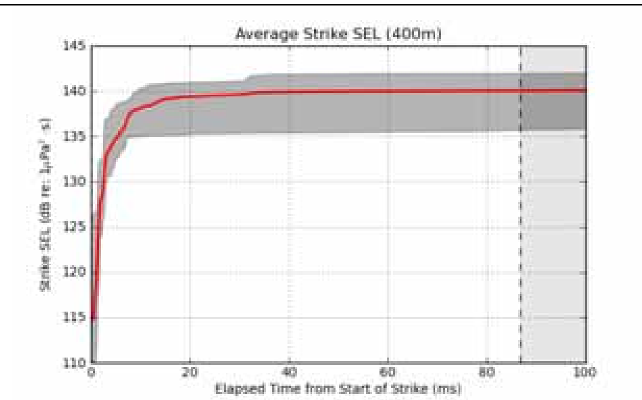
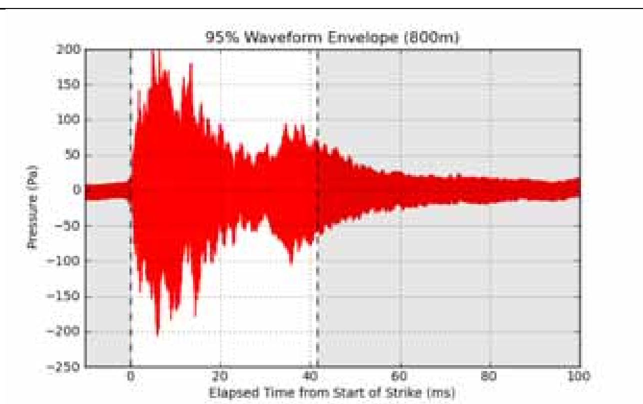
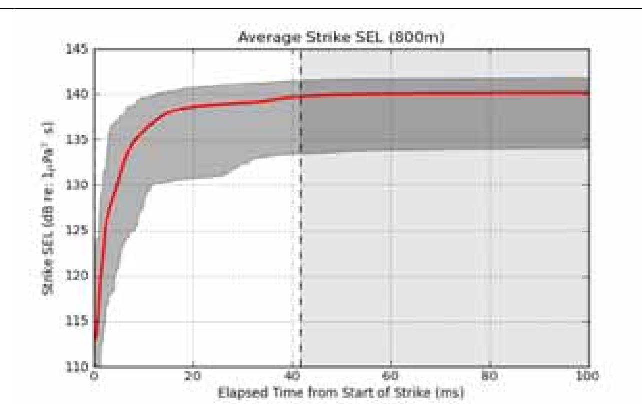


ST1400 – 10 meters





Strike Series Analysis: Pile A-1, Air On, February 11, 2011 16:40 (pg 2 of 3)

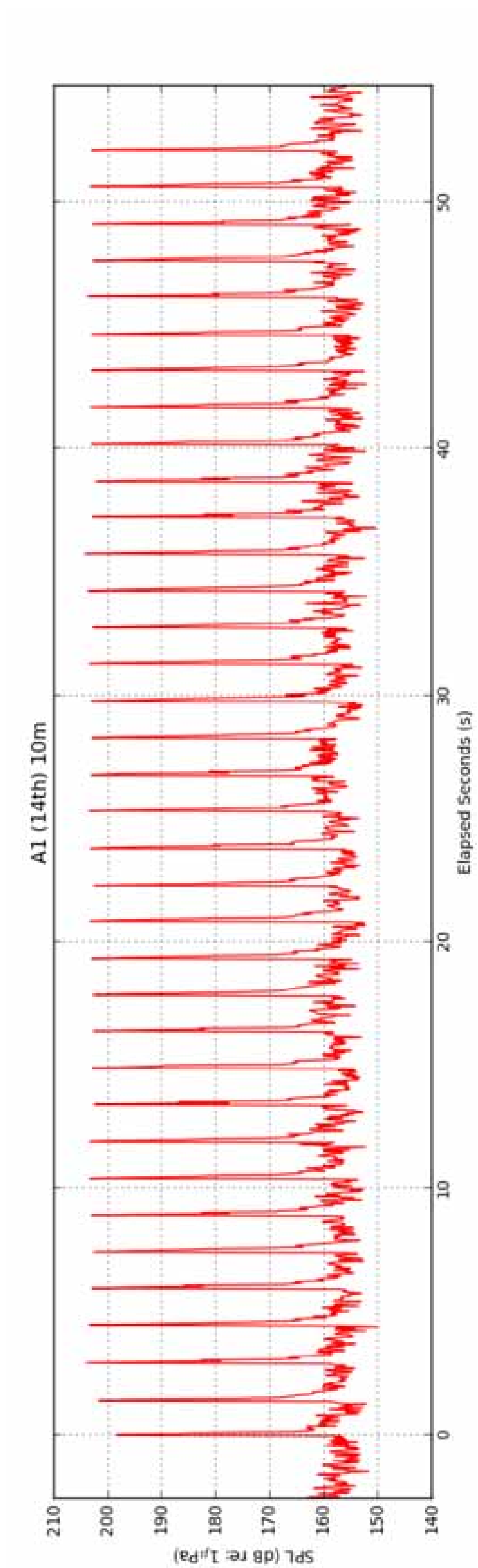
Waveforms	SELs	
		COHO – 200 meter s
		SOCKEYE – 400 meters
No data	No data	SUPERCUBE – 800 meters
		KOKANEE – 800 meters

Strike Series Analysis: Pile A-1, Air On, February 11, 2011 16:40 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
	Range From Pile	10	231	430	No Data	753	10	231	430	No Data	753
	Number of Strikes: Total	311	311	311		311	311	311	311		311
	Number of Strikes: Analyzed	241	241	241		241	241	241	241		241
Strike Series Statistics	Series RMS $_{(0-90\%)}$	176.4	151.9	150.2		152.7	174.0	150.2	148.8		152.3
	Series RMS $_{(5-95\%)}$	176.8	147.6	146.8		152.9	174.2	145.7	145.4		152.5
	Cumulative $SEL_{Analyzed}$	186.8	163.2	163.9		163.7	184.4	161.6	162.7		163.3
	Cumulative SEL	187.9	164.3	165.0		164.8	185.5	162.7	163.8		164.4
	Peak $Strikes_{Maximum}$	195.4	169.6	169.0		171.3	195.4	169.6	169.0		171.3
	Peak $Strikes_{Mean}$	189.5	165.6	166.2		167.1	189.5	165.6	166.2		167.1
	Peak $Strikes_{1\sigma}$	1.9	1.4	0.8		1.7	1.9	1.4	0.8		1.7
	Maximum $Overpressure_{Mean}$	2910.8	157.2	156.0		211.7	2488.3	134.8	159.6		205.6
	Maximum $Overpressure_{1\sigma}$	693.5	27.6	24.2		45.8	696.8	22.5	25.9		46.0
	Maximum $Underpressure_{Mean}$	-2680.0	-191.2	-204.2		-212.7	-2344.8	-151.1	-171.9		-207.5
	Maximum $Underpressure_{1\sigma}$	667.8	32.7	20.2		44.7	799.0	34.2	25.4		48.6
	RMS $_{(0-90\%)\ Maximum}$	187.0	154.6	155.3		154.7	177.2	153.3	154.5		154.4
	RMS $_{(5-95\%)\ Maximum}$	180.4	153.9	153.7		154.9	178.2	153.0	152.4		154.6
	RMS $_{(0-90\%)\ Peak\ Strike}$	177.0	154.2	151.0		154.5	175.5	153.3	148.4		154.1
	RMS $_{(5-95\%)\ Peak\ Strike}$	177.5	153.9	147.6		154.7	175.9	153.0	146.1		154.3
	RMS $_{(0-90\%)\ Mean}$	176.3	151.9	151.0		152.6	173.9	150.2	149.5		152.2
	RMS $_{(5-95\%)\ Mean}$	176.7	147.8	146.8		152.8	174.3	145.9	145.3		152.4
	RMS $_{(0-90\%)\ 1\sigma}$	2.0	1.8	3.1		1.1	3.0	2.0	3.5		1.2
	RMS $_{(5-95\%)\ 1\sigma}$	2.1	2.6	1.3		1.2	3.5	2.7	1.5		1.4
	$SEL_{Maximum}$	173.2	141.1	141.7		141.4	163.9	139.9	140.8		141.1
	$SEL_{Peak\ Strike}$	163.5	140.7	141.0		141.0	162.0	139.9	139.7		140.6
	SEL_{Mean}	162.6	139.3	140.0		139.7	160.2	137.6	138.8		139.3
	$SEL_{1\sigma}$	1.6	1.1	0.7		1.0	2.2	1.2	1.0		1.1
Time Strike Series Statistics	Time to $Peak_{Minimum}$	12.5	10.9	11.9		12.7	12.5	10.9	11.2		12.2
	Time to $Peak_{Mean}$	20.3	17.4	16.0		18.3	25.0	18.0	15.6		18.3
	Time to $Peak_{1\sigma}$	9.7	6.1	4.0		3.6	19.9	7.7	7.3		4.9
	Strike Time $_{(0-90\%)\ Mean}$	45.6	56.2	96.6		51.6	45.9	57.8	102.9		51.7
	Strike Time $_{(5-95\%)\ Mean}$	43.1	156.3	220.1		49.4	43.5	163.3	222.8		49.4
	Strike Time $_{(0-90\%)\ 1\sigma}$	34.1	16.5	64.1		2.1	34.4	18.9	66.4		2.1
	Strike Time $_{(5-95\%)\ 1\sigma}$	44.3	57.9	29.3		5.5	46.0	56.6	27.8		5.5
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%		0%	0%	0%	0%		0%
	Pct Exceeding 187dB SEL	0%	0%	0%		0%	0%	0%	0%		0%
	Pct Exceeding 183dB SEL	0%	0%	0%		0%	0%	0%	0%		0%
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	23%	2%		98%	100%	10%	1%		96%
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	87%	66%		99%	100%	58%	51%		97%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		17.6	14.3		12.0		17.6	14.3		12.0
	Cumulative SEL		17.3	14.0		12.4		18.5	14.8		12.6
	Series RMS $_{(0-90\%)}$		18.0	16.0		12.6		19.3	16.9		12.8
	Series RMS $_{(5-95\%)}$		21.5	18.4		12.7		22.8	19.2		12.9

Strike Series Analysis: Pile A-1, Air Off, February 14, 2011 08:53 (pg 1 of 3)

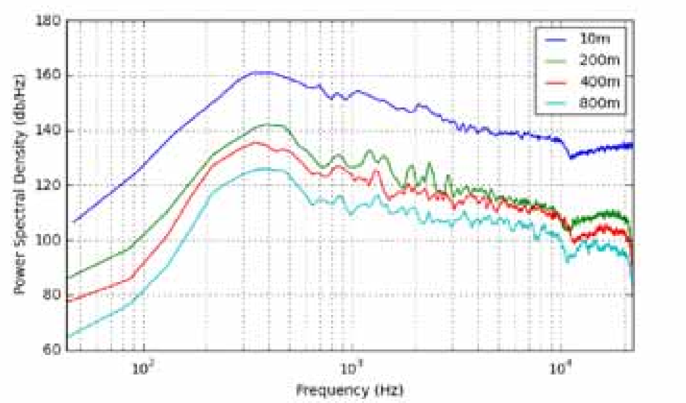
Time Series of Strikes at 10 meters



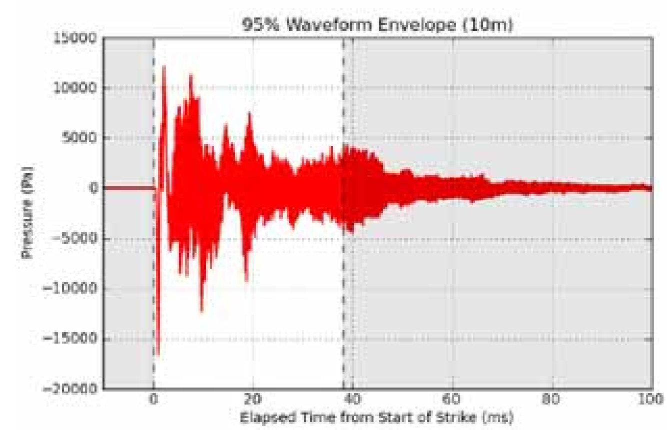
Pile A-1, 24" diameter

Date: February 14, 2011   Time: 08:53

Attenuation: Restrike
Number of Strikes: 36
Number of Strikes Analyzed: 36
Air: Off

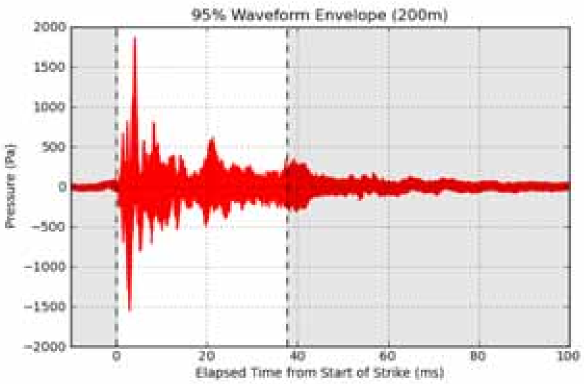
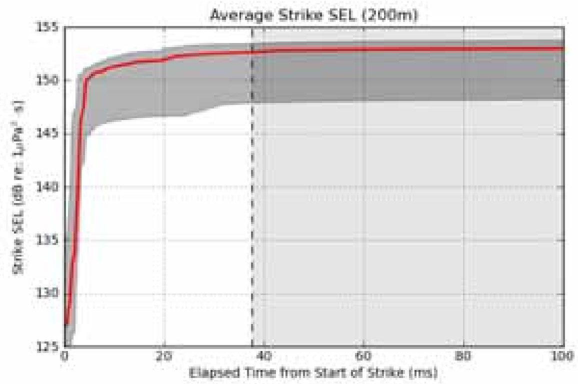
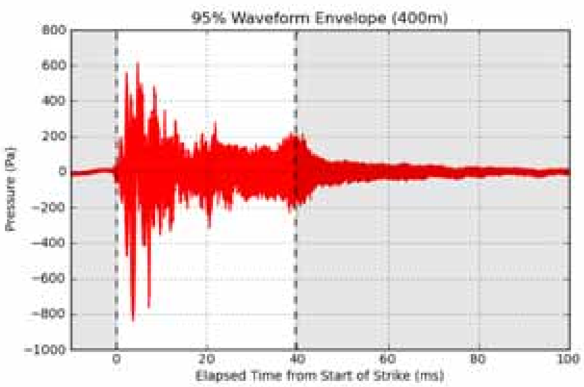
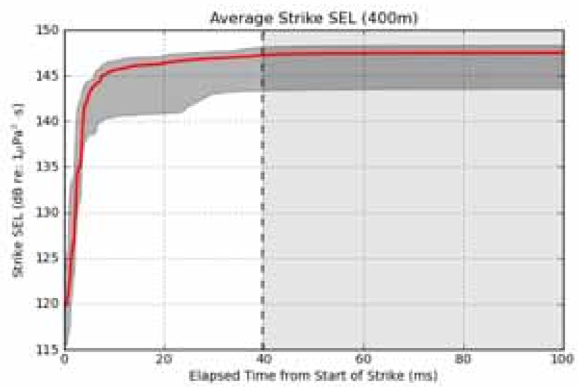
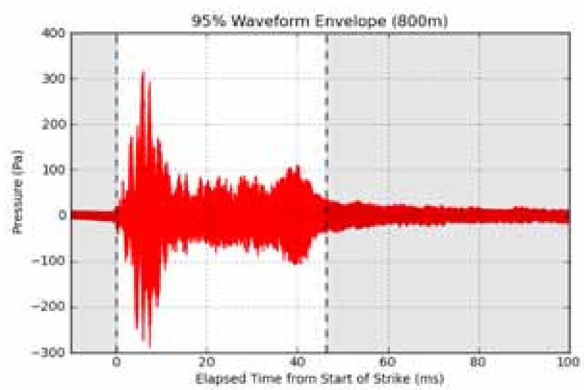
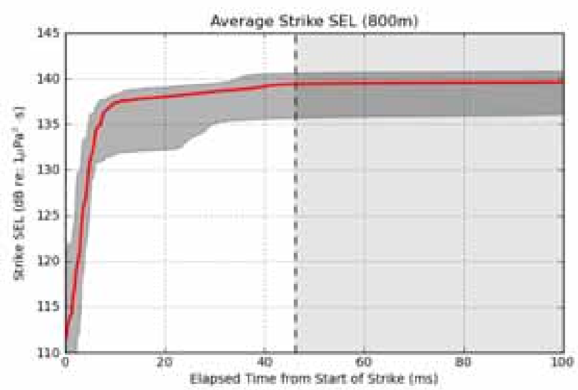
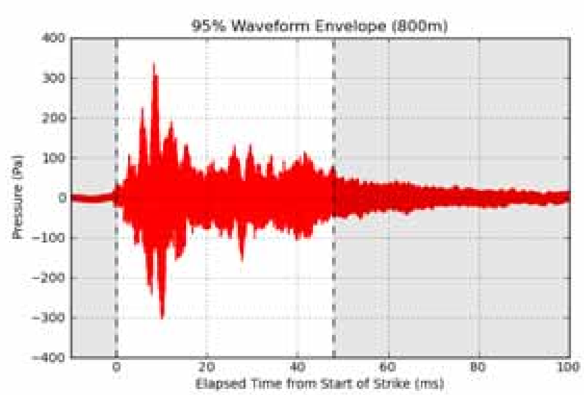
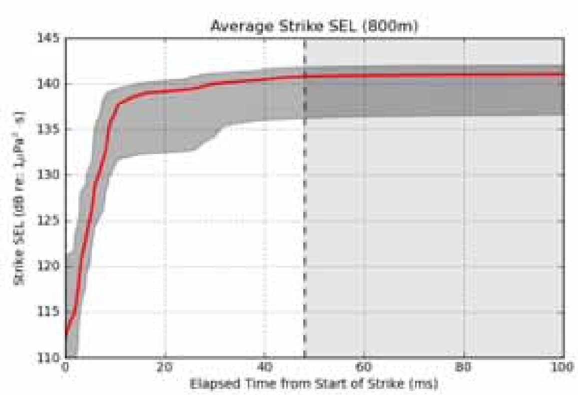


Spectral Density



ST1400 – 10 meters

Strike Series Analysis: Pile A-1, Air Off, February 14, 2011 08:53 (pg 2 of 3)

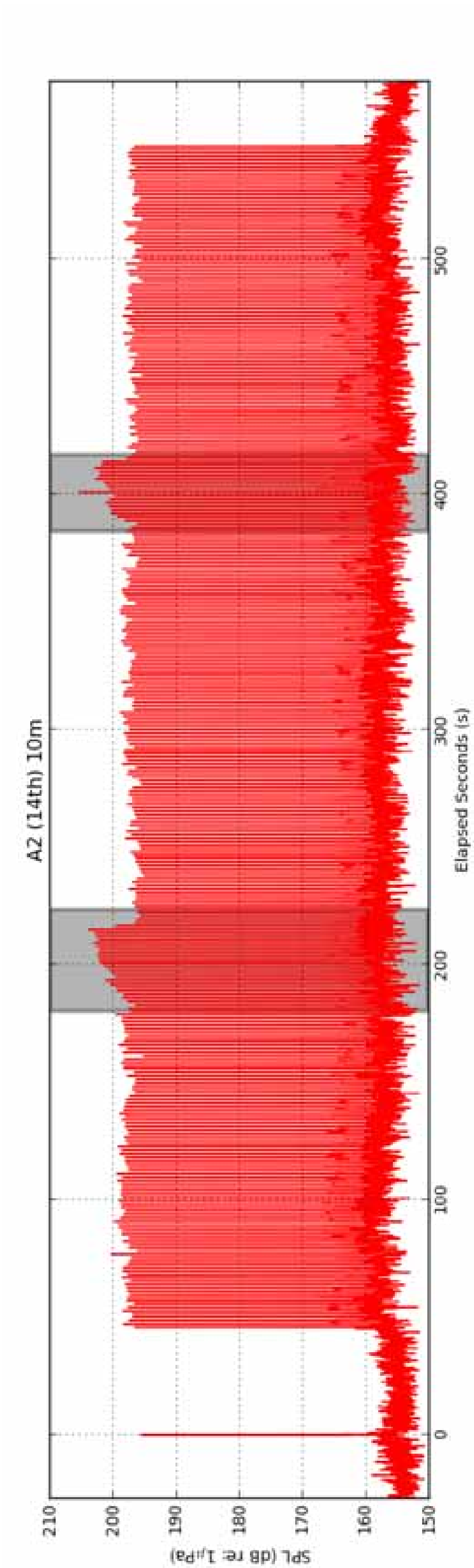
Waveforms	SELs	
		COHO – 200 meter s
		SOCKEYE – 400 meters
		SUPERCUBE – 800 meters
		KOKANEE – 800 meters

Strike Series Analysis: Pile A-1, Air Off, February 14, 2011 08:53 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	237	433	851	750	10	237	433	851	750
	Number of Strikes: Total	36	36	36	36	36	36	36	36	36	36
	Number of Strikes: Analyzed	36	36	36	36	36	36	36	36	36	36
	Series RMS $_{(0-90\%)}$	187.4	165.9	160.3	151.9	153.2	186.3	165.0	159.4	151.1	152.0
	Series RMS $_{(5-95\%)}$	187.9	166.1	160.7	147.4	153.2	186.9	165.2	159.6	146.2	151.9
	Cumulative $SEL_{Analyzed}$	189.8	168.3	162.8	155.0	156.4	188.8	167.4	161.9	154.2	155.2
	Cumulative SEL	189.8	168.3	162.8	155.0	156.4	188.8	167.4	161.9	154.2	155.2
	Peak $Strikes_{Maximum}$	204.1	183.1	175.5	171.6	172.8	204.1	183.1	175.5	171.6	172.8
	Peak $Strikes_{Mean}$	202.8	182.0	174.0	167.0	169.1	202.8	182.0	174.0	167.0	169.1
	Peak $Strikes_{1\sigma}$	0.9	1.1	0.9	1.4	1.6	0.9	1.1	0.9	1.4	1.6
	Maximum $Overpressure_{Mean}$	11112.6	1273.5	438.2	212.9	258.2	9436.4	1107.8	419.3	189.9	238.7
	Maximum $Overpressure_{1\sigma}$	1345.1	130.6	45.2	24.1	43.3	1209.1	108.6	59.0	19.7	50.4
	Maximum $Underpressure_{Mean}$	-13842.0	-1011.7	-498.6	-211.5	-275.1	-13248.3	-934.7	-434.5	-190.0	-235.7
	Maximum $Underpressure_{1\sigma}$	1220.6	74.7	53.0	47.4	57.7	1121.6	76.3	43.3	42.6	51.2
	RMS $_{(0-90\%)\ Maximum}$	188.6	167.0	161.2	153.2	154.3	187.5	166.0	160.3	152.5	153.2
	RMS $_{(5-95\%)\ Maximum}$	188.9	167.0	161.4	150.1	154.2	187.9	166.2	160.4	149.1	153.0
	RMS $_{(0-90\%)\ Peak\ Strike}$	187.9	166.4	161.2	153.2	154.0	186.7	165.5	160.3	152.5	153.0
	RMS $_{(5-95\%)\ Peak\ Strike}$	188.1	167.0	161.3	148.8	153.8	187.1	166.0	160.3	147.8	152.7
	RMS $_{(0-90\%)\ Mean}$	187.4	165.9	160.3	151.9	153.1	186.3	164.9	159.3	151.0	151.9
	RMS $_{(5-95\%)\ Mean}$	187.9	166.1	160.7	147.4	153.1	186.8	165.2	159.6	146.2	151.8
	RMS $_{(0-90\%)\ 1\sigma}$	0.7	0.9	0.7	0.8	1.0	0.7	0.9	0.6	0.8	0.9
	RMS $_{(5-95\%)\ 1\sigma}$	0.7	1.1	0.8	1.0	1.0	0.7	1.1	0.7	1.0	1.0
	$SEL_{Maximum}$	175.2	153.4	148.0	140.6	141.7	174.3	152.6	147.2	140.0	140.7
	$SEL_{Peak\ Strike}$	174.3	153.4	148.0	140.6	141.6	173.3	152.5	147.2	140.0	140.7
	SEL_{Mean}	174.2	152.6	147.2	139.4	140.8	173.1	151.7	146.3	138.6	139.6
	$SEL_{1\sigma}$	0.7	0.9	0.8	0.8	0.9	0.7	0.9	0.7	0.7	0.9
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.0	11.5	12.3	15.6	15.9	11.0	11.5	12.3	14.4	17.6
	Time to $Peak_{Mean}$	12.2	13.9	16.9	18.4	19.6	12.1	13.9	17.4	18.3	20.3
	Time to $Peak_{1\sigma}$	2.7	0.6	3.4	5.4	3.8	4.0	0.6	3.2	5.4	5.1
	Strike Time $_{(0-90\%)\ Mean}$	48.1	47.6	49.6	56.2	57.9	48.4	48.0	49.7	57.1	58.5
	Strike Time $_{(5-95\%)\ Mean}$	42.6	43.5	45.6	166.8	58.3	42.8	44.3	46.5	175.6	59.0
	Strike Time $_{(0-90\%)\ 1\sigma}$	2.5	2.4	1.8	2.2	2.7	2.3	2.1	1.8	2.3	2.8
	Strike Time $_{(5-95\%)\ 1\sigma}$	1.8	3.0	2.3	24.3	2.6	1.8	3.1	2.3	23.3	2.6
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	3%	97%	100%	100%	100%	0%	97%
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	97%	97%	100%	100%	100%	97%	97%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		15.1	17.6	18.6	18.0		15.1	17.6	18.6	18.0
	Cumulative SEL		15.7	16.5	18.0	17.8		16.3	17.0	18.4	18.5
	Series RMS $_{(0-90\%)}$		15.6	16.6	18.4	18.2		16.3	17.1	18.8	18.9
	Series RMS $_{(5-95\%)}$		15.8	16.6	21.0	18.5		16.5	17.3	21.6	19.2

Strike Series Analysis: Pile A-2, Air On, February 14, 2011 12:24 (pg 1 of 3)

Time Series of Strikes at 10 meters

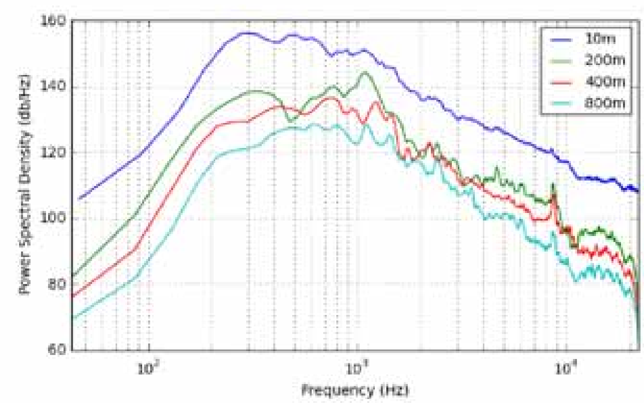


Pile A-2, 24" diameter

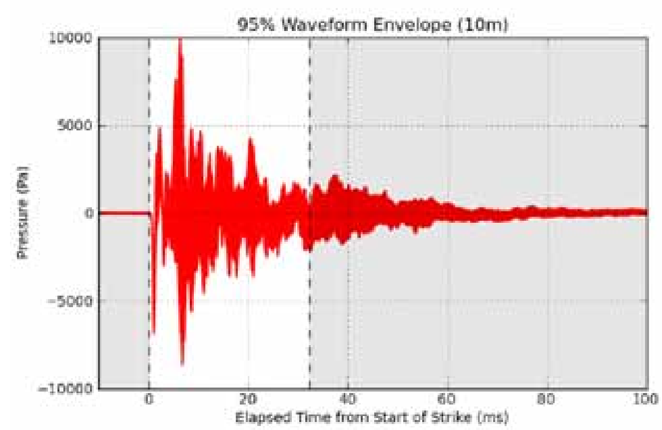
Date: February 14, 2011   Time: 12:24

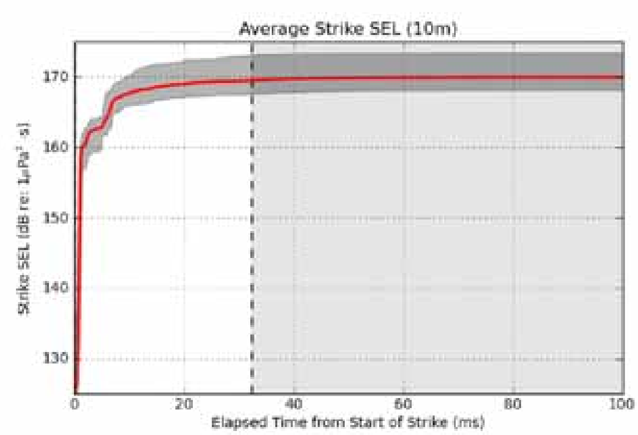
Attenuation: Confined Bubble Curtain
Number of Strikes: 348
Number of Strikes Analyzed: 293
Air: Off

Spectral Density



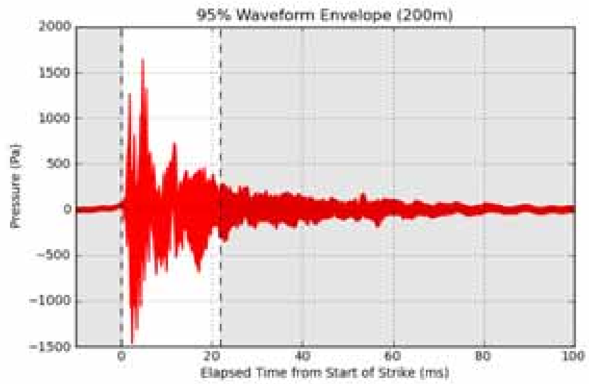
ST1400 – 10 meters

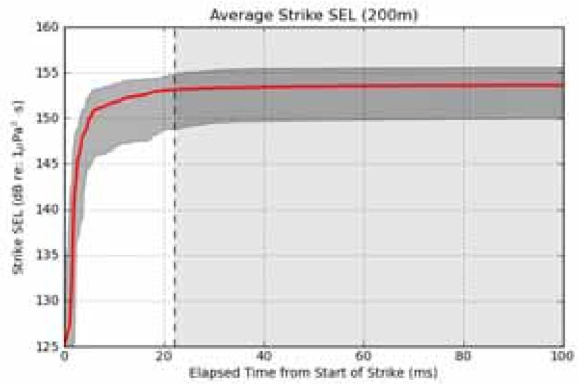




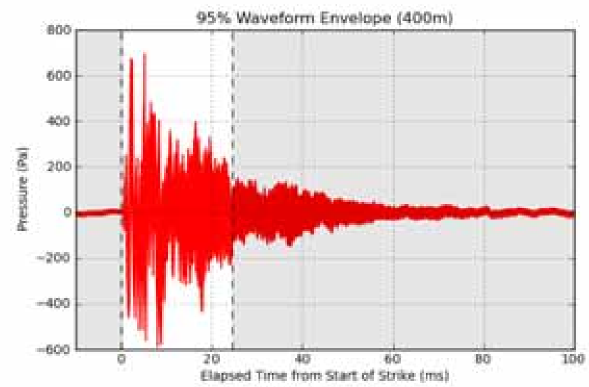
Strike Series Analysis: Pile A-2, Air On, February 14, 2011 12:24 (pg 2 of 3)

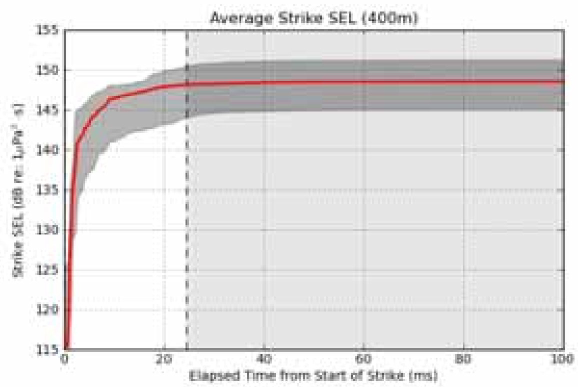
Waveforms	SELs



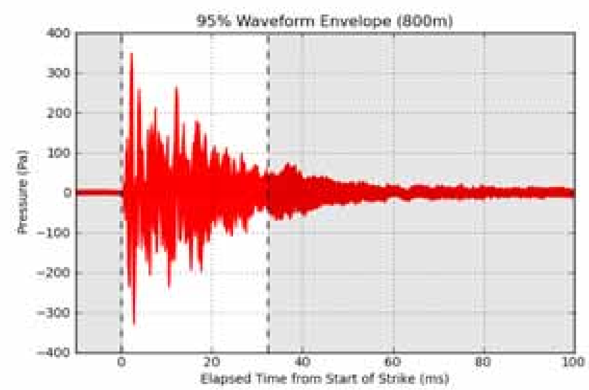


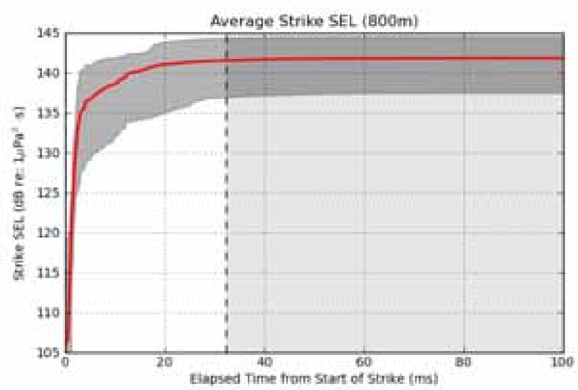
COHO – 200 meter s



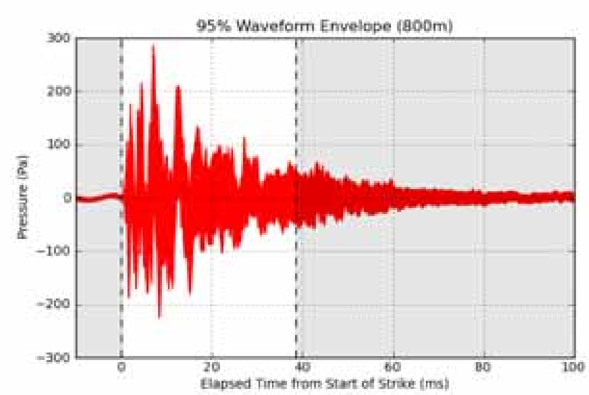


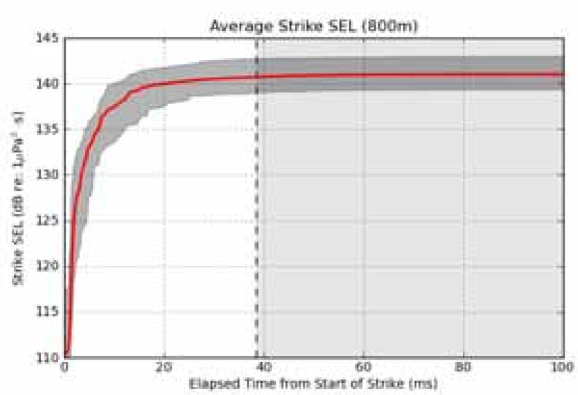
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





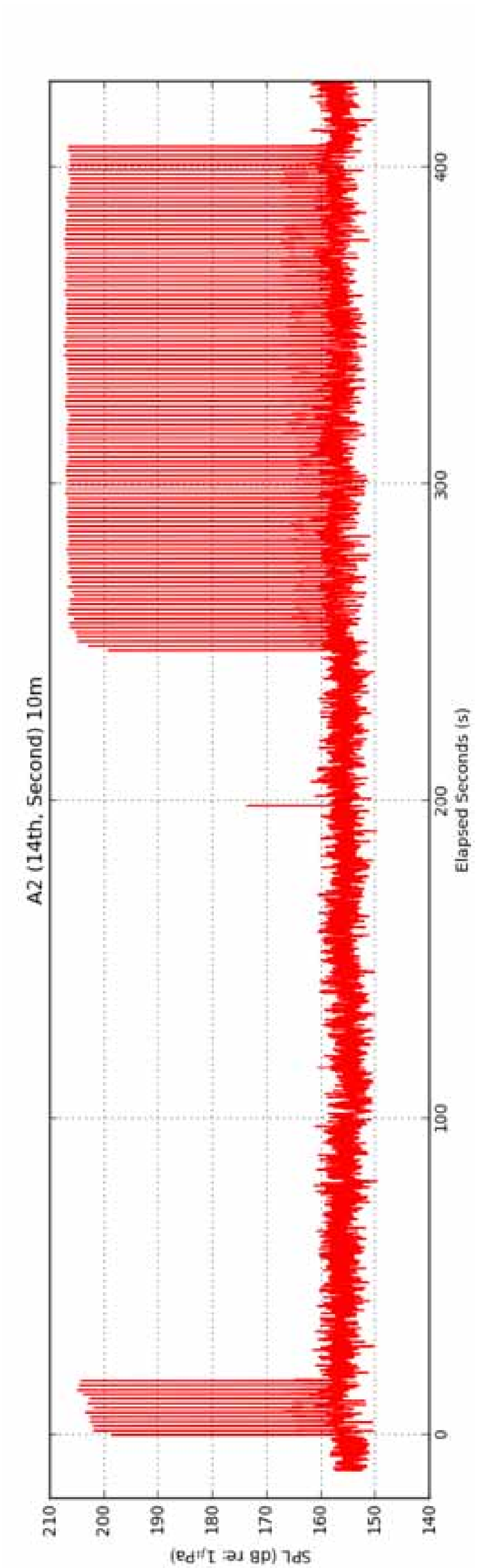
KOKANEE – 800 meters

Strike Series Analysis: Pile A-2, Air On, February 14, 2011 12:24 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	219	415	834	768	10	219	415	834	768
	Number of Strikes: Total	348	348	348	348	348	348	348	348	348	348
	Number of Strikes: Analyzed	293	293	293	293	293	293	293	293	293	293
	Series RMS $_{(0\text{-}90\%)}$	183.4	168.2	162.9	155.4	153.9	182.0	167.0	162.1	155.0	152.6
	Series RMS $_{(5\text{-}95\%)}$	183.8	167.7	162.9	154.4	154.1	182.4	166.5	162.1	154.0	152.7
	Cumulative $SEL_{Analyzed}$	194.4	177.9	172.9	166.3	165.5	192.9	176.8	172.2	165.9	164.1
	Cumulative SEL	195.1	178.7	173.7	167.1	166.2	193.7	177.5	172.9	166.7	164.9
	Peak $Strikes_{Maximum}$	200.2	183.4	178.4	173.2	170.3	200.2	183.4	178.4	173.2	170.3
	Peak $Strikes_{Mean}$	197.3	181.0	174.6	168.4	166.6	197.3	181.0	174.6	168.4	166.6
	Peak $Strikes_{1\sigma}$	0.9	1.5	1.1	1.6	1.5	0.9	1.5	1.1	1.6	1.5
	Maximum $Overpressure_{Mean}$	7182.4	1107.3	524.6	255.2	214.6	6056.3	964.2	501.8	248.9	184.8
	Maximum $Overpressure_{1\sigma}$	848.1	192.9	78.8	54.1	40.4	780.7	206.4	82.7	57.1	32.7
	Maximum $Underpressure_{Mean}$	-6308.1	-1006.0	-464.3	-248.6	-180.8	-6093.0	-841.4	-438.6	-244.4	-175.7
	Maximum $Underpressure_{1\sigma}$	829.2	189.6	60.9	47.7	29.1	908.3	185.8	60.5	50.8	30.9
	RMS $_{(0\text{-}90\%)\ Maximum}$	187.0	170.2	165.0	158.5	156.2	185.5	169.5	164.2	158.1	154.9
	RMS $_{(5\text{-}95\%)\ Maximum}$	187.6	170.0	165.7	158.4	156.0	186.0	169.1	164.8	158.0	154.6
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	186.6	168.9	163.9	157.5	154.3	184.8	168.1	163.3	157.3	153.4
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	187.5	167.9	163.3	156.6	154.6	185.7	167.0	162.7	156.4	153.7
	RMS $_{(0\text{-}90\%)\ Mean}$	183.3	168.2	162.8	155.3	153.9	181.9	167.0	162.0	154.9	152.5
	RMS $_{(5\text{-}95\%)\ Mean}$	183.7	167.7	162.8	154.5	154.0	182.3	166.4	162.0	154.1	152.6
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	1.5	1.2	1.1	1.3	1.0	1.6	1.5	1.2	1.4	1.0
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	1.5	1.2	1.3	1.9	0.9	1.5	1.5	1.3	2.0	0.9
	$SEL_{Maximum}$	173.0	155.2	150.8	144.2	142.6	171.2	153.9	150.1	143.8	141.2
	$SEL_{Peak\ Strike}$	172.8	153.4	148.6	142.7	140.9	171.0	152.6	148.0	142.5	140.1
	SEL_{Mean}	169.5	153.2	148.1	141.5	140.7	168.1	152.0	147.4	141.2	139.4
	$SEL_{1\sigma}$	1.2	0.8	1.0	1.0	0.9	1.2	1.0	1.0	1.1	0.8
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.1	12.0	11.9	11.6	11.4	11.1	11.3	11.3	11.5	11.4
	Time to $Peak_{Mean}$	16.0	16.0	16.8	17.5	18.4	16.8	16.2	16.2	16.9	17.8
	Time to $Peak_{1\sigma}$	1.6	4.3	5.5	5.9	3.5	4.4	4.4	6.1	6.0	3.9
	Strike Time $_{(0\text{-}90\%)\ Mean}$	42.4	31.9	34.4	42.2	48.5	42.4	31.9	34.5	42.2	48.8
	Strike Time $_{(5\text{-}95\%)\ Mean}$	38.6	36.1	34.7	54.1	47.6	38.6	36.0	34.7	53.8	47.8
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	5.4	5.7	5.2	4.8	3.4	5.5	5.7	5.2	4.8	3.3
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	3.5	4.9	3.3	24.6	3.1	3.5	4.9	3.3	24.3	3.1
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	100%	98%	100%	100%	100%	100%	97%	100%
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		12.2	14.0	15.0	16.3		12.2	14.0	15.0	16.3
	Cumulative SEL		12.3	13.2	14.6	15.3		13.1	13.7	14.8	16.0
	Series RMS $_{(0\text{-}90\%)}$		11.3	12.7	14.6	15.6		12.2	13.2	14.8	16.3
	Series RMS $_{(5\text{-}95\%)}$		12.0	12.9	15.3	15.8		12.9	13.4	15.5	16.5

Strike Series Analysis: Pile A-2, Air Off, February 14, 2011 13:35 (pg 1 of 3)

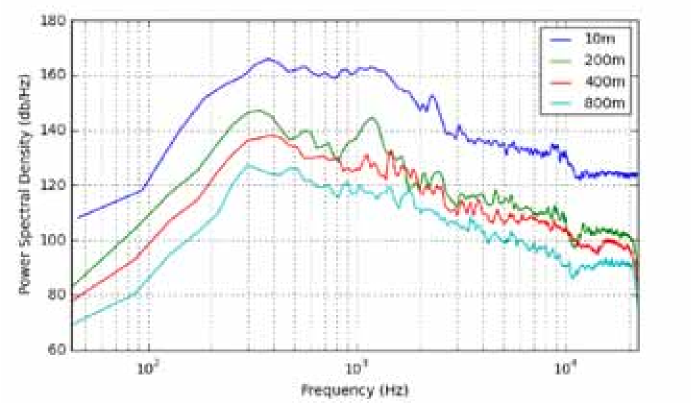
Time Series of Strikes at 10 meters



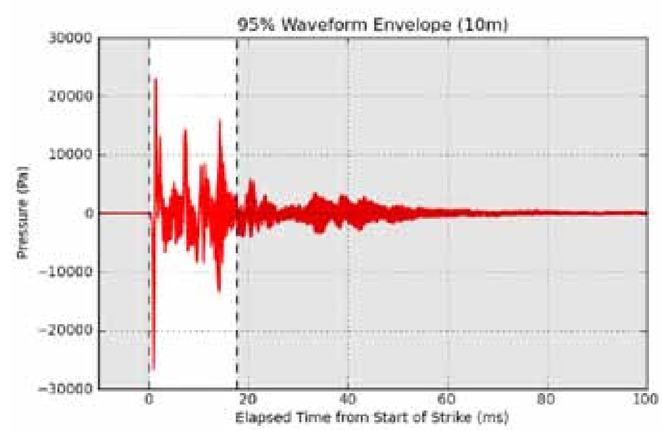
Pile A-2, 24" diameter

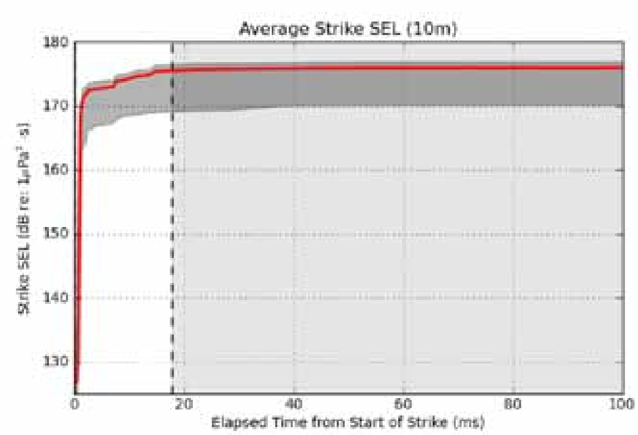
Date: February 14, 2011 Time: 13:35

Attenuation: Unattenuated Driving Strikes
Number of Strikes: 123
Number of Strikes Analyzed: 121
Air: Off



Spectral Density

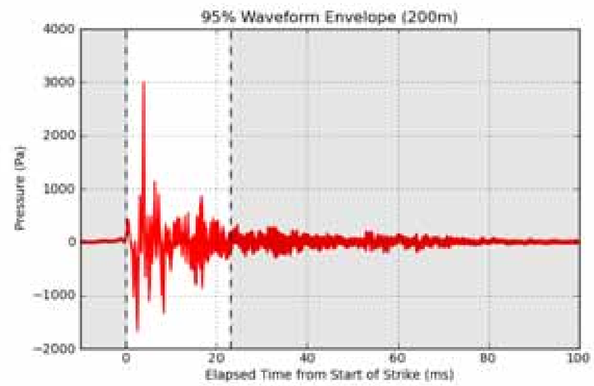


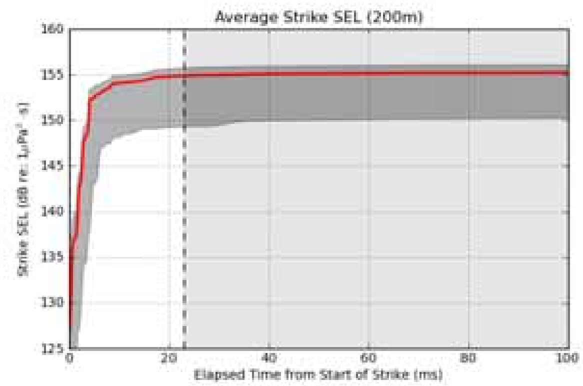


ST1400 – 10 meters

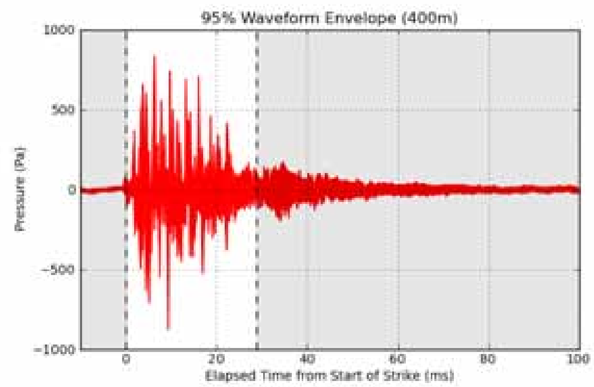
Strike Series Analysis: Pile A-2, Air Off, February 14, 2011 13:35 (pg 2 of 3)

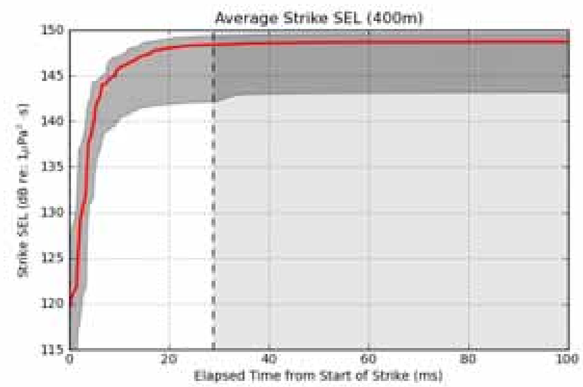
Waveforms	SELs	



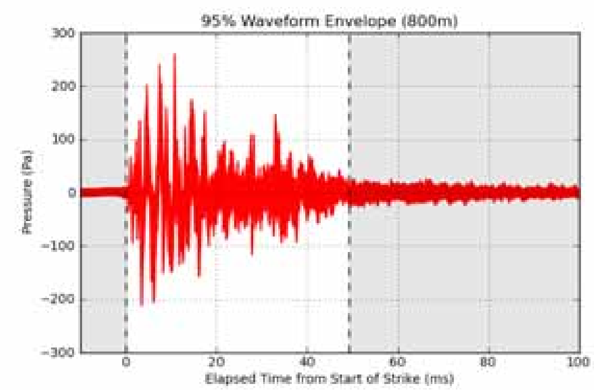


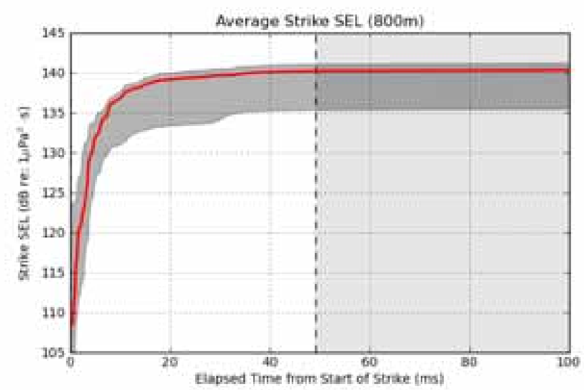
COHO – 200 meter s



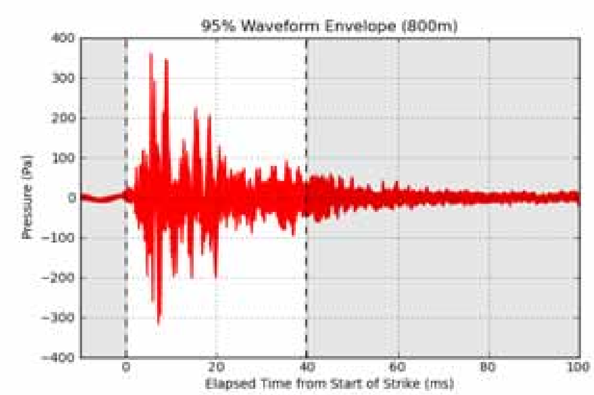


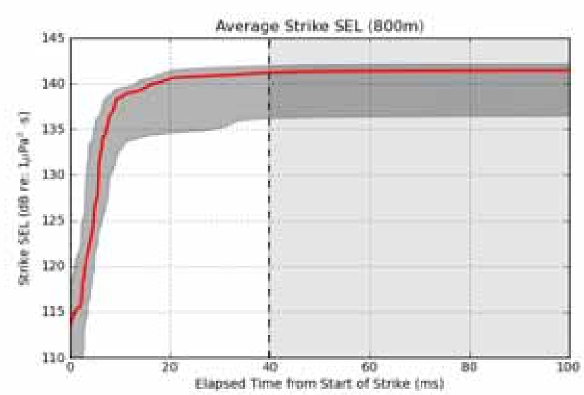
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





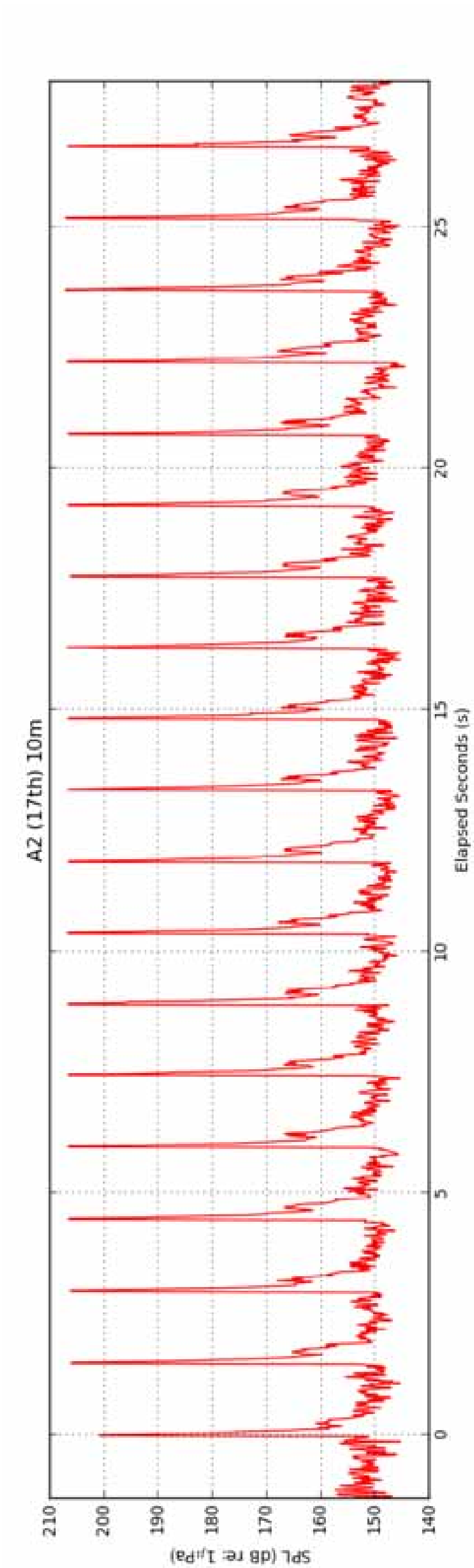
KOKANEE – 800 meters

Strike Series Analysis: Pile A-2, Air Off, February 14, 2011 13:35 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	219	415	834	768	10	219	415	834	768
	Number of Strikes: Total	123	123	123	123	123	123	123	123	123	123
	Number of Strikes: Analyzed	121	121	121	121	121	121	121	121	121	121
	Series RMS $_{(0\text{-}90\%)}$	191.1	169.7	162.6	152.5	154.3	190.4	168.5	161.8	151.7	153.3
	Series RMS $_{(5\text{-}95\%)}$	190.8	169.0	162.8	146.9	154.4	190.0	167.9	162.1	146.1	153.4
	Cumulative $SEL_{Analyzed}$	196.4	175.8	169.3	161.1	162.1	195.6	174.6	168.6	160.4	161.1
	Cumulative SEL	196.4	175.8	169.4	161.2	162.1	195.7	174.7	168.7	160.5	161.2
	Peak $Strikes_{Maximum}$	207.4	187.0	177.4	167.9	171.3	207.4	187.0	177.4	167.9	171.3
	Peak $Strikes_{Mean}$	206.1	185.5	175.0	165.5	167.4	206.1	185.5	175.0	165.5	167.4
	Peak $Strikes_{1\sigma}$	1.5	1.5	1.3	0.9	1.0	1.5	1.5	1.3	0.9	1.0
	Maximum $Overpressure_{Mean}$	15097.4	1916.8	526.7	188.1	234.5	14415.9	1717.1	500.6	187.9	227.0
	Maximum $Overpressure_{1\sigma}$	2298.4	270.1	54.4	20.0	24.4	2394.2	247.9	55.6	17.5	29.1
	Maximum $Underpressure_{Mean}$	-20371.0	-1170.3	-543.6	-156.5	-203.4	-20058.0	-994.7	-537.0	-150.0	-196.1
	Maximum $Underpressure_{1\sigma}$	2920.5	132.0	92.0	15.0	27.6	2989.2	101.9	99.6	15.5	27.7
	RMS $_{(0\text{-}90\%)\ Maximum}$	192.3	170.8	164.0	153.8	155.3	191.6	169.7	163.3	153.1	154.4
	RMS $_{(5\text{-}95\%)\ Maximum}$	192.6	170.1	164.0	150.1	155.7	191.9	169.2	163.3	149.4	154.8
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	192.2	170.8	164.0	153.6	154.1	191.4	169.6	163.3	152.9	153.3
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	191.2	170.0	164.0	147.3	154.0	190.5	169.1	163.3	146.5	153.2
	RMS $_{(0\text{-}90\%)\ Mean}$	191.1	169.7	162.5	152.5	154.2	190.3	168.4	161.8	151.8	153.2
	RMS $_{(5\text{-}95\%)\ Mean}$	190.8	168.9	162.7	146.9	154.4	190.0	167.8	162.0	146.1	153.4
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	1.3	1.3	1.2	0.8	0.9	1.4	1.5	1.2	0.9	0.9
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	1.5	1.2	1.2	0.8	1.0	1.5	1.4	1.2	0.7	1.1
	$SEL_{Maximum}$	176.4	155.7	149.2	141.0	141.9	175.7	154.6	148.6	140.3	141.0
	$SEL_{Peak\ Strike}$	176.3	155.6	149.2	140.7	140.7	175.5	154.5	148.5	140.0	140.0
	SEL_{Mean}	175.5	154.8	148.4	140.2	141.2	174.7	153.7	147.7	139.5	140.2
	$SEL_{1\sigma}$	0.9	0.9	1.0	0.8	0.8	1.0	1.1	1.0	0.8	0.8
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.0	13.9	14.4	13.1	14.9	11.0	13.9	14.4	13.6	13.7
	Time to $Peak_{Mean}$	11.3	14.0	17.5	18.7	17.6	11.3	14.0	18.3	20.6	16.1
	Time to $Peak_{1\sigma}$	1.6	0.4	2.3	2.7	1.7	1.3	0.4	2.1	2.9	1.3
	Strike Time $_{(0\text{-}90\%)\ Mean}$	27.7	32.9	38.8	59.2	49.8	27.8	33.5	39.4	60.9	50.4
	Strike Time $_{(5\text{-}95\%)\ Mean}$	30.0	36.8	36.4	224.7	48.0	30.2	37.5	36.8	227.9	49.1
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	3.2	3.9	3.3	10.3	2.7	3.3	4.1	3.3	11.9	2.7
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	4.9	3.2	2.5	35.4	4.4	4.9	3.6	2.4	34.4	4.6
Threshold	Pct Exceeding 206dB Peak	81%	0%	0%	0%	0%	81%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	100%	1%	98%	100%	100%	100%	0%	98%
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	100%	98%	98%	100%	100%	100%	96%	98%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		15.3	19.2	21.1	20.5		15.3	19.2	21.1	20.5
	Cumulative SEL		15.4	16.7	18.4	18.2		16.2	17.1	18.7	18.7
	Series RMS $_{(0\text{-}90\%)}$		15.9	17.6	20.1	19.5		16.9	18.1	20.5	20.1
	Series RMS $_{(5\text{-}95\%)}$		16.3	17.3	22.9	19.3		17.1	17.8	23.3	19.8

Strike Series Analysis: Pile A-2, Air Off, February 17, 2011 13:20 (pg 1 of 3)

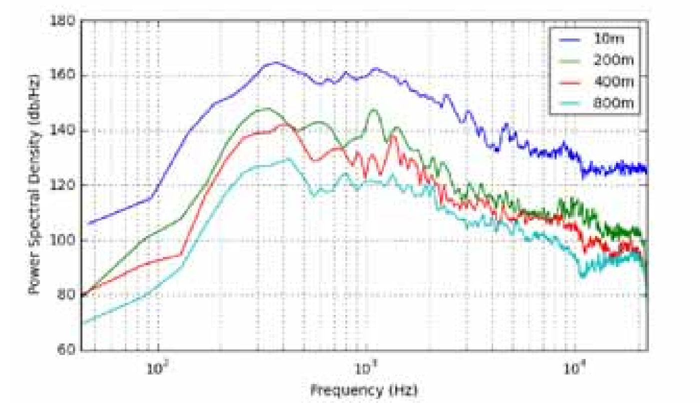
Time Series of Strikes at 10 meters



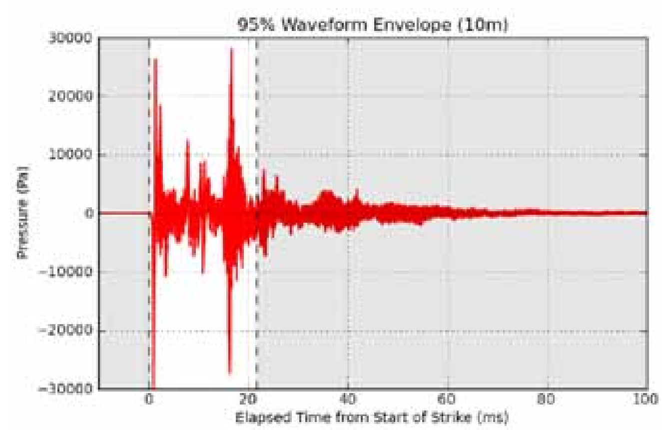
Pile A-2, 24" diameter

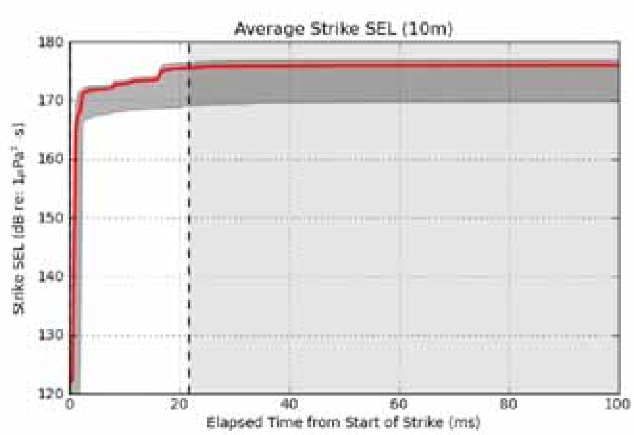
Date: February 17, 2011 Time: 13:20

Attenuation: Restrike
Number of Strikes: 19
Number of Strikes Analyzed: 19
Air: Off



Spectral Density



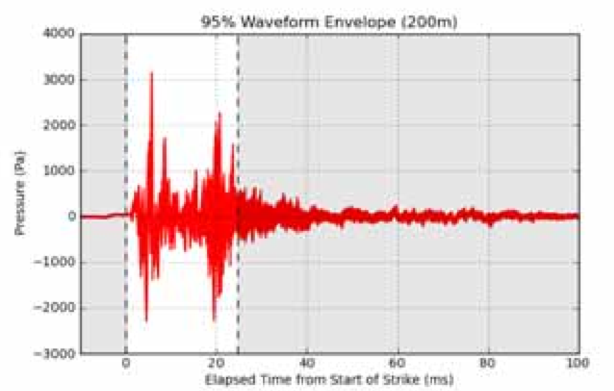


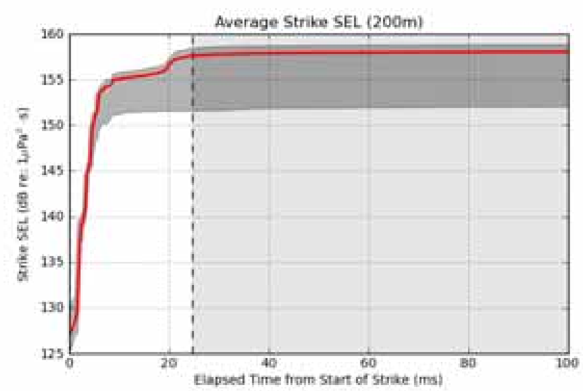
ST1400 – 10 meters

Strike Series Analysis: Pile A-2, Air Off, February 17, 2011 13:20 (pg 2 of 3)

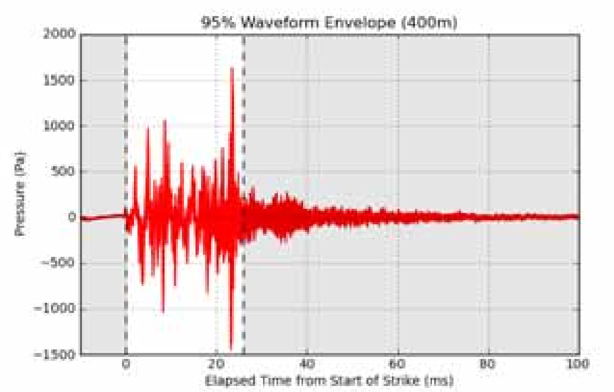
Waveforms | **SELs**

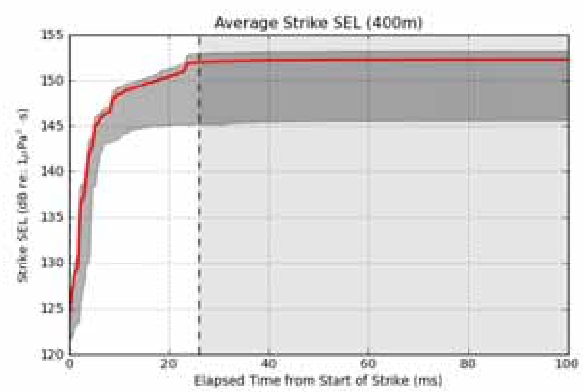
COHO – 200 meter s



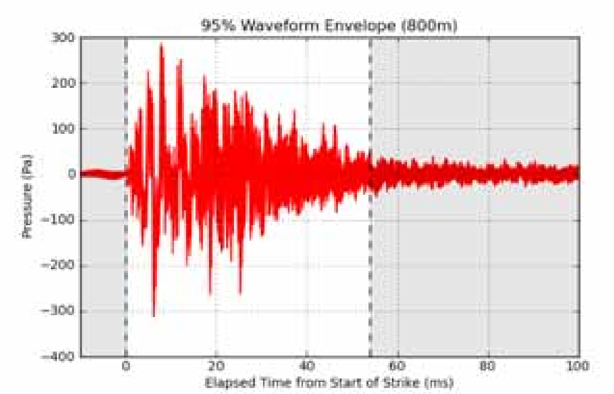


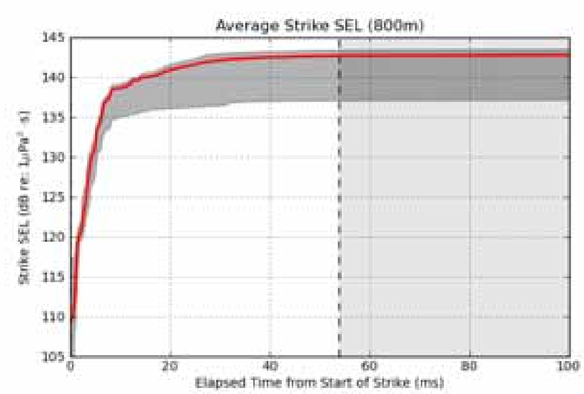
SOCKEYE – 400 meters



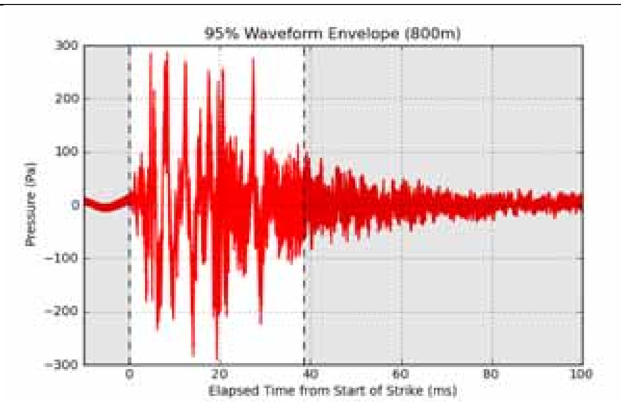


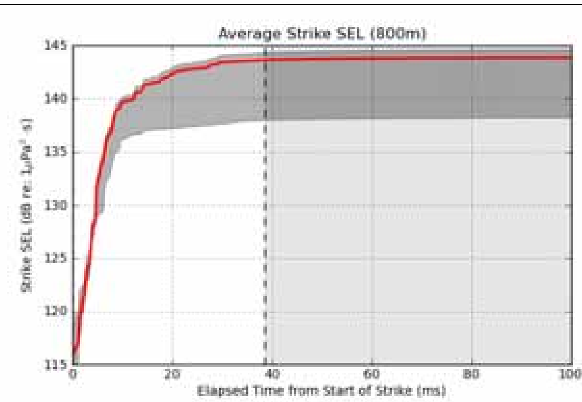
SUPERCUBE – 800 meters





KOKANEE – 800 meters



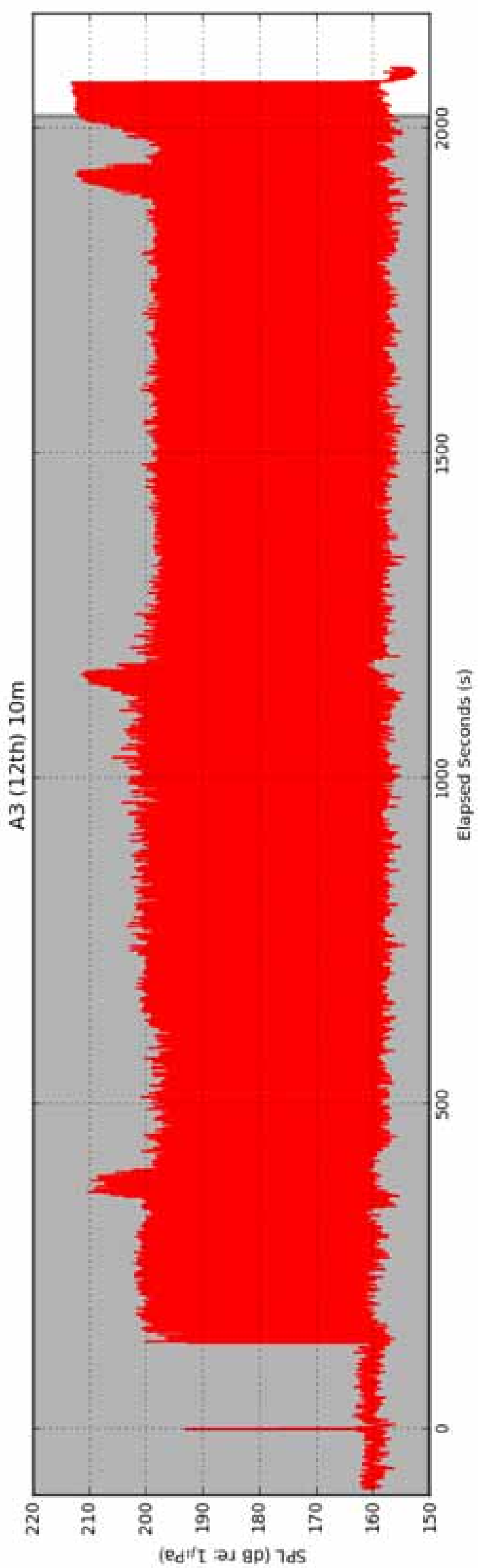


Strike Series Analysis: Pile A-2, Air Off, February 17, 2011 13:20 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	213	411	815	780	10	213	411	815	780
	Number of Strikes: Total	19	19	19	19	19	19	19	19	19	19
	Number of Strikes: Analyzed	19	19	19	19	19	19	19	19	19	19
	Series RMS $_{(0\text{-}90\%)}$	190.7	172.4	166.6	154.8	156.9	190.2	171.9	166.1	154.0	155.4
	Series RMS $_{(5\text{-}95\%)}$	191.2	173.0	167.0	149.1	156.6	190.6	172.6	166.6	148.4	155.0
	Cumulative $SEL_{Analyzed}$	188.5	170.6	164.9	155.6	156.5	188.0	170.1	164.5	155.0	155.1
	Cumulative SEL	191.2	173.0	167.0	149.1	156.6	188.0	170.1	164.5	155.0	155.1
	Peak $Strikes_{Maximum}$	207.1	186.7	182.4	168.9	169.0	207.1	186.7	182.4	168.9	169.0
	Peak $Strikes_{Mean}$	206.2	185.6	181.0	167.7	167.8	206.2	185.6	181.0	167.7	167.8
	Peak $Strikes_{1\sigma}$	1.3	1.1	2.2	1.1	0.8	1.3	1.1	2.2	1.1	0.8
	Maximum $Overpressure_{Mean}$	17516.1	1903.5	1143.3	232.5	239.3	16966.4	1861.6	1095.9	213.9	228.1
	Maximum $Overpressure_{1\sigma}$	3464.4	233.5	207.1	30.9	22.1	3430.7	214.4	207.9	27.9	25.5
	Maximum $Underpressure_{Mean}$	-20576.8	-1483.8	-1016.3	-235.1	-232.0	-20371.1	-1386.0	-1039.4	-206.8	-185.0
	Maximum $Underpressure_{1\sigma}$	2374.8	107.1	190.3	25.8	20.8	2361.2	115.0	204.5	26.8	17.2
	RMS $_{(0\text{-}90\%)\ Maximum}$	191.7	173.1	167.5	155.7	157.3	191.3	172.7	167.1	155.1	155.9
	RMS $_{(5\text{-}95\%)\ Maximum}$	192.8	174.3	168.2	149.7	157.2	192.3	173.9	167.8	149.1	155.7
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	191.4	171.7	167.4	154.9	157.3	190.9	171.0	167.1	154.3	155.9
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	192.6	172.9	167.9	149.3	156.8	192.1	172.3	167.5	148.7	155.2
	RMS $_{(0\text{-}90\%)\ Mean}$	190.5	172.2	166.4	154.6	156.7	190.0	171.6	165.9	153.8	155.2
	RMS $_{(5\text{-}95\%)\ Mean}$	191.1	172.9	166.8	149.0	156.5	190.5	172.4	166.4	148.2	154.8
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	1.8	1.4	1.9	1.1	1.3	2.0	1.6	2.0	1.2	1.4
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	1.9	1.7	1.8	1.1	1.3	2.1	1.8	1.9	1.3	1.4
	$SEL_{Maximum}$	176.4	158.4	152.8	143.4	144.3	175.9	158.0	152.4	142.8	142.9
	$SEL_{Peak\ Strike}$	176.1	157.0	152.7	143.1	144.0	175.7	156.2	152.4	142.5	142.6
	SEL_{Mean}	175.5	157.6	151.9	142.7	143.6	175.0	157.1	151.5	142.0	142.1
	$SEL_{1\sigma}$	1.5	1.5	1.6	1.4	1.4	1.7	1.6	1.8	1.5	1.4
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.1	15.2	18.8	16.2	14.7	11.1	15.2	18.8	16.2	14.6
	Time to $Peak_{Mean}$	19.9	15.7	32.1	18.4	20.6	22.4	16.5	32.1	19.8	15.9
	Time to $Peak_{1\sigma}$	7.4	0.1	4.4	5.4	5.3	6.7	3.1	4.4	6.1	3.7
	Strike Time $_{(0\text{-}90\%)\ Mean}$	31.6	34.6	35.9	63.9	48.5	31.8	34.9	36.1	66.1	49.2
	Strike Time $_{(5\text{-}95\%)\ Mean}$	28.4	28.9	31.1	238.7	52.1	28.5	29.0	31.3	241.7	53.4
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	2.9	1.1	2.9	6.0	1.5	2.9	1.0	2.9	6.9	1.3
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	5.0	3.1	2.3	14.8	1.0	5.0	3.2	2.3	10.7	0.7
Threshold	Pct Exceeding 206dB Peak	89%	0%	0%	0%	0%	89%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	100%	0%	100%	100%	100%	100%	0%	95%
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	100%	100%	100%	100%	100%	100%	95%	95%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		15.5	15.7	20.2	20.3		15.5	15.7	20.2	20.3
	Cumulative SEL		13.5	14.6	17.2	16.9		13.9	14.9	17.5	17.7
	Series RMS $_{(0\text{-}90\%)}$		13.8	14.9	18.8	17.9		14.2	15.2	19.2	18.7
	Series RMS $_{(5\text{-}95\%)}$		13.7	15.0	22.0	18.3		14.0	15.3	22.4	19.1

Strike Series Analysis: Pile A-3, Air Off, February 12, 2011 16:40 (pg 1 of 3)

Time Series of Strikes at 10 meters

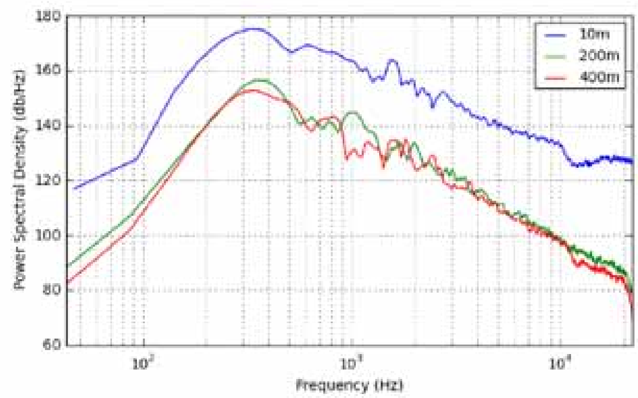


Pile A-3, 48" diameter

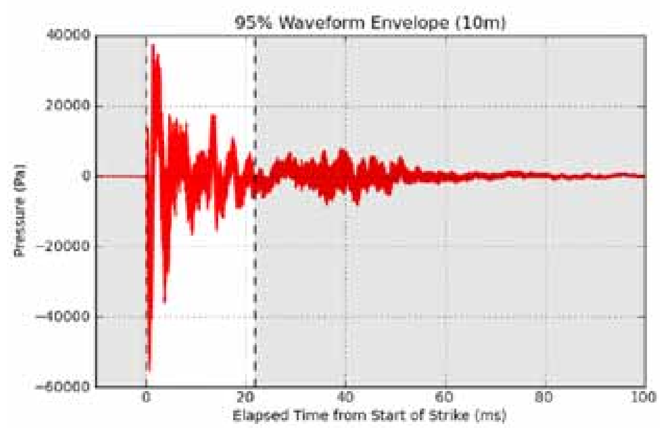
Date: February 12, 2011 Time: 16:40

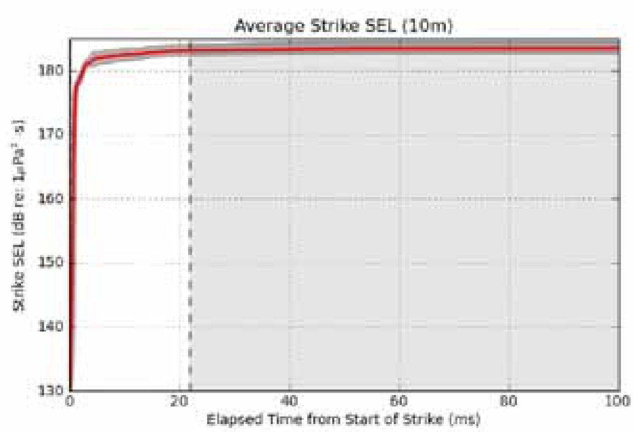
Attenuation: Unconfined Bubble Curtain
Number of Strikes: 1242
Number of Strikes Analyzed: 33
Air: Off

Spectral Density



ST1400 – 10 meters





Strike Series Analysis: Pile A-3, Air Off, February 12, 2011 16:40 (pg 2 of 3)

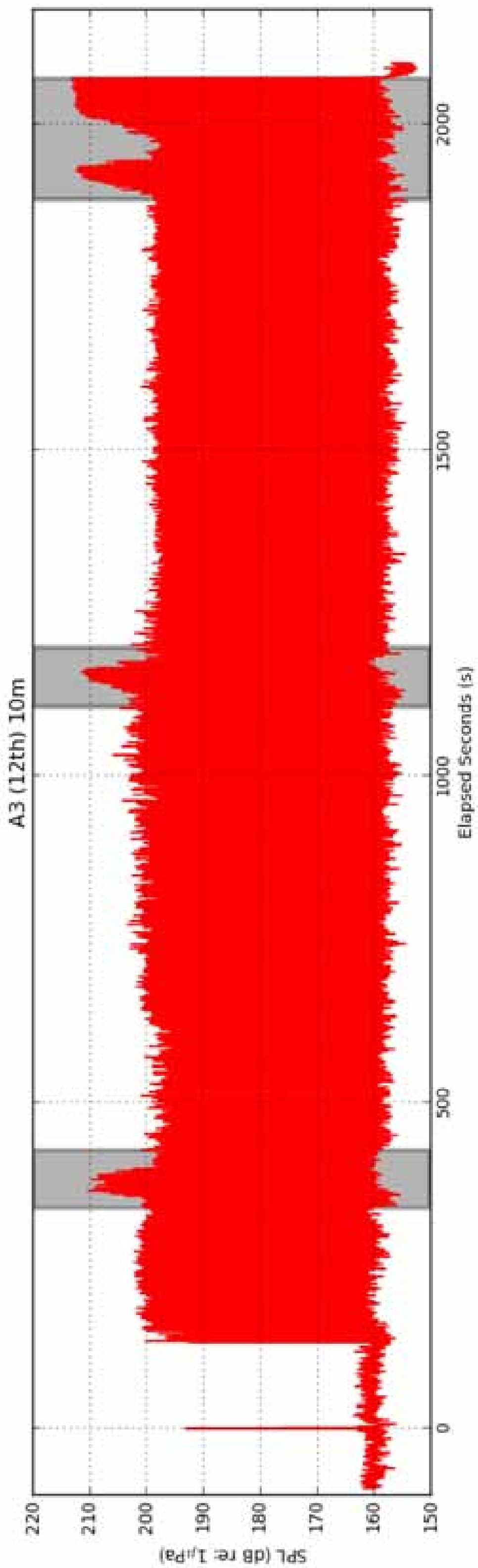
Waveforms	SELs	
No data	No data	COHO – 200 meter s
No data	No data	SOCKEYE – 400 meters
No data	No data	SUPERCUBE – 800 meters
No data	No data	KOKANEE – 800 meters

Strike Series Analysis: Pile A-3, Air Off, February 12, 2011 16:40 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10					10				
	Number of Strikes: Total	1242					1242				
	Number of Strikes: Analyzed	33					33				
	Series RMS $_{(0-90\%)}$	198.1					196.0				
	Series RMS $_{(5-95\%)}$	197.5					195.4				
	Cumulative $SEL_{Analyzed}$	198.3					196.4				
	Cumulative SEL	214.0					212.1				
	Peak $Strikes_{Maximum}$	213.2	No Data	No Data	No Data	No Data	213.2	No Data	No Data	No Data	No Data
	Peak $Strikes_{Mean}$	212.3					212.3				
	Peak $Strikes_{1\sigma}$	0.4					0.4				
	Maximum $Overpressure_{Mean}$	27751.1					18326.4				
	Maximum $Overpressure_{1\sigma}$	1832.1					2074.9				
	Maximum $Underpressure_{Mean}$	-41482.1					-37632.6				
	Maximum $Underpressure_{1\sigma}$	2081.3					2305.3				
	RMS $_{(0-90\%)\ Maximum}$	199.5					197.6				
	RMS $_{(5-95\%)\ Maximum}$	198.9					197.1				
	RMS $_{(0-90\%)\ Peak\ Strike}$	198.2					196.5				
	RMS $_{(5-95\%)\ Peak\ Strike}$	198.9					197.1				
	RMS $_{(0-90\%)\ Mean}$	198.1					196.0				
	RMS $_{(5-95\%)\ Mean}$	197.5					195.3				
	RMS $_{(0-90\%)\ 1\sigma}$	0.6					0.8				
	RMS $_{(5-95\%)\ 1\sigma}$	0.5					0.6				
	$SEL_{Maximum}$	184.2					182.6				
	$SEL_{Peak\ Strike}$	184.2					182.6				
	SEL_{Mean}	183.1					181.1				
	$SEL_{1\sigma}$	0.4					0.5				
Time Strike Series Statistics	Time to $Peak_{Minimum}$	10.6					10.6				
	Time to $Peak_{Mean}$	10.9					10.9				
	Time to $Peak_{1\sigma}$	0.2					0.2				
	Strike Time $_{(0-90\%)\ Mean}$	31.4					32.7				
	Strike Time $_{(5-95\%)\ Mean}$	38.3					38.8				
	Strike Time $_{(0-90\%)\ 1\sigma}$	3.6					4.2				
	Strike Time $_{(5-95\%)\ 1\sigma}$	1.5					1.4				
Threshold	Pct Exceeding 206dB Peak	100%					100%				
	Pct Exceeding 187dB SEL	0%					0%				
	Pct Exceeding 183dB SEL	76%					0%				
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%					100%				
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%					100%				
Transmission Loss Coefficients	Peak $Strike_{Mean}$										
	Cumulative SEL										
	Series RMS $_{(0-90\%)}$										
	Series RMS $_{(5-95\%)}$										

Strike Series Analysis: Pile A-3, Air On, February 12, 2011 16:40 (pg 1 of 3)

Time Series of Strikes at 10 meters

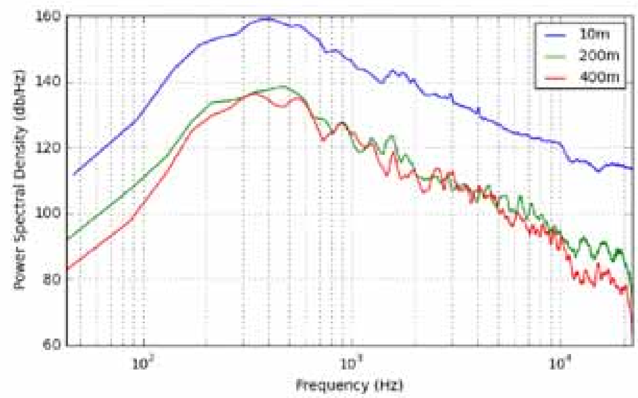


Pile A-3, 48" diameter

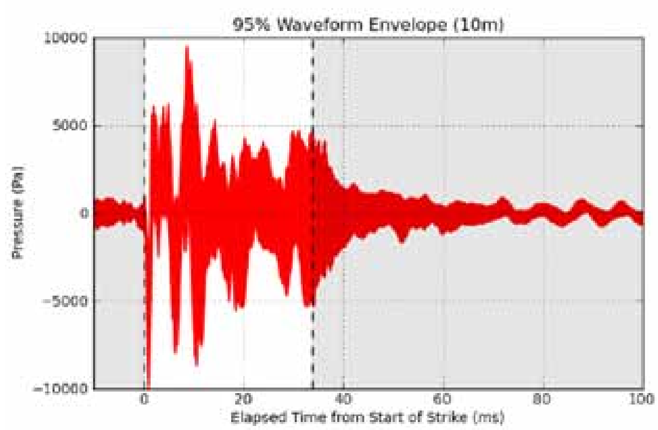
Date: February 12, 2011   Time: 16:40

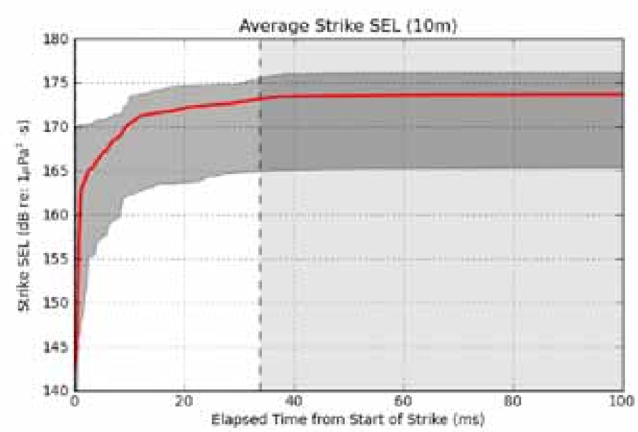
Attenuation: Unconfined Bubble Curtain
Number of Strikes: 1242
Number of Strikes Analyzed: 1006
Air: On

Spectral Density

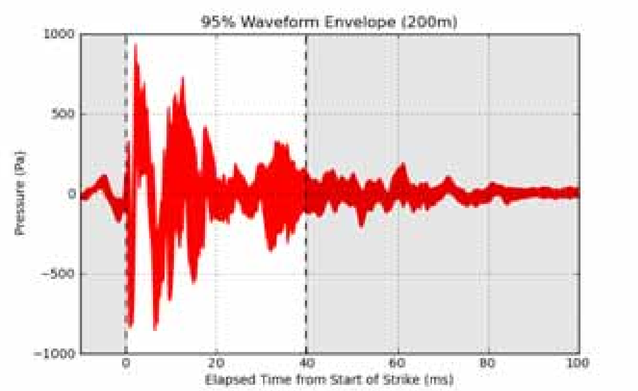
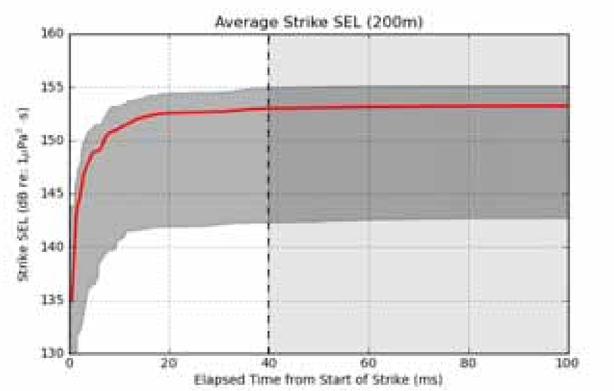
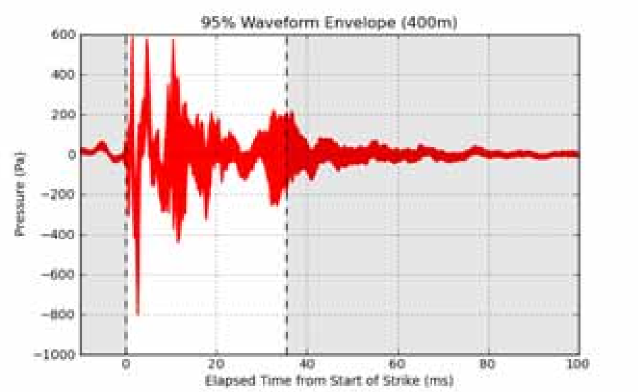
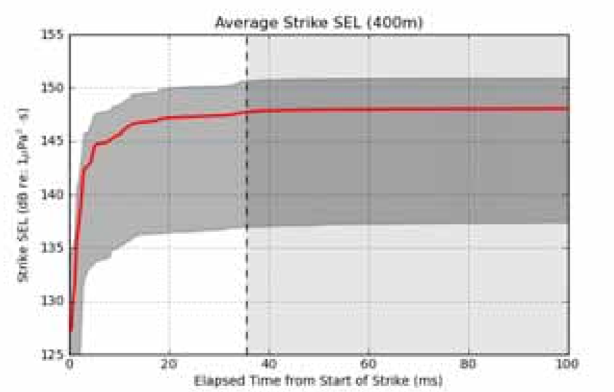


ST1400 – 10 meters





Strike Series Analysis: Pile A-3, Air On, February 12, 2011 16:40 (pg 2 of 3)

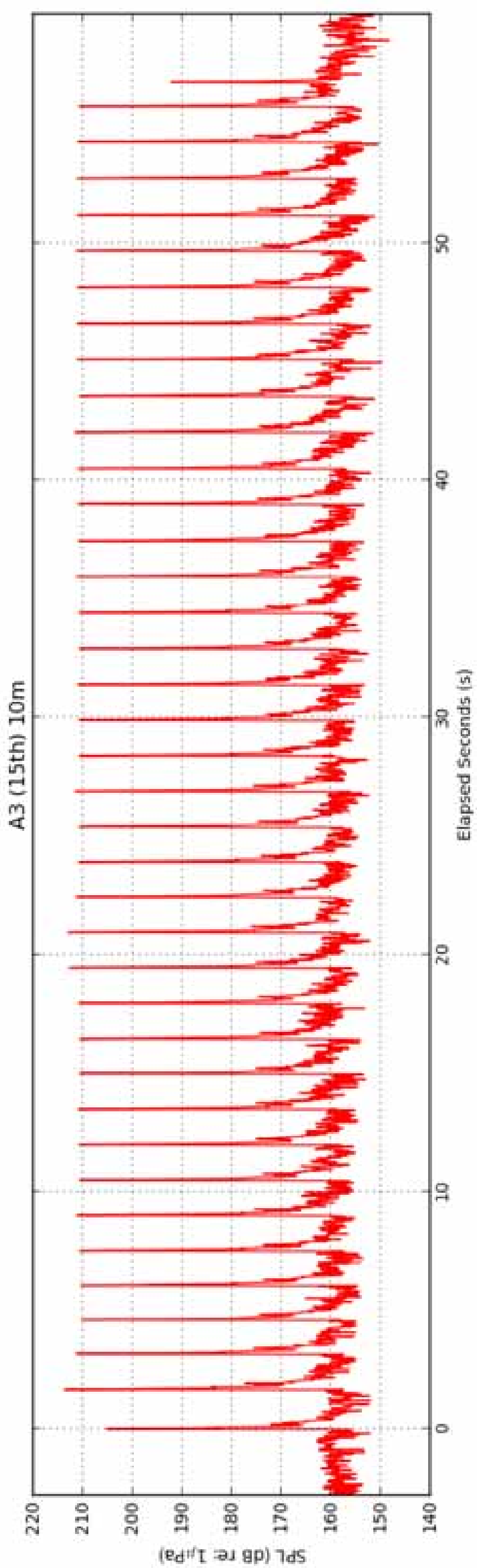
Waveforms	SELs	
		**COHO – 200 meter s**
		**SOCKEYE – 400 meters**
No data	No data	**SUPERCUBE – 800 meters**
No data	No data	**KOKANEE – 800 meters**

Strike Series Analysis: Pile A-3, Air On, February 12, 2011 16:40 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	214	513			10	231	430		
	Number of Strikes: Total	1242	1242	1242			1242	1242	1242		
	Number of Strikes: Analyzed	1006	1006	1006			1006	1006	1006		
	Series RMS $_{(0-90\%)}$	187.0	166.2	161.4			174.0	150.2	148.8		
	Series RMS $_{(5-95\%)}$	187.8	164.8	160.2			174.2	145.7	145.4		
	Cumulative SEL$_{Analyzed}$	203.5	183.1	178.0			184.4	161.6	162.7		
	Cumulative SEL	204.4	184.1	178.9			185.3	162.5	163.6		
	Peak Strikes$_{Maximum}$	205.7	179.9	176.9	No Data	No Data	195.4	169.6	169.0	No Data	No Data
	Peak Strikes$_{Mean}$	199.1	177.1	173.6			189.5	165.6	166.2		
	Peak Strikes$_{1\sigma}$	1.7	1.2	1.5			1.9	1.4	0.8		
	Maximum Overpressure$_{Mean}$	7067.1	675.1	439.3			2488.3	134.8	159.6		
	Maximum Overpressure$_{1\sigma}$	1972.4	88.5	71.7			696.8	22.5	25.9		
	Maximum Underpressure$_{Mean}$	-8702.9	-708.2	-479.0			-2344.8	-151.1	-171.9		
	Maximum Underpressure$_{1\sigma}$	1993.0	102.4	73.9			799.0	34.2	25.4		
	RMS $_{(0-90\%)\ Maximum}$	189.1	168.8	164.1			177.2	153.3	154.5		
	RMS $_{(5-95\%)\ Maximum}$	190.8	168.7	164.8			178.2	153.0	152.4		
	RMS $_{(0-90\%)\ Peak\ Strike}$	186.6	166.8	163.7			175.5	153.3	148.4		
	RMS $_{(5-95\%)\ Peak\ Strike}$	185.6	167.2	164.4			175.9	153.0	146.1		
	RMS $_{(0-90\%)\ Mean}$	186.9	166.1	161.2			173.9	150.2	149.5		
	RMS $_{(5-95\%)\ Mean}$	187.7	165.1	160.7			174.3	145.9	145.3		
	RMS $_{(0-90\%)\ 1\sigma}$	0.9	1.4	1.6			3.0	2.0	3.5		
	RMS $_{(5-95\%)\ 1\sigma}$	1.1	2.3	2.9			3.5	2.7	1.5		
	SEL$_{Maximum}$	175.7	154.9	150.6			163.9	139.9	140.8		
	SEL$_{Peak\ Strike}$	169.7	153.7	150.1			162.0	139.9	139.7		
	SEL$_{Mean}$	173.3	153.0	147.8			160.2	137.6	138.8		
	SEL$_{1\sigma}$	1.2	1.2	1.5			2.2	1.2	1.0		
Time Strike Series Statistics	Time to Peak$_{Minimum}$	10.7	10.8	11.4			12.5	10.9	11.2		
	Time to Peak$_{Mean}$	23.7	16.3	14.8			25.0	18.0	15.6		
	Time to Peak$_{1\sigma}$	13.5	4.4	6.2			19.9	7.7	7.3		
	Strike Time $_{(0-90\%)\ Mean}$	43.8	49.4	45.5			45.9	57.8	102.9		
	Strike Time $_{(5-95\%)\ Mean}$	36.6	67.5	60.9			43.5	163.3	222.8		
	Strike Time $_{(0-90\%)\ 1\sigma}$	5.3	6.6	4.2			34.4	18.9	66.4		
	Strike Time $_{(5-95\%)\ 1\sigma}$	4.2	37.5	46.9			46.0	56.6	27.8		
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%			0%	0%	0%		
	Pct Exceeding 187dB SEL	0%	0%	0%			0%	0%	0%		
	Pct Exceeding 183dB SEL	0%	0%	0%			0%	0%	0%		
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%			100%	10%	1%		
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%			100%	58%	51%		
Transmission Loss Coefficients	Peak Strike$_{Mean}$		16.5	14.9				24.6	20.1		
	Cumulative SEL		15.3	14.9				30.7	25.0		
	Series RMS $_{(0-90\%)}$		15.7	15.0				27.0	23.4		
	Series RMS $_{(5-95\%)}$		17.2	16.1				30.9	25.9		

Strike Series Analysis: Pile A-3, Air Off, February 15, 2011 8:41 (pg 1 of 3)

Time Series of Strikes at 10 meters

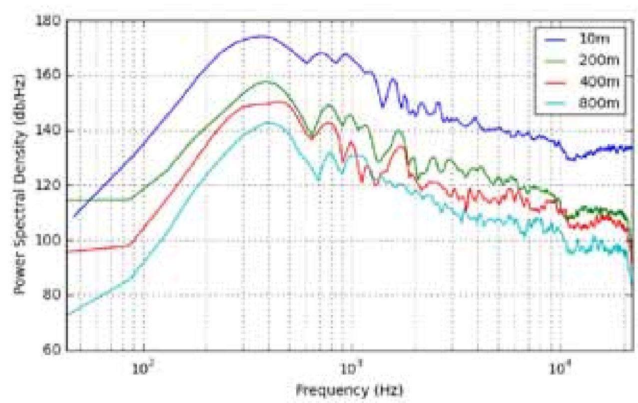


Pile A-3, 48" diameter

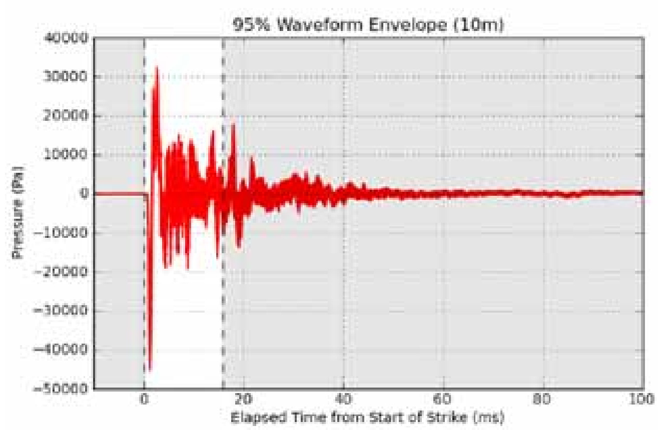
Date: February 15, 2011 Time: 08:41

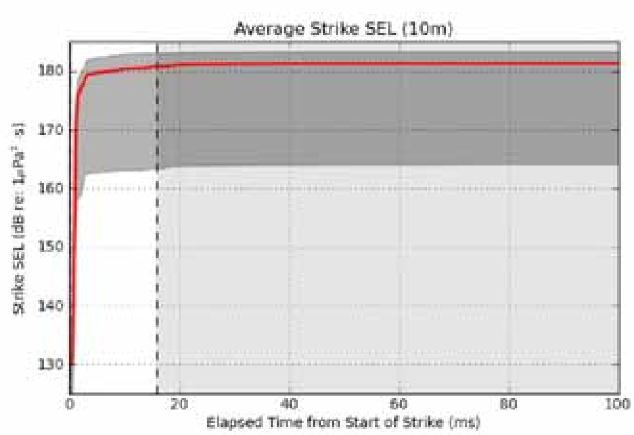
Attenuation: Restrike
Number of Strikes: 41
Number of Strikes Analyzed: 39
Air: Off

Spectral Density



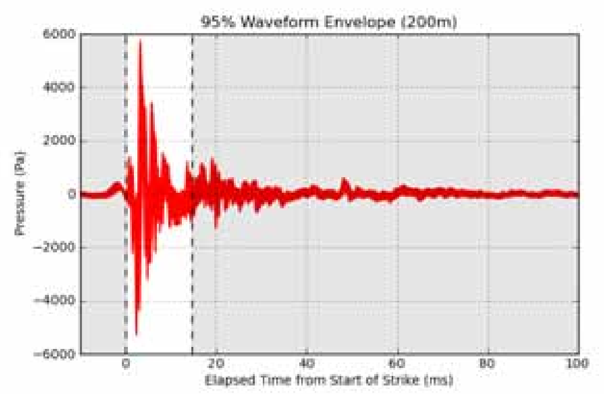
ST1400 – 10 meters

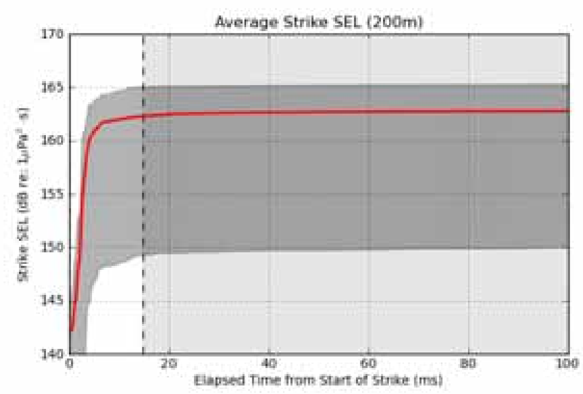




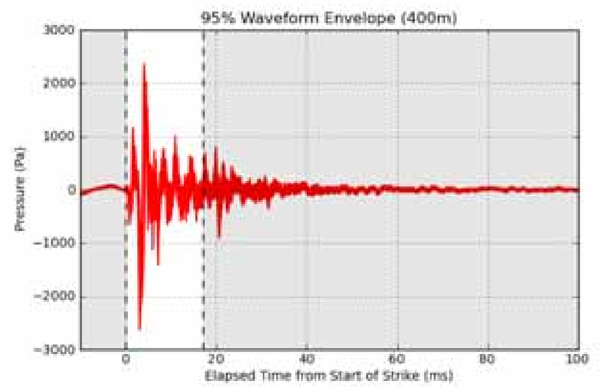
Strike Series Analysis: Pile A-3, Air Off, February 15, 2011 8:41 (pg 2 of 3)

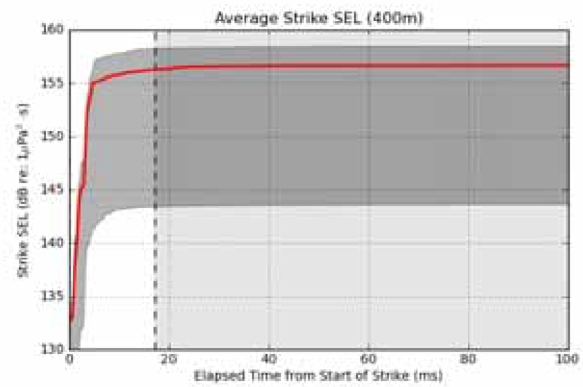
Waveforms	SELs	



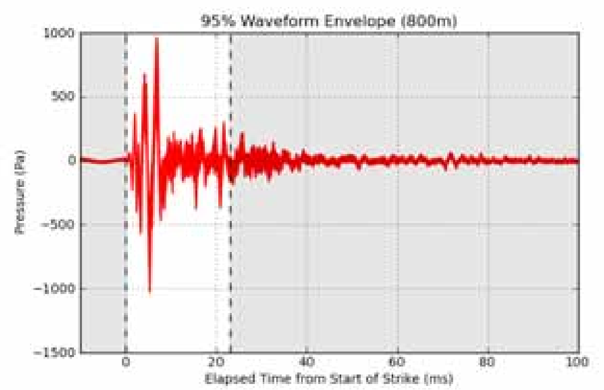


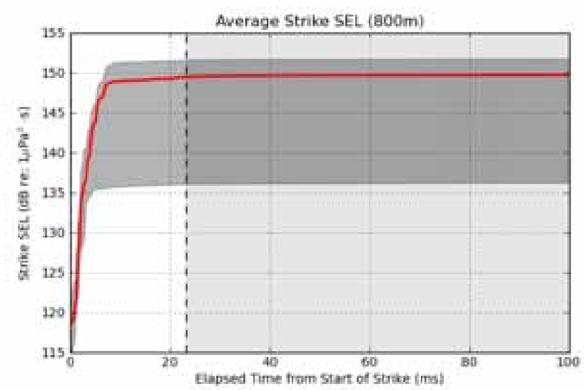
COHO – 200 meter s



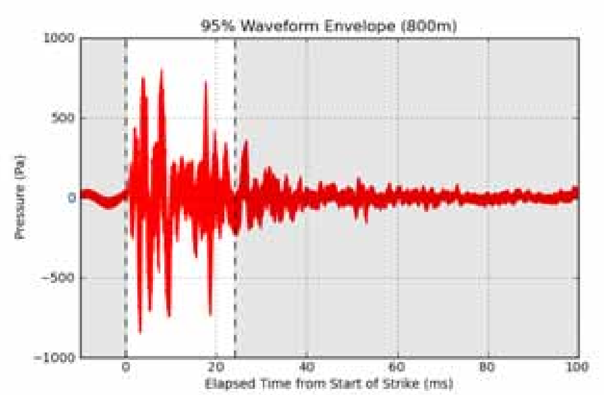


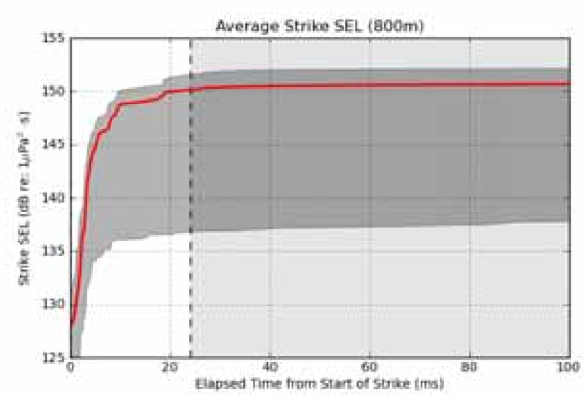
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





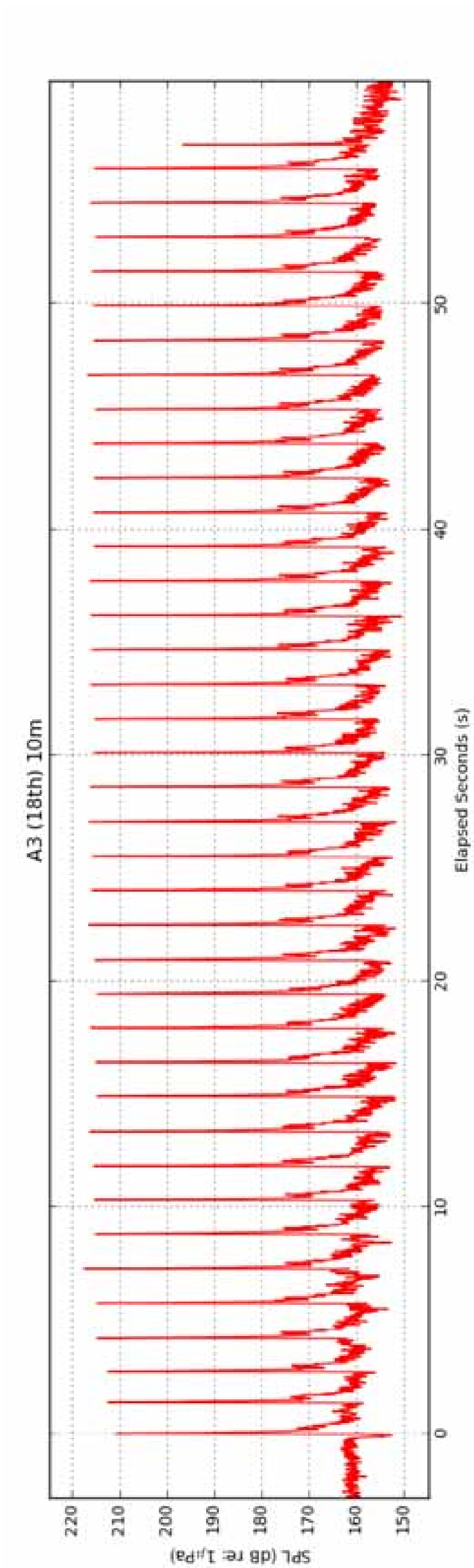
KOKANEE – 800 meters

Strike Series Analysis: Pile A-3, Air Off, February 15, 2011 8:41 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	244	442	860	744	10	244	442	860	744
	Number of Strikes: Total	41	41	41	41	41	41	41	41	41	41
	Number of Strikes: Analyzed	39	39	39	39	39	39	39	39	39	39
	Series RMS $_{(0-90\%)}$	197.1	178.7	172.3	164.6	165.2	195.8	177.6	171.5	163.9	164.0
	Series RMS $_{(5-95\%)}$	198.6	180.2	173.8	161.4	165.6	197.1	179.0	172.9	160.3	164.3
	Cumulative $SEL_{Analyzed}$	197.1	178.5	172.6	165.8	166.5	195.9	177.5	171.7	165.1	165.3
	Cumulative SEL	197.4	178.7	172.8	166.0	166.7	196.1	177.7	172.0	165.3	165.5
	Peak $Strikes_{Maximum}$	213.5	194.2	187.4	179.3	176.6	213.5	194.2	187.4	179.3	176.6
	Peak $Strikes_{Mean}$	210.3	190.8	184.8	177.5	175.5	210.3	190.8	184.8	177.5	175.5
	Peak $Strikes_{1\sigma}$	3.2	2.7	2.4	2.2	1.9	3.2	2.7	2.4	2.2	1.9
	Maximum $Overpressure_{Mean}$	25277.2	3040.1	1614.6	712.4	602.7	18083.3	2659.8	1424.9	613.7	534.4
	Maximum $Overpressure_{1\sigma}$	3865.6	510.0	272.1	115.5	82.7	2726.4	429.4	237.3	96.0	82.1
	Maximum $Underpressure_{Mean}$	-33927.4	-3578.3	-1769.6	-763.1	-527.7	-30735.7	-3144.0	-1535.5	-697.0	-558.9
	Maximum $Underpressure_{1\sigma}$	6543.8	696.7	316.7	132.3	63.8	5896.4	617.3	270.3	121.5	77.4
	RMS $_{(0-90\%)\ Maximum}$	199.8	181.7	174.5	166.6	166.2	198.4	180.8	173.5	165.8	165.2
	RMS $_{(5-95\%)\ Maximum}$	201.5	183.7	175.8	162.8	167.0	199.9	182.1	174.6	161.4	165.9
	RMS $_{(0-90\%)\ Peak\ Strike}$	199.8	181.7	174.5	166.6	165.2	198.4	180.8	173.5	165.8	163.8
	RMS $_{(5-95\%)\ Peak\ Strike}$	201.5	183.7	175.8	161.7	164.0	199.9	182.1	174.6	160.1	162.6
	RMS $_{(0-90\%)\ Mean}$	196.7	178.4	172.0	164.3	164.8	195.5	177.3	171.2	163.5	163.6
	RMS $_{(5-95\%)\ Mean}$	198.2	179.9	173.5	161.0	165.2	196.8	178.7	172.6	160.0	164.0
	RMS $_{(0-90\%)\ 1\sigma}$	3.0	2.4	2.1	2.4	2.3	3.0	2.4	2.1	2.4	2.4
	RMS $_{(5-95\%)\ 1\sigma}$	2.9	2.3	2.1	2.6	2.6	2.9	2.3	2.0	2.6	2.7
	$SEL_{Maximum}$	182.9	164.5	158.0	151.5	151.7	181.4	163.5	157.1	150.7	150.6
	$SEL_{Peak\ Strike}$	182.8	164.5	158.0	151.5	150.9	181.4	163.5	157.1	150.7	149.5
	SEL_{Mean}	180.8	162.2	156.3	149.5	150.2	179.6	161.2	155.5	148.8	149.0
	$SEL_{1\sigma}$	3.0	2.5	2.5	2.5	2.6	2.9	2.5	2.4	2.5	2.6
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.2	12.4	13.1	11.9	13.2	11.2	12.4	13.1	11.9	13.0
	Time to $Peak_{Mean}$	11.4	12.7	13.4	15.5	17.7	11.4	12.9	13.5	15.4	14.9
	Time to $Peak_{1\sigma}$	0.3	0.4	0.4	0.8	3.9	0.4	0.8	0.4	0.7	4.4
	Strike Time $_{(0-90\%)\ Mean}$	25.8	24.7	27.2	33.1	34.2	26.0	25.0	27.3	33.7	34.1
	Strike Time $_{(5-95\%)\ Mean}$	19.3	17.4	19.7	72.2	32.4	19.7	17.9	20.0	78.2	32.5
	Strike Time $_{(0-90\%)\ 1\sigma}$	3.2	4.9	4.5	3.5	3.0	3.1	5.0	4.4	3.5	3.0
	Strike Time $_{(5-95\%)\ 1\sigma}$	2.6	3.8	2.7	12.0	3.7	2.7	3.8	2.7	14.1	3.8
Threshold	Pct Exceeding 206dB Peak	95%	0%	0%	0%	0%	95%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	97%	100%	100%	100%	100%	97%	100%
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		14.0	15.5	16.9	18.6		14.0	15.5	16.9	18.6
	Cumulative SEL		13.4	14.9	16.2	16.4		14.2	15.4	16.6	17.0
	Series RMS $_{(0-90\%)}$		13.3	15.1	16.8	17.0		14.1	15.6	17.2	17.7
	Series RMS $_{(5-95\%)}$		13.2	15.1	19.2	17.6		14.1	15.6	19.8	18.3

Strike Series Analysis: Pile A-3, Air Off, February 18, 2011 12:48 (pg 1 of 3)

Time Series of Strikes at 10 meters

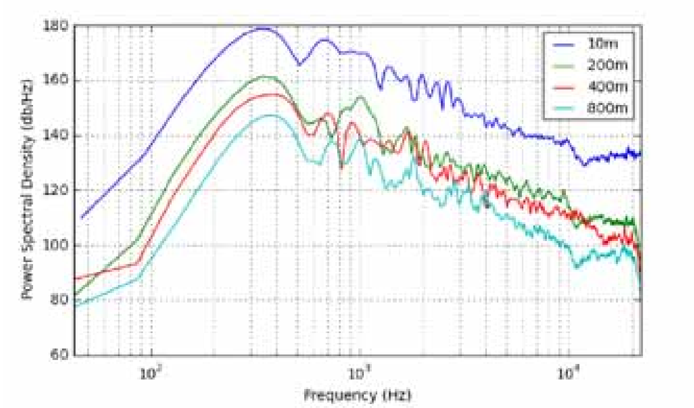


Pile A-3, 48" diameter

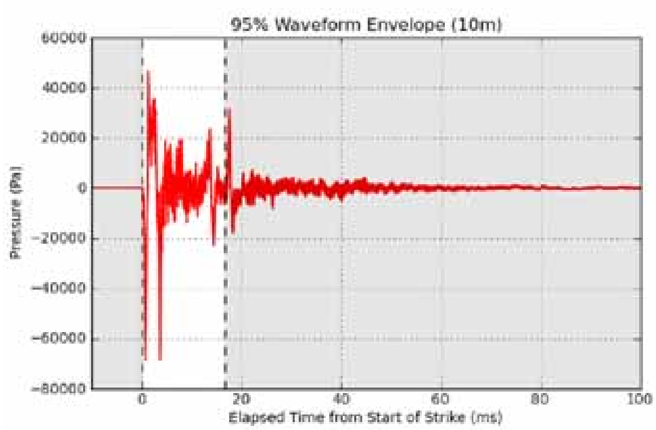
Date: February 18, 2011   Time: 12:48

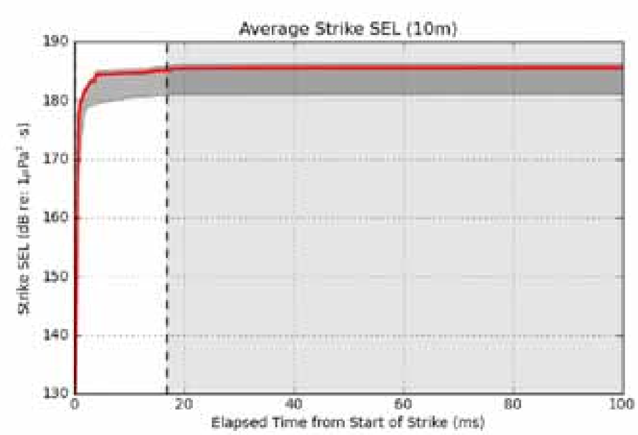
Attenuation: Unattenuated Driving Strikes
Number of Strikes: 39
Number of Strikes Analyzed: 37
Air: Off

Spectral Density



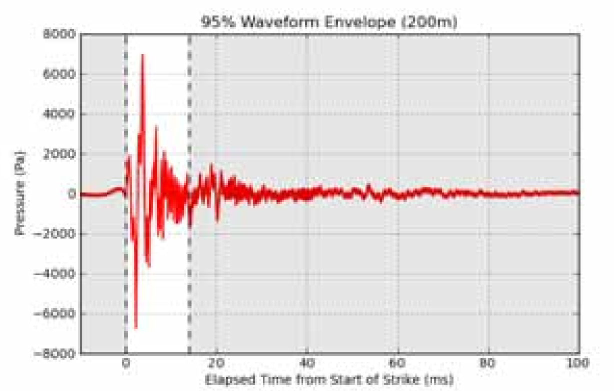
ST1400 – 10 meters

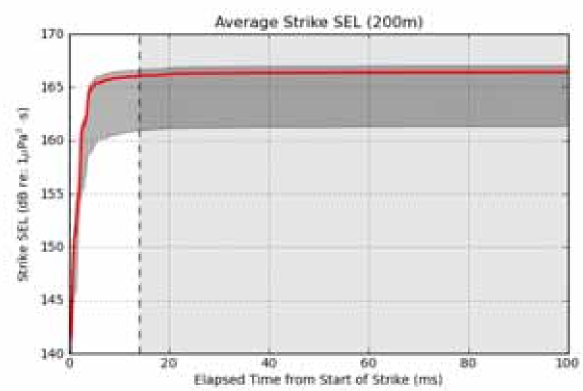




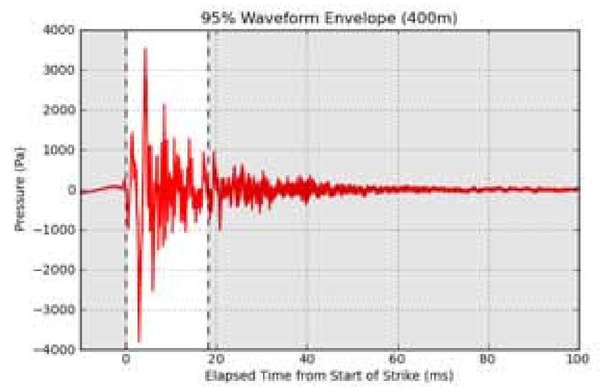
Strike Series Analysis: Pile A-3, Air Off, February 18, 2011 12:48 (pg 2 of 3)

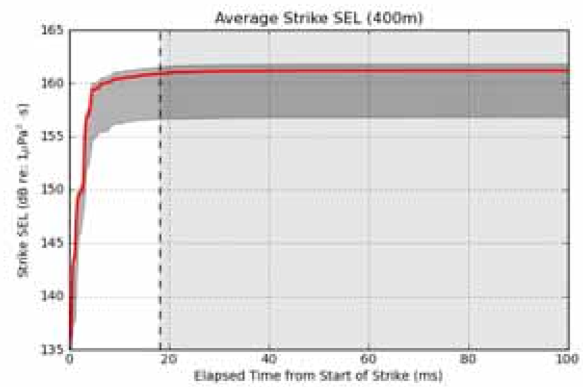
Waveforms	SELs	



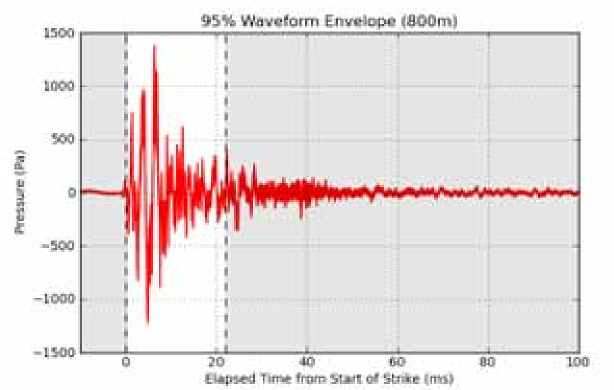


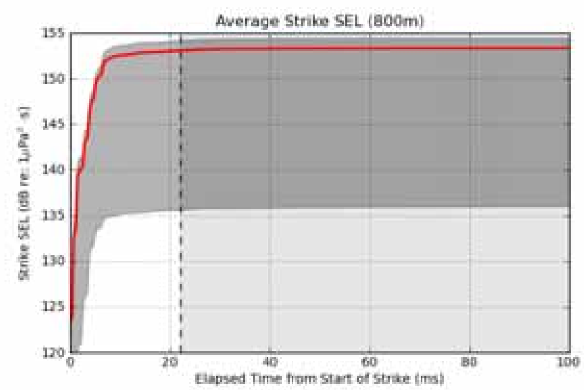
COHO – 200 meter s



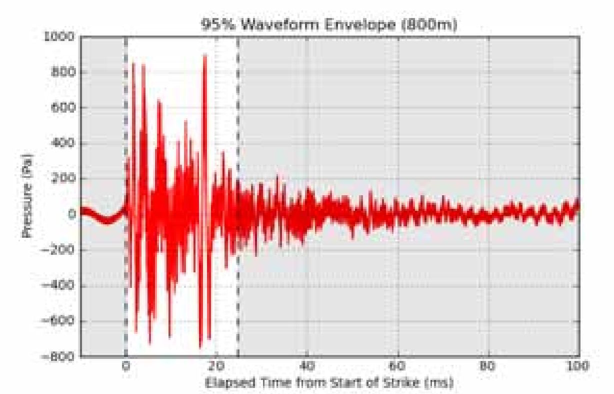


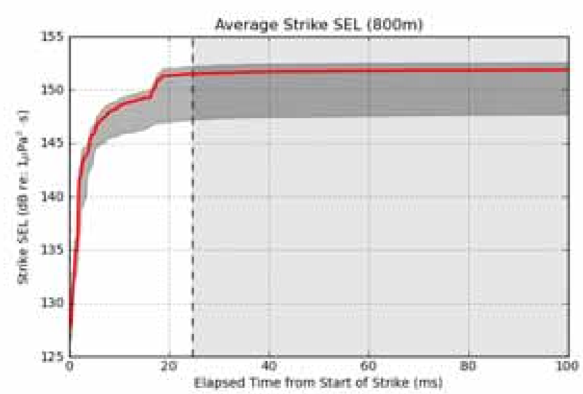
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





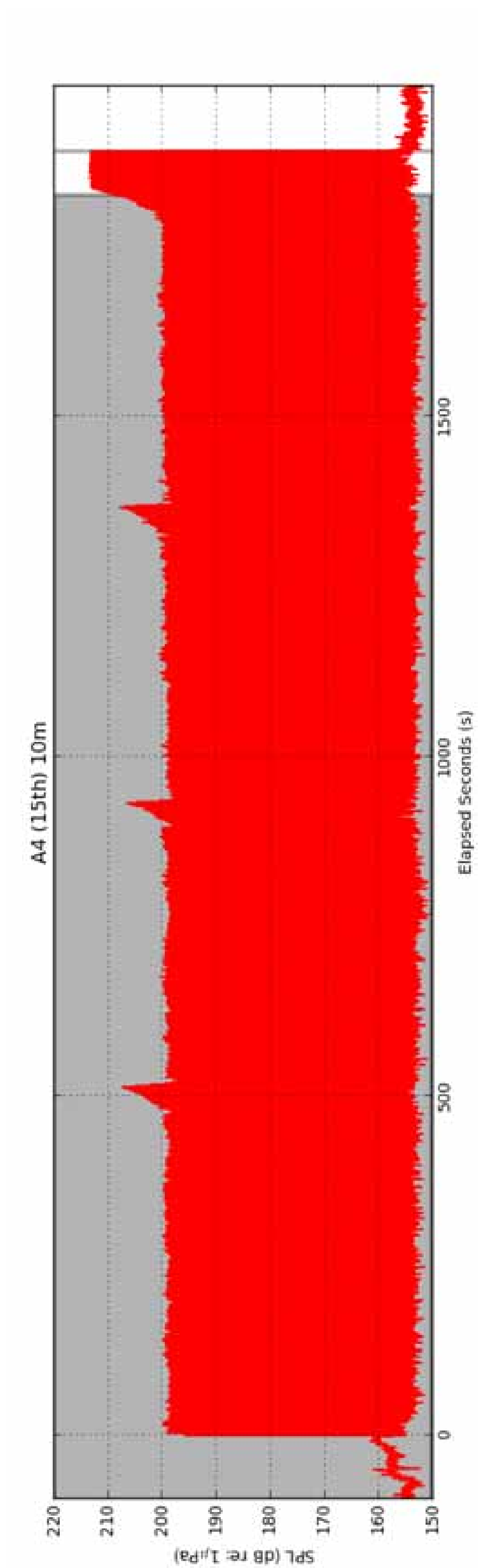
KOKANEE – 800 meters

Strike Series Analysis: Pile A-3, Air Off, February 18, 2011 12:48 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
	Range From Pile	10	240	431	838	757	10	240	431	838	757
	Number of Strikes: Total	39	39	39	39	39	39	39	39	39	39
	Number of Strikes: Analyzed	37	37	37	37	37	37	37	37	37	37
Strike Series Statistics	Series RMS $_{(0-90\%)}$	201.0	182.3	176.5	168.4	166.2	199.7	181.1	175.5	167.6	165.4
	Series RMS $_{(5-95\%)}$	202.9	183.3	177.3	167.8	165.6	201.5	182.0	176.3	166.7	164.8
	Cumulative $SEL_{Analyzed}$	200.9	181.8	176.6	169.2	167.3	199.6	180.7	175.7	168.4	166.5
	Cumulative SEL	191.2	173.0	167.0	149.1	156.6	199.8	180.9	175.9	168.6	166.7
	Peak $Strikes_{Maximum}$	217.4	196.2	190.6	181.7	176.8	217.4	196.2	190.6	181.7	176.8
	Peak $Strikes_{Mean}$	215.2	195.0	189.8	179.9	176.6	215.2	195.0	189.8	179.9	176.6
	Peak $Strikes_{1\sigma}$	1.2	1.2	1.1	2.9	0.2	1.2	1.2	1.1	2.9	0.2
	Maximum $Overpressure_{Mean}$	32538.9	5684.7	2902.6	1024.0	678.6	26947.3	4743.7	2545.0	904.9	672.2
	Maximum $Overpressure_{1\sigma}$	1576.0	640.1	299.5	165.5	17.0	1666.9	529.7	253.1	139.9	22.9
	Maximum $Underpressure_{Mean}$	-57792.6	-5371.4	-3103.5	-934.5	-554.8	-54066.1	-4803.7	-2690.8	-798.2	-563.2
	Maximum $Underpressure_{1\sigma}$	7420.7	651.8	319.5	161.7	9.7	6338.5	564.4	284.7	136.0	26.1
	RMS $_{(0-90\%)\ Maximum}$	201.6	182.9	177.1	169.2	166.8	200.3	181.7	176.1	168.3	166.0
	RMS $_{(5-95\%)\ Maximum}$	203.5	183.8	178.3	169.6	166.6	202.2	182.6	177.1	168.4	165.8
	RMS $_{(0-90\%)\ Peak\ Strike}$	201.4	182.6	176.7	168.4	166.4	200.1	181.2	175.7	167.4	165.6
	RMS $_{(5-95\%)\ Peak\ Strike}$	203.4	183.6	177.7	168.3	166.1	202.2	182.3	176.5	167.3	165.3
	RMS $_{(0-90\%)\ Mean}$	200.9	182.2	176.4	168.0	166.1	199.6	181.0	175.4	167.1	165.3
	RMS $_{(5-95\%)\ Mean}$	202.8	183.2	177.2	167.7	165.5	201.5	181.9	176.2	166.6	164.8
	RMS $_{(0-90\%)\ 1\sigma}$	0.8	1.0	0.8	3.1	1.1	0.7	1.0	0.7	3.1	1.1
	RMS $_{(5-95\%)\ 1\sigma}$	1.0	1.1	1.0	4.3	1.3	0.9	1.0	0.9	4.4	1.3
	$SEL_{Maximum}$	185.8	166.6	161.5	154.1	152.2	184.5	165.5	160.5	153.3	151.4
	$SEL_{Peak\ Strike}$	185.8	166.5	161.2	153.9	151.7	184.5	165.4	160.2	153.1	150.9
	SEL_{Mean}	185.1	166.0	160.9	153.1	151.5	183.9	164.9	160.0	152.2	150.7
	$SEL_{1\sigma}$	0.9	1.0	0.9	3.0	0.9	0.8	1.0	0.9	3.0	0.9
Time Strike Series Statistics	Time to $Peak_{Minimum}$	10.7	12.2	12.9	13.8	11.7	10.7	12.2	12.9	13.8	13.5
	Time to $Peak_{Mean}$	12.6	13.5	13.1	16.0	20.0	12.2	12.8	13.3	15.9	26.4
	Time to $Peak_{1\sigma}$	1.4	0.5	0.4	0.7	7.3	1.5	0.7	0.5	0.9	3.7
	Strike Time $_{(0-90\%)\ Mean}$	26.7	24.0	28.2	32.0	34.7	26.8	24.6	28.6	32.5	34.8
	Strike Time $_{(5-95\%)\ Mean}$	17.6	19.7	23.4	38.1	40.3	17.7	19.8	24.0	40.2	39.9
	Strike Time $_{(0-90\%)\ 1\sigma}$	1.2	1.4	1.4	1.3	2.8	1.1	1.5	1.4	1.2	2.8
	Strike Time $_{(5-95\%)\ 1\sigma}$	0.8	0.7	1.3	25.8	5.1	0.9	0.7	1.1	27.7	5.1
Threshold	Pct Exceeding 206dB Peak	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	97%	0%	0%	0%	0%	92%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	97%	100%	100%	100%	100%	97%	100%
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%	100%	100%	100%	100%	97%	100%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		14.6	15.5	18.3	20.5		14.6	15.5	18.3	20.5
	Cumulative SEL		13.8	14.8	16.5	17.9		14.7	15.4	16.9	18.3
	Series RMS $_{(0-90\%)}$		13.5	15.0	16.9	18.5		14.4	15.6	17.4	18.9
	Series RMS $_{(5-95\%)}$		14.2	15.6	18.2	19.8		15.1	16.3	18.8	20.2

Strike Series Analysis: Pile A-4, Air Off, February 15, 2011 14:08 (pg 1 of 3)

Time Series of Strikes at 10 meters

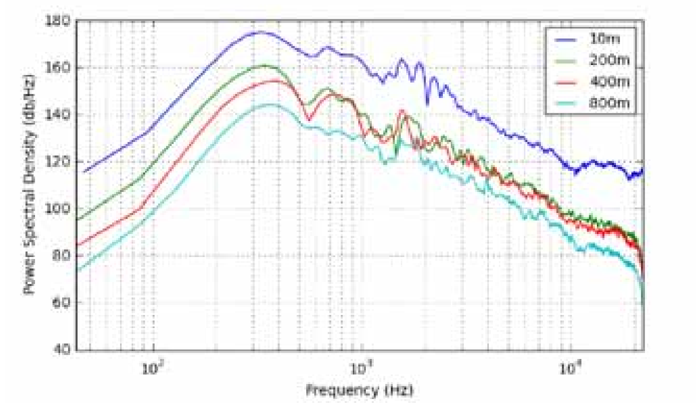


Pile A-4, 48" diameter

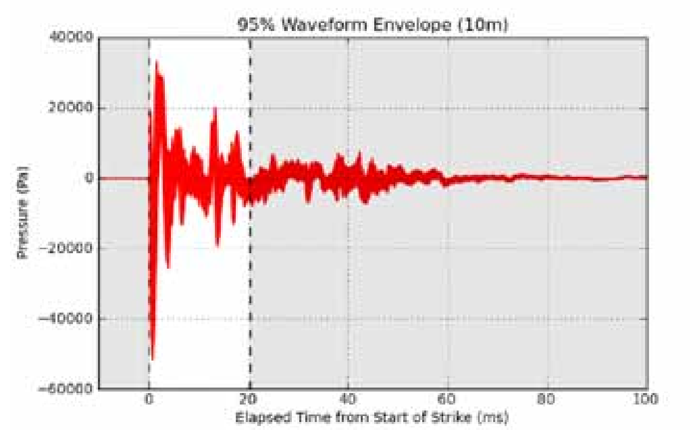
Date: February 15, 2011   Time: 14:08

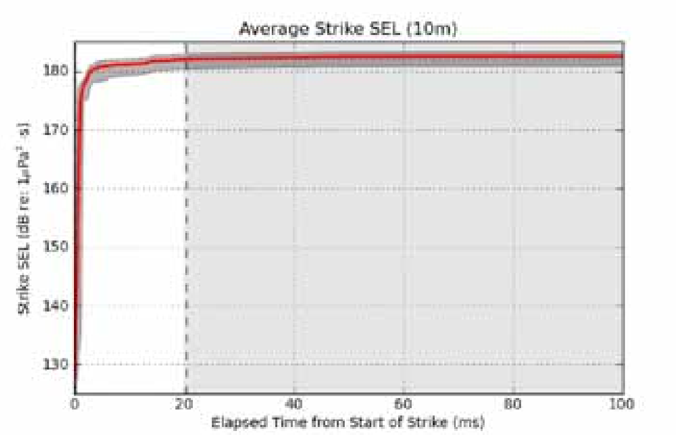
Attenuation: Confined Bubble Curtain
Number of Strikes: 1216
Number of Strikes Analyzed: 31
Air: Off

Spectral Density



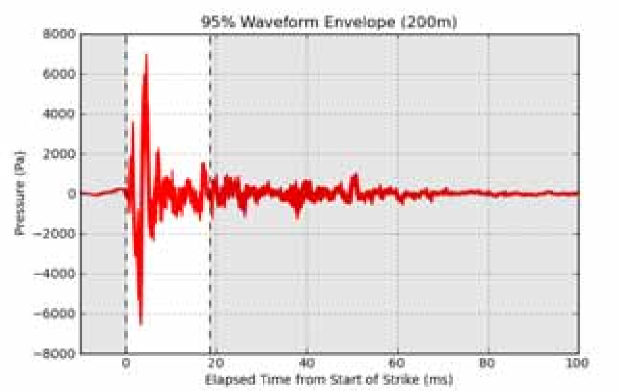
ST1400 – 10 meters



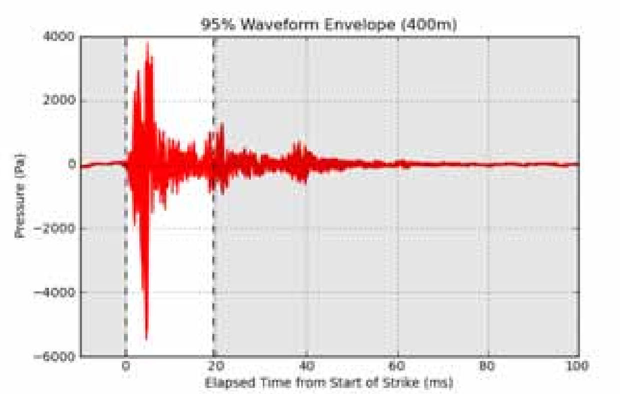


Strike Series Analysis: Pile A-4, Air Off, February 15, 2011 14:08 (pg 2 of 3)

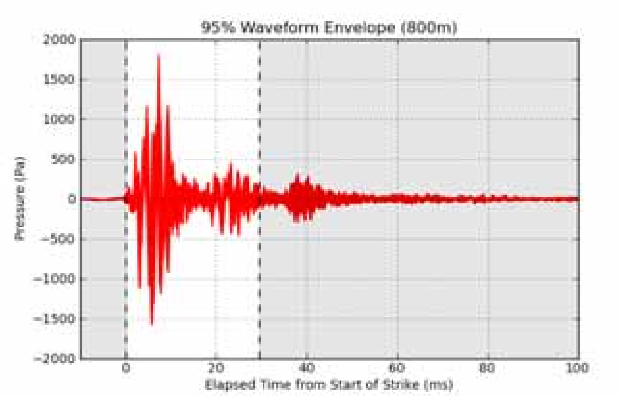
Waveforms	SELs	

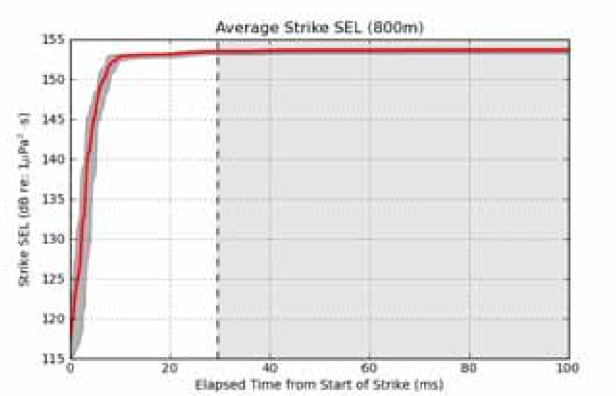


COHO – 200 meter s



SOCKEYE – 400 meters





SUPERCUBE – 800 meters

No data

No data

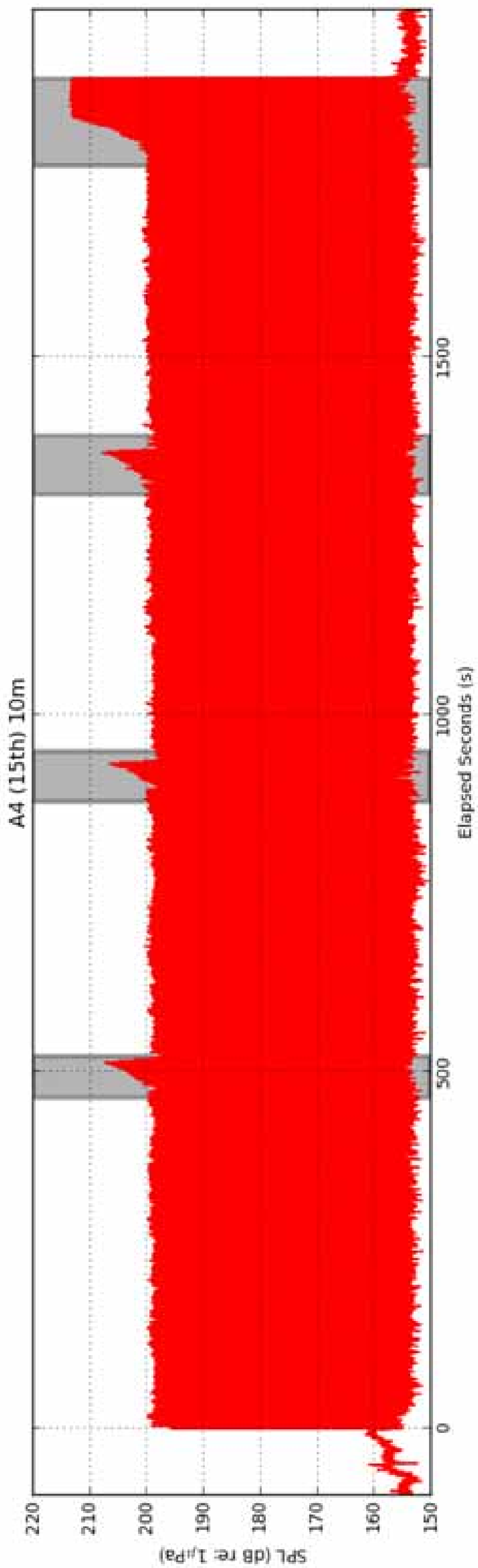
KOKANEE – 800 meters

Strike Series Analysis: Pile A-4, Air Off, February 15, 2011 14:08 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	227	425	844		10	227	425	844	
	Number of Strikes: Total	1216	1216	1216	1216		1216	1216	1216	1216	
	Number of Strikes: Analyzed	31	31	31	31		31	31	31	31	
	Series RMS $_{(0-90\%)}$	197.2	181.5	175.8	167.5		195.7	179.4	174.7	166.2	
	Series RMS $_{(5-95\%)}$	196.8	180.8	176.4	167.6		195.0	178.6	175.2	166.5	
	Cumulative $SEL_{Analyzed}$	196.9	181.0	175.4	168.4		195.4	179.0	174.4	167.3	
	Cumulative SEL	212.9	196.9	191.3	184.3		211.4	194.9	190.3	183.3	
	Peak $Strikes_{Maximum}$	213.5	195.1	190.5	181.2	No Data	213.5	195.1	190.5	181.2	No Data
	Peak $Strikes_{Mean}$	212.6	194.7	189.6	180.3		212.6	194.7	189.6	180.3	
	Peak $Strikes_{1\sigma}$	1.2	0.2	2.2	0.7		1.2	0.2	2.2	0.7	
	Maximum $Overpressure_{Mean}$	24003.3	5427.3	2368.6	1023.2		15354.2	4097.2	2101.3	852.0	
	Maximum $Overpressure_{1\sigma}$	1669.1	136.3	339.4	97.6		1183.3	133.7	288.7	76.5	
	Maximum $Underpressure_{Mean}$	-43212.6	-4727.7	-3087.3	-962.7		-38190.8	-3701.5	-2693.2	-880.9	
	Maximum $Underpressure_{1\sigma}$	5102.8	366.0	441.6	46.3		5233.6	414.0	393.7	28.8	
	RMS $_{(0-90\%)\ Maximum}$	198.1	181.8	176.1	168.2		196.6	179.7	175.1	167.1	
	RMS $_{(5-95\%)\ Maximum}$	197.9	181.7	177.1	167.9		196.2	179.3	176.0	166.8	
	RMS $_{(0-90\%)\ Peak\ Strike}$	197.6	181.7	175.8	167.3		196.0	179.7	174.8	165.9	
	RMS $_{(5-95\%)\ Peak\ Strike}$	197.5	180.9	176.8	167.8		195.7	178.8	175.7	166.7	
	RMS $_{(0-90\%)\ Mean}$	197.2	181.5	175.5	167.5		195.6	179.4	174.5	166.2	
	RMS $_{(5-95\%)\ Mean}$	196.8	180.9	176.2	167.6		195.0	178.6	175.0	166.5	
	RMS $_{(0-90\%)\ 1\sigma}$	0.6	0.2	2.0	0.6		0.7	0.3	2.0	0.6	
	RMS $_{(5-95\%)\ 1\sigma}$	0.8	0.4	2.1	0.2		0.8	0.3	2.0	0.3	
	$SEL_{Maximum}$	182.9	166.4	160.8	153.7		181.4	164.5	159.9	152.7	
	$SEL_{Peak\ Strike}$	182.4	166.4	160.7	153.7		180.9	164.5	159.7	152.7	
	SEL_{Mean}	182.0	166.1	160.2	153.4		180.5	164.1	159.2	152.4	
	$SEL_{1\sigma}$	0.7	0.2	2.2	0.2		0.8	0.3	2.2	0.2	
Time Strike Series Statistics	Time to $Peak_{Minimum}$	10.5	14.1	12.7	15.1		10.5	14.0	12.7	13.0	
	Time to $Peak_{Mean}$	10.9	14.5	14.4	17.5		10.9	14.5	14.4	15.8	
	Time to $Peak_{1\sigma}$	0.3	0.2	0.5	1.0		0.3	0.2	0.5	1.6	
	Strike Time $_{(0-90\%)\ Mean}$	30.0	28.5	29.4	39.5		30.6	29.4	29.6	41.9	
	Strike Time $_{(5-95\%)\ Mean}$	35.2	33.9	26.2	38.5		35.9	35.1	26.8	39.0	
	Strike Time $_{(0-90\%)\ 1\sigma}$	1.9	0.8	1.7	5.1		2.0	0.9	1.7	5.3	
	Strike Time $_{(5-95\%)\ 1\sigma}$	2.9	3.2	3.7	0.8		2.7	2.2	3.9	1.0	
Threshold	Pct Exceeding 206dB Peak	100%	0%	0%	0%		100%	0%	0%	0%	
	Pct Exceeding 187dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	6%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	100%		100%	100%	100%	100%	
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%		100%	100%	100%	100%	
Transmission Loss Coefficients	Peak $Strike_{Mean}$		13.2	14.1	16.8			13.2	14.1	16.8	
	Cumulative SEL		11.8	13.2	14.8			13.2	13.9	15.4	
	Series RMS $_{(0-90\%)}$		11.6	13.2	15.5			13.2	13.8	16.1	
	Series RMS $_{(5-95\%)}$		11.8	12.5	15.1			13.4	13.2	15.7	

Strike Series Analysis: Pile A-4, Air On, February 15, 2011 14:08 (pg 1 of 3)

Time Series of Strikes at 10 meters

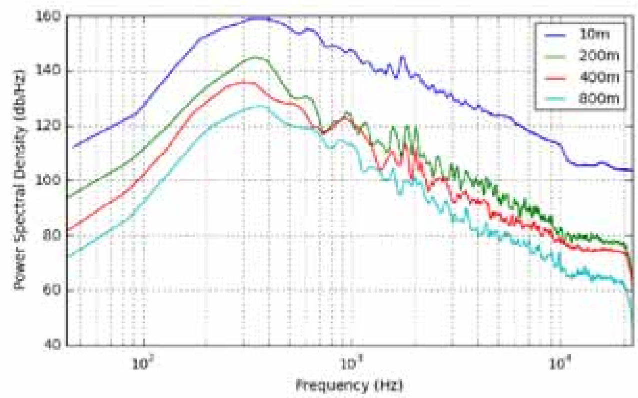


Pile A-4, 48" diameter

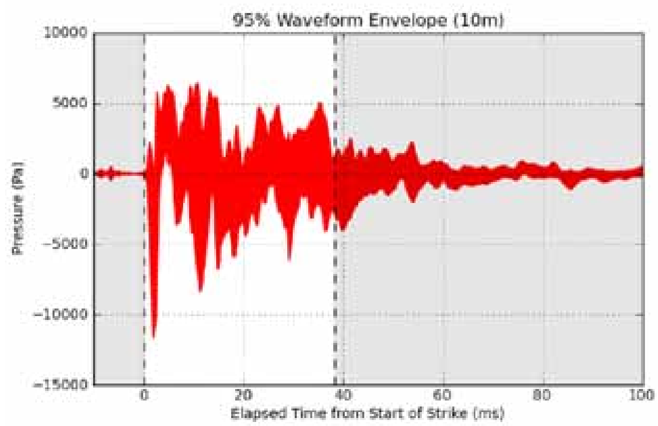
Date: February 15, 2011 Time: 14:08

Attenuation: Confined Bubble Curtain
Number of Strikes: 1216
Number of Strikes Analyzed: 999
Air: On

Spectral Density

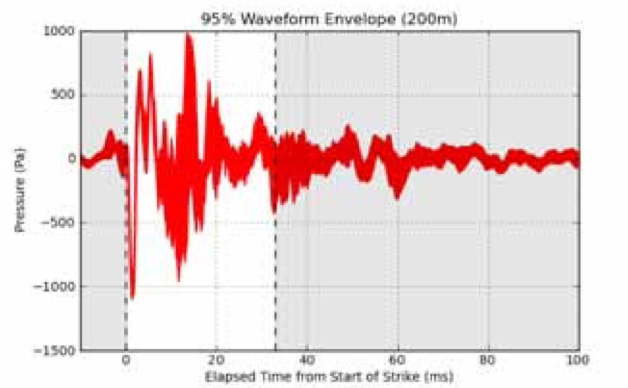


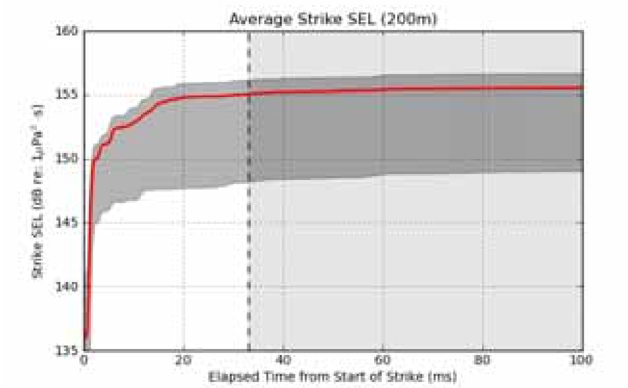
ST1400 – 10 meters



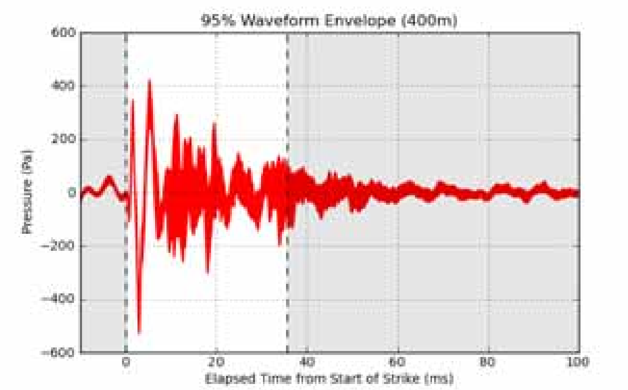
Strike Series Analysis: Pile A-4, Air On, February 15, 2011 14:08 (pg 2 of 3)

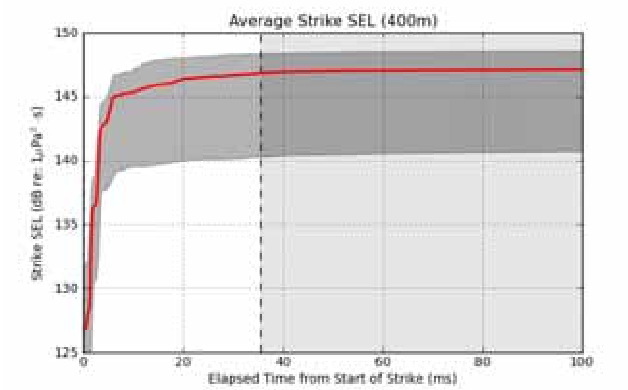
Waveforms	SELs	



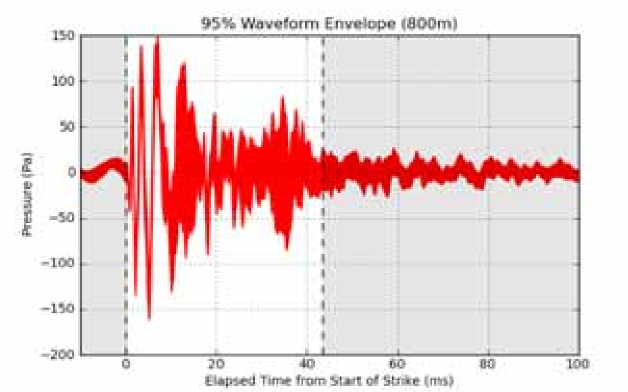


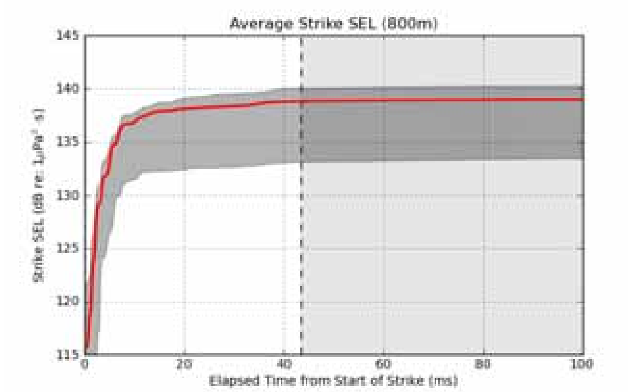
COHO – 200 meter s



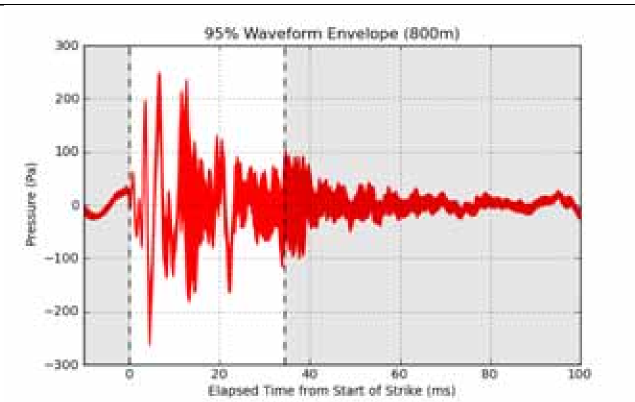


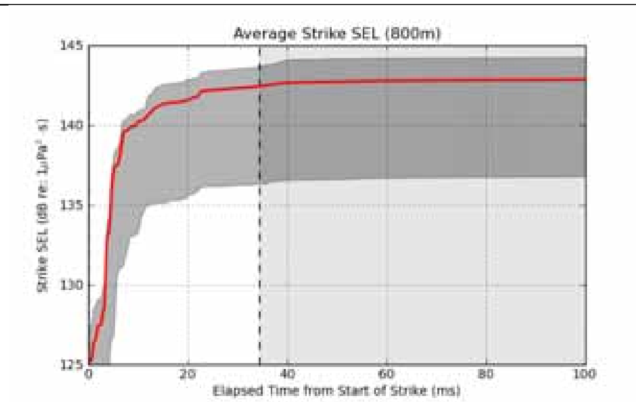
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





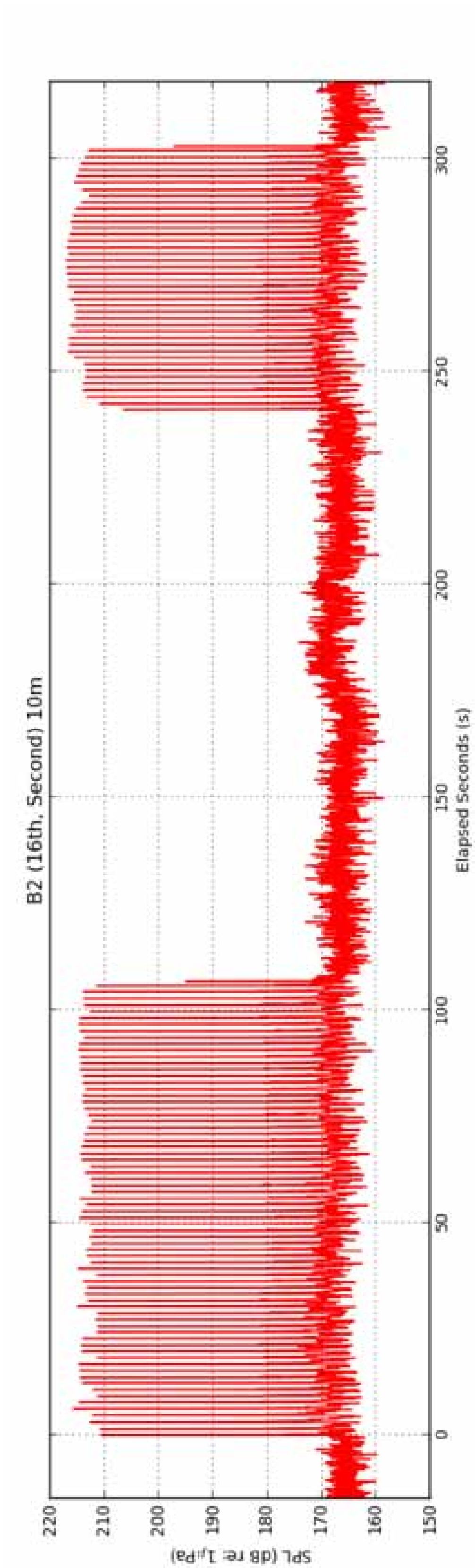
KOKANEE – 800 meters

Strike Series Analysis: Pile A-4, Air On, February 15, 2011 14:08 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	227	425	844		10	227	425	844	
	Number of Strikes: Total	1216	1216	1216	1216		1216	1216	1216	1216	
	Number of Strikes: Analyzed	999	999	999	999		999	999	999	999	
	Series RMS $_{(0-90\%)}$	186.7	168.8	160.3	151.5		183.0	164.2	156.5	148.9	
	Series RMS $_{(5-95\%)}$	187.3	168.9	160.3	145.1		183.7	164.1	156.5	142.4	
	Cumulative SEL$_{Analyzed}$	203.5	185.1	176.9	168.8		199.9	180.6	173.2	166.3	
	Cumulative SEL	204.4	185.9	177.7	169.7		200.7	181.4	174.0	167.1	
	Peak Strikes$_{Maximum}$	200.7	181.0	175.8	164.5		200.7	181.0	175.8	164.5	
	Peak Strikes$_{Mean}$	199.1	180.1	173.5	163.0		199.1	180.1	173.5	163.0	
	Peak Strikes$_{1\sigma}$	0.5	0.3	0.5	0.5		0.5	0.3	0.5	0.5	
	Maximum Overpressure$_{Mean}$	6225.4	752.7	347.4	125.7		5344.5	459.7	295.2	112.1	
	Maximum Overpressure$_{1\sigma}$	934.4	66.0	35.0	9.6		1245.2	38.4	19.7	12.2	
	Maximum Underpressure$_{Mean}$	-9020.3	-1014.1	-475.6	-141.3		-6195.1	-544.9	-287.9	-108.5	
	Maximum Underpressure$_{1\sigma}$	579.8	34.0	23.2	9.0		462.5	25.4	19.8	7.5	
	RMS $_{(0-90\%)\ Maximum}$	188.1	170.3	162.9	152.7		184.7	165.7	159.6	150.4	
	RMS $_{(5-95\%)\ Maximum}$	188.9	169.9	162.6	153.2		185.5	165.4	159.2	150.7	
	RMS $_{(0-90\%)\ Peak\ Strike}$	185.9	168.7	162.9	152.3	No Data	181.5	162.8	159.6	150.2	No Data
	RMS $_{(5-95\%)\ Peak\ Strike}$	186.3	169.4	162.6	145.2		181.8	163.3	159.2	143.0	
	RMS $_{(0-90\%)\ Mean}$	186.6	168.8	160.3	151.6		183.0	164.2	156.5	148.9	
	RMS $_{(5-95\%)\ Mean}$	187.3	168.9	160.4	145.1		183.6	164.1	156.5	142.4	
	RMS $_{(0-90\%)\ 1\sigma}$	0.6	0.5	0.7	0.6		0.9	0.7	0.8	0.8	
	RMS $_{(5-95\%)\ 1\sigma}$	0.7	0.5	0.7	1.2		1.0	0.7	0.9	1.2	
	SEL$_{Maximum}$	175.1	156.2	148.1	140.1		171.5	152.0	144.9	137.8	
	SEL$_{Peak\ Strike}$	172.7	155.5	148.1	139.6		168.3	149.5	144.9	137.5	
	SEL$_{Mean}$	173.5	155.1	146.9	138.8		169.8	150.5	143.2	136.2	
	SEL$_{1\sigma}$	0.7	0.5	0.4	0.5		0.9	0.6	0.6	0.6	
Time Strike Series Statistics	Time to Peak$_{Minimum}$	11.2	11.3	12.4	12.1		11.3	11.3	11.0	12.1	
	Time to Peak$_{Mean}$	12.5	11.5	13.0	15.3		16.3	12.4	12.0	13.7	
	Time to Peak$_{1\sigma}$	2.6	0.8	0.1	1.1		7.8	2.8	0.7	2.2	
	Strike Time $_{(0-90\%)\ Mean}$	48.4	42.7	45.6	53.4		48.4	43.8	46.7	54.5	
	Strike Time $_{(5-95\%)\ Mean}$	40.8	43.0	45.5	249.1		40.9	44.4	47.2	251.4	
	Strike Time $_{(0-90\%)\ 1\sigma}$	2.6	5.9	4.5	11.6		2.6	5.3	4.2	14.4	
	Strike Time $_{(5-95\%)\ 1\sigma}$	2.7	4.9	4.7	49.1		2.8	4.7	4.9	48.4	
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 187dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	1%		100%	100%	100%	0%	
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	99%		100%	100%	100%	3%	
Transmission Loss Coefficients	Peak Strike$_{Mean}$		14.0	15.7	18.7			14.0	15.7	18.7	
	Cumulative SEL		13.6	16.4	18.0			16.9	18.6	19.3	
	Series RMS $_{(0-90\%)}$		13.2	16.2	18.3			16.6	18.5	19.6	
	Series RMS $_{(5-95\%)}$		13.6	16.6	21.9			17.2	18.9	23.3	

Strike Series Analysis: Pile A-4, Air Off, February 15, 2011 15:01 (pg 1 of 3)

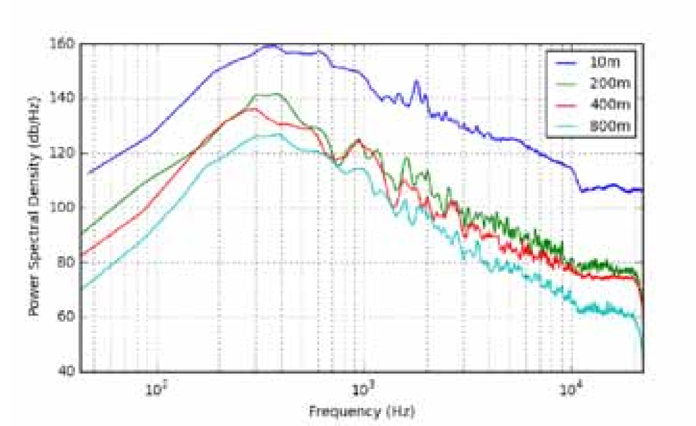
Time Series of Strikes at 10 meters



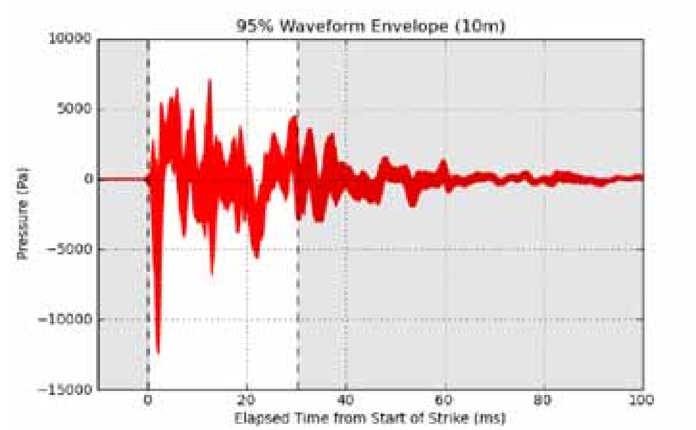
Pile A-4, 48" diameter

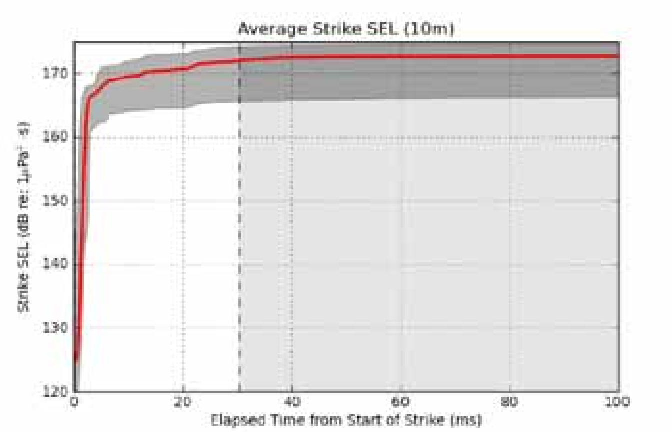
Date: February 15, 2011   Time: 15:01

Attenuation: Confined Bubble Curtain
Number of Strikes: 213
Number of Strikes Analyzed: 211
Air: Off



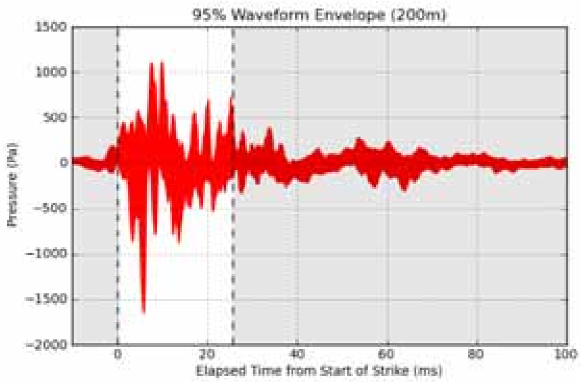
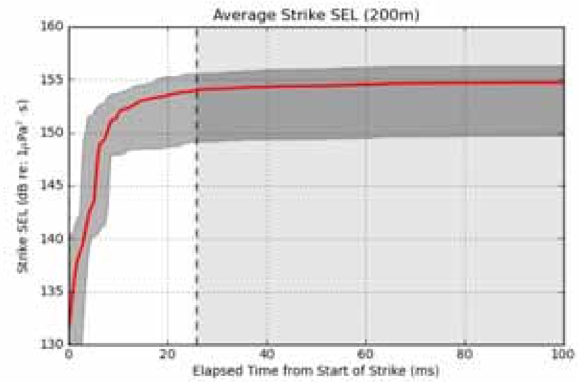
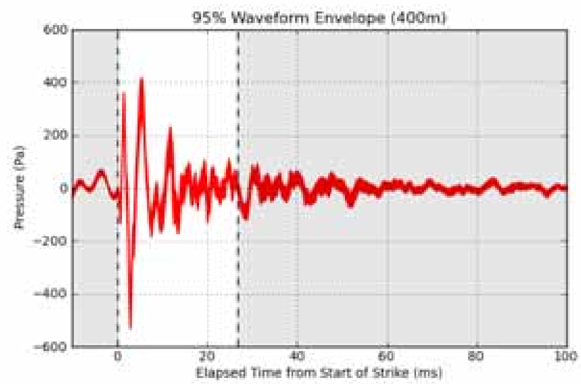
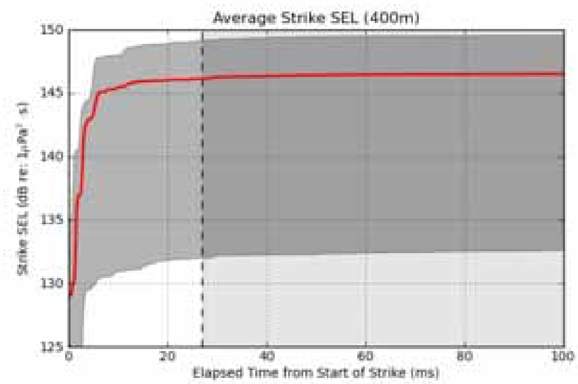
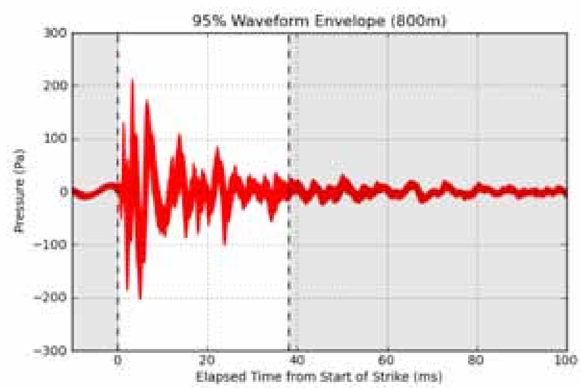
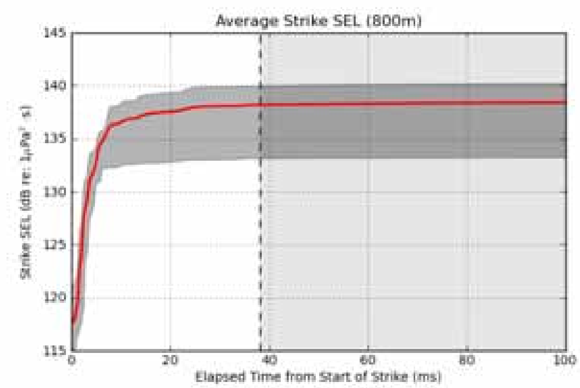
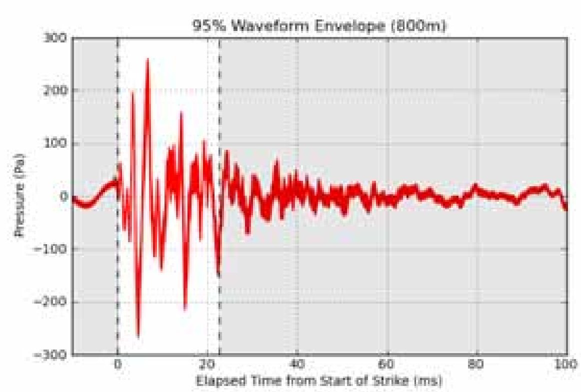
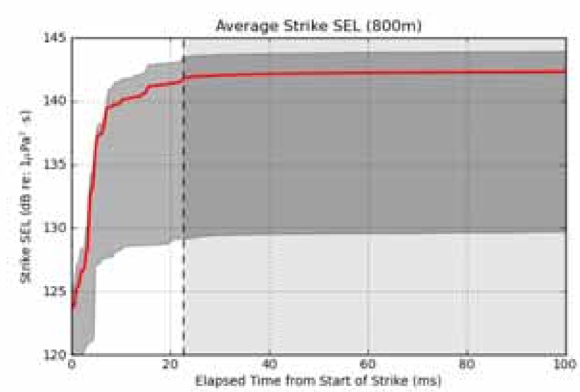
Spectral Density





ST1400 – 10 meters

Strike Series Analysis: Pile A-4, Air Off, February 15, 2011 15:01 (pg 2 of 3)

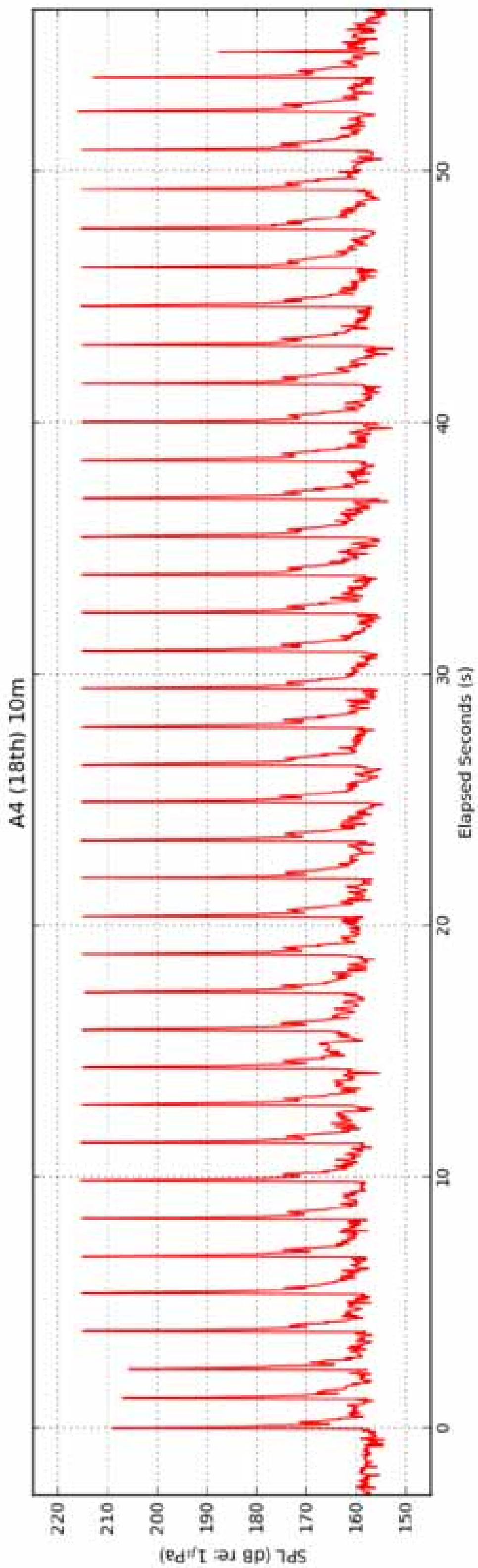
Waveforms	SELs	
		COHO – 200 meter s
		SOCKEYE – 400 meters
		SUPERCUBE – 800 meters
		KOKANEE – 800 meters

Strike Series Analysis: Pile A-4, Air Off, February 15, 2011 15:01 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	227	425	844	761	10	227	425	844	761
	Number of Strikes: Total	213	213	213	213	213	213	213	213	213	213
	Number of Strikes: Analyzed	211	211	211	211	211	211	211	211	211	211
	Series RMS $_{(0\text{-}90\%)}$	186.0	168.5	160.5	151.4	156.6	182.4	163.3	155.9	148.3	154.0
	Series RMS $_{(5\text{-}95\%)}$	186.7	168.4	159.9	144.1	156.9	183.1	163.0	155.1	140.9	154.1
	Cumulative $SEL_{Analyzed}$	195.3	177.2	169.5	161.4	165.0	191.6	172.1	165.0	158.4	162.3
	Cumulative SEL	195.3	177.3	169.5	161.5	165.0	191.7	172.1	165.0	158.5	162.4
	Peak $Strikes_{Maximum}$	201.0	181.5	175.1	164.6	169.2	201.0	181.5	175.1	164.6	169.2
	Peak $Strikes_{Mean}$	199.3	179.9	173.2	163.0	166.8	199.3	179.9	173.2	163.0	166.8
	Peak $Strikes_{1\sigma}$	0.7	0.4	1.0	0.5	0.9	0.7	0.4	1.0	0.5	0.9
	Maximum $Overpressure_{Mean}$	5481.0	671.9	352.2	122.6	210.1	4780.5	416.4	294.0	116.6	184.6
	Maximum $Overpressure_{1\sigma}$	690.5	41.8	39.0	10.6	23.2	946.3	23.3	25.4	11.5	13.3
	Maximum $Underpressure_{Mean}$	-9227.8	-989.0	-456.3	-141.3	-214.1	-6432.8	-540.4	-269.1	-100.1	-150.9
	Maximum $Underpressure_{1\sigma}$	637.4	44.2	33.8	8.4	14.4	561.9	24.1	23.6	5.6	10.6
	RMS $_{(0\text{-}90\%)\ Maximum}$	188.0	169.8	163.8	153.1	158.1	184.3	164.9	159.2	149.6	154.9
	RMS $_{(5\text{-}95\%)\ Maximum}$	188.6	169.6	163.3	148.2	158.0	184.9	164.9	158.7	145.1	155.2
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	187.7	169.8	163.8	153.1	158.1	183.6	164.5	159.2	149.6	154.9
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	188.2	169.5	163.3	146.6	158.0	183.8	164.1	158.7	143.1	154.9
	RMS $_{(0\text{-}90\%)\ Mean}$	186.0	168.5	160.5	151.4	156.6	182.4	163.3	155.9	148.4	153.9
	RMS $_{(5\text{-}95\%)\ Mean}$	186.7	168.4	159.9	144.1	156.9	183.0	163.0	155.2	140.9	154.1
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	0.6	0.4	1.2	0.8	1.0	0.6	0.6	1.2	0.8	0.9
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	0.6	0.5	1.6	0.7	1.0	0.6	0.6	1.7	0.7	0.9
	$SEL_{Maximum}$	174.2	155.6	149.0	140.0	143.6	170.5	150.4	144.5	136.6	140.4
	$SEL_{Peak\ Strike}$	173.2	155.6	149.0	140.0	143.6	169.1	150.4	144.5	136.6	140.4
	SEL_{Mean}	172.0	154.0	146.1	138.2	141.7	168.4	148.8	141.7	135.2	139.0
	$SEL_{1\sigma}$	0.6	0.5	1.1	0.5	1.0	0.7	0.5	1.0	0.4	0.9
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.3	12.8	12.5	13.2	12.8	11.3	12.9	11.0	12.2	12.8
	Time to $Peak_{Mean}$	12.2	15.8	12.9	15.3	15.5	12.8	15.9	11.7	13.7	13.5
	Time to $Peak_{1\sigma}$	0.9	1.4	0.2	0.6	1.1	2.5	1.4	0.5	0.6	0.1
	Strike Time $_{(0\text{-}90\%)\ Mean}$	40.2	35.7	37.0	48.0	32.7	39.7	36.1	38.4	48.7	32.6
	Strike Time $_{(5\text{-}95\%)\ Mean}$	36.0	37.2	44.0	271.5	32.1	36.0	38.7	46.6	273.3	32.8
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	2.2	2.4	2.9	18.3	1.3	2.5	2.6	3.2	19.2	1.5
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	1.1	4.0	16.9	31.0	2.8	1.2	4.2	19.9	29.4	2.6
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	100%	0%	100%	100%	100%	99%	0%	100%
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	100%	98%	100%	100%	100%	100%	0%	99%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		14.3	16.0	18.8	17.3		14.3	16.0	18.8	17.3
	Cumulative SEL		13.3	15.9	17.6	16.1		17.1	18.6	19.1	17.5
	Series RMS $_{(0\text{-}90\%)}$		12.9	15.6	18.0	15.6		16.8	18.5	19.6	17.0
	Series RMS $_{(5\text{-}95\%)}$		13.5	16.5	22.1	15.8		17.5	19.4	23.8	17.3

Strike Series Analysis: Pile A-4, Air Off, February 18, 2011 08:35 (pg 1 of 3)

Time Series of Strikes at 10 meters

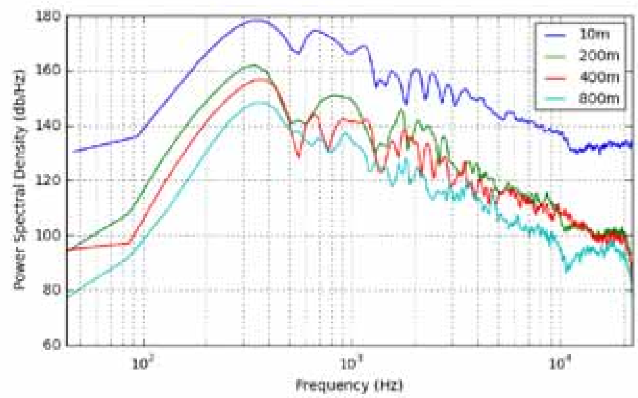


Pile A-4, 48" diameter

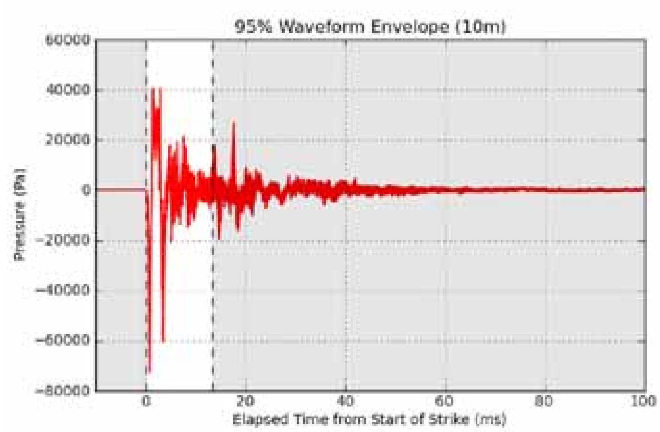
Date: February 18, 2011 Time: 08:35

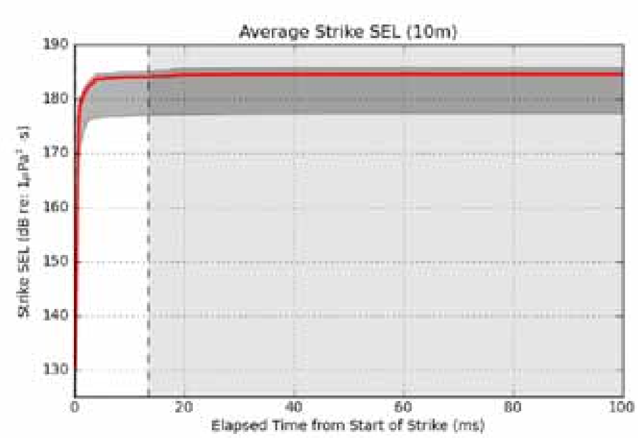
Attenuation: Restrike
Number of Strikes: 38
Number of Strikes Analyzed: 36
Air: Off

Spectral Density



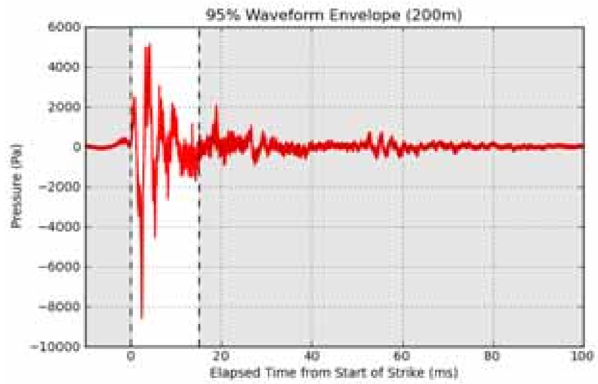
ST1400 – 10 meters

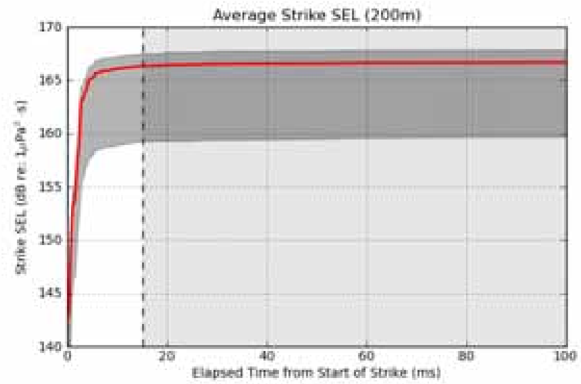




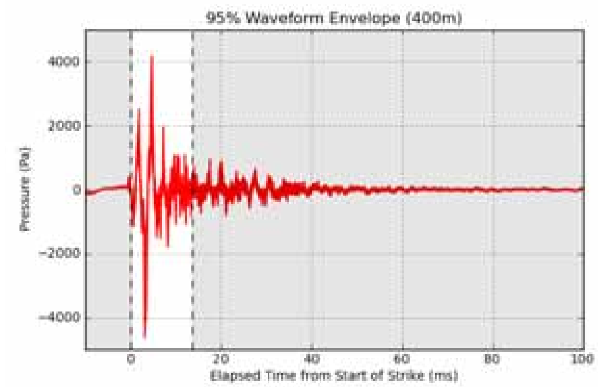
Strike Series Analysis: Pile A-4, Air Off, February 18, 2011 08:35 (pg 2 of 3)

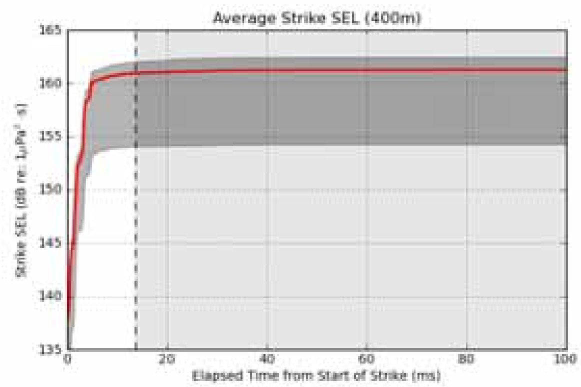
Waveforms | **SELs**



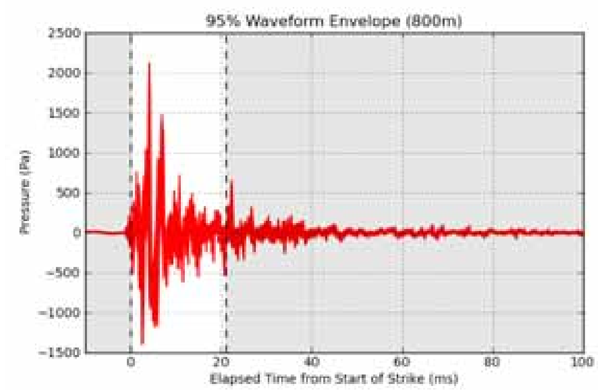


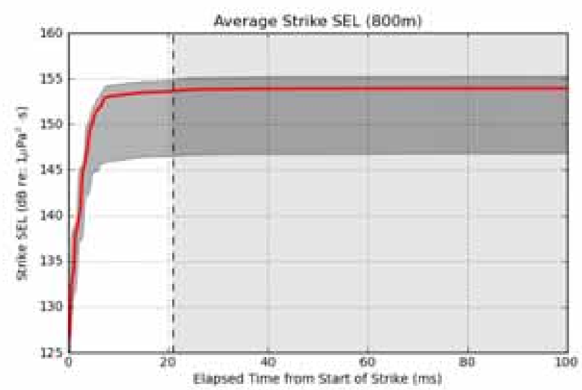
COHO – 200 meter s



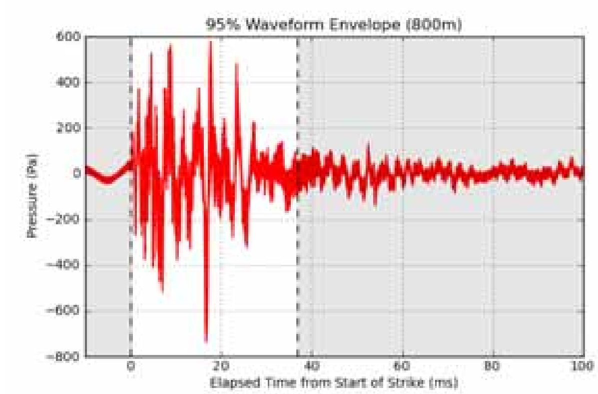


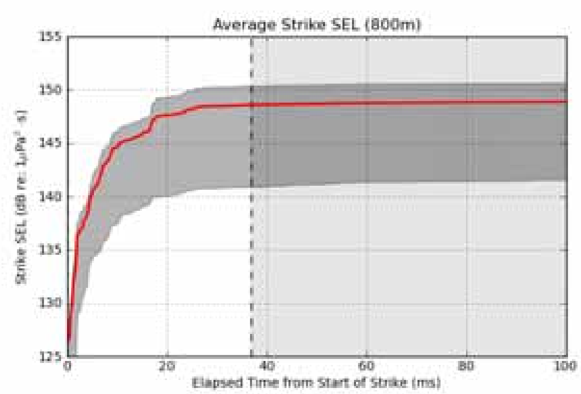
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





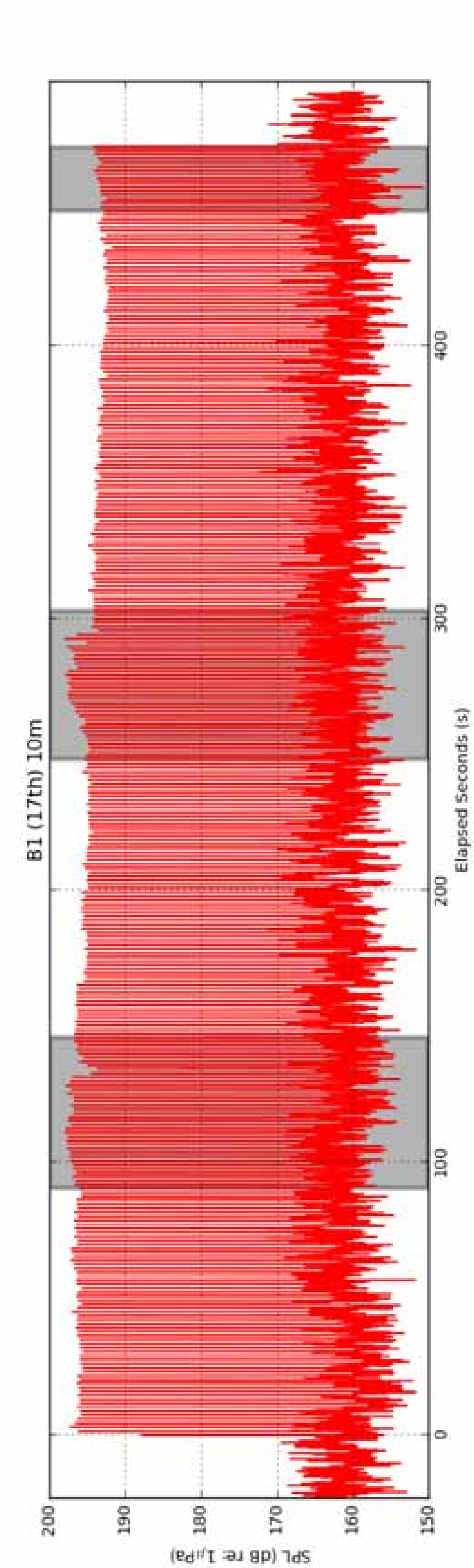
KOKANEE – 800 meters

Strike Series Analysis: Pile A-4, Air Off, February 18, 2011 8:35 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	224	415	822	774	10	224	415	822	774
	Number of Strikes: Total	38	38	38	38	38	38	38	38	38	38
	Number of Strikes: Analyzed	36	36	36	36	36	36	36	36	36	36
	Series RMS $_{(0-90\%)}$	200.7	182.6	177.5	169.0	162.2	199.5	180.7	176.3	168.0	160.6
	Series RMS $_{(5-95\%)}$	202.5	182.2	178.0	169.1	160.8	201.3	180.0	176.8	167.9	159.2
	Cumulative $SEL_{Analyzed}$	200.0	182.1	176.7	169.5	164.5	198.8	180.3	175.6	168.6	162.9
	Cumulative SEL	191.2	173.0	167.0	149.1	156.6	199.0	180.6	175.9	168.8	163.1
	Peak $Strikes_{Maximum}$	215.9	197.6	191.3	181.9	175.2	215.9	197.6	191.3	181.9	175.2
	Peak $Strikes_{Mean}$	214.3	195.8	190.1	180.6	173.9	214.3	195.8	190.1	180.6	173.9
	Peak $Strikes_{1\sigma}$	2.2	2.4	2.0	1.9	2.4	2.2	2.4	2.0	1.9	2.4
	Maximum $Overpressure_{Mean}$	31794.4	3922.7	2870.8	1091.2	447.4	25999.8	3625.9	2489.0	1044.9	399.6
	Maximum $Overpressure_{1\sigma}$	3343.6	624.9	407.5	185.9	82.6	2484.6	546.3	347.3	182.2	83.3
	Maximum $Underpressure_{Mean}$	-53371.9	-6331.3	-3247.2	-867.9	-501.5	-50822.8	-5098.2	-2654.3	-810.7	-431.2
	Maximum $Underpressure_{1\sigma}$	9404.2	1190.1	585.0	111.8	110.0	8892.0	1007.2	486.1	140.0	95.5
	RMS $_{(0-90\%)\ Maximum}$	202.5	183.5	178.1	169.9	164.4	201.2	181.6	176.9	168.9	163.0
	RMS $_{(5-95\%)\ Maximum}$	205.3	183.3	179.3	170.7	163.1	203.8	181.0	178.0	169.6	161.7
	RMS $_{(0-90\%)\ Peak\ Strike}$	201.0	183.4	177.7	169.8	162.9	199.7	181.5	176.6	168.9	161.5
	RMS $_{(5-95\%)\ Peak\ Strike}$	202.9	182.9	178.6	169.9	161.7	201.6	180.8	177.4	168.8	160.2
	RMS $_{(0-90\%)\ Mean}$	200.5	182.4	177.2	168.8	161.9	199.3	180.4	176.1	167.7	160.3
	RMS $_{(5-95\%)\ Mean}$	202.4	181.9	177.8	168.8	160.5	201.1	179.7	176.5	167.6	158.8
	RMS $_{(0-90\%)\ 1\sigma}$	1.7	1.8	1.6	1.9	2.7	1.7	1.8	1.6	1.9	2.9
	RMS $_{(5-95\%)\ 1\sigma}$	1.8	2.0	1.6	1.9	2.8	1.7	2.2	1.7	1.9	3.0
	$SEL_{Maximum}$	185.4	167.5	162.0	154.9	150.2	184.1	165.6	161.0	154.0	148.9
	$SEL_{Peak\ Strike}$	185.4	167.3	162.0	154.9	149.3	184.1	165.5	161.0	154.0	147.8
	SEL_{Mean}	184.1	166.3	160.9	153.7	148.6	183.0	164.5	159.8	152.7	146.9
	$SEL_{1\sigma}$	1.9	1.9	1.8	1.9	2.1	1.9	1.9	1.8	1.9	2.3
Time Strike Series Statistics	Time to $Peak_{Minimum}$	10.8	12.5	13.1	13.2	16.8	10.8	12.5	13.1	13.1	11.9
	Time to $Peak_{Mean}$	10.9	12.6	13.3	14.0	24.0	11.1	12.6	13.3	13.9	22.1
	Time to $Peak_{1\sigma}$	0.5	0.0	0.4	0.3	3.9	0.9	0.0	0.4	0.3	6.0
	Strike Time $_{(0-90\%)\ Mean}$	23.3	24.7	23.5	31.0	46.8	23.5	25.7	23.9	31.5	47.1
	Strike Time $_{(5-95\%)\ Mean}$	15.8	28.0	21.0	31.2	65.9	16.2	29.5	21.6	32.6	67.0
	Strike Time $_{(0-90\%)\ 1\sigma}$	4.5	2.0	2.3	2.2	8.1	4.4	2.3	2.4	2.0	8.2
	Strike Time $_{(5-95\%)\ 1\sigma}$	3.5	1.5	2.8	3.1	13.6	3.4	2.4	2.8	3.0	13.9
Threshold	Pct Exceeding 206dB Peak	97%	0%	0%	0%	0%	97%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	92%	0%	0%	0%	0%	86%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	100%	100%	100%	100%	100%	100%	94%
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		13.7	15.0	17.6	21.4		13.7	15.0	17.6	21.4
	Cumulative SEL		13.2	14.4	15.9	18.8		14.5	15.0	16.4	19.6
	Series RMS $_{(0-90\%)}$		13.4	14.4	16.5	20.4		14.9	15.1	17.1	21.2
	Series RMS $_{(5-95\%)}$		15.1	15.1	17.5	22.1		16.7	15.9	18.1	23.0

Strike Series Analysis: Pile B-1, Air On, February 17, 2011 9:43 (pg 1 of 3)

Time Series of Strikes at 10 meters

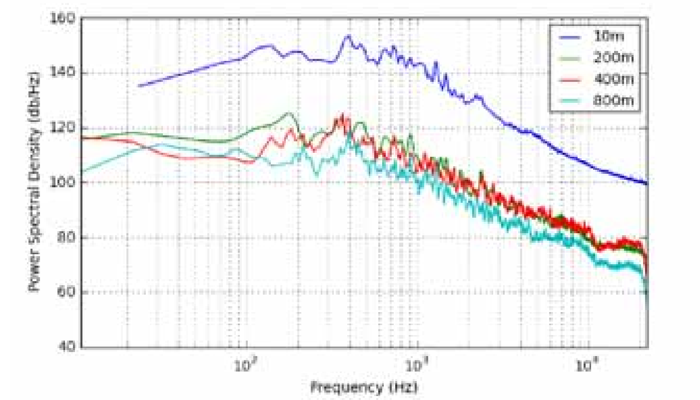


Pile B-1, 24" diameter

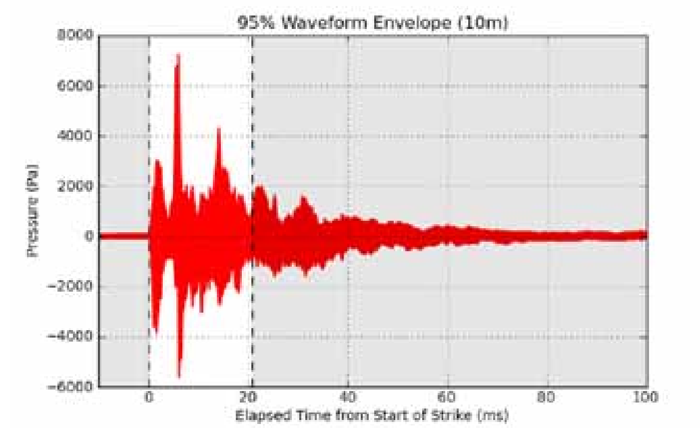
Date: February 17, 2011   Time: 9:43

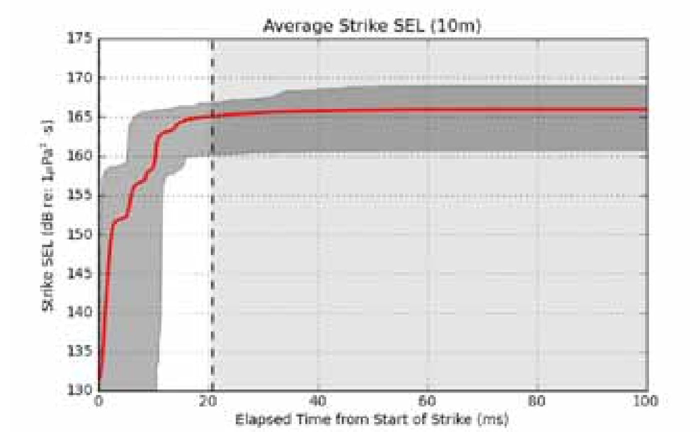
Attenuation: Confined Bubble Curtain
Number of Strikes: 322
Number of Strikes Analyzed: 245
Air: On

Spectral Density



ST1400 – 10 meters

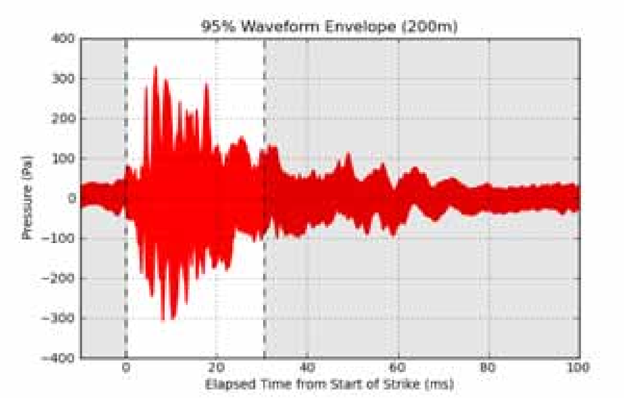


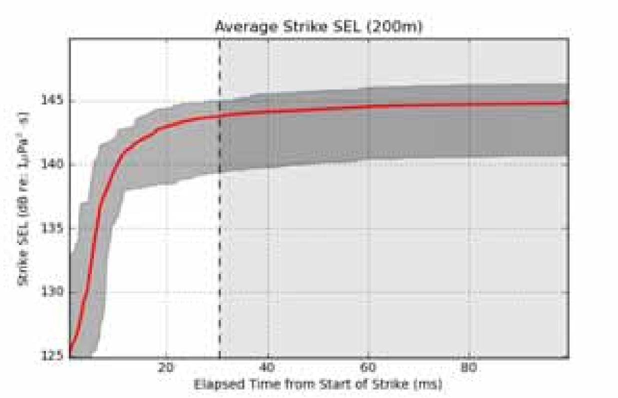


Strike Series Analysis: Pile B-1, Air On, February 17, 2011 9:43 (pg 2 of 3)

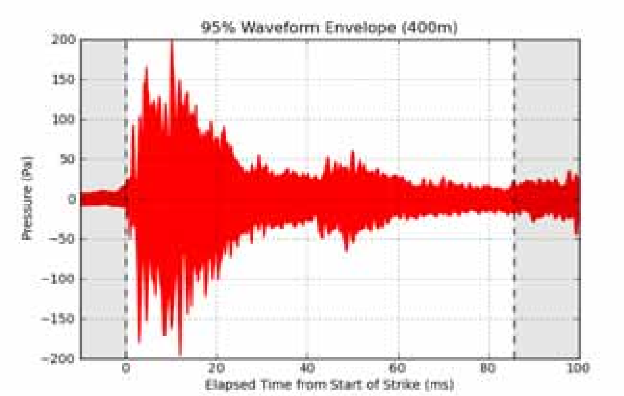
Waveforms | **SELs**

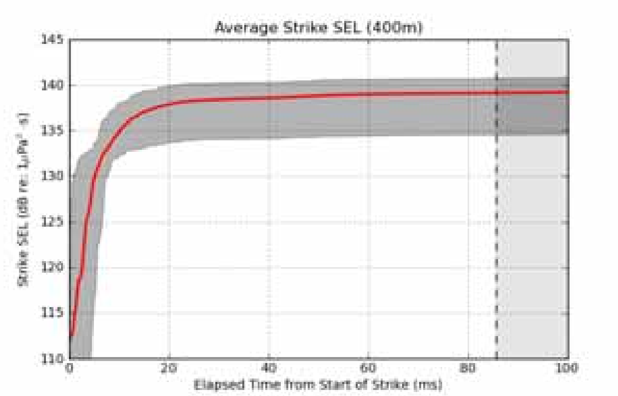
COHO – 200 meter s



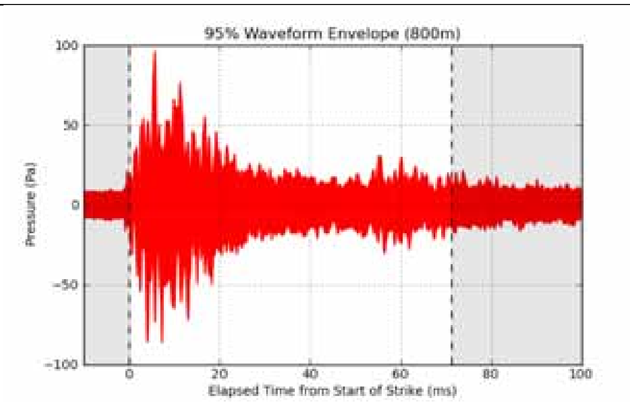


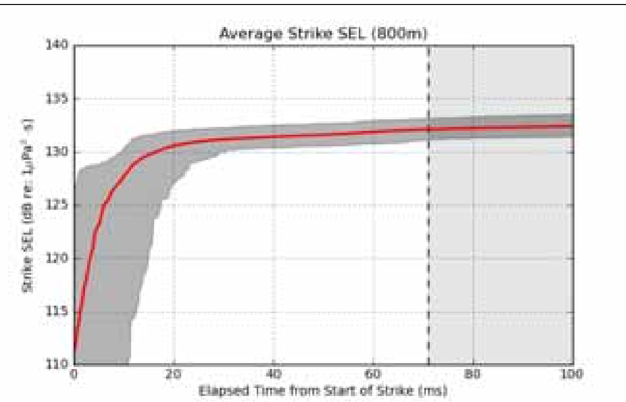
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





KOKANEE – 800 meters

No data

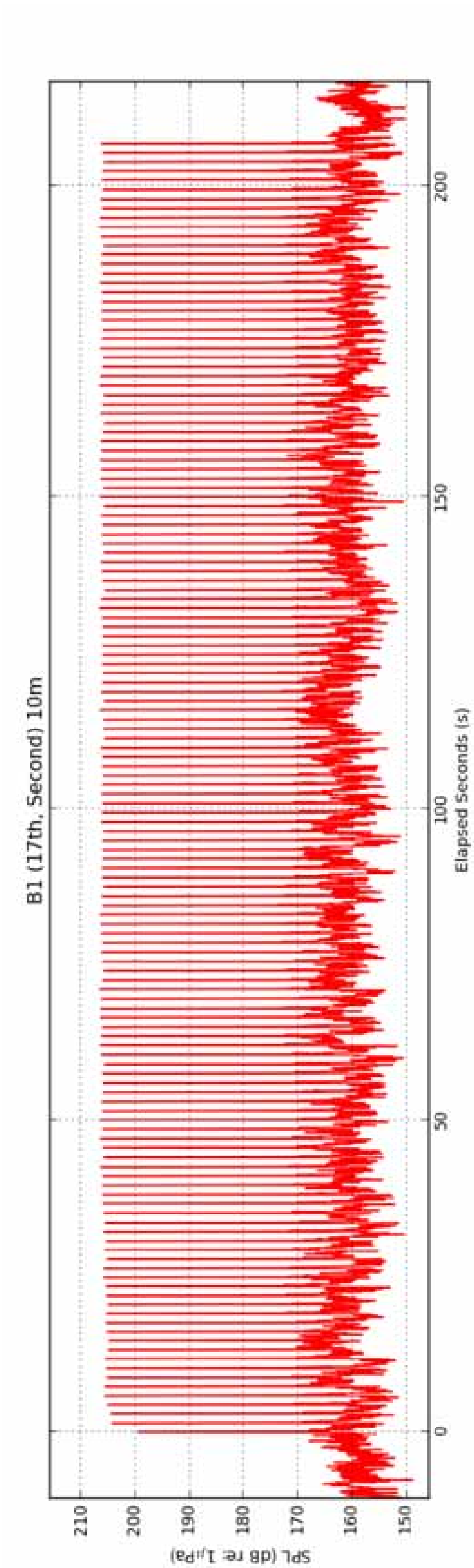
No data

Strike Series Analysis: Pile B-1, Air On, February 17, 2011 09:43 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
	Range From Pile	10	205	388	789		10	205	388	789	
	Number of Strikes: Total	322	322	322	322		322	322	322	322	
	Number of Strikes: Analyzed	245	245	245	245		245	245	245	245	
Strike Series Statistics	Series RMS $_{(0\text{-}90\%)}$	181.0	158.1	149.1	142.9		179.9	156.5	147.4	141.5	
	Series RMS $_{(5\text{-}95\%)}$	181.8	157.6	147.0	142.0		180.7	155.9	145.2	140.4	
	Cumulative $SEL_{Analyzed}$	189.4	167.8	163.1	156.0		188.3	166.2	161.6	154.7	
	Cumulative SEL	190.5	168.9	164.3	157.2		189.5	167.4	162.8	155.9	
	Peak $Strikes_{Maximum}$	197.2	170.9	165.4	158.2	No Data	197.2	170.9	165.4	158.2	No Data
	Peak $Strikes_{Mean}$	194.7	169.0	162.6	155.9		194.7	169.0	162.6	155.9	
	Peak $Strikes_{1\sigma}$	1.5	0.9	1.2	0.8		1.5	0.9	1.2	0.8	
	Maximum $Overpressure_{Mean}$	5508.2	259.9	119.3	53.7		4561.8	233.7	101.2	47.7	
	Maximum $Overpressure_{1\sigma}$	902.9	22.1	16.2	5.8		874.2	12.5	16.2	4.6	
	Maximum $Underpressure_{Mean}$	-4175.7	-264.9	-134.8	-58.3		-4217.3	-229.8	-110.5	-51.7	
	Maximum $Underpressure_{1\sigma}$	625.2	40.4	18.7	9.8		824.7	41.8	20.0	8.0	
	RMS $_{(0\text{-}90\%)\ Maximum}$	182.3	159.5	152.3	144.2		181.3	158.1	151.0	142.9	
	RMS $_{(5\text{-}95\%)\ Maximum}$	183.5	159.5	150.4	144.0		182.4	158.1	148.8	142.4	
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	182.1	159.2	152.1	143.9		181.2	157.7	149.8	142.5	
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	183.1	159.5	149.7	143.3		182.2	158.1	147.9	141.8	
	RMS $_{(0\text{-}90\%)\ Mean}$	180.9	158.1	149.2	143.0		179.8	156.5	147.4	141.6	
	RMS $_{(5\text{-}95\%)\ Mean}$	181.7	157.6	147.1	142.2		180.6	155.9	145.2	140.7	
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	0.7	0.6	1.5	0.8		0.8	0.9	1.8	0.9	
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	1.0	0.8	1.6	1.2		1.1	1.0	1.8	1.5	
	$SEL_{Maximum}$	168.6	145.7	140.7	133.2		167.7	143.8	139.4	132.0	
	$SEL_{Peak\ Strike}$	168.6	144.6	140.6	132.4		167.7	143.1	139.4	131.1	
	SEL_{Mean}	165.3	143.8	139.2	132.1		164.2	142.3	137.6	130.8	
	$SEL_{1\sigma}$	1.2	0.6	0.8	0.5		1.3	0.7	1.0	0.4	
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.4	12.5	12.6	14.0		11.1	12.5	12.6	14.0	
	Time to $Peak_{Mean}$	15.3	17.8	17.4	17.9		15.3	16.0	21.4	17.9	
	Time to $Peak_{1\sigma}$	0.5	4.1	3.8	3.8		1.1	3.2	5.0	4.2	
	Strike Time $_{(0\text{-}90\%)\ Mean}$	28.2	37.6	102.7	84.1		28.2	37.9	108.7	85.7	
	Strike Time $_{(5\text{-}95\%)\ Mean}$	23.6	42.9	171.3	107.9		23.8	43.2	180.9	111.3	
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	5.3	5.9	28.1	24.7		5.4	5.8	29.6	26.8	
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	5.2	5.5	54.4	54.0		5.2	5.4	57.8	56.2	
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 187dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	3%	0%		100%	100%	0%	0%	
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	29%	0%		100%	100%	4%	0%	
Transmission Loss Coefficients	Peak $Strike_{Mean}$		19.6	20.2	20.5			19.6	20.2	20.5	
	Cumulative SEL		16.5	16.5	17.6			17.7	17.5	18.3	
	Series RMS $_{(0\text{-}90\%)}$		17.4	20.0	20.1			18.6	21.2	20.8	
	Series RMS $_{(5\text{-}95\%)}$		18.4	21.9	21.0			19.7	23.0	21.8	

Strike Series Analysis: Pile B-1, Air Off, February 17, 2011 10:45 (pg 1 of 3)

Time Series of Strikes at 10 meters

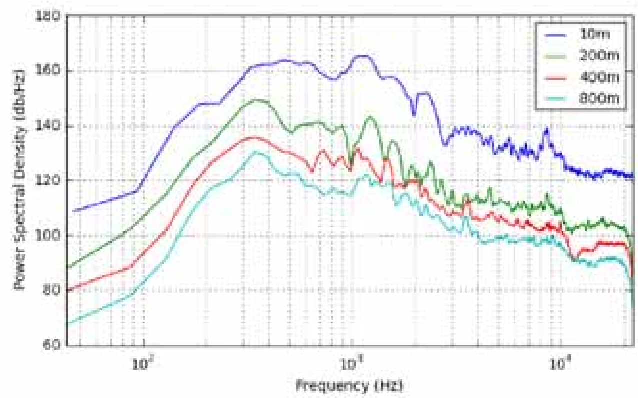


Pile B-1, 24" diameter

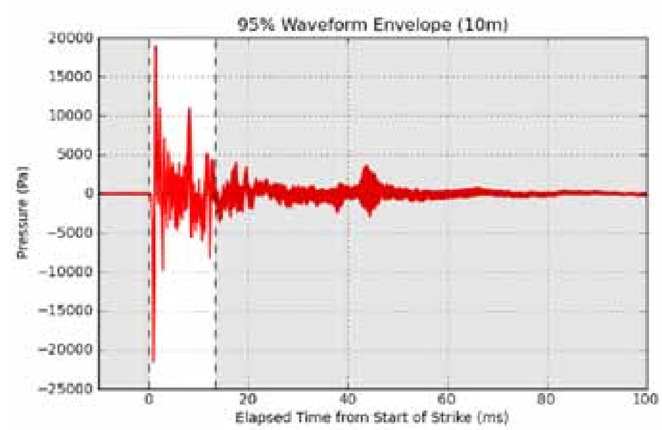
Date: February 17, 2011 Time: 10:45

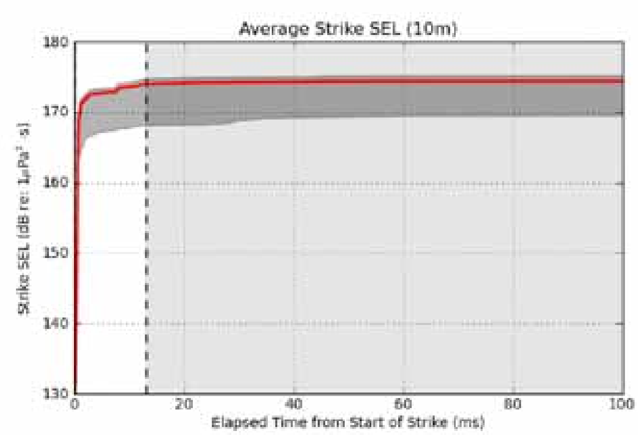
Attenuation: Unattenuated Driving Strikes
Number of Strikes: 140
Number of Strikes Analyzed: 140
Air: Off

Spectral Density



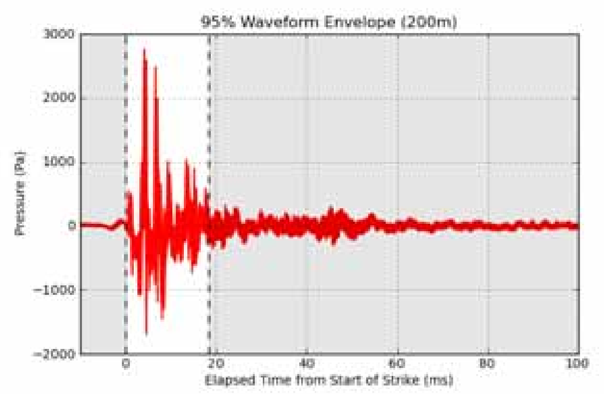
ST1400 – 10 meters

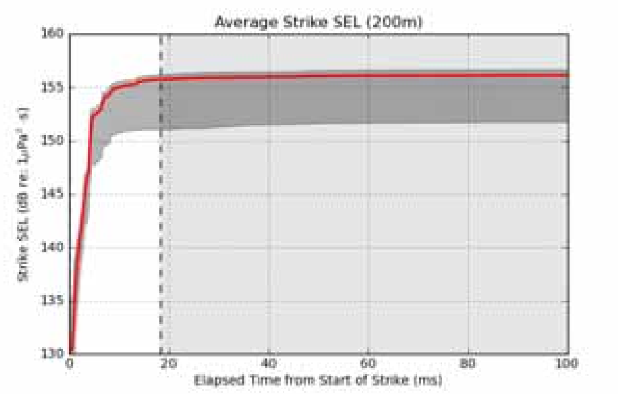




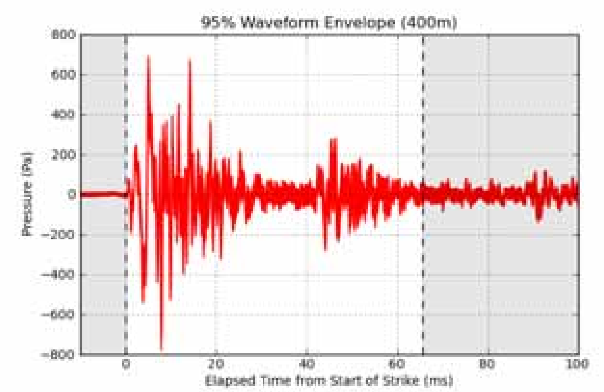
Strike Series Analysis: Pile B-1, Air Off, February 17, 2011 10:45 (pg 2 of 3)

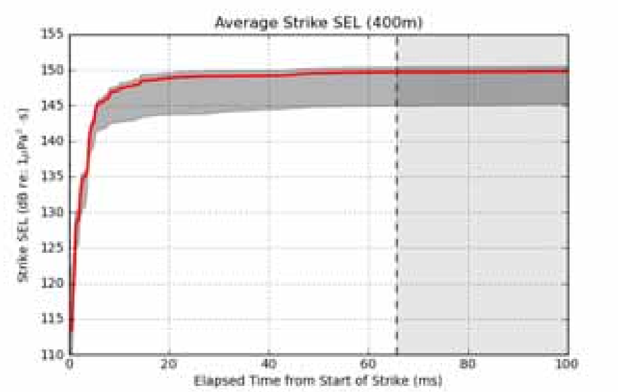
Waveforms | **SELs**



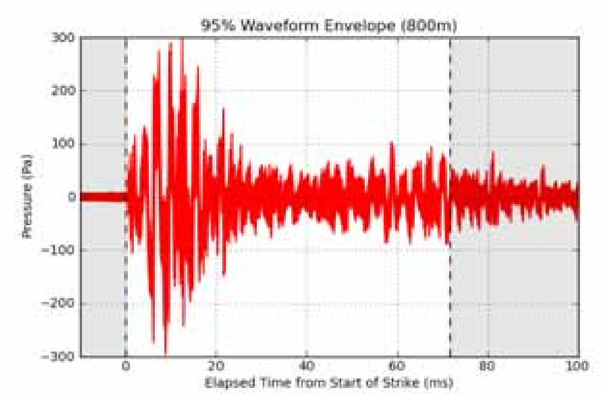


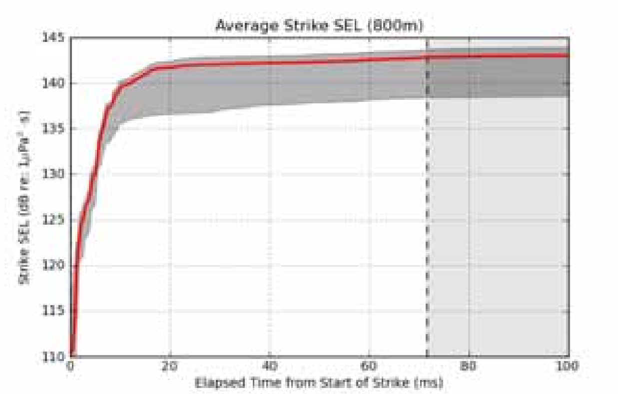
COHO – 200 meter s



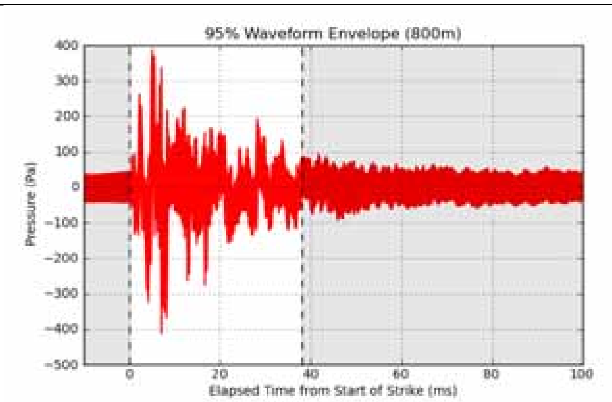


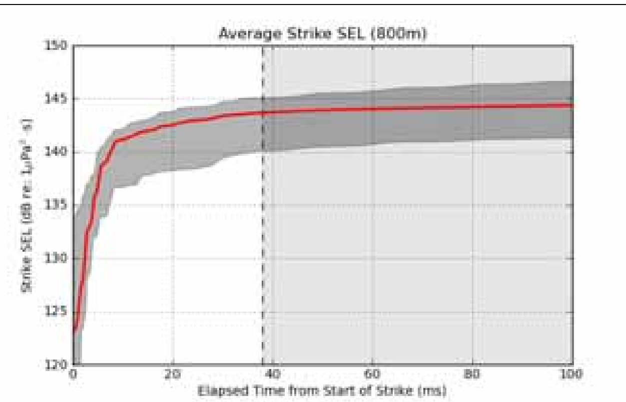
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





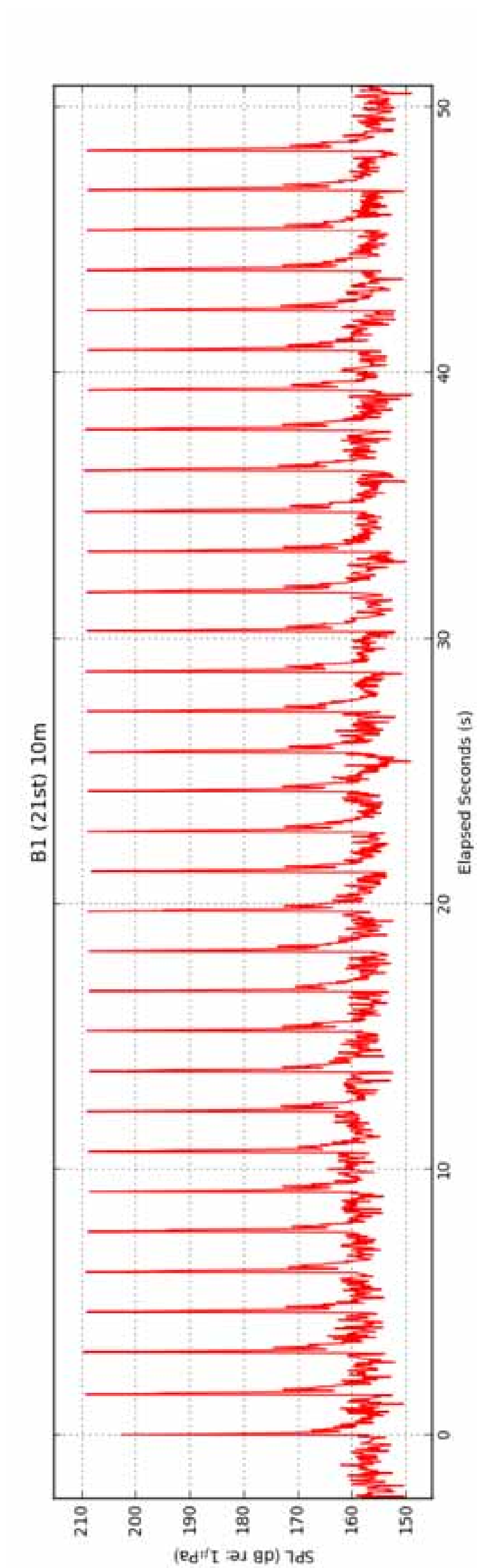
KOKANEE – 800 meters

Strike Series Analysis: Pile B-1, Air Off, February 17, 2011 10:45 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	205	388	789	805	10	205	388	789	805
	Number of Strikes: Total	140	140	140	140	140	140	140	140	140	140
	Number of Strikes: Analyzed	140	140	140	140	140	140	140	140	140	140
	Series RMS $_{(0-90\%)}$	190.2	171.2	160.9	153.7	156.9	189.7	170.3	159.9	152.9	154.9
	Series RMS $_{(5-95\%)}$	190.6	169.9	159.3	153.3	156.9	190.0	169.1	158.3	152.4	154.9
	Cumulative $SEL_{Analyzed}$	195.4	177.2	171.2	164.3	165.1	194.9	176.3	170.2	163.5	163.2
	Cumulative SEL	195.4	177.2	171.2	164.3	165.1	194.9	176.3	170.2	163.5	163.2
	Peak $Strikes_{Maximum}$	206.5	186.7	177.6	169.6	171.0	206.5	186.7	177.6	169.6	171.0
	Peak $Strikes_{Mean}$	205.8	185.8	176.1	167.6	169.7	205.8	185.8	176.1	167.6	169.7
	Peak $Strikes_{1\sigma}$	0.7	0.6	0.6	0.8	0.6	0.7	0.6	0.6	0.8	0.6
	Maximum $Overpressure_{Mean}$	16272.0	1948.8	610.4	229.7	293.4	16243.6	1703.4	528.5	237.4	238.5
	Maximum $Overpressure_{1\sigma}$	1321.3	120.6	43.7	17.4	25.0	1347.4	109.2	40.2	18.3	15.3
	Maximum $Underpressure_{Mean}$	-19484.0	-1087.3	-622.3	-229.4	-278.8	-18790.7	-969.6	-535.3	-191.1	-227.8
	Maximum $Underpressure_{1\sigma}$	1213.2	90.4	50.5	27.3	28.8	1179.7	86.0	47.2	23.5	16.1
	RMS $_{(0-90\%)\ Maximum}$	191.0	172.0	162.1	154.5	158.5	190.5	171.1	161.1	153.8	155.6
	RMS $_{(5-95\%)\ Maximum}$	192.9	172.3	160.3	154.2	158.4	192.5	171.3	159.3	153.5	155.5
	RMS $_{(0-90\%)\ Peak\ Strike}$	190.6	172.0	161.6	154.4	157.6	190.2	171.1	160.5	153.6	155.0
	RMS $_{(5-95\%)\ Peak\ Strike}$	192.9	171.6	159.4	154.1	157.5	192.5	170.8	158.1	153.3	154.9
	RMS $_{(0-90\%)\ Mean}$	190.2	171.2	161.0	153.7	156.8	189.7	170.3	159.9	152.8	154.9
	RMS $_{(5-95\%)\ Mean}$	190.8	170.0	159.3	153.3	156.9	190.3	169.1	158.3	152.4	154.9
	RMS $_{(0-90\%)\ 1\sigma}$	0.7	0.7	1.0	0.5	0.6	0.8	0.8	1.0	0.5	0.6
	RMS $_{(5-95\%)\ 1\sigma}$	1.5	0.8	0.8	0.5	0.6	1.6	0.8	0.8	0.5	0.5
	$SEL_{Maximum}$	174.7	156.3	150.3	143.7	145.0	174.2	155.4	149.4	142.9	142.4
	$SEL_{Peak\ Strike}$	174.1	156.0	150.0	143.5	144.2	173.6	155.1	149.0	142.8	141.7
	SEL_{Mean}	173.9	155.7	149.7	142.8	143.6	173.4	154.9	148.8	142.0	141.7
	$SEL_{1\sigma}$	0.5	0.4	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.4
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.0	14.0	15.0	16.9	13.9	11.0	14.0	15.0	18.9	13.7
	Time to $Peak_{Mean}$	11.1	14.3	17.1	19.0	16.4	11.1	14.3	18.1	19.9	15.7
	Time to $Peak_{1\sigma}$	0.0	0.2	1.7	0.9	2.4	0.0	0.5	3.0	0.5	2.3
	Strike Time $_{(0-90\%)\ Mean}$	23.5	28.3	75.6	81.6	48.0	23.5	28.7	77.6	82.7	48.2
	Strike Time $_{(5-95\%)\ Mean}$	21.9	36.7	107.2	89.7	48.1	22.0	37.6	109.1	91.9	48.1
	Strike Time $_{(0-90\%)\ 1\sigma}$	2.4	3.4	11.3	1.1	3.6	2.5	3.6	12.2	1.5	3.7
	Strike Time $_{(5-95\%)\ 1\sigma}$	8.7	5.0	10.3	2.7	2.9	8.8	4.6	11.3	3.3	2.9
Threshold	Pct Exceeding 206dB Peak	31%	0%	0%	0%	0%	31%	0%	0%	0%	0%
	Pct Exceeding 187dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 183dB SEL	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	99%	100%	100%	100%	100%	99%	100%
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	99%	100%	100%	100%	100%	99%	100%
Transmission Loss Coefficients	Peak $Strike_{Mean}$		15.2	18.7	20.1	18.9		15.2	18.7	20.1	18.9
	Cumulative SEL		13.9	15.2	16.4	15.9		14.5	15.8	16.8	16.9
	Series RMS $_{(0-90\%)}$		14.5	18.4	19.2	17.5		15.2	19.1	19.7	18.6
	Series RMS $_{(5-95\%)}$		15.7	19.6	19.6	17.7		16.4	20.3	20.1	18.7

Strike Series Analysis: Pile B-1, Air Off, February 21, 2011 10:30 (pg 1 of 3)

Time Series of Strikes at 10 meters

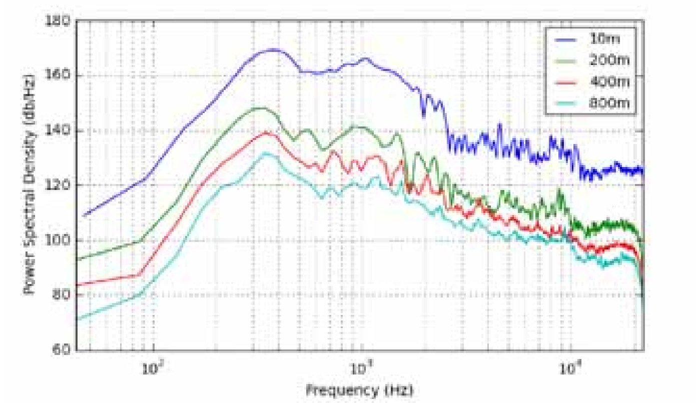


Pile B-1, 24" diameter

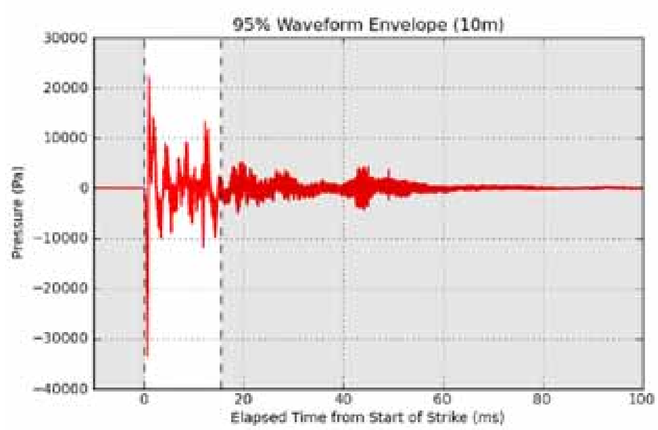
Date: February 21, 2011 Time: 10:30

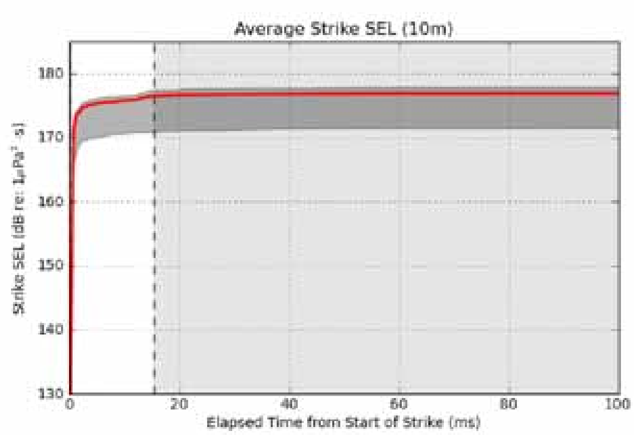
Attenuation: Restrike
Number of Strikes: 33
Number of Strikes Analyzed: 33
Air: Off

Spectral Density

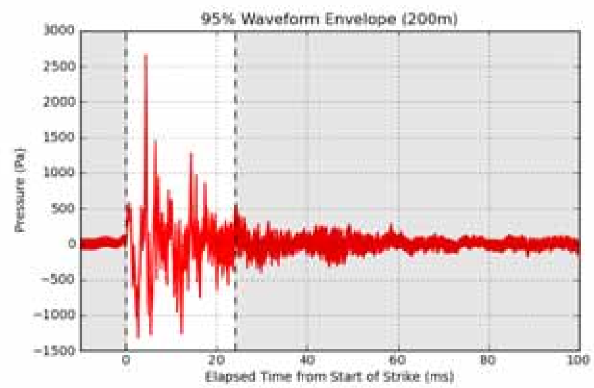
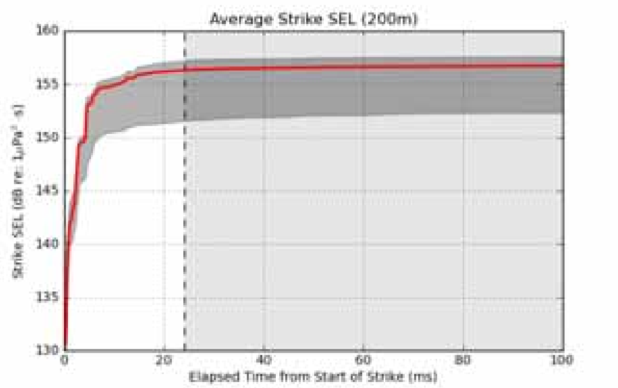
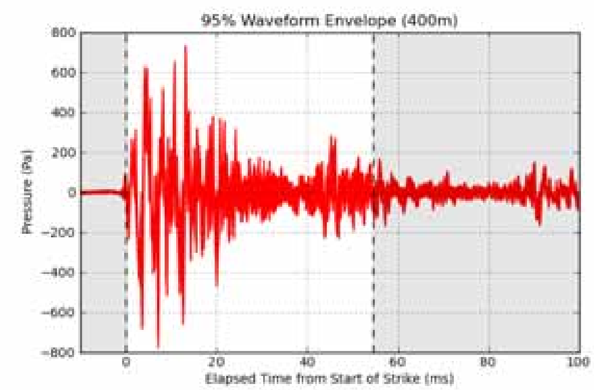
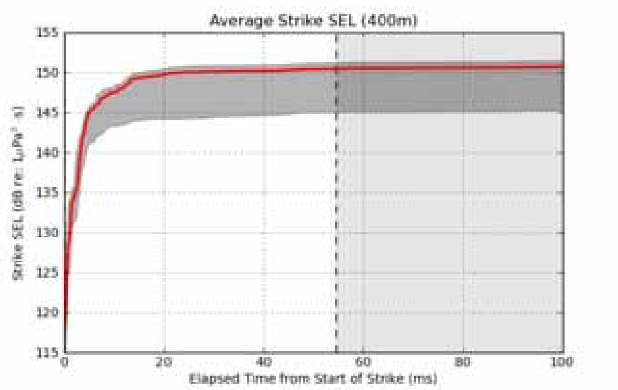
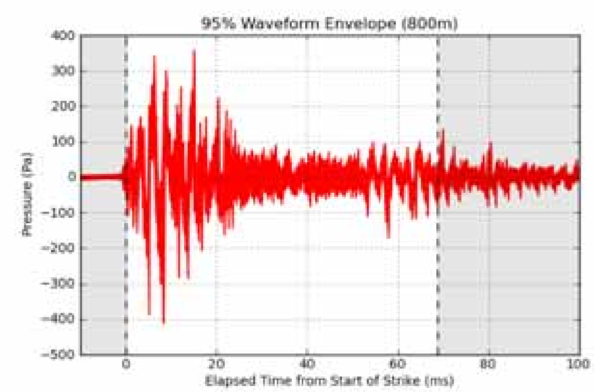
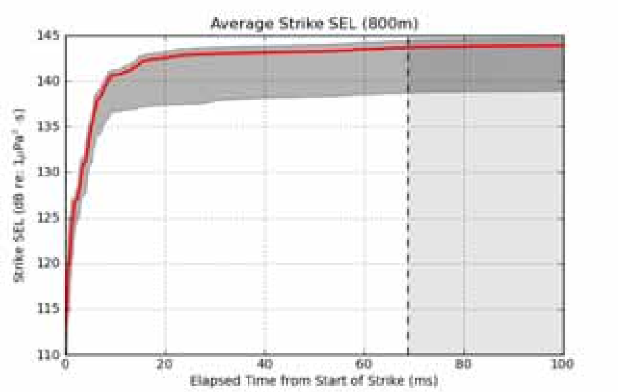


ST1400 – 10 meters





Strike Series Analysis: Pile B-1, Air Off, February 21, 2011 10:30 (pg 2 of 3)

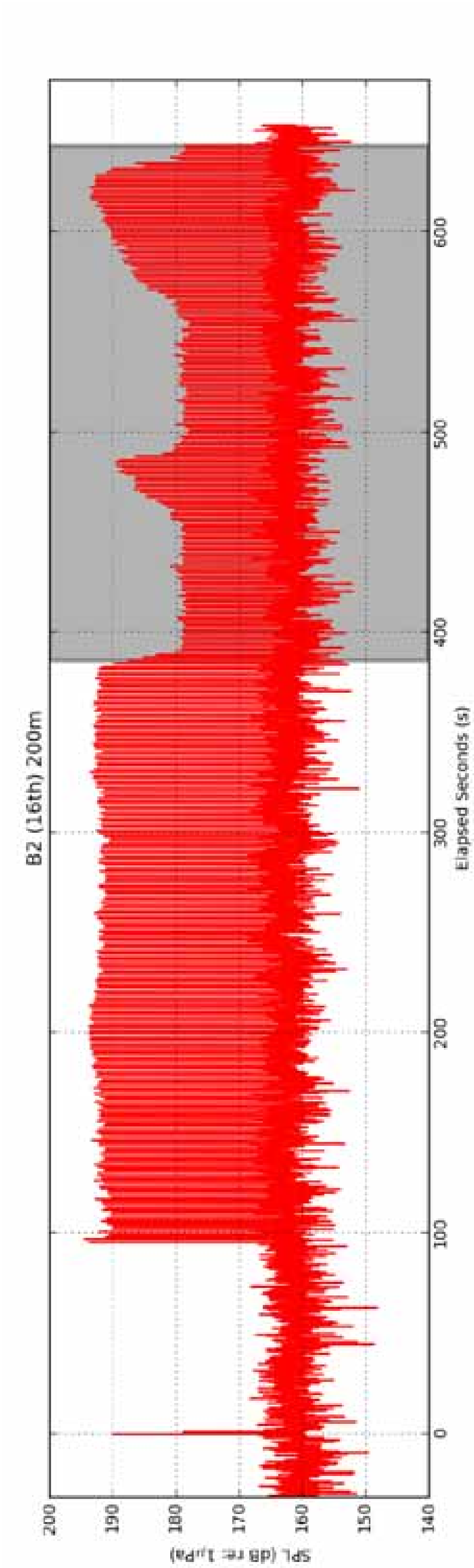
Waveforms	SELs	
		COHO – 200 meter s
		SOCKEYE – 400 meters
		SUPERCUBE – 800 meters
No data	No data	KOKANEE – 800 meters

Strike Series Analysis: Pile B-1, Air Off, February 21, 2011 10:30 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	190	386	784	No Data	10	190	386	784	No Data
	Number of Strikes: Total	33	33	33	33		33	33	33	33	
	Number of Strikes: Analyzed	33	33	33	33		33	33	33	33	
	Series RMS $_{(0\text{-}90\%)}$	192.4	171.0	162.4	154.7		191.8	169.6	161.4	153.8	
	Series RMS $_{(5\text{-}95\%)}$	193.2	169.9	160.7	154.6		192.4	168.7	159.6	153.7	
	Cumulative $SEL_{Analyzed}$	191.7	171.6	165.7	158.9		191.0	170.2	164.8	158.1	
	Cumulative SEL	191.7	171.6	165.7	158.9		191.0	170.2	164.8	158.1	
	Peak $Strikes_{Maximum}$	209.6	187.7	177.6	169.4		209.6	187.7	177.6	169.4	
	Peak $Strikes_{Mean}$	208.7	186.5	175.7	168.4		208.7	186.5	175.7	168.4	
	Peak $Strikes_{1\sigma}$	1.1	1.6	1.0	0.9		1.1	1.6	1.0	0.9	
	Maximum $Overpressure_{Mean}$	17443.1	2147.0	597.7	262.1		16651.2	1974.6	573.0	238.7	
	Maximum $Overpressure_{1\sigma}$	1774.3	264.2	56.4	23.2		1770.0	233.1	63.7	24.6	
	Maximum $Underpressure_{Mean}$	-27522.5	-1158.3	-589.5	-241.0		-27083.7	-1150.7	-498.9	-217.3	
	Maximum $Underpressure_{1\sigma}$	2596.5	83.9	68.6	23.9		2530.3	104.6	55.8	22.6	
	RMS $_{(0\text{-}90\%)\ Maximum}$	193.1	171.9	163.0	155.4		192.5	170.6	162.0	154.6	
	RMS $_{(5\text{-}95\%)\ Maximum}$	194.5	171.6	161.4	155.2		193.7	170.3	160.4	154.3	
	RMS $_{(0\text{-}90\%)\ Peak\ Strike}$	193.1	171.9	162.5	154.5		192.5	170.6	161.3	153.6	
	RMS $_{(5\text{-}95\%)\ Peak\ Strike}$	192.6	171.6	160.7	154.4		191.8	170.3	159.5	153.4	
	RMS $_{(0\text{-}90\%)\ Mean}$	192.4	171.0	162.3	154.7		191.7	169.6	161.3	153.8	
	RMS $_{(5\text{-}95\%)\ Mean}$	193.2	169.9	160.6	154.5		192.4	168.6	159.6	153.6	
	RMS $_{(0\text{-}90\%)\ 1\sigma}$	1.4	1.1	1.2	0.9		1.4	1.2	1.2	0.9	
	RMS $_{(5\text{-}95\%)\ 1\sigma}$	1.5	1.0	1.0	0.9		1.6	1.1	1.1	0.9	
	$SEL_{Maximum}$	177.4	157.2	151.2	144.4		176.8	155.9	150.2	143.6	
	$SEL_{Peak\ Strike}$	176.6	156.7	150.6	143.5		176.1	155.3	149.4	142.6	
	SEL_{Mean}	176.4	156.3	150.5	143.7		175.7	154.9	149.5	142.8	
	$SEL_{1\sigma}$	1.0	0.9	1.0	0.9		1.1	1.0	1.0	0.9	
Time Strike Series Statistics	Time to $Peak_{Minimum}$	10.8	14.3	14.6	16.2		10.8	14.3	14.0	15.3	
	Time to $Peak_{Mean}$	10.8	14.4	19.9	17.6		10.8	14.4	22.6	18.7	
	Time to $Peak_{1\sigma}$	0.0	0.0	3.6	1.1		0.0	0.0	2.9	1.5	
	Strike Time $_{(0\text{-}90\%)\ Mean}$	25.4	34.0	65.0	79.4		25.4	34.4	65.8	80.1	
	Strike Time $_{(5\text{-}95\%)\ Mean}$	21.8	40.4	95.6	81.8		22.4	41.1	97.0	83.7	
	Strike Time $_{(0\text{-}90\%)\ 1\sigma}$	4.1	3.2	3.2	0.9		4.2	3.4	3.6	0.8	
	Strike Time $_{(5\text{-}95\%)\ 1\sigma}$	4.6	4.3	2.3	1.4		5.3	3.8	1.9	1.5	
Threshold	Pct Exceeding 206dB Peak	97%	0%	0%	0%		97%	0%	0%	0%	
	Pct Exceeding 187dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0\text{-}90\%)}$	100%	100%	100%	97%		100%	100%	100%	97%	
	Pct Exceeding 150dB RMS $_{(5\text{-}95\%)}$	100%	100%	100%	97%		100%	100%	100%	97%	
Transmission Loss Coefficients	Peak $Strike_{Mean}$		17.4	20.8	21.3			17.4	20.8	21.3	
	Cumulative SEL		15.7	16.3	17.3			16.8	17.0	17.7	
	Series RMS $_{(0\text{-}90\%)}$		16.7	18.9	19.9			17.8	19.6	20.4	
	Series RMS $_{(5\text{-}95\%)}$		18.2	20.5	20.4			19.2	21.2	20.9	

Strike Series Analysis: Pile B-2, Air Off, February 16, 2011 11:00 (pg 1 of 3)

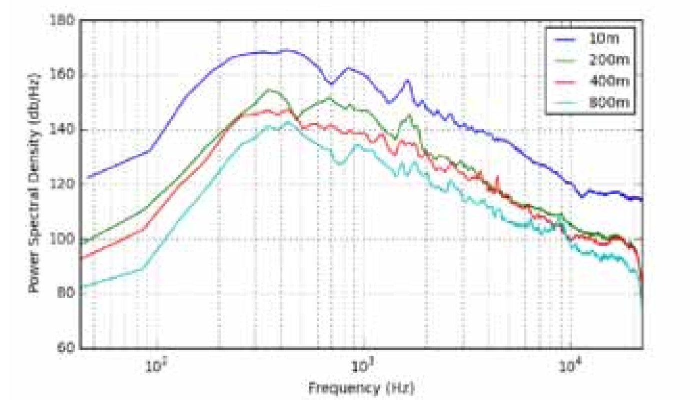
Time Series of Strikes at 10 meters



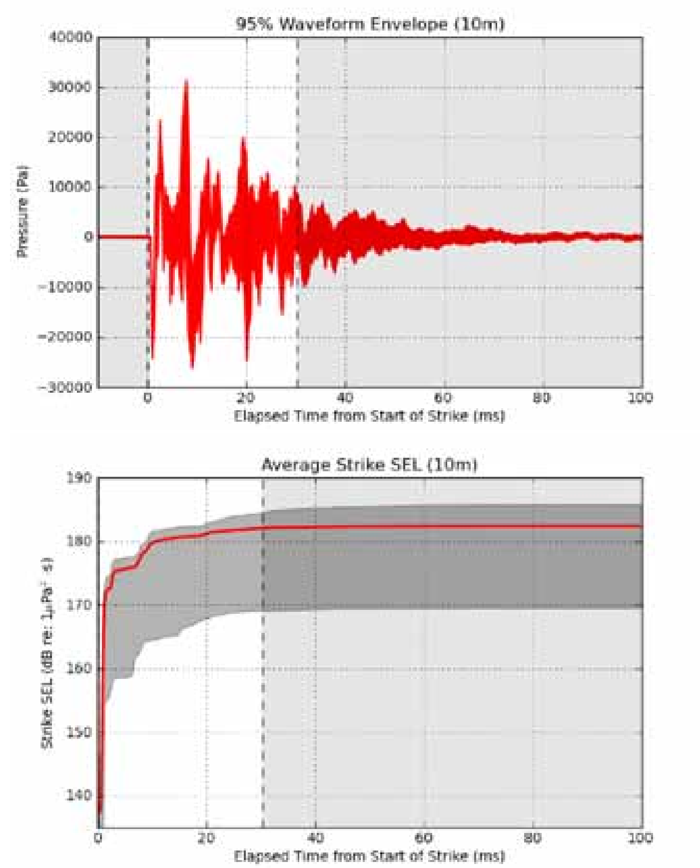
Pile B-2, 48" diameter

Date: February 16, 2011   Time: 11:00

Attenuation: Confined Bubble Curtain
Number of Strikes: 382
Number of Strikes Analyzed: 207
Air: Off

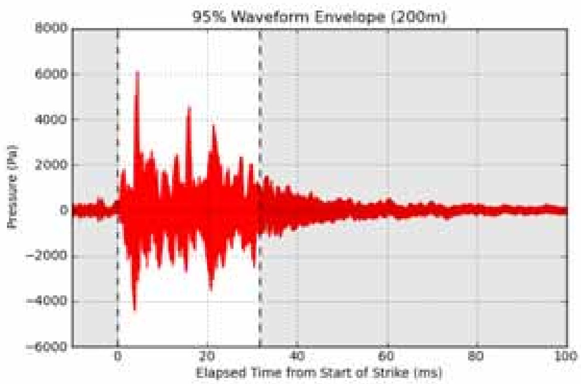
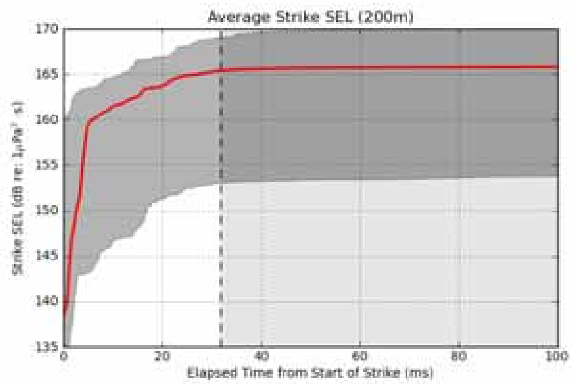
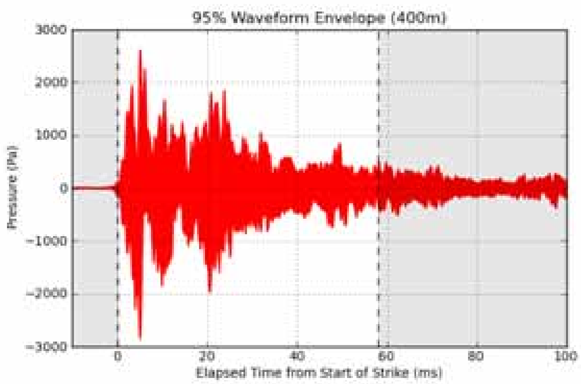
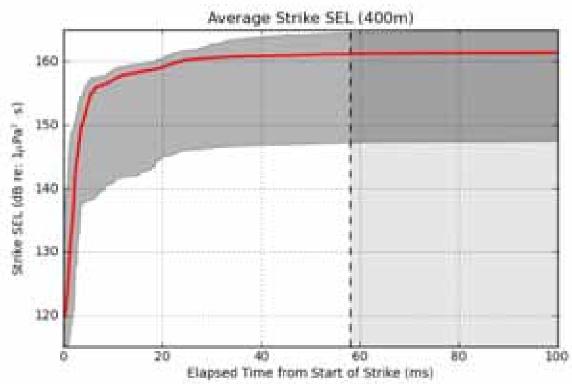
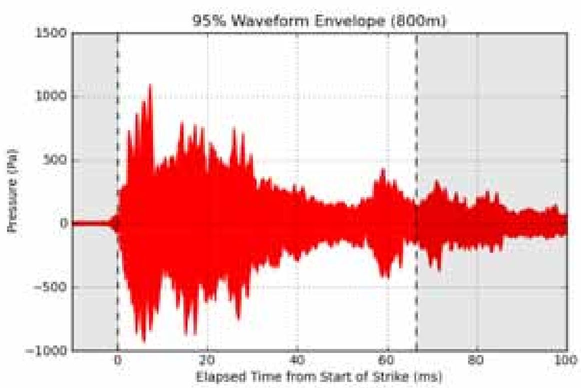
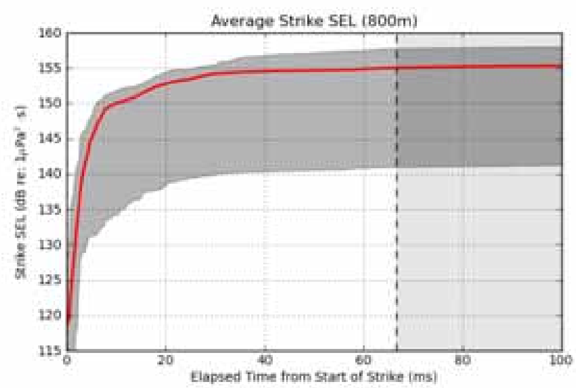


Spectral Density



ST1400 – 10 meters

Strike Series Analysis: Pile B-2, Air Off, February 16, 2011 11:00 (pg 2 of 3)

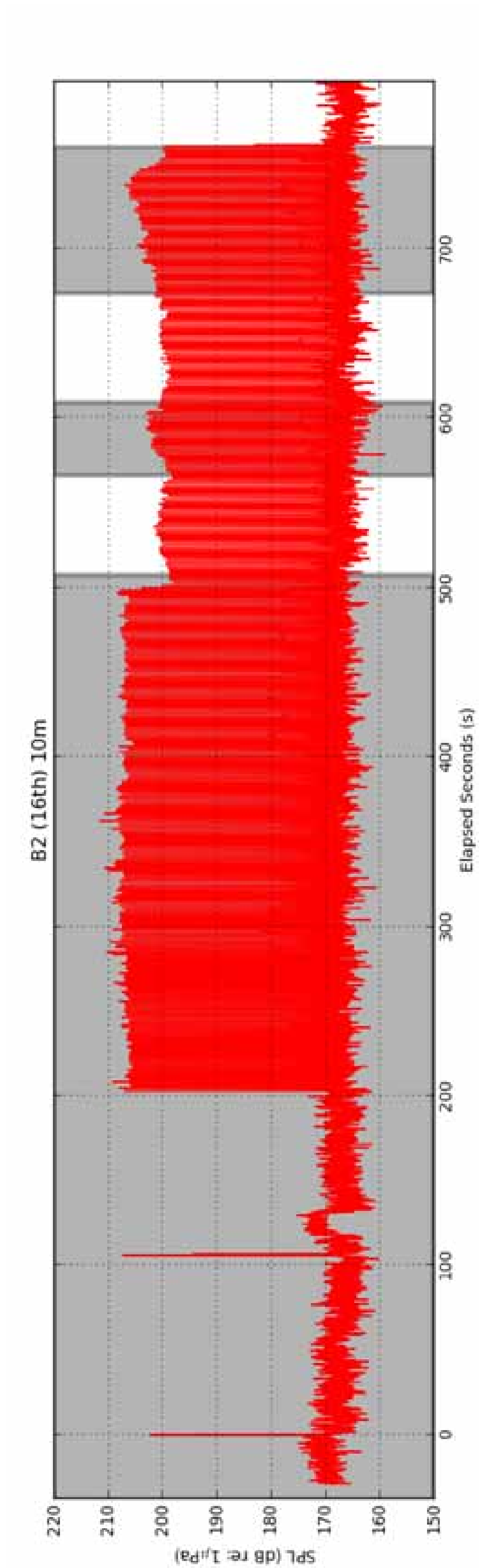
Waveforms	SELs	
		COHO – 200 meter s
		SOCKEYE – 400 meters
		SUPERCUBE – 800 meters
No data	No data	KOKANEE – 800 meters

Strike Series Analysis: Pile B-2, Air Off, February 16, 2011 11:00 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	180	369	773		10	180	369	773	
	Number of Strikes: Total	382	382	382	382		382	382	382	382	
	Number of Strikes: Analyzed	207	207	207	207		207	207	207	207	
	Series RMS $_{(0-90\%)}$	196.1	179.3	172.9	166.2		193.5	178.7	171.7	165.6	
	Series RMS $_{(5-95\%)}$	196.7	180.0	171.4	166.2		194.1	179.5	170.1	165.6	
	Cumulative $SEL_{Analyzed}$	205.3	188.6	184.4	178.2		202.7	188.0	183.2	177.6	
	Cumulative SEL	207.9	191.3	187.1	180.9		205.4	190.7	185.8	180.3	
	Peak $Strikes_{Maximum}$	211.5	194.4	188.0	181.1	No Data	211.5	194.4	188.0	181.1	No Data
	Peak $Strikes_{Mean}$	207.1	192.0	185.8	178.5		207.1	192.0	185.8	178.5	
	Peak $Strikes_{1\sigma}$	1.4	1.2	1.3	1.3		1.4	1.2	1.3	1.3	
	Maximum $Overpressure_{Mean}$	21699.8	4013.1	1928.0	845.0		16976.8	3821.4	1667.7	771.0	
	Maximum $Overpressure_{1\sigma}$	2604.4	438.3	238.3	101.6		2067.9	424.1	217.4	99.8	
	Maximum $Underpressure_{Mean}$	-21960.0	-3002.5	-1736.1	-714.9		-17522.5	-2751.0	-1447.0	-678.3	
	Maximum $Underpressure_{1\sigma}$	3323.2	459.1	242.0	85.4		3754.0	394.0	214.9	91.3	
	RMS $_{(0-90\%)\ Maximum}$	198.0	182.7	175.7	168.5		196.1	182.2	174.5	167.7	
	RMS $_{(5-95\%)\ Maximum}$	199.1	182.6	174.6	168.2		197.1	182.2	173.4	167.3	
	RMS $_{(0-90\%)\ Peak\ Strike}$	196.6	182.7	172.7	168.5		193.8	182.2	171.4	167.7	
	RMS $_{(5-95\%)\ Peak\ Strike}$	197.4	182.6	171.2	168.2		194.7	182.2	169.8	167.3	
	RMS $_{(0-90\%)\ Mean}$	196.0	179.2	172.9	166.2		193.4	178.5	171.6	165.5	
	RMS $_{(5-95\%)\ Mean}$	196.7	179.9	171.4	166.2		194.0	179.4	170.0	165.5	
	RMS $_{(0-90\%)\ 1\sigma}$	1.2	1.2	1.2	1.1		1.2	1.2	1.2	1.2	
	RMS $_{(5-95\%)\ 1\sigma}$	1.3	1.3	1.2	1.2		1.2	1.3	1.2	1.2	
	$SEL_{Maximum}$	185.3	169.6	164.7	157.8		183.1	169.1	163.6	157.1	
	$SEL_{Peak\ Strike}$	182.4	169.6	161.0	157.8		179.8	169.1	159.7	157.1	
	SEL_{Mean}	182.0	165.4	161.2	155.0		179.4	164.7	159.9	154.4	
	$SEL_{1\sigma}$	1.1	1.2	1.1	1.1		1.1	1.2	1.1	1.1	
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.0	11.6	13.7	12.5		11.0	11.6	12.7	12.4	
	Time to $Peak_{Mean}$	19.2	17.1	20.4	20.1		20.6	17.3	22.0	22.5	
	Time to $Peak_{1\sigma}$	5.7	5.9	8.0	6.9		7.5	6.3	8.7	8.9	
	Strike Time $_{(0-90\%)\ Mean}$	40.2	41.6	68.0	76.6		40.4	41.7	68.8	77.1	
	Strike Time $_{(5-95\%)\ Mean}$	34.9	33.8	95.4	77.3		35.1	33.9	96.8	78.0	
	Strike Time $_{(0-90\%)\ 1\sigma}$	4.1	3.4	5.6	4.0		4.1	3.5	5.7	4.0	
	Strike Time $_{(5-95\%)\ 1\sigma}$	4.5	3.9	6.5	3.8		4.5	4.0	6.4	3.9	
Threshold	Pct Exceeding 206dB Peak	88%	0%	0%	0%		88%	0%	0%	0%	
	Pct Exceeding 187dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	5%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	100%		100%	100%	100%	100%	
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%		100%	100%	100%	100%	
Transmission Loss Coefficients	Peak $Strike_{Mean}$		12.0	13.6	15.1			12.0	13.6	15.1	
	Cumulative SEL		13.3	13.3	14.3			13.8	14.1	14.7	
	Series RMS $_{(0-90\%)}$		13.4	14.8	15.8			13.9	15.6	16.2	
	Series RMS $_{(5-95\%)}$		13.3	16.1	16.1			13.7	17.0	16.5	

Strike Series Analysis: Pile B-2, Air On, February 16, 2011 11:00 (pg 1 of 3)

Time Series of Strikes at 10 meters

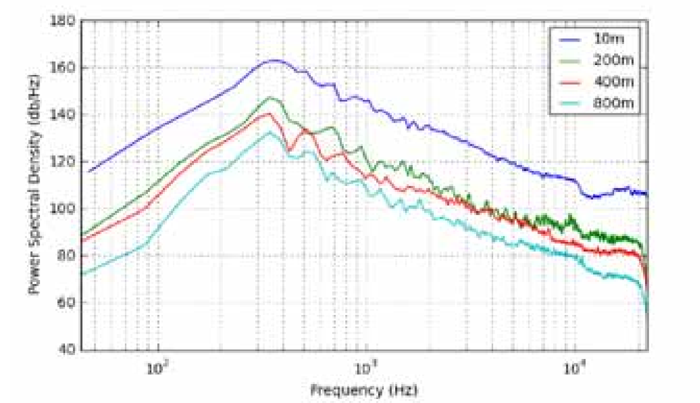


Pile B-2, 48" diameter

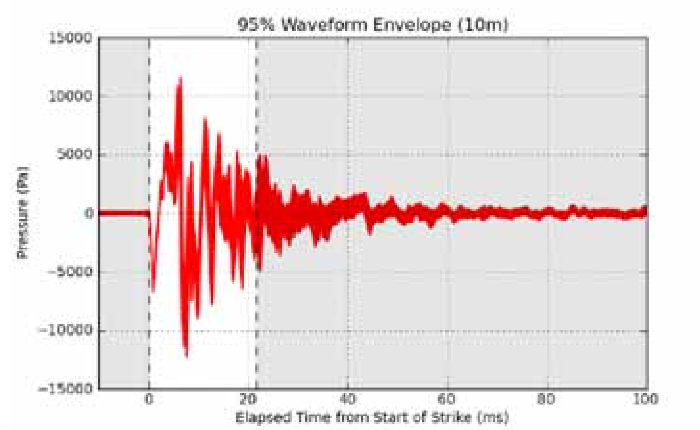
Date: February 16, 2011 Time: 11:00

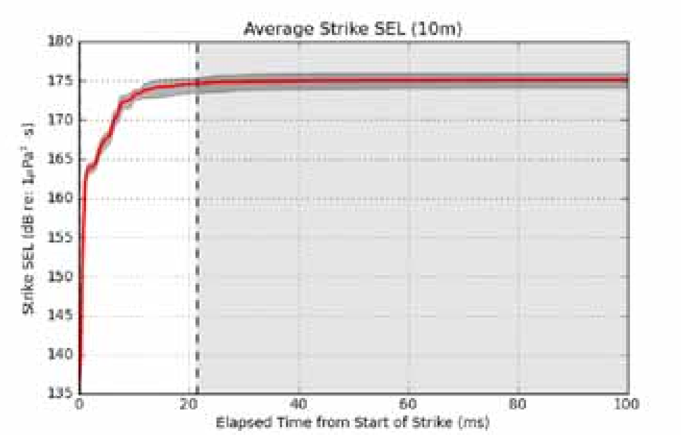
Attenuation: Confined Bubble Curtain
Number of Strikes: 382
Number of Strikes Analyzed: 81
Air: On

Spectral Density



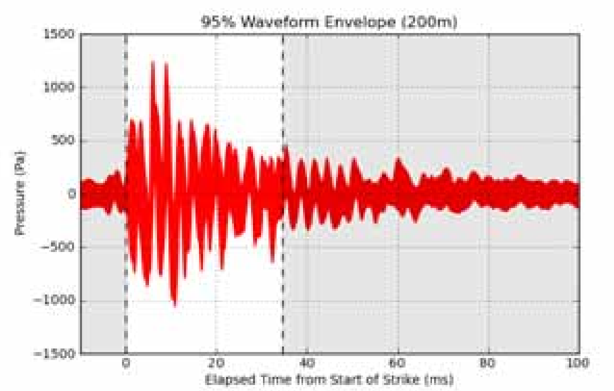
ST1400 – 10 meters

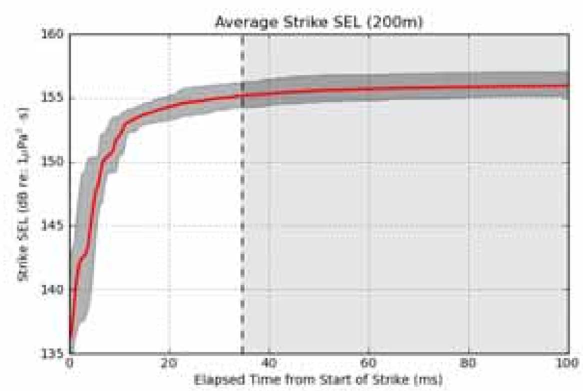




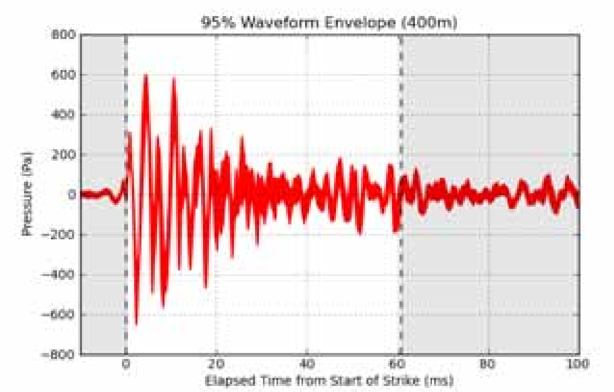
Strike Series Analysis: Pile B-2, Air On, February 16, 2011 11:00 (pg 2 of 3)

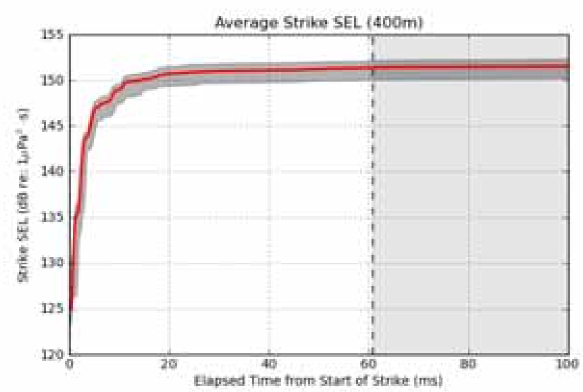
Waveforms | **SELs**



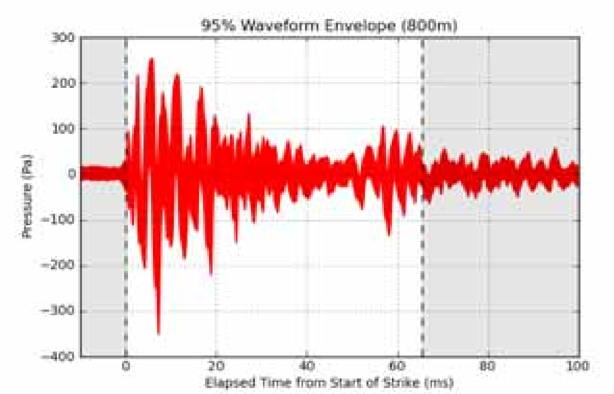


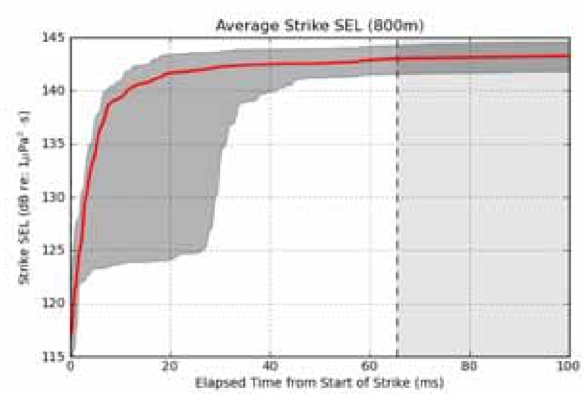
COHO – 200 meter s





SOCKEYE – 400 meters





SUPERCUBE – 800 meters

No data

No data

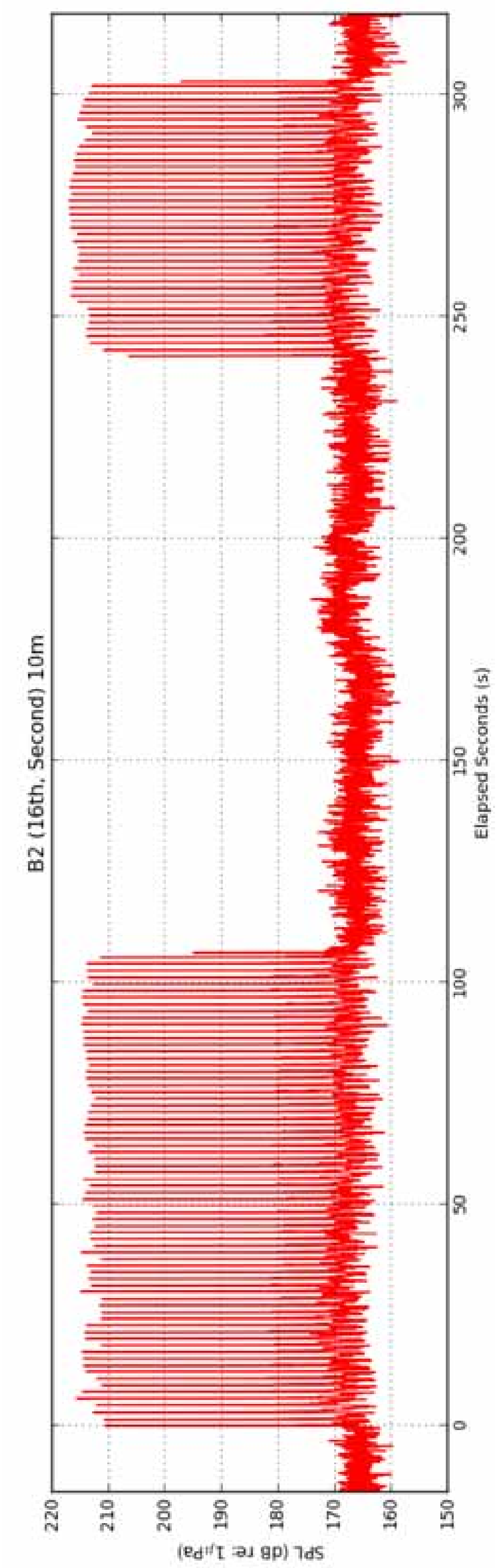
KOKANEE – 800 meters

Strike Series Analysis: Pile B-2, Air On, February 16, 2011 11:00 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	180	369	773		10	180	369	773	
	Number of Strikes: Total	382	382	382	382		382	382	382	382	
	Number of Strikes: Analyzed	81	81	81	81		81	81	81	81	
	Series RMS $_{(0-90\%)}$	189.7	168.7	162.9	154.2		186.6	166.2	159.9	152.3	
	Series RMS $_{(5-95\%)}$	190.4	168.8	161.0	153.3		187.8	166.8	157.7	151.0	
	Cumulative SEL$_{Analyzed}$	193.8	174.3	170.4	162.1		190.7	171.7	167.7	160.2	
	Cumulative SEL	200.5	181.0	177.2	168.8		197.4	178.5	174.4	167.0	
	Peak Strikes$_{Maximum}$	201.4	180.9	175.0	168.6		201.4	180.9	175.0	168.6	
	Peak Strikes$_{Mean}$	199.8	178.9	174.2	166.6		199.8	178.9	174.2	166.6	
	Peak Strikes$_{1\sigma}$	0.7	0.6	0.4	1.1		0.7	0.6	0.4	1.1	
	Maximum Overpressure$_{Mean}$	8635.8	870.5	508.1	172.6		6773.8	717.4	326.0	138.9	
	Maximum Overpressure$_{1\sigma}$	819.7	67.7	25.0	13.6		568.0	39.0	33.1	21.3	
	Maximum Underpressure$_{Mean}$	-9827.6	-743.0	-501.3	-214.5		-7050.7	-519.4	-367.9	-162.6	
	Maximum Underpressure$_{1\sigma}$	839.9	78.7	20.8	27.4		586.5	39.4	41.7	26.5	
	RMS $_{(0-90\%)\ Maximum}$	191.0	169.8	163.9	155.6		188.1	167.5	161.3	154.0	
	RMS $_{(5-95\%)\ Maximum}$	192.2	170.2	163.8	156.1		190.1	168.1	161.0	154.6	
	RMS $_{(0-90\%)\ Peak\ Strike}$	189.9	169.5	163.7	154.7	No Data	186.7	166.8	161.2	152.8	No Data
	RMS $_{(5-95\%)\ Peak\ Strike}$	190.3	169.9	162.9	153.9		187.6	167.4	159.9	151.7	
	RMS $_{(0-90\%)\ Mean}$	189.7	168.7	162.9	154.2		186.5	166.1	159.9	152.3	
	RMS $_{(5-95\%)\ Mean}$	190.5	168.8	161.2	153.4		187.7	166.8	157.8	151.2	
	RMS $_{(0-90\%)\ 1\sigma}$	0.5	0.5	0.8	0.8		0.8	0.7	1.1	1.0	
	RMS $_{(5-95\%)\ 1\sigma}$	0.7	0.6	1.5	1.5		1.1	0.7	1.7	1.9	
	SEL$_{Maximum}$	175.6	156.2	152.1	144.3		172.9	153.8	149.5	142.5	
	SEL$_{Peak\ Strike}$	174.8	155.8	152.1	143.4		171.7	153.2	149.5	141.5	
	SEL$_{Mean}$	174.6	155.2	151.3	143.0		171.5	152.6	148.5	141.1	
	SEL$_{1\sigma}$	0.4	0.4	0.5	0.5		0.8	0.6	0.7	0.6	
Time Strike Series Statistics	Time to Peak$_{Minimum}$	15.8	16.0	12.4	15.4		16.1	16.0	12.5	12.6	
	Time to Peak$_{Mean}$	17.3	18.6	14.8	17.4		18.2	18.5	16.4	17.5	
	Time to Peak$_{1\sigma}$	0.6	1.5	2.5	3.1		2.5	1.3	2.4	3.0	
	Strike Time $_{(0-90\%)\ Mean}$	31.5	44.5	70.4	75.4		31.7	44.4	74.0	77.4	
	Strike Time $_{(5-95\%)\ Mean}$	23.4	38.7	109.9	96.6		23.5	38.8	121.7	105.5	
	Strike Time $_{(0-90\%)\ 1\sigma}$	2.0	1.9	9.4	7.8		1.9	1.7	12.2	9.6	
	Strike Time $_{(5-95\%)\ 1\sigma}$	2.8	1.4	32.4	30.8		2.6	1.4	39.2	41.5	
Threshold	Pct Exceeding 206dB Peak	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 187dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	0%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	98%		100%	100%	100%	77%	
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%		100%	100%	100%	96%	
Transmission Loss Coefficients	Peak Strike$_{Mean}$		16.7	16.4	17.6			16.7	16.4	17.6	
	Cumulative SEL		15.5	14.9	16.8			17.5	16.7	17.7	
	Series RMS $_{(0-90\%)}$		16.7	17.1	18.8			18.7	19.0	19.8	
	Series RMS $_{(5-95\%)}$		17.3	18.8	19.7			18.8	20.9	20.9	

Strike Series Analysis: Pile B-2, Air Off, February 16, 2011 11:50 (pg 1 of 3)

Time Series of Strikes at 10 meters

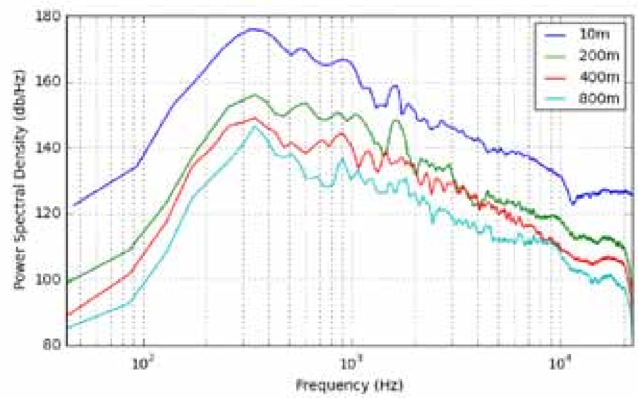


Pile B-2, 48" diameter

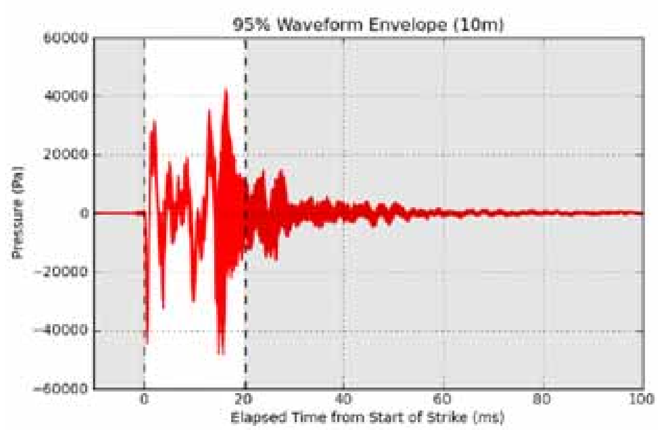
Date: February 16, 2011 Time: 11:50

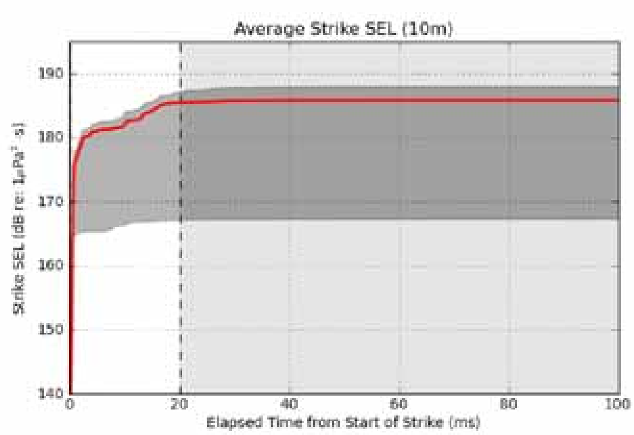
Attenuation: Unattenuated Driving Strikes
Number of Strikes: 114
Number of Strikes Analyzed: 112
Air: Off

Spectral Density

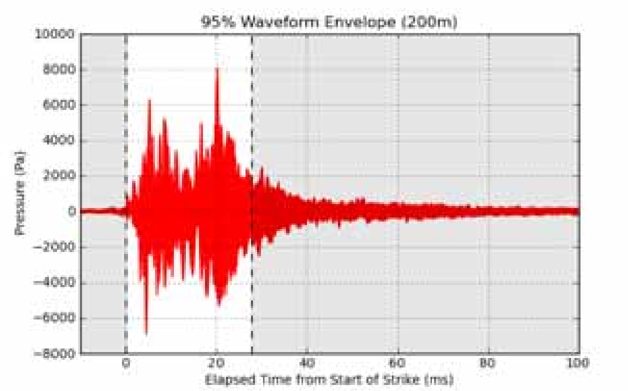
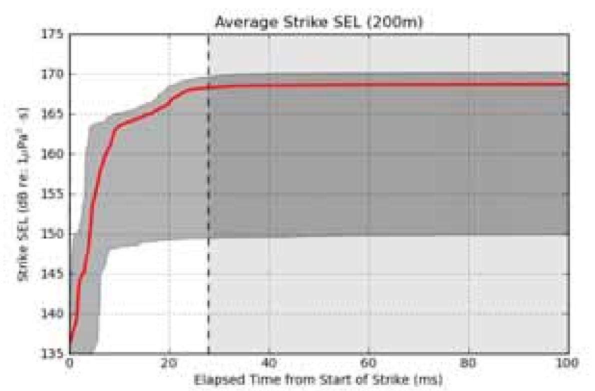
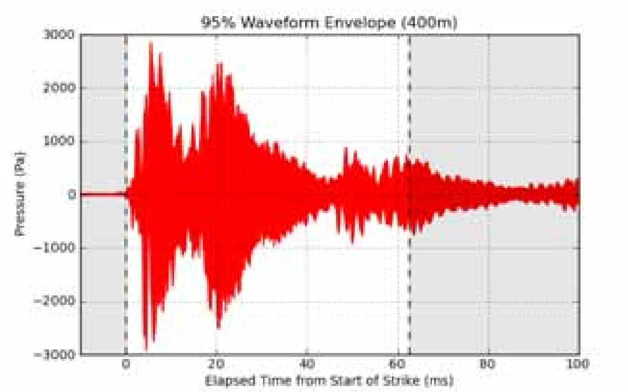
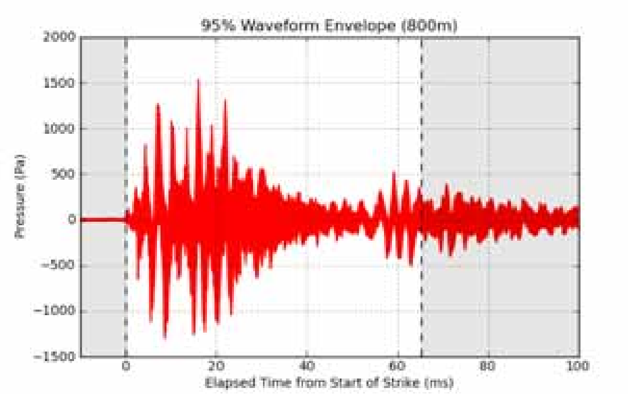


ST1400 – 10 meters





Strike Series Analysis: Pile B-2, Air Off, February 16, 2011 11:50 (pg 2 of 3)

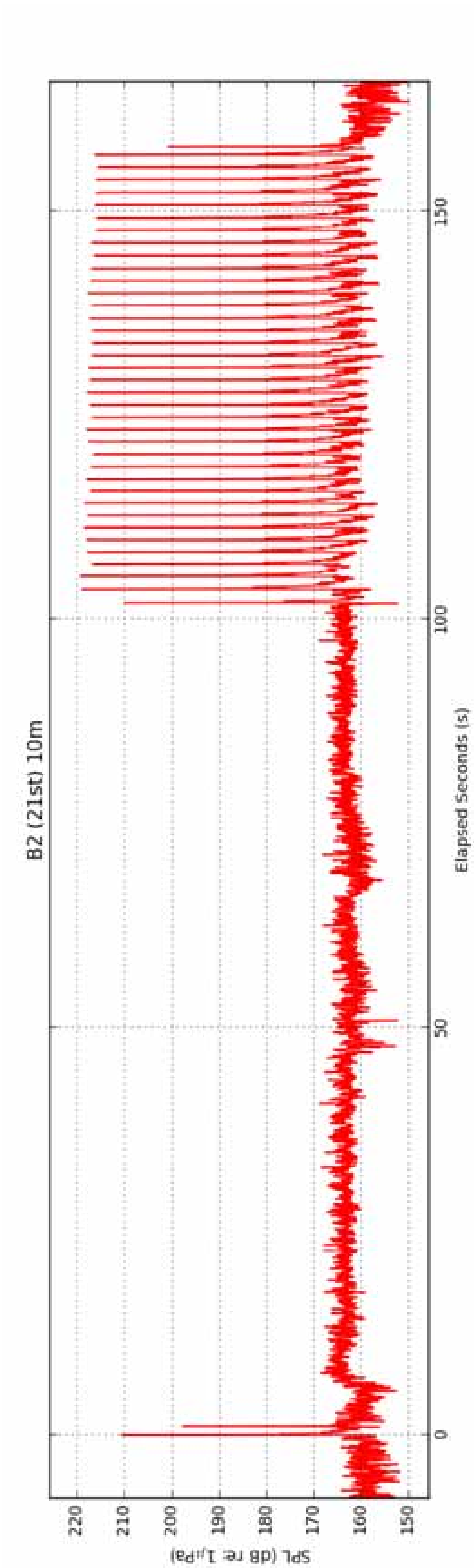
Waveforms	SELs	
		COHO – 200 meter s
		SOCKEYE – 400 meters
		SUPERCUBE – 800 meters
No data	No data	KOKANEE – 800 meters

Strike Series Analysis: Pile B-2, Air Off, February 16, 2011 11:50 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	180	369	773		10	180	369	773	
	Number of Strikes: Total	114	114	114	114		114	114	114	114	
	Number of Strikes: Analyzed	112	112	112	112		112	112	112	112	
	Series RMS $_{(0-90\%)}$	200.9	182.4	174.6	168.1		198.9	181.7	173.2	167.1	
	Series RMS $_{(5-95\%)}$	201.8	183.4	173.4	168.1		199.9	182.8	171.9	167.0	
	Cumulative $SEL_{Analyzed}$	206.2	188.4	183.6	177.3		204.3	187.6	182.3	176.4	
	Cumulative SEL	206.3	188.4	183.7	177.4		204.4	187.7	182.4	176.5	
	Peak $Strikes_{Maximum}$	217.0	199.3	190.5	184.5	No Data	217.0	199.3	190.5	184.5	No Data
	Peak $Strikes_{Mean}$	213.6	195.7	187.7	180.6		213.6	195.7	187.7	180.6	
	Peak $Strikes_{1\sigma}$	2.5	2.4	2.1	2.1		2.5	2.4	2.1	2.1	
	Maximum $Overpressure_{Mean}$	30561.5	6194.0	2354.1	1060.9		29150.5	5867.9	2039.7	962.3	
	Maximum $Overpressure_{1\sigma}$	4410.6	1280.5	401.1	182.0		7027.2	1209.0	383.2	187.2	
	Maximum $Underpressure_{Mean}$	-49427.2	-4967.9	-2336.0	-983.9		-45452.3	-4721.2	-2021.3	-945.4	
	Maximum $Underpressure_{1\sigma}$	10249.5	681.9	300.5	158.1		10021.9	723.3	305.8	154.6	
	RMS $_{(0-90\%)\ Maximum}$	202.5	183.5	176.2	170.1		200.4	182.7	175.1	169.4	
	RMS $_{(5-95\%)\ Maximum}$	203.5	184.5	175.6	170.0		201.7	183.9	174.5	169.2	
	RMS $_{(0-90\%)\ Peak\ Strike}$	201.2	183.4	175.9	170.1		199.7	182.7	174.7	169.4	
	RMS $_{(5-95\%)\ Peak\ Strike}$	201.9	184.1	175.4	170.0		200.4	183.6	174.2	169.2	
	RMS $_{(0-90\%)\ Mean}$	200.7	182.2	174.4	167.9		198.8	181.5	173.0	166.9	
	RMS $_{(5-95\%)\ Mean}$	201.6	183.2	173.3	167.9		199.7	182.6	171.8	166.8	
	RMS $_{(0-90\%)\ 1\sigma}$	1.9	1.9	2.3	2.0		1.9	2.1	2.4	2.1	
	RMS $_{(5-95\%)\ 1\sigma}$	1.9	1.9	2.6	2.0		1.8	2.1	2.6	2.1	
	$SEL_{Maximum}$	187.7	169.2	164.7	158.4		185.7	168.7	163.6	157.7	
	$SEL_{Peak\ Strike}$	185.9	168.4	164.1	158.4		184.4	167.8	162.9	157.7	
	SEL_{Mean}	185.5	167.7	162.9	156.6		183.6	166.9	161.5	155.7	
	$SEL_{1\sigma}$	2.0	2.0	2.1	1.9		2.0	2.1	2.1	2.0	
Time Strike Series Statistics	Time to $Peak_{Minimum}$	11.1	13.6	14.1	14.9		11.1	13.6	14.7	13.7	
	Time to $Peak_{Mean}$	25.1	27.3	26.5	26.0		25.1	27.9	28.4	25.9	
	Time to $Peak_{1\sigma}$	3.4	3.9	7.2	3.4		3.8	2.9	5.8	2.6	
	Strike Time $_{(0-90\%)\ Mean}$	30.5	35.4	71.7	74.2		30.7	35.5	72.2	75.5	
	Strike Time $_{(5-95\%)\ Mean}$	24.6	27.2	92.6	75.7		24.7	27.3	94.4	77.2	
	Strike Time $_{(0-90\%)\ 1\sigma}$	2.7	2.3	4.9	4.1		2.7	2.3	5.6	4.5	
	Strike Time $_{(5-95\%)\ 1\sigma}$	1.9	1.7	17.3	4.1		1.9	1.8	18.3	4.3	
Threshold	Pct Exceeding 206dB Peak	99%	0%	0%	0%		99%	0%	0%	0%	
	Pct Exceeding 187dB SEL	3%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	96%	0%	0%	0%		93%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	100%		100%	100%	99%	99%	
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	100%		100%	100%	100%	99%	
Transmission Loss Coefficients	Peak $Strike_{Mean}$		14.3	16.5	17.5			14.3	16.5	17.5	
	Cumulative SEL		14.2	14.4	15.3			14.8	15.3	15.8	
	Series RMS $_{(0-90\%)}$		14.7	16.8	17.3			15.3	17.6	17.9	
	Series RMS $_{(5-95\%)}$		14.7	18.1	17.9			15.2	19.1	18.4	

Strike Series Analysis: Pile B-2, Air Off, February 21, 2011 08:45 (pg 1 of 3)

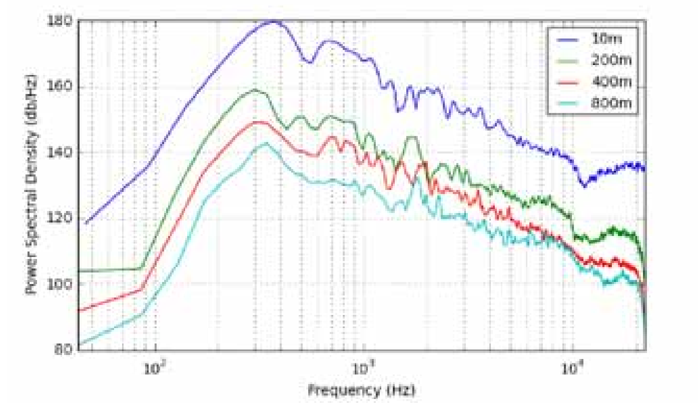
Time Series of Strikes at 10 meters



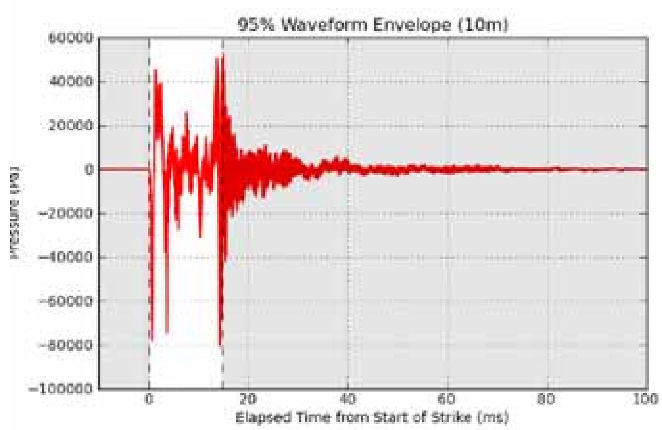
Pile B-2, 48" diameter

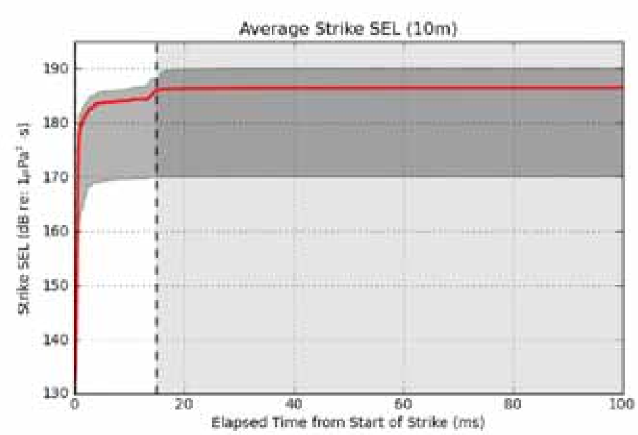
Date: February 21, 2011 Time: 08:45

Attenuation: Restrike
Number of Strikes: 40
Number of Strikes Analyzed: 40
Air: Off



Spectral Density



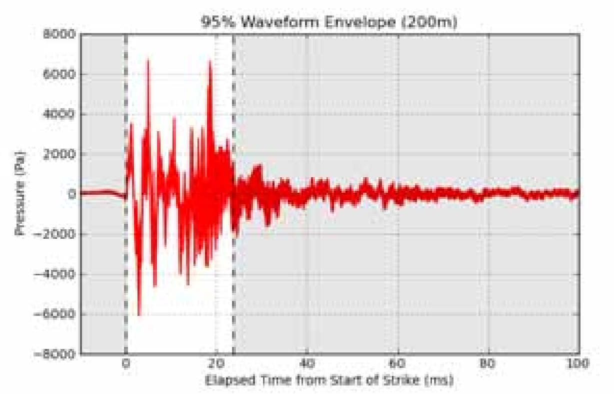


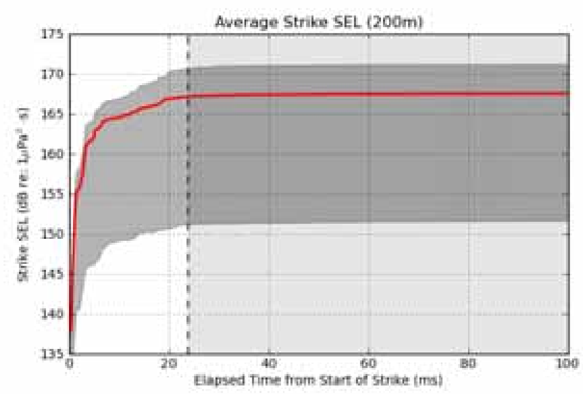
ST1400 – 10 meters

Strike Series Analysis: Pile B-2, Air Off, February 21, 2011 08:45 (pg 2 of 3)

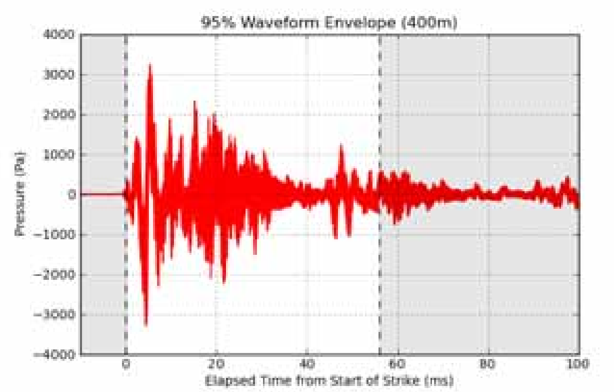
Waveforms | **SELs**

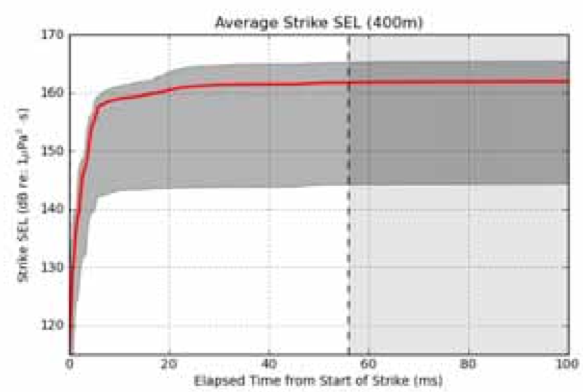
COHO – 200 meter s



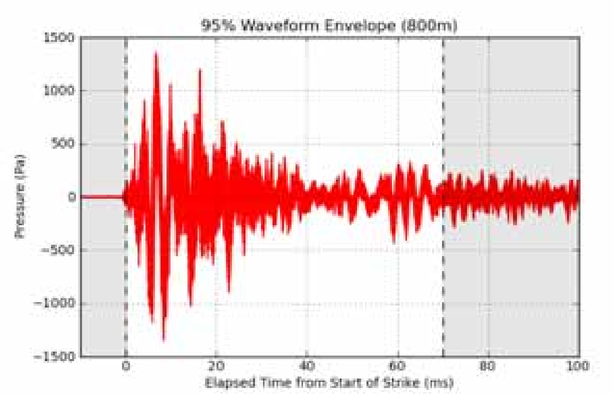


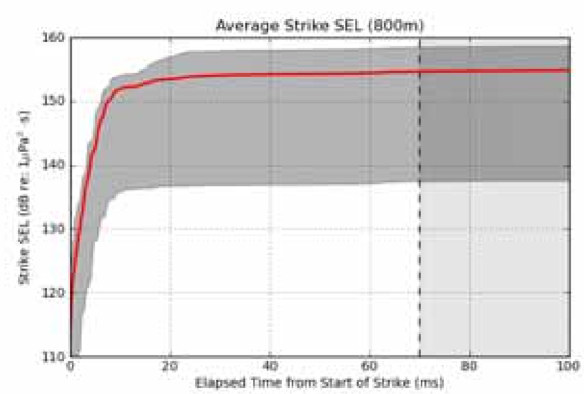
SOCKEYE – 400 meters





SUPERCUBE – 800 meters





KOKANEE – 800 meters

No data

No data

Strike Series Analysis: Pile B-2, Air Off, February 21, 2011 8:45 (pg 3 of 3)

		BROADBAND					HIGH PASS FILTER 75 Hz				
	Distance (m)	10	200	400	800	800K	10	200	400	800	800K
Strike Series Statistics	Range From Pile	10	174	370	768		10	174	370	768	
	Number of Strikes: Total	40	40	40	40		40	40	40	40	
	Number of Strikes: Analyzed	40	40	40	40		40	40	40	40	
	Series RMS $_{(0-90\%)}$	202.9	182.7	174.4	166.4		202.0	180.8	172.9	165.1	
	Series RMS $_{(5-95\%)}$	204.6	182.3	172.6	166.2		203.7	180.5	171.0	164.9	
	Cumulative $SEL_{Analyzed}$	202.9	184.0	178.6	171.4		202.0	182.2	177.2	170.2	
	Cumulative SEL	202.9	184.0	178.6	171.4		202.0	182.2	177.2	170.2	
	Peak $Strikes_{Maximum}$	219.0	197.1	189.9	182.1	No Data	219.0	197.1	189.9	182.1	No Data
	Peak $Strikes_{Mean}$	215.7	193.5	187.2	179.6		215.7	193.5	187.2	179.6	
	Peak $Strikes_{1\sigma}$	4.2	4.2	3.6	3.7		4.2	4.2	3.6	3.7	
	Maximum $Overpressure_{Mean}$	35080.0	5066.1	2434.7	990.3		32987.6	4267.0	1804.0	832.6	
	Maximum $Overpressure_{1\sigma}$	8032.3	1383.7	565.5	228.4		9860.0	1181.3	427.5	201.4	
	Maximum $Underpressure_{Mean}$	-65639.5	-4308.4	-2056.2	-983.3		-65685.9	-3273.1	-1879.7	-867.1	
	Maximum $Underpressure_{1\sigma}$	16933.8	987.5	464.9	227.3		16893.2	735.9	455.3	206.4	
	RMS $_{(0-90\%)\ Maximum}$	205.4	185.0	176.8	169.7		203.9	183.0	175.2	168.5	
	RMS $_{(5-95\%)\ Maximum}$	206.7	185.0	175.2	169.3		205.2	183.1	173.4	167.9	
	RMS $_{(0-90\%)\ Peak\ Strike}$	204.4	183.6	175.0	169.7		203.3	182.1	173.5	168.5	
	RMS $_{(5-95\%)\ Peak\ Strike}$	205.1	183.6	173.4	169.3		204.0	182.4	171.8	167.9	
	RMS $_{(0-90\%)\ Mean}$	202.1	181.9	173.6	165.6		201.2	180.0	172.0	164.3	
	RMS $_{(5-95\%)\ Mean}$	203.9	181.6	171.8	165.4		203.0	179.6	170.2	164.0	
	RMS $_{(0-90\%)\ 1\sigma}$	3.6	3.6	3.9	3.9		3.6	3.9	4.0	3.9	
	RMS $_{(5-95\%)\ 1\sigma}$	3.5	3.6	4.0	3.7		3.5	4.0	4.1	3.8	
	$SEL_{Maximum}$	189.8	170.8	165.2	158.3		188.3	168.8	163.6	157.1	
	$SEL_{Peak\ Strike}$	188.7	169.1	163.0	158.3		187.7	167.6	161.6	157.1	
	SEL_{Mean}	186.1	167.1	161.7	154.6		185.2	165.3	160.3	153.4	
	$SEL_{1\sigma}$	3.9	3.8	4.1	4.0		3.9	4.1	4.2	4.0	
Time Strike Series Statistics	Time to $Peak_{Minimum}$	10.8	12.9	14.8	15.0		10.8	15.0	13.9	14.2	
	Time to $Peak_{Mean}$	21.0	20.5	15.5	18.3		21.3	20.7	15.4	19.8	
	Time to $Peak_{1\sigma}$	5.7	6.9	0.2	2.9		5.5	6.7	2.8	4.1	
	Strike Time $_{(0-90\%)\ Mean}$	24.9	33.6	65.9	80.0		25.0	33.9	66.7	81.6	
	Strike Time $_{(5-95\%)\ Mean}$	16.7	33.9	96.9	84.1		16.9	34.6	98.2	85.9	
	Strike Time $_{(0-90\%)\ 1\sigma}$	1.5	2.0	3.7	4.6		1.5	1.9	3.6	4.9	
	Strike Time $_{(5-95\%)\ 1\sigma}$	2.5	2.7	3.8	5.2		2.6	3.0	3.7	5.0	
Threshold	Pct Exceeding 206dB Peak	95%	0%	0%	0%		88%	0%	0%	0%	
	Pct Exceeding 187dB SEL	65%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 183dB SEL	90%	0%	0%	0%		0%	0%	0%	0%	
	Pct Exceeding 150dB RMS $_{(0-90\%)}$	100%	100%	100%	98%		100%	100%	100%	100%	
	Pct Exceeding 150dB RMS $_{(5-95\%)}$	100%	100%	100%	98%		100%	100%	100%	100%	
Transmission Loss Coefficients	Peak $Strike_{Mean}$		17.9	18.1	19.1			17.9	18.1	19.1	
	Cumulative SEL		15.3	15.5	16.7			16.7	16.4	17.3	
	Series RMS $_{(0-90\%)}$		16.3	18.2	19.4			17.8	19.1	20.1	
	Series RMS $_{(5-95\%)}$		18.0	20.4	20.4			19.5	21.4	21.1	

Appendix III

CRC Bubble Curtain Specifications

INTRODUCTION

The following Amendments and Special Provisions shall be used in conjunction with the 2010 Standard Specifications for Road, Bridge, and Municipal Construction.

AMENDMENTS TO THE STANDARD SPECIFICATIONS

The following Amendments to the Standard Specifications are made a part of this contract and supersede any conflicting provisions of the Standard Specifications. For informational purposes, the date following each Amendment title indicates the implementation date of the Amendment or the latest date of revision.

Each Amendment contains all current revisions to the applicable section of the Standard Specifications and may include references which do not apply to this particular project.

SECTION 1-01, DEFINITIONS AND TERMS
August 2, 2010

1-01.2(1) Associations and Miscellaneous

The abbreviation and definition "AREA American Railway Engineering Association" is replaced with the following:

> AREMA American Railway Engineering and Maintenance Association

SECTION 1-02, BID PROCEDURES AND CONDITIONS
January 4, 2010

1-02.7 Bid Deposit

In the first paragraph, the third sentence is revised to read:

> For projects scheduled for bid opening in Olympia, the proposal bond may be in hard copy or electronic format via Surety2000.com or Insurevision.com and BidX.com.

1-02.9 Delivery of Proposal

In the first paragraph, the first sentence is revised to read:

> For projects scheduled for bid opening in Olympia, each Proposal shall be sealed and submitted in the envelope provided with it, or electronically via Expedite software and BidX.com at the location and time identified in Section 1-02.12.

The following new paragraph is inserted after the first paragraph:

> For projects scheduled for bid opening in the Region, each Proposal shall be sealed and submitted in the envelope provided with it, at the location and time identified in Section 1-02.12. The Bidder shall fill in all blanks on this envelope to ensure proper handling and delivery.

SECTION 1-06, CONTROL OF MATERIALS
April 5, 2010

1-06.1 Approval of Materials Prior to Use

This section is supplemented with the following new sub-section:

1-06.1(4) Fabrication Inspection Expense

In the event the Contractor elects to have items fabricated beyond 300 miles from Seattle, Washington the Contracting Agency will deduct from payment due the Contractor costs to perform fabrication inspection on the following items:

- Steel Bridges and Steel Bridge components
- Cantilever Sign Structures and Sign Bridges
- Cylindrical, Disc, Pin, and Spherical Bearings
- Modular Expansion Joints
- Additional items as may be determined by the Engineer.

The deductions for fabrication inspection costs will be as shown in the Payment Table below.

Zone	Place of Fabrication	Reduction in Payment
1	Within 300 airline miles from Seattle	None
2	Between 300 and 3,000 airline miles from Seattle	$700.00 per *inspection day
3	Over 3,000 airline miles from Seattle	$1,000 per *inspection day, but not less than $2,500 per trip

*Note - An inspection day includes any calendar day or portion of a calendar day spent inspecting at or traveling to and from a place of fabrication.

Where fabrication of an item takes place in more than one zone, the reduction in payment will be computed on the basis of the entire item being fabricated in the furthest of zones where any fabrication takes place on that item.

The rates for Zone 2 and 3 shall be applied for the full duration time of all fabrication inspection activities to include but not limited to; plant approvals, prefabrication meetings, fabrication, coatings and final inspection.

1-06.2(2)A General

Table 2 “Pay Factors” on page 1-39 is revised to read:

Table 2
Pay Factors

PAY FACTOR	Minimum Required Percent of Work Within Specification Limits for a Given Factor (PU + PL) – 100													
Category	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
1.05						100	100	100	100	100	100	100	100	100	100
1.04					100	99	97	95	96	96	96	97	97	97	97
1.03				100	98	96	94	92	93	93	94	95	95	96	96
1.02				99	97	94	91	89	90	91	92	93	93	94	94
1.01	100	100	100	98	95	92	89	87	88	89	90	91	92	92	93
1.00	69	75	78	80	82	83	84	85	86	87	88	89	90	91	92
0.99	66	72	76	78	80	81	82	83	84	85	86	87	89	90	91
0.98	64	70	74	76	78	79	80	81	82	84	85	86	87	88	90
0.97	63	68	72	74	76	77	78	79	81	82	83	84	86	87	88
0.96	61	67	70	72	74	75	76	78	79	81	82	83	84	86	87
0.95	59	65	68	71	72	74	75	76	78	79	80	82	83	84	86
0.94	58	63	67	69	71	72	73	75	76	78	79	80	82	83	85
0.93	57	62	65	67	69	71	72	73	75	76	78	79	80	82	84
0.92	55	60	63	66	68	69	70	72	73	75	76	78	79	81	82
0.91	54	59	62	64	66	68	69	70	72	74	75	76	78	79	81
0.90	53	57	61	63	65	66	67	69	71	72	74	75	77	78	80
0.89	51	56	59	62	63	65	66	68	69	71	72	74	75	77	79
0.88	50	55	58	60	62	64	65	66	68	70	71	73	74	76	78
0.87	49	53	57	59	61	62	63	65	67	68	70	71	73	75	77
0.86	48	52	55	58	59	61	62	64	66	67	69	70	72	74	76

(Continued)

Table 2 “Pay Factors” on page 1-40 is revised to read:

Table 2
Pay Factors (continued)

PAY FACTOR	Minimum Required Percent of Work Within Specification Limits for a Given Factor (P_U + P_L) – 100													
Category	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
0.85	46	51	54	56	58	60	61	62	64	66	67	69	71	72	75
0.84	45	49	53	55	57	58	60	61	63	65	66	68	70	71	73
0.83	44	48	51	54	56	57	58	60	62	64	65	67	69	70	72
0.82	43	47	50	53	54	56	57	59	61	62	64	66	67	69	71
0.81	41	46	49	51	53	55	56	58	59	61	63	64	66	68	70
0.80	40	44	48	50	52	54	55	56	58	60	62	63	65	67	69
0.79	39	43	46	49	51	52	54	55	57	59	61	62	64	66	68
0.78	38	42	45	48	50	51	52	54	56	58	59	61	63	65	67
0.77	36	41	44	46	48	50	51	53	55	57	58	60	62	64	66
0.76	35	39	43	45	47	49	50	52	54	56	57	59	61	63	65
0.75	33	38	42	44	46	48	49	51	53	54	56	58	60	62	64
REJECT	Values Less Than Those Shown Above														
Reject Quality Levels Less Than Those Specified for a 0.75 Pay Factor **Note:** If the value of (P_U + P_L) - 100 does not correspond to a (P_U + P_L) - 100 value in this table, use the next smaller (P_U + P_L) - 100 value.															

SECTION 1-07, LEGAL RELATIONS AND RESPONSIBILITIES TO THE PUBLIC August 2, 2010

1-07.2 Sales Tax

The third sentence in the first paragraph is revised to read:

The Contractor should contact Vendor Payments (a division of Accounting & Financial Services) of the Department of Transportation in Olympia, Washington for answers to questions in this area.

The first sentence in the third paragraph is revised to read:

The Contracting Agency will pay the retained percentage only if the Contractor has obtained from the State Department of Revenue a certificate showing that all Contract-related taxes have been paid (RCW 60.28.051).

1-07.9(1) General

The second sentence in the fourth paragraph is revised to read:

When the project involves highway Work, heavy Work and building Work, the Contract Provisions may list a Federal wage and fringe benefit rate for the highway Work, a separate Federal wage and fringe benefit rate for both the heavy Work and the building Work.

1-07.13(4) Repair of Damage

The last sentence in the first paragraph is revised to read:

For damage qualifying for relief under Sections 1-07.13(1), 1-07.13(2), 1-07.13(3), or 8-17.5, payment will be made in accordance with Section 1-09.4 using the estimated Bid item “Reimbursement for Third Party Damage”.

1-07.15 Temporary Water Pollution/Erosion Control

The fourth paragraph is deleted.

1-07.15(1) Spill Prevention, Control and Countermeasures Plan

The third sentence in the first paragraph is revised to read:

No on-site construction activities may commence until the Contracting Agency accepts a SPCC Plan for the project.

In item number 10., the first paragraph below the pay item “SPCC Plan,” lump sum is revised to read:

When the written SPCC Plan is accepted by the Contracting Agency, the Contractor shall receive 50-percent of the lump sum Contract price for the plan.

1-07.16(2) Vegetation Protection and Restoration

The second paragraph is revised to read:

Damage which may require replacement of vegetation includes torn bark stripping, broken branches, exposed root systems, cut root systems, poisoned root systems, compaction of surface soil and roots, puncture wounds, drastic reduction of surface roots or leaf canopy, changes in grade greater than 6-inches, or any other changes to the location that may jeopardize the survival or health of the vegetation to be preserved.

The third paragraph is revised to read:

When large roots of trees designated to be saved are exposed by the Contractor's operation, they shall be wrapped with heavy, moist material such as burlap or canvas for protection and to prevent excessive drying. The material shall be kept moist and securely fastened until the roots are covered to finish grade. All material and fastening material shall be removed from the roots before covering. All roots 1-inch or larger in diameter, which are damaged, shall be pruned with a sharp saw or pruning shear. Damaged, torn, or ripped bark shall be removed as ordered by the Engineer at no additional cost to the Contracting Agency.

The fourth paragraph is revised to read:

Any pruning activity required to complete the Work as specified shall be performed by a Certified Arborist as designated by the Engineer.

SECTION 1-08, PROSECUTION AND PROGRESS
April 5, 2010

1-08.1 Subcontracting

The second and third sentences in the eighth paragraph are revised to read:

This Certification shall be submitted to the Project Engineer on WSDOT form 421-023, "Quarterly Report of Amounts Paid as MBE/WBE Participants", quarterly for the State fiscal quarters: January 1 through March 31, April 1 through June 30, July 1 through September 30, October 1 through December 31, and for any remaining portion of a quarter through Physical Completion of the Contract. The report is due 20 calendar days following the fiscal quarter end or 20-calendar days after Physical Completion of the Contract.

The last sentence in the ninth paragraph is revised to read:

When required, this "Quarterly Report of Amounts Credited as DBE Participation" is in lieu of WSDOT form 421-023, "Quarterly Report of Amounts Paid as MBE/WBE Participants".

1-08.5 Time for Completion

The last two sentences in the first paragraph are revised to read:

When any of these holidays fall on a Sunday, the following Monday shall be counted a nonworking day. When the holiday falls on a Saturday, the preceding Friday shall be counted a nonworking day. The days between December 25 and January 1 will be classified as nonworking days.

SECTION 1-09, MEASUREMENT AND PAYMENT
August 2, 2010

1-09.9 Payments

The first paragraph is revised to read:

The basis of payment will be the actual quantities of Work performed according to the Contract and as specified for payment.

The Contractor shall submit a breakdown of the cost of lump sum Items to enable the Project Engineer to determine the Work performed on a monthly basis. Lump sum item breakdowns shall be submitted prior to the first progress payment that includes payment for the Bid Item in question. A breakdown is not required for lump sum items that include a basis for incremental payments as part of the respective Specification. Absent a lump sum breakdown the Project Engineer will make a determination based on information available. The Project Engineer's determination of the cost of work shall be final.

In the third paragraph, the second sentence is deleted.

1-09.11(1)A Disputes Review Board Membership

This section is supplemented with the following new paragraph:

The Contracting Agency and Contractor shall indemnify and hold harmless the Board Members from and against all claims, damages, losses and expenses, including but not limited to attorney's fees arising out of and resulting from the actions and recommendations of the Board.

SECTION 1-10, TEMPORARY TRAFFIC CONTROL
April 5, 2010

In Division 1-10, all references to "truck mounted" are revised to read "transportable".

1-10.2(3) Conformance to Established Standards

In the fifth paragraph, the reference "(TMA's)" is deleted.

1-10.3(2)C Lane Closure Setup/Takedown

In the second paragraph, the reference to "TMA/arrow board" is revised to read "transportable attenuator/arrow board".

1-10.3(3)A Construction Signs

In the fourth paragraph "height" is replaced with "top of the ballast".

1-10.3(3)J Truck Mounted Attenuator

The title for this section is revised to read:

1-10.3(3)J Transportable Attenuator

In the second and fourth paragraphs, the references to "TMA" are revised to read "Transportable Attenuator".

In the first paragraph, the first sentence is revised to read:

Where shown on an approved traffic control plan or where ordered by the Engineer, the Contractor shall provide, operate, and maintain transportable impact attenuators as required in Section 9-35.12.

In the third paragraph, the reference to "truck's" is revised to read "host vehicle's".

1-10.4(2) Item Bids with Lump Sum for Incidentals

All references to "Truck Mounted Impact Attenuator(s)" are revised to read "Transportable Attenuator(s)".

In the eighth paragraph, the first sentence is revised to read:

> "Transportable Attenuator" will be measured per each one time only for each host vehicle with mounted or attached impact attenuator used on the project.

In the last sentence of the ninth paragraph, the reference to "TMA" is replaced with "transportable attenuator".

1-10.5(2) Item Bids with Lump Sum for Incidentals

All references to "truck mounted impact attenuator(s)" are revised to read "transportable attenuator(s)".

SECTION 2-01, CLEARING, GRUBBING, AND ROADSIDE CLEANUP
April 5, 2010

2-01.3(2) Grubbing

In the first paragraph Item 2. e. is revised to read:

> e. Upon which embankments will be placed except stumps may be close-cut or trimmed as allowed in Section 2-01.3(1) item 3.

SECTION 2-02, REMOVAL OF STRUCTURES AND OBSTRUCTIONS
January 4, 2010

2-02.3 Construction Requirements

The fourth paragraph is revised to read:

> The Contractor may dispose of waste material in Contracting Agency owned sites if the Special Provisions or the Engineer permits it. Otherwise, the Contractor shall arrange to dispose of waste at no expense to the Contracting Agency and the disposal shall meet the requirements of Section 2-03.3(7)C.

SECTION 2-09, STRUCTURE EXCAVATION
August 2, 2010

2-09.3(2) Classification of Structure Excavation

Item number 1 is revised to read:

> 1. **Class A.** Structure excavation required for bridge and retaining wall footings, geosynthetic retaining wall footings, structural earth wall and sign structure footings, pile or drilled shaft caps, seals, wingwall footings, detention vaults, and noise barrier wall footings shall be classified as Structure excavation Class A. If the excavation requires a cofferdam, structural shoring, or extra excavation, the work outside the neat lines of the Structure excavation Class A shall be classified as shoring or extra excavation Class A.

SECTION 5-01, CEMENT CONCRETE PAVEMENT REHABILITATION
August 2, 2010

5-01.2 Materials
The referenced section for the following item is revised to read:

Dowel Bars	9-07.5(1)

5-01.3(4) Replace Portland Cement Concrete Panel
The thirteenth paragraph is revised to read:

> The tie bar and dowel bar holes shall be blown clean with compressed air before grouting. The bar shall be centered in the hole and all voids around the bar completely filled with grout. Dams, if needed, shall be placed at the front of the holes to confine the grout and center the bars in the holes. The dams shall permit the escape of air without leaking grout and shall not be removed until grout has cured in the hole.

5-01.3(6) Dowel Bar Retrofit
The last paragraph is deleted.

5-01.3(9) Portland Cement Concrete Pavement Grinding
The third sentence in the first paragraph is revised to read:

> Grind one pass along the edge adjacent to Portland Cement Concrete Pavement (PCCP) placed in accordance with Section 5-05, before the PCCP is placed.

The second sentence in the second paragraph is deleted.

SECTION 5-02, BITUMINOUS SURFACE TREATMENT
August 2, 2010

5-02.5 Payment
The following pay item and related statements are deleted:

> "Asphalt Emulsion Price Adjustment", by calculation.

SECTION 5-04, HOT MIX ASPHALT
April 5, 2010

5-04.3(8)A1 General
The second sentence in the second paragraph is revised to read:

> Statistical evaluation will be used for a class of HMA with the same PG grade of asphalt binder, when the Proposal quantities exceed 4,000-tons.

The third paragraph is revised to read:

> Nonstatistical evaluation will be used for the acceptance of HMA when the Proposal quantities for a class of HMA, with the same PG grade of asphalt binder, are 4,000-tons or less.

5-04.3(8)A4 Definition of Sampling Lot and Sublot

The first sentence in the first paragraph is revised to read:

> A lot is represented by randomly selected samples of the same mix design that will be tested for acceptance with a maximum of 15 sublots per lot; the final lot for a mix design may be increased to 25 sublots

5-04.3(10)B1 General

The first sentence in the second paragraph is revised to read:

> A lot is represented by randomly selected samples of the same mix design that will be tested for acceptance with a maximum of 15 sublots per lot; the final lot for a mix design may be increased to 25 sublots.

SECTION 5-05, CEMENT CONCRETE PAVEMENT
August 2, 2010

5-05.3(1) Concrete Mix Design For Paving

In number 3.c., the last paragraph is deleted.

5-05.3(4)A Acceptance of Portland Cement Concrete Pavement

All references to “AASHTO T 22” are revised to read “WSDOT FOP for AASHTO T 22”.

In the fifth paragraph “WAQTC FOP for TM 2” is revised to read “WAQTC TM 2”.

The eighth paragraph is revised to read:

> Acceptance testing for compliance of air content and 28-day compressive strength shall be conducted from samples prepared according to WSDOT FOP for WAQTC TM 2. Air content shall be determined by conducting WSDOT FOP for WAQTC /AASHTO T 152. Compressive Strength shall be determined by WSDOT FOP for AASHTO T 23 and WSDOT FOP for AASHTO T 22.

5-05.3(11) Finishing

The first sentence in the third paragraph is revised to read:

> On projects requiring less than 500-square yards of cement concrete pavement or irregular areas the surface finish may be either longitudinal tining or be given a final finish surface by texturing with a comb perpendicular to the centerline of the pavement.

The third sentence in the third paragraph is deleted.

The last sentence in the third paragraph is revised to read:

> Regardless of the surface finish, if the pavement has a raised curb without a formed concrete gutter, the texturing shall end 2-feet from the curb line.

This section is supplemented with the following two new paragraphs:

> The standard method of surface finish shall be longitudinal tining. In advance of curing operations, where longitudinal tining is required, the pavement shall be given an initial

and a final texturing. Initial texturing shall be performed with a burlap drag or broom device that will produce striations parallel with centerline. Final texturing shall be performed with a spring steel tine device that will produce grooves parallel with the centerline. The spring steel tine device shall be operated within 5-inches, but not closer than 3-inches, of pavement edges.

Burlap drags, brooms and tine devices shall be installed on self-propelled equipment having external alignment control. The installation shall be such that when texturing, the area of burlap in contact with the pavement surface shall be maintained constant at all times. Broom and tine devices shall be provided with positive elevation control. Downward pressure on pavement surface shall be maintained at all times during texturing so as to achieve uniform texturing without measurable variations in pavement profile. Self-propelled texturing machines shall be operated so that travel speed when texturing is maintained constant. Failure of equipment to conform to all provisions in this paragraph shall constitute cause for stopping placement of concrete until the equipment deficiency or malfunction is corrected. Spring steel tines of the final texturing device shall be rectangular in cross section, $^{3}/_{32}$ to $^{1}/_{8}$ inch wide, on ¾ inch centers, and of sufficient length, thickness and resilience to form grooves approximately $^{3}/_{16}$ inch deep in the fresh concrete surface. Final texture shall be uniform in appearance with substantially all of the grooves having a depth between $^{1}/_{16}$ inch and $^{5}/_{16}$ inch.

5-05.3(12) Surface Smoothness

The first paragraph is revised to read:

The pavement smoothness will be checked with equipment furnished and operated by the Contractor, under supervision of the Engineer, within 48-hours following placement of concrete. Smoothness of all pavement placed except Shoulders, ramp tapers, intersections, tight horizontal curves, and small or irregular areas as defined by Section 5-05.3(3) unless specified otherwise, will be measured with a recording profilograph, as specified in Section 5-05.3(3), parallel to centerline, from which the profile index will be determined in accordance with WSDOT Test Method 807. Tight horizontal curves are curves having a centerline radius of curve less than 1,000 feet and pavement within the superelevation transition of those curves.

5-05.3(13)A Curing Compound

The tenth paragraph is deleted.

5-05.3(16) Protection of Pavement

All references to “AASHTO T 22” are revised to read “WSDOT FOP for AASHTO T 22”.

5-05.3(17) Opening to Traffic

All references to “AASHTO T 22” are revised to read “WSDOT FOP for AASHTO T 22”.

SECTION 6-01, GENERAL REQUIREMENTS FOR STRUCTURES
August 2, 2010

6-01.6 Load Restrictions on Bridges Under Construction

In the first paragraph “roadway deck” is deleted and replaced with “bridge deck”.

6-01.8 Approaches to Movable Spans

In the first paragraph “roadway” is deleted and replaced with “bridge deck”.

SECTION 6-02, CONCRETE STRUCTURES
December 8, 2010

In Division 6-02, all references to "roadway slab", "roadway deck" and "deck slab" are deleted and replaced with "bridge deck".

6-02.3(1) Classification of Structural Concrete

The first paragraph is deleted and replaced with the following two new paragraphs:

> The class of concrete to be used shall be as noted in the Plans and these Specifications. The Class includes the specified minimum compressive strength in psi at 28 days (numerical class) and may include a letter suffix to denote structural concrete for a specific use. Letter suffixes include A for bridge approach slabs, D for bridge decks, P for piling and shafts, and W for underwater. The numerical class without a letter suffix denotes structural concrete for general purposes.
>
> Concrete of a numerical class greater than 4000 shall conform to the requirements specified for either Class 4000 (if general purpose) or for the appropriate Class 4000 with a letter suffix, as follows:
>
> 1. Mix ingredients and proportioning specified in Section 6-02.3(2) and Section 6-02.3(2)A.
>
> 2. Consistency requirements specified in Section 6-02.3(4)C.
>
> 3. Curing requirements specified in 6-02.3(11).

6-02.3(2) Proportioning Materials

The table following the third paragraph is supplemented with the following:

Lean Concrete	35	40

6-02.3(2)D Lean Concrete

This section is revised to read:

> Lean concrete shall have a minimum cementitious material content of between 145 and 200-pounds per cubic yard and have a maximum water/cement ratio of 2.

6-02.3(6) Placing Concrete

The third paragraph is revised to read:

> All foundations, forms, and contacting concrete surfaces shall be moistened with water just before the concrete is placed. Any standing water on the foundation, on the concrete surface, or in the form shall be removed.

The following new sentence is added after the fourth sentence in the fourth paragraph:

> The submittal to the Engineer shall include justification that the concrete mix design will remain fluid for interruptions longer than 30-minutes between placements.

6-02.3(6)D Protection Against Vibration

The first paragraph is revised to read:

> Freshly placed concrete shall not be subjected to excessive vibration and shock waves during the curing period until it has reached a 2000-psi minimum compressive strength for structural concrete and lower strength classes of concrete.

6-02.3(10)D Concrete Placement, Finishing, and Texturing

The following paragraph is inserted at the beginning of this section:

> Before placing bridge approach slab concrete, the subgrade shall be constructed in accordance with Sections 2-06 and 5-05.3(6).

6-02.3(11) Curing Concrete

In the fifth paragraph “Type 1D” is revised to read “Type 1D, Class B”.

6-02.3(17)B Allowable Design Stresses and Deflections

Under the heading **“Timber”**, the second sentence is revised to read:

> The allowable stresses and loads shall not exceed the lesser of stresses and loads given in the table below or factored stresses for designated species and grade in Table 7.3 of the Timber Construction Manual, latest Edition by the American Institute of Timber Construction

Under the heading **“Steel”**, the first sentence is revised to read:

> For identified grades of steel, design stresses shall not exceed those specified in the Steel Construction Manual, latest Edition by the American Institute of Steel Construction, except as follows:

6-02.3(17)F Bracing

Under the heading "**Temporary Bracing for Bridge Girders**", the table is revised to read:

Girder Series	Distance in Inches
W42G	30
W50G	42
W58G	63
W74G	66
Prestressed concrete tub girders with webs with flanges	30
WF36G, WF42G, WF50G, WF58G, WF66G, WF74G, WF83G, WF95G, and WF100G	70
W32BTG, W38BTG, and W62BTG	70
WF74PTG, WF83PTG, WF95PTG, and WF100PTG	70

6-02.3(17)N Removal of Falsework and Forms

The first paragraph including table is revised to read:

> If the Engineer does not specify otherwise, the Contractor may remove forms based on an applicable row of criteria in the table below. Both compressive strength and minimum time criteria must be met if both are listed in the applicable row. The minimum time shall be from the time of the last concrete placement the forms support. In no case shall the Contractor remove forms or falsework without the Engineer's approval.

Concrete Placed In	Percent of Specified Minimum Compressive Strength1	Minimum Compressive Strength1	Minimum Time
Columns, walls, non-sloping box girder webs, abutments, footings, pile caps,, traffic and pedestrian barriers, and any other side form not supporting the concrete weight.	—	—	3 days
Columns, walls, non-sloping box girder webs, abutments, traffic and pedestrian barriers, and any other side form not supporting the concrete weight or other loads.	—	1400 psi	18 hours
Side forms of footings, pile caps, and shaft caps.[2]	—	—	18 hours
Crossbeams, shaft caps, struts, inclined columns and inclined walls.	80	—	5 days
Bridge decks supported on wood or steel stringers or on steel or prestressed concrete girders.[3]	80	—	10 days
Box girders, T-beam girders, and flat-slab Superstructure.[3]	80	—	14 days
Arches.[3]	80	—	21 days

1 Strength shall be proved by test cylinders made from the last concrete placed into the form. The cylinders shall be cured according to WSDOT FOP for AASHTO T 23.

2 Curing compound shall be immediately applied to the sides when forms are removed.

3 Where continuous spans are involved, the time for all spans will be determined by the last concrete placed affecting any span.

The third and fourth paragraphs are deleted.

The fifth paragraph is revised to read:

Curing shall comply as required in Section 6-02.3(11). The concrete surface shall not become dry during form removal if removed during the cure period.

6-02.3(20) Grout for Anchor Bolts and Bridge Bearings

In the fourth paragraph "9-20.3(4)" is revised to read "Section 9-20.3(4)".

6-02.3(24) Reinforcement

This first paragraph is revised to read:

Although a bar list is normally included in the Plans, the Contracting Agency does not guarantee its accuracy and it shall be used at the Contractor's risk. Reinforcement fabrication details shall be determined from the information provided in the Plans.

The third paragraph is deleted.

6-02.3(24)C Placing and Fastening

The eighth paragraph is revised to read:

Mortar blocks may be accepted based on a Manufacturer's Certificate of Compliance.

The 14th paragraph is revised to read:

Clearances for main bars shall be at least:

4-inches between:	Bars and the surface of any concrete masonry exposed to the action of salt or alkaline water.
3-inches between:	Bars and the surface of any concrete deposited against earth without intervening forms.
2-½-inches between:	Adjacent bars in a layer. Bridge deck bars and the top of the bridge deck.
2-inches between:	Adjacent layers. Bars and the surface of concrete exposed to earth. Reinforcing bars and the faces of forms for exposed aggregate finish.
1-½-inches between:	Bars and the surface of concrete when not specified otherwise in this Section or in the Plans. Barrier and curb bars and the surface of concrete.
1-inch between:	Slab bars and the bottom of the slab. Slab bars and the top surface of the bottom slab of a cast-in-place concrete box girder.

The following new paragraph is inserted after the 14th paragraph:

Cover to ties and stirrups may be ½-inch less than the values specified for main bars but shall not be less than 1-inch.

6-02.3(24)F Mechanical Splices

Items 1, 2, and 3 in the fourth paragraph are revised to read:

1. Mechanical splices shall develop at least 125 percent of the specified yield strength of the unspliced bar. The ultimate tensile strength of the mechanical splice shall exceed that of the unspliced bar.

2. The total slip of the bar within the spliced sleeve of the connector after loading in tension to 30.0 ksi and relaxing to 3.0 ksi shall not exceed the following measured displacements between gage points clear of the splice sleeve:

    a. 0.01 inches for bar sizes up to No. 14.

    b. 0.03 inches for No. 18 bars.

3. The maximum allowable bar size for mechanical laps splices shall be No. 6.

6-02.3(25) Prestressed Concrete Girders

Under the heading "**Prestressed Concrete Wide Flange I Girder**" the last sentence is revised to read:

> WSDOT standard girders in this category include Series WF36G, WF42G, WF50G, WF58G, WF66G, WF74G, WF83G, WF95G and WF100G.

Under the heading "**Spliced Prestressed Concrete Girder**" the last sentence is revised to read:

> WSDOT standard girders in this category include Series WF74PTG, WF83PTG, WF95PTG and WF100PTG.

6-02.3(25)L Handling and Storage

In the third sentence of the second paragraph, the reference to "1-foot-9-inches" is revised to read "3-foot-0-inches".

6-02.3(25)N Prestressed Concrete Girder Erection

The seventh paragraph is supplemented with the following:

> The aspect ratio (height/width) of oak block wedges at the girder centerline shall not exceed 1.0.

6-02.3(26)E Ducts

Beneath the heading "**Ducts for Internal Embedded Installation**" the second sentence in the second paragraph is revised to read:

> Polypropylene ducts shall conform to ASTM D 4101 with a cell classification range of PP0340B14541 to PP0340B67884.

This section is supplemented with the following:

> All duct splices, joints, couplings and connections to anchorages shall be made with devices or methods (mechanical couplers, plastic sleeves, shrink sleeve) that are approved by the duct manufacturer and produce a smooth interior alignment with no lips

or kinks. All connections and fittings shall be air and mortar tight. Taping is not acceptable for connections and fittings.

6-02.3(27) Concrete for Precast Units

In the third paragraph “Section 9-12” is revised to read “Section 9-05.50”.

6-02.3(28)F Tolerances

The reference to "PCI-MNL-166" is revised to read "PCI-MNL-116".

SECTION 6-03, STEEL STRUCTURES
August 2, 2010

6-03.3(25) Repair Welding

In the first paragraph “2002” is revised to read “2008”.

6-03.3(25)A Welding Inspection

In the first paragraph “2002” is revised to read “2008”.

In the paragraph below the heading “**Radiographic Inspection**” “2002 Structural” is revised to read “2008 Bridge”.

6-03.3(29) Vacant

This section including title is revised to read:

Welded Shear Connectors

All welded shear connectors on steel girder top flanges shall be installed in the field after the forms for the concrete bridge deck are in place. The steel surface to be welded shall be prepared to SSPC-SP 11, power tool cleaning, just prior to welding. Installation, production control, and inspection of welded shear connectors shall conform to Chapter 7 of the AASHTO/AWS D1.5M/D1.5:2008 Bridge Welding Code. After the welded shear connectors are installed, the weld and the disturbed steel surface shall be cleaned and painted in accordance with Section 6-07.3(9)I.

6-03.3(33) Bolted Connections

This section is revised to read:

Fastener components shall consist of bolts, nuts, washers, tension control bolt assemblies, and direct tension indicators. Fastener components shall meet the requirements of Section 9-06.5(3).

The Contractor shall submit documentation of the bolt tension calibrator for approval by the Engineer and shall include brand, capacity, model, date of last calibration, and manufacturer’s instructions for use. The Contractor shall be responsible to supply the approved bolt tension calibrator and all accompanying hardware and calibrated torque wrenches to conduct all testing and inspection described herein. Use of the bolt tension calibrator shall comply with manufacturer’s recommendations.

Fastener components shall be protected from dirt and moisture in closed containers at the site of installation. Only as many fastener components as are anticipated to be installed during the Work shift shall be taken from protected storage. Fastener components that are not incorporated into the Work shall be returned to protected storage at the end of the Work shift. Fastener components shall not be cleaned or modified from the as-delivered condition. Fastener components that accumulate rust or dirt shall not be incorporated into the Work. Tension control bolt assemblies shall not be relubricated, except by the manufacturer.

All bolted connections are slip critical. Painted structures require either Type 1 or Type 3 bolts. Unpainted structures require Type 3 bolts. AASHTO M 253 bolts shall not be galvanized or be used in contact with galvanized metal.
Washers are required under turned elements for bolted connections and as required in the following:

1. Washers shall be used under both the head and the nut when AASHTO M 253 bolts are to be installed in structural carbon steel, as specified in Section 9-06.1.

2. Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, a beveled washer shall be used.

3. Washers shall not be stacked unless otherwise approved by the Engineer.

4. It is acceptable to place a washer under the unturned element.

All galvanized nuts shall be lubricated by the manufacturer with a lubricant containing a visible dye so a visual check for the lubricant can be made at the time of field installation. Black bolts shall be lubricated by the manufacturer and shall be “oily” to the touch when installed.

After assembly, bolted parts shall fit solidly together. They shall not be separated by washers, gaskets, or any other material. Assembled joint surfaces, including those next to bolt heads, nuts, and washers, shall be free of loose mill scale, burrs, dirt, and other foreign material that would prevent solid seating.

When all bolts in a joint are tight, each bolt shall carry at least the proof load shown in Table 3 below:

Table 3
Minimum Bolt Tension

Bolt Size (inches)	AASHTO M 164 and ASTM F 1852 (pounds)	AASHTO M 253 (pounds)
$^{1}/_{2}$	12,050	14,900
$^{5}/_{8}$	19,200	23,700
$^{3}/_{4}$	28,400	35,100
$^{7}/_{8}$	39,250	48,500
1	51,500	63,600
$1^{1}/_{8}$	56,450	80,100
$1^{1}/_{4}$	71,700	101,800
$1^{3}/_{8}$	85,450	121,300
$1^{1}/_{2}$	104,000	147,500

Prior to final tightening of any bolts in a bolted connection, the connection shall be compacted to a snug-tight condition. Snug tight shall include bringing all plies of the connection into firm contact and snug-tightening all bolts in accordance with Section 6-03.3(32).

Final tightening may be done by either the turn-of-nut method, the direct-tension indicator method, or twist off type tension control structural bolt/nut/washer assembly method. Preferably, the nut shall be turned tight while the bolt is prevented from rotating. However, if required by either turn-of-nut or direct-tension-indicator methods, because of bolt entering and/or wrench operational clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

1. **Turn-of-Nut Method.** After all specified bolting conditions satisfied, and before final tightening, the Contractor shall match-mark with crayon or paint the outer face of each nut and the protruding part of the bolt. Each bolt shall be final tightened to the specified minimum tension by rotating the amount specified in Table 4. To ensure that this tightening method is followed, the Engineer will (1) observe as the Contractor installs, snug-tightens, and final tightens all bolts and (2) inspect each match-mark.

Table 4
Turn-of-Nut Tightening Method Nut Rotational from Snug-Tight Condition

Bolt Length	**Disposition of Outer Faces of Bolted Parts**		
	Condition 1	***Condition 2***	***Condition 3***
L <= 4D	$^1/_3$ turn	$^1/_2$ turn	$^2/_3$ turn
4D < L<= 8D	$^1/_2$ turn	$^2/_3$ turn	$^5/_6$ turn
8D < L<= 12D	$^2/_3$ turn	$^5/_6$ turn	1 turn

Bolt length measured from underside of head to top of nut.

Condition 1 — both faces at right angles to bolt axis.

Condition 2 — one face at right angle to bolt axis, one face sloped no more than 1:20, without bevel washer.

Condition 3 — both faces sloped no more than 1:20 from right angle to bolt axis, without bevel washer.

Nut rotation is relative to the bolt regardless of which element (nut or bolt) is being turned. Tolerances permitted plus or minus 30 degrees ($^1/_{12}$ turn) for final turns of $^1/_2$ turn or less; plus or minus 45 degrees ($^1/_8$ turn) for final turns of $^2/_3$ turn or more.

D = nominal bolt diameter of bolt being tightened.

When bolt length exceeds 12D, the rotation shall be determined by actual tests in which a suitable tension device simulates actual conditions.

2. **Direct-Tension-Indicator Method.** Direct-Tension-Indicators (DTIs) shall not be used under the turned element. DTIs shall be placed under the bolt head with the

protrusions facing the bolt head when the nut is turned. DTIs shall be placed under the nut with the protrusions facing the nut when the bolt is turned.

Table 5 Direct Tension Indicator Requirements						
Bolt Size, inches	DTI Spaces		Maximum Snug-tight Refusals		Minimum Final Tighten Refusals	
	M 164	M 253	M 164	M 253	M 164	M 253
1/2	4	5	1	2	2	3
5/8	4	5	1	2	2	3
3/4	5	6	2	2	3	3
7/8	5	6	2	2	3	3
1	6	7	2	3	3	4
1-1/8	6	7	2	3	3	4
1-1/4	7	8	3	3	4	4
1-3/8	7	8	3	3	4	4
1-1/2	8	9	3	4	4	5

Gap refusal shall be measured with a 0.005 inch tapered feeler gage. After all specified bolting conditions are satisfied, the snug-tightened gaps shall meet Table 5 snug-tight limits.

Each bolt shall be final-tightened to meet Table 5 final tighten limits. If the bolt is tensioned so that no visible gap in any space remains, the bolt and DTI shall be removed and replaced by a new properly tensioned bolt and DTI.

The Contractor shall tension all bolts, inspecting all DTIs with a feeler gage, in the presence of the Engineer. DTIs shall be installed by 2 or more person crews with 1 individual preventing the element at the DTI from turning, and measuring the gap of the DTI to determine the proper tension of the bolt.

If a bolt, that has had its DTI brought to full load, loosens during the course of bolting the connection, it shall be rejected. Reuse of the bolt and nut are subject to the provisions of this section. The used DTI shall not be reinstalled.

3. **Twist Off Type Tension Control Structural Bolt/Nut/Washer Assembly Method (Tension Control Bolt Assembly).** Tension control bolt assemblies shall include the bolt, nut, and washer(s) packaged and shipped as a single assembly. Tension control bolt assembly components shall not be interchanged for testing or installation and shall comply with all provisions of ASTM F 1852.

The tension control bolts shall incorporate a design feature intended to either indirectly indicate, or to automatically provide, the minimum tension specified in Table 3 of Section 6-03.3(33).

The Contractor shall submit the tension control bolt assembly to the Engineer for approval with bolt capacities, type of bolt, nut, and washer lubricant, method of packaging and protection of the lubricated bolt, installation equipment, calibration equipment, and installation procedures.

The tension control bolt manufacturer's installation procedure shall be followed for installation of bolts in the verification testing device, in all calibration devices, and in all structure connections.

In some cases, proper tensioning of the bolts may require more than one cycle of systematic partial tightening prior to final yield or fracture of the tension control element of each bolt. If yield or fracture of the tension control element of a bolt occurs prior to the final tightening cycle, that bolt shall be replaced with a new one.

Additional field verification testing shall be performed as requested by the Engineer.

All bolts and connecting hardware shall be stored and handled in a manner to prevent corrosion and loss of lubricant. Bolts which are installed without the same lubricant coating as tested under the verification test will be rejected and shall be removed from the joint and be replaced with new lubricated bolts at no additional cost to the Contracting Agency.

AASHTO M 253 bolts, galvanized AASHTO M 164 bolts, and ASTM F 1852 tension control bolt assemblies shall not be reused. Black AASHTO M 164 bolts may be reused once if approved by the Engineer. All bolts to be reused shall have their threads inspected for distortion by reinstalling the used nut on the bolt and turning the nut for the full length of the bolt threads by hand. Bolts to be reused shall be relubricated in accordance with the manufacturer's recommendations and as approved by the Engineer. Used bolts shall be subject to a rotational capacity test as specified in Section 6-03.3(33)A Pre-Erection Testing. Touching up or retightening bolts previously tightened by the turn-of-nut method, which may have been loosened by the tightening of adjacent bolts shall not be considered as reuse, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that required by Table 4.

6-03.3(33)A Pre-Erection Testing

This section is revised to read:

High strength bolt assemblies (bolt, nut, direct tension indicator, and washer), black and galvanized, shall be subjected to a field rotational capacity test, as outlined below, prior to any permanent fastener installation. For field installations, the rotational capacity test shall be conducted at the jobsite. Each combination of bolt production lot, nut production lot, washer production lot, and direct tension indicator production lot shall be tested as an assembly, except tension control bolt assemblies which shall be tested as supplied by the manufacturer. Each rotational capacity test shall include three assemblies. Once an assembly passes the rotational capacity test, it is approved for use for the remainder of the project, unless the Engineer deems further testing is necessary. All tests shall be performed in a bolt tension calibrator by the Contractor in the presence of the Engineer. High-strength bolt assemblies used in this test shall not be reused. The bolt assemblies shall meet the following requirements after being pretensioned to 15 percent of the minimum bolt tension in Table 3. The assembly shall be considered as nonconforming if the assembly fails to pass any one of the following specified requirements.

1. The measured torque to produce the minimum bolt tension shall not exceed the maximum allowed torque value obtained by the following equation.
   Torque = 0.25 PD
   Where: Torque = Calculated Torque (foot-pounds)
   P = Measured Bolt Tension (pounds)
   D = Normal Bolt Diameter (feet)

2. After placing the assembly through two cycles of the required number of turns, where turns are measured from the 15 percent pretention condition, as indicated in Table 4 of Section 6-03.3(33),

   a. The maximum recorded tension after the two turns shall be equal to or greater than 1.15 times the minimum bolt tension listed in Table 3 of Section 6.03.3(33).

   b. Each assembly shall be successfully installed to the specified number of turns.

   c. The fastener components in the assembly shall not exhibit shear failure or stripping of the threads as determined by visual examination of bolt and nut threads following removal.

   d. The bolts in the assembly shall not exhibit torsional or torsional/tension failure.

3. If any specimen fails, the assembly will be rejected. Elongation of the bolt between the bolt head and the nut is not considered to be a failure.

Bolts that are too short to test in the bolt tension calibrator shall be tested in a steel joint The Contractor shall (1) install the high-strength bolt assemblies (bolt, nut, direct tension indicator and washer) in a steel joint of the proper thickness, (2) tighten to the snug tight condition, (3) match-mark the outer face of each nut and the protruding part of the bolt with crayon or paint, (4) rotate to the requirements of Table 4, and (5) record the torque that is required to achieve the required amount of rotation. The assembly shall be considered as non-conforming if the assembly fails to pass any one of the following specified requirements.

1. The recorded torque to produce the minimum rotation shall not exceed the maximum allowed torque value obtained by the following equation.
   Torque = 0.25 PD
   Where: Torque = Calculated Maximum Allowed Torque (foot-pounds)
   P = Specified Bolt Tension per Table 3, multiplied by a factor of 1.15 (pounds)
   D = Normal Bolt Diameter (feet)
2. After placing the assembly through two cycles of the required number of turns, where turns are measured from the snug tight condition specified in Section 6-03.3(32),

a. Each assembly shall be successfully installed to the specified number of turns.

b. The fastener components in the assembly shall not exhibit shear failure or stripping of the threads as determined by visual examination of bolt and nut threads following removal.

c. The bolts in the assembly shall not exhibit torsional or torsional/tension failure.

3. If any specimen fails, the assembly will be rejected. Elongation of the bolt between the bolt head and the nut is not considered to be a failure.

The Contractor shall submit the manufacturer's detailed procedure for pre-erection (rotational capacity) testing of tension control bolt assemblies to the Engineer for approval and shall have an approved procedure prior to testing.

Three DTIs, per lot, shall be tested in a bolt tension calibrator. The bolts shall be tensioned to 105-percent of the tension shown in Table 3 of Section 6-03.3(33). If all of the DTI protrusions are completely crushed (all 5 openings with zero gap), this lot of DTIs is rejected.

6-03.3(33)B Bolting Inspection

The first paragraph is revised to read:

The Contractor, in the presence of the Engineer, shall inspect the tightened bolt using a calibrated inspection torque wrench, regardless of bolting method. The Contractor shall supply the inspection torque wrench.

The first sentence in the second paragraph is revised to read:

If the bolts to be installed are not long enough to fit in the bolt tension calibrator, five bolts of the same grade, size, and condition as those under inspection shall be tested using Direct-Tension-Indicators (DTIs) to measure bolt tension.

The first sentence in the third paragraph is revised to read:

Five representative bolts/nuts/washers and DTIs, if used (provided by the Contractor) of the same grade, size, and condition as those under inspection shall be placed individually in a bolt tension calibrator to measure bolt tension.

The fourth and fifth sentences in the third paragraph are revised to read:

In the bolt tension calibrator, each bolt shall be tightened by any convenient means to the specified tension. The inspection torque wrench shall then be applied to the tightened bolt to determine the torque required to turn the nut or head 5 degrees (approximately 1-inch at a 12-inch radius) in the tightening direction.

The fourth paragraph is revised to read:

Ten percent (at least two), or as specified by the Engineer, of the tightened bolts on the Structure represented by the test bolts shall be selected at random in each connection.

The job-inspection torque shall then be applied to each with the inspecting wrench turned in the tightening direction, with no restraint applied to the opposite end of the bolt. If this torque turns no bolt head or nut, the Contracting Agency will accept the connection as being properly tightened. If the torque turns one or more bolt heads or nuts, the job-inspection torque shall then be applied to all bolts in the connection. Except for tension control bolt assemblies and DTIs with zero gap at all protrusion spaces, any bolt whose head or nut turns at this stage shall be tightened and reinspected. Any tension control bolt assemblies or DTIs that have zero gap at all protrusion spaces shall be replaced if the head or nut turns at this stage.

This section is supplemented with the following new paragraph:

The Contractor shall submit the manufacturer's detailed procedure for routine observation to ensure proper use of the tension control bolt assemblies to the Engineer for approval and shall have an approved procedure prior to any assembling of bolted connections.

6-03.3(39) Swinging the Span

In the first paragraph "roadway slabs" is revised to read "bridge deck".

SECTION 6-07, PAINTING
August 2, 2010

6-07.3(2)C Paint System Manufacturer and Paint System Information Submittal Component

Item 1 in the first paragraph is supplemented with the following:

h. Minimum wet film thickness for each coat to achieve the specified minimum dry film thickness.

6-07.3(9)G Application of Shop Primer Coat

In the second paragraph, the second, third, and fourth sentences are deleted.

6-07.3(9)I Application of Field Coatings

The following new paragraph is inserted preceding the first paragraph:

Prior to applying field coatings, the Contractor shall field install welded shear connectors on the steel girder top flanges in accordance with Section 6-03.3(29) and as shown in the Plans. After installation of the welded shear connectors, the weld and the disturbed surface of the steel girder top flange shall be cleaned in accordance with SSPC-SP 11 and primed.

6-07.3(10)H Paint System

In the first sentence of the first paragraph "new steel" is revised to read "existing steel".

6-07.3(10)K Coating Thickness

This section is revised to read:

The minimum dry film thickness of each coat (primer, intermediate, top, and all stripe coats) shall not be less than 3.0 mils. The dry film thickness shall not be thicker than the paint manufacturer's recommended maximum thickness.

The minimum wet film thickness of each coat shall be specified by the paint manufacturer to achieve the minimum dry film thickness.

Film thickness, wet and dry, will be measured by gages conforming to Section 6-07.3(8)A. Wet measurements will be taken immediately after the paint is applied in accordance with ASTM D 4414. Dry measurements will be taken after the coating is dry and hard in accordance with SSPC Paint Application Specification Section No. 2.

Each painter shall be equipped with a wet film thickness gauge, and shall be responsible for performing frequent checks of the paint film thickness throughout application.

Coating thickness measurements may be made by the Engineer after the application of each coat and before the application of the succeeding coat. In addition, the Engineer may inspect for uniform and complete coverage and appearance. One hundred percent of all thickness measurements shall meet or exceed the minimum wet film thickness. In areas where wet film thickness measurements are impractical, dry film thickness measurements may be made. If a question arises about an individual coat thickness or coverage, it may be verified by the use of a Tooke gauge in accordance with ASTM D 4138.

If the specified number of coats does not produce a combined dry film thickness of at least the sum of the thicknesses required per coat, or if an individual coat does not meet the minimum thickness, or if visual inspection shows incomplete coverage, the coating system will be rejected, and the Contractor shall discontinue painting and surface preparation operations and shall submit a proposal for repair to the Engineer The repair proposal shall include documentation demonstrating the cause of the less than minimum thickness along with physical test results, as necessary, and modifications to work methods to prevent similar results. The Contractor shall not resume painting or surface preparation operations until receiving the Engineer's approval of the completed repair.

SECTION 6-09, MODIFIED CONCRETE OVERLAYS
August 2, 2010

6-09.3(1)E Air Compressor
In the first paragraph "roadway" is deleted and replaced with "bridge".

6-09.3(6) Further Deck Preparation
In the second paragraph, item number 3. and 4. are revised to read:

3. Existing non-concrete patches as authorized by the Engineer.

4. Additionally, for concrete surfaces scarified by rotomilling only, exposure of reinforcing steel to a depth of one-half of the periphery of a bar for a distance of 12-inches or more along the bar.

6-09.3(6)B Deck Repair Preparation
In the first paragraph, the second sentence is revised to read:

For concrete surfaces scarified by rotomilling, concrete shall be removed to provide a ¾-inch minimum clearance around the top mat of steel reinforcing bars only where unsound concrete exists around the top mat of steel reinforcing bars, or if the bond between concrete and the top mat of steel is broken.

SECTION 6-10, CONCRETE BARRIER
January 4, 2010

6-10.3(1) Precast Concrete Barrier

In the 12th paragraph, the first sentence is revised to read:

Only 1 section less than 20-feet long for single slope barrier and 10-feet long for all other barriers may be used in any single run of precast barrier, and it must be at least 8-feet long.

6-10.3(6) Placing Concrete Barrier

The first paragraph is revised to read:

Precast concrete barrier Type 2, 3, 4 and transitions shall rest on a paved foundation shaped to a uniform grade and section. The foundation surface for precast concrete barrier Type 2, 3, 4 and transitions shall meet this test for uniformity:

When a 10-foot straightedge is placed on the surface parallel to the centerline for the barrier, the surface shall not vary more than ¼-inch from the lower edge of the straightedge. If deviations exceed ¼-inch, the Contractor shall correct them as required in Section 5-04.3(13).

In the second paragraph, the first sentence is revised to read:

The Contractor shall align the joints of all precast barrier segments so that they offset no more than ¼-inch transversely and no more than ¾-inch vertically.

SECTION 6-12, NOISE BARRIER WALLS
April 5, 2010

6-12.3(6) Precast Concrete Panel Fabrication and Erection

The second sentence of the first paragraph in Item 3 is revised to read:

The Contractor shall cast the precast concrete panels horizontally.

SECTION 6-13, STRUCTURAL EARTH WALLS
August 2, 2010

6-13.3(3) Excavation and Foundation Preparation

The first sentence in the first paragraph is revised to read:

Excavation shall conform to Section 2-09.3(3).

6-13.4 Measurement

The fourth paragraph is deleted

6-13.5 Payment

The bid items “Structure Excavation Class B”, per cubic yard, “Structure Excavation Class B Incl. Haul”, per cubic yard, and “Shoring Or Extra Excavation Class B”, per square foot, are deleted from this section.

SECTION 6-14, GEOSYNTHETIC RETAINING WALLS
August 2, 2010

6-14.3(3) Excavation and Foundation Preparation

The first sentence in the first paragraph is revised to read:

> Excavation shall conform to Section 2-09.3(3).

6-14.4 Measurement

The fifth paragraph is deleted

6-14.5 Payment

The bid items “Structure Excavation Class B”, per cubic yard, “Structure Excavation Class B Incl. Haul”, per cubic yard, and “Shoring Or Extra Excavation Class B”, per square foot, are deleted from this section.

SECTION 6-16, SOLDIER PILE AND SOLDIER PILE TIEBACK WALLS
August 2, 2010

6-16.5 Payment

The first sentence in the paragraph following the bid item “Furnishing Soldier Pile ____”, per linear foot, is revised to read:

> All costs in connection with furnishing soldier pile assemblies shall be included in the unit contract price per linear foot for “Furnishing Soldier Pile - ___”, including fabricating and painting the pile assemblies, and field splicing and field trimming the soldier piles.

SECTION 6-17, PERMANENT GROUND ANCHORS
January 4, 2010

6-17.3(7) Installing Permanent Ground Anchors

In the third paragraph, the first sentence is revised to read:

> The tendon shall be inserted into the drill hole to the desired depth prior to grouting.

In the third paragraph, the following sentence is inserted after the first sentence:

> Wet setting of permanent ground anchors will not be allowed.

SECTION 7-02, CULVERTS
January 4, 2010

7-02.2 Materials

In the first paragraph, the following two items are inserted after the item "Corrugated Polyethylene Culvert Pipe 9-05.19":

Steel Rib Reinforced Polyethylene Culvert Pipe 9-05.21
High Density Polyethylene (HDPE) Pipe 9-05.23

7-02.5 Payment

This section is supplemented with the following:

"Steel Rib Reinforced Polyethylene Culvert Pipe ____ In. Diam.", per linear foot.
"High Density Polyethylene (HDPE) Pipe ____ In. Diam.", per linear foot.

SECTION 7-04, STORM SEWERS
January 4, 2010

7-04.2 Materials

In the first paragraph, the following two items are inserted after the item "Corrugated Polyethylene Storm Sewer Pipe 9-05.20":

Steel Rib Reinforced Polyethylene Storm Sewer Pipe 9-05.22
High Density Polyethylene (HDPE) Pipe 9-05.23

7-04.5 Payment

This section is supplemented with the following:

"Steel Rib Reinforced Polyethylene Storm Sewer Pipe ____ In. Diam.", per linear foot.
"High Density Polyethylene (HDPE) Pipe ____ In. Diam.", per linear foot.

SECTION 8-01, EROSION CONTROL AND WATER POLLUTION CONTROL
August 2, 2010

8-01.2 Materials

In the first paragraph, the following is inserted after the first sentence:

Corrugated Polyethylene Drain Pipe 9-05.1(6)

8-01.3(1) General

In the sixth paragraph, the first sentence is revised to read:

When natural elements rut or erode the slope, the Contractor shall restore and repair the damage with the eroded material where possible, and remove and dispose of any remaining material found in ditches and culverts.

In the seventh paragraph the first two sentences are deleted.

The table in the seventh paragraph is revised to read:

Western Washington (West of the Cascade Mountain crest)	
May 1 through September 30	17 Acres
October 1 through April 30	5 Acres

Eastern Washington (East of the Cascade Mountain crest.)	
April 1 through October 31	17 Acres
November 1 through March 31	5 Acres

The eighth paragraph is revised to read:

The Engineer may increase or decrease the limits based on project conditions.

The ninth paragraph is revised to read:

Erodible earth is defined as any surface where soils, grindings, or other materials may be capable of being displaced and transported by rain, wind, or surface water runoff.

The 10th paragraph is revised to read:

Erodible earth not being worked, whether at final grade or not, shall be covered within the specified time period, (see the tables below) using an approved soil covering practice.

Western Washington (West of the Cascade Mountain crest)

October 1 through April 30	2-days maximum
May 1 to September 30	7-days maximum

Eastern Washington (East of the Cascade Mountain crest.)

October 1 through June 30	5-days maximum
July 1 through September 30	10-days maximum

8-01.3(1)A Submittals

This section is revised to read:

When a Temporary Erosion and Sediment Control (TESC) Plan is included in the Plans, the Contractor shall either adopt or modify the existing TESC Plan. If modified, the Contractor's TESC Plan shall meet all requirements of Chapter 6-2 of the current edition of the WSDOT Highway Runoff Manual. The Contractor shall provide a schedule for TESC Plan implementation and incorporate it into the Contractor's progress schedule. The Contractor shall obtain the Engineer's approval of the TESC Plan and schedule prior to the beginning of Work. The TESC Plan shall cover all areas that maybe affected inside and outside the limits of the project (including all Contracting Agency-provided sources, disposal sites, and haul roads, and all nearby land, streams, and other bodies of water).

The Contractor shall allow at least 5-working days for the Engineer to review any original or revised TESC Plan. Failure to approve all or part of any such Plan shall not make the Contracting Agency liable to the Contractor for any Work delays.

8-01.3(1)B Erosion and Sediment Control (ESC) Lead

In the last paragraph, "Form Number 220-030 EF" is revised to read "WSDOT Form Number 220-030 EF".

8-01.3(1)C Water Management

In number 2., the reference to "Standard Specification" is revised to read "Section".

Number 3., is revised to read:

3. Offsite Water

Prior to disruption of the normal watercourse, the Contractor shall intercept the offsite stormwater and pipe it either through or around the project site. This water shall not be combined with onsite stormwater. It shall be discharged at its pre-construction outfall point in such a manner that there is no increase in erosion below the site. The method for performing this Work shall be submitted by the Contractor for the Engineer's approval.

8-01.3(1)D Dispersion/Infiltration

This section is revised to read:

Water shall be conveyed only to dispersion or infiltration areas designated in the TESC Plan or to sites approved by the Engineer. Water shall be conveyed to designated dispersion areas at a rate such that, when runoff leaves the area, and enters waters of the State, turbidity standards are achieved. Water shall be conveyed to designated infiltration areas at a rate that does not produce surface runoff.

8-01.3(2)B Seeding and Fertilizing

The fourth paragraph is revised to read:

The seed applied using a hydroseeder shall have a tracer added to visibly aid uniform application. This tracer shall not be harmful to plant, aquatic or animal life. If HECP Type 3 Mulch is used as a tracer, the application rate shall not exceed 250-pounds per acre.

In the fifth paragraph, "hydro seeder" is revised to read "hydroseeder".

8-01.3(2)D Mulching

In the second paragraph, the second sentence is revised to read:

Wood strand mulch shall be applied by hand or by straw blower on seeded areas.

In the third paragraph, "1" is revised to read "a single" and "hydro seeder" is revised to read "hydroseeder".

The fourth paragraph is revised to read:

Temporary seed applied outside the application windows established in 8-01.3(2)F shall be covered with a mulch containing either HECP Type 2 Mulch or HECP Type 1 Mulch, as designated by the Engineer.

8-01.3(2)E Tacking Agent and Soil Binders

The following new paragraph is inserted at the beginning of this Section:

Tacking agent or soil binders applied using a hydroseeder shall have a mulch tracer added to visibly aid uniform application. This tracer shall not be harmful to plant, aquatic or animal life. If HECP Type 3 Mulch is used as a tracer, the application rate shall not exceed 250-pounds per acre.

The second sentence in the first paragraph below "**Soil Binding Using Polyacrylamide (PAM)**" is revised to read:

A minimum of 200-pounds per acre of HECP Type 3 Mulch shall be applied with the dissolved PAM.

In the second paragraph below "**Soil Binding Using Polyacrylamide (PAM)**", "within" is revised to read "after".

The paragraph "**Soil Binding Using Bonded Fiber Matrix (BFM)**" including title is revised to read:

Soil Binding Using HECP Type 2 Mulch

The HECP Type 2 Mulch shall be hydraulically applied in accordance with the manufacturer's installation instructions. The HECP Type 2 Mulch may require a 24 to 48 hour curing period to achieve maximum performance and shall not be applied when precipitation is predicted within 24 to 48 hours, or on saturated soils, as determined by the Engineer.

The last paragraph including titled is revised to read:

Soil Binding Using HECP Type 1 Mulch

The HECP Type 1 Mulch shall be hydraulically applied in accordance with the manufacturer's installation instructions and recommendations.

8-01.3(2)F Dates for Application of Final Seed, Fertilizer, and Mulch

The first paragraph is revised to read:

Unless otherwise approved by the Engineer, the final application of seeding, fertilizing, and mulching of slopes shall be performed during the following periods:

<u>Western Washington</u>[1]	<u>Eastern Washington</u>
(West of the Cascade Mountain crest)	(East of the Cascade Mountain crest)
March 1 through May 15	October 1 through November 15 only
September 1 through October 1	

[1] Where Contract timing is appropriate, seeding, fertilizing, and mulching shall be accomplished during the fall period listed above. Written permission to seed after October 1 will only be given when Physical Completion of the project is imminent and the environmental conditions are conducive to satisfactory growth.

8-01.3(2)G Protection and Care of Seeded Areas

The first paragraph is revised to read:

The Contractor shall be responsible to ensure a healthy stand of grass. The Contractor shall restore eroded areas, clean up and properly dispose of eroded materials, and reapply the seed, fertilizer, and mulch, at no additional cost to the Contracting Agency.

In the second paragraph, number 1. is revised to read:

1. At the Contractor's expense, seed, fertilizer and mulch shall be reapplied in areas that have been damaged through any cause prior to final inspection, and reapplied to areas that have failed to receive a uniform application at the specified rate.

8-01.3(2)H Inspection

The first sentence is revised to read:

> Inspection of seeded areas will be made upon completion of seeding, temporary seeding, fertilizing, and mulching.

The third sentence is revised to read:

> Areas that have not received a uniform application of seed, fertilizer, or mulch at the specified rate, as determined by the Engineer, shall be reseeded, refertilized, or remulched at the Contractor's expense prior to payment.

8-01.3(2)I Mowing

In the first paragraph, the last sentence is revised to read:

> Trimming around traffic facilities, Structures, planting areas, or other features extending above ground shall be accomplished preceding or simultaneously with each mowing.

8-01.3(3) Placing Erosion Control Blanket

In the first sentence, "Standard" is deleted.

The second sentence is revised to read:

> Temporary erosion control blankets, having an open area of 60-percent or greater, may be installed prior to seeding.

8-01.3(4) Placing Compost Blanket

In the first paragraph, "before" is revised to read "prior to".

The last sentence is revised to read:

> Compost shall be Coarse Compost.

8-01.3(5) Placing Plastic Covering

The first sentence is revised to read:

> Plastic shall be placed with at least a 12-inch overlap of all seams.

8-01.3(6)A Geotextile-Encased Check Dam

The first paragraph is deleted.

8-01.3(6)B Rock Check Dam

This section including title is revised to read:

> **8-01.3(6)B Quarry Spall Check Dam**
>
> The rock used to construct rock check dams shall meet the requirements for quarry spalls.

8-01.3(6)D Wattle Check Dam

This section is revised to read:

Wattle check dams shall be installed in accordance with the Plans.

8-01.3(6)E Coir Log

This section is revised to read:

Coir logs shall be installed in accordance with the Plans.

8-01.3(9)A Silt Fence

In the second paragraph, the second sentence is revised to read:

The strength of the wire or plastic mesh shall be equivalent to or greater than what is required in Section 9-33.2(1), Table 6 for unsupported geotextile (i.e., 180 lbs. grab tensile strength in the machine direction).

8-01.3(9)B Gravel Filter, Wood Chip or Compost Berm

In the second paragraph, the last sentence is deleted.

The third paragraph is revised to read:

The Compost Berm shall be constructed in accordance with the detail in the Plans. Compost shall be Coarse Compost.

8-01.3(9)C Straw Bale Barrier

This section is revised to read:

Straw Bale Barriers shall be installed in accordance with the Plans.

8-01.3(9)D Inlet Protection

The first three paragraphs are revised to read:

Inlet protection shall be installed below or above, or as a prefabricated cover at each inlet grate, as shown in the Plans. Inlet protection devices shall be installed prior to beginning clearing, grubbing, or earthwork activities.

Geotextile fabric in all prefabricated inlet protection devices shall meet or exceed the requirements of Section 9-33.2, Table 1 for Moderate Survivability, and the minimum filtration properties of Table 2.

When the depth of accumulated sediment and debris reaches approximately ½ the height of an internal device or ⅓ the height of the external device (or less when so specified by the manufacturers) or as designated by the Engineer, the deposits shall be removed and stabilized on site in accordance with Section 8-01.3(16).

8-01.3(10) Wattles

In the first paragraph, the third sentence is revised to read:

Excavated material shall be spread evenly along the uphill slope and be compacted using hand tamping or other method approved by the Engineer.

This section is supplemented with the following new paragraph:

The Contractor shall exercise care when installing wattles to ensure that the method of installation minimizes disturbance of waterways and prevents sediment or pollutant discharge into waterbodies.

8-01.3(12) Compost Sock

In the first paragraph, "sock" is revised to read "socks" and "streambed" is revised to read "waterbodies".

In the second paragraph "bank" is revised to read "slope".

In the third paragraph "and" is revised to read "or".

This section is supplemented with the following new paragraph:

Compost for Compost Socks shall be Coarse Compost.

8-01.3(14) Temporary Pipe Slope Drain

The first paragraph is revised to read:

Temporary pipe slope drain shall be Corrugated Polyethylene Drain Pipe and shall be constructed in accordance with the Plans

The last paragraph is revised to read:

Placement of outflow of the pipe shall not pond water on road surface.

8-01.3(15) Maintenance

In the fourth paragraph, the last sentence is revised to read:

Clean sediments may be stabilized on site using approved BMPs as approved by the Engineer.

8-01.3(16) Removal

In the second paragraph, the last sentence is revised to read:

This may include, but is not limited to, ripping the soil, incorporating soil amendments, and seeding with the specified seed.

8-01.4 Measurement

The eighth paragraph is revised to read:

Silt fence, gravel filter, compost berms, and wood chip berms will be measured by the linear foot along the ground line of completed barrier.

8-01.5 Payment

The following bid items are relocated after the bid item "Check Dam":

"Inlet Protection", per each.

"Gravel Filter Berm", per linear foot.

The following new paragraph is inserted before the bid item "Stabilized Construction Entrance":

> The unit Contract price per linear foot for “Check Dam” and “Gravel Filter Berm” and per each for “Inlet Protection” shall be full pay for all equipment, labor and materials to perform the Work as specified, including installation, removal and disposal at an approved disposal site.

The paragraph after the bid item "Temporary Curb" is revised to read:

> The unit Contract price per linear foot for temporary curb shall include all costs to install, maintain, remove, and dispose of the temporary curb.

The following bid item is inserted after the bid item “Mulching with Pam”:

> “Mulching with HECP Type 3 Mulch”, per acre.

The bid item “Mulching with BFM” is revised to read:

> “Mulching with HECP Type 2 Mulch”

The bid item “Mulching with MBFM/FRM” is revised to read:

> “Mulching with HECP Type 1 Mulch”

SECTION 8-02, ROADSIDE RESTORATION
January 4, 2010

8-02.3(2) Roadside Work Plan

In the first paragraph, the second sentence is revised to read:

> The roadside work plan shall define the Work necessary to provide all Contract requirements, including: wetland excavation, soil preparation, habitat, Structure placement, planting area preparation, seeding area preparation, bark mulch and compost placement, seeding, planting, plant replacement, irrigation, and weed control in narrative form.

The first sentence under "**Progress Schedule**" is revised to read:

> A progress schedule shall be submitted in accordance with Section 1-08.3. The Progress Schedule shall include the planned time periods for Work necessary to provide all Contract requirements in accordance with Sections 8-01, 8-02, and 8-03.

The first sentence under "**Weed and Pest Control Plan**" is revised to read:

> The Weed and Pest Control Plan shall be submitted and approved prior to starting any Work defined in Sections 8-01, and 8-02.

In the third paragraph under "**Weed and Pest Control Plan**" the first and second sentences are revised to read:

The plan shall be prepared and signed by a licensed Commercial Pest Control Operator or Consultant when chemical pesticides are proposed. The plan shall include methods of weed control; dates of weed control operations; and the name, application rate, and Material Safety Data Sheets of all proposed herbicides.

The last paragraph under "**Plant Establishment Plan**" is deleted.

8-02.3(2)A Chemical Pesticides
This section is deleted.

8-02.3(2)B Weed and Pest Control
This section is deleted.

8-02.3(3) Planting Area Weed Control
This section including title is revised to read:

8-02.3(3) Weed and Pest Control
The Contractor shall control weed and pest species within the project area using integrated pest management principles consisting of mechanical, biological and chemical controls that are outlined in the Weed and Pest Control Plan or as designated by the Engineer.

Those weeds specified as noxious by the Washington State Department of Agriculture, the local Weed District, or the County Noxious Weed Control Board and other species identified by the Contracting Agency shall be controlled on the project in accordance with the weed and pest control plan.

The Contractor shall control weeds not otherwise covered in accordance with Section 8-02.3(3)A, **Planting Area Weed Control** in all areas within the project limits, including erosion control seeding area and vegetation preservation areas, as designated by the Engineer.

This section is supplemented with the following new sub-sections:

8-02.3(3)A Planting Area Weed Control
All planting areas shall be prepared so that they are weed and debris free at the time of planting and until completion of the project. The planting areas shall include the entire ground surface, regardless of cover, all planting beds, areas around plants, and those areas shown in the Plans.

All applications of post-emergent herbicides shall be made while green and growing tissue is present. Should unwanted vegetation reach the seed stage, in violation of these Specifications, the Contractor shall physically remove and bag the seed heads. All physically removed vegetation and seed heads shall be disposed of off site at no cost to the Contracting Agency.

Weed barrier mats shall be installed as shown in the Plans. Mats shall be 3-feet square and shall be secured by a minimum of 5-staples per mat. Mats and staples shall be installed according to the manufacturer’s recommendations.

8-02.3(3)B Chemical Pesticides

Application of chemical pesticides shall be in accordance with the label recommendations, the Washington State Department of Ecology, local sensitive area ordinances, and Washington State Department of Agriculture laws and regulations. Only those herbicides listed in the table *Herbicides Approved for Use on WSDOT Rights of Way* at http://www.wsdot.wa.gov/Maintenance/Roadside/herbicide_use.htm may be used.

The applicator shall be licensed by the State of Washington as a Commercial Applicator or Commercial Operator with additional endorsements as required by the Special Provisions or the proposed weed control plan. The Contractor shall furnish the Engineer evidence that all operators are licensed with appropriate endorsements, and that the pesticide used is registered for use by the Washington State Department of Agriculture. All chemicals shall be delivered to the job site in the original containers. The licensed applicator or operator shall complete a Commercial Pesticide Application Record (DOT Form 540-509) each day the pesticide is applied, and furnish a copy to the Engineer by the following business day.

The Contractor shall ensure confinement of the chemicals within the areas designated. The use of spray chemical pesticides shall require the use of anti-drift and activating agents, and a spray pattern indicator unless otherwise allowed by the Engineer.

The Contractor shall assume all responsibility for rendering any area unsatisfactory for planting by reason of chemical application. Damage to adjacent areas, either on or off the Highway Right of Way, shall be repaired to the satisfaction of the Engineer or the property owner, and the cost of such repair shall be borne by the Contractor.

8-02.3(5) Planting Area Preparation

In the first paragraph, the second sentence is revised to read:

Material displaced by the Contractor’s operations that interferes with drainage shall be removed from the channel and disposed of as approved by the Engineer.

8-02.3(7) Layout of Planting

The second paragraph is deleted.

8-02.3(8) Planting

In the second paragraph, the first and second sentences are revised to read:

Under no circumstances will planting be permitted during unsuitable soil or weather conditions as determined by the Engineer. Unsuitable conditions may include frozen soil, freezing weather, saturated soil, standing water, high winds, heavy rains, and high water levels.

The fourth paragraph is revised to read:

Plants shall not be placed below the finished grade.

The fifth paragraph is revised to read:

Planting hole sizes for plant material shall be in accordance with the details shown in the Plans. Any glazed surface of the planting hole shall be roughened prior to planting.

The following new paragraph is inserted after the fifth paragraph:

> All cuttings shall be planted immediately if buds begin to swell.

8-02.3(9) Pruning, Staking, Guying, and Wrapping

In the first paragraph, the last sentence is revised to read:

> All other pruning shall be performed only after the plants have been in the ground at least one year and when plants are dormant.

8-02.3(13) Plant Establishment

In the third paragraph, the first sentence is revised to read:

> During the first-year plant establishment period, the Contractor shall perform all Work necessary to ensure the resumption and continued growth of the transplanted material.

In the fourth paragraph, "propose" is revised to read "submit".

8-02.3(15) Live Fascines

In the first paragraph, the fourth sentence is revised to read:

> Dead branches may be placed within the live fascine and on the side exposed to the air.

In the second paragraph, the third sentence is deleted.

In the second paragraph, the seventh sentence is revised to read:

> The live stakes shall be driven through the live fascine vertically into the slope.

8-02.3(16)A Lawn Installation

In the third paragraph, the last two items "West of the summit of the Cascade Range - March 1 to October 1." and "East of the summit of the Cascade Range - April 15 to October 1." are revised to read:

Western Washington (West of the Cascade Mountain crest)	Eastern Washington (East of the Cascade Mountain crest)
March through May 15	October 1 through November 15
September 1 through October 1	

The fifth paragraph is revised to read:

> Topsoil for seeded or sodded lawns shall be placed at the depth and locations as shown in the Plans. The topsoil shall be cultivated to the specified depth, raked to a smooth even grade without low areas that trap water and compacted, all as approved by the Engineer.

In the sixth paragraph, the last sentence is revised to read:

> Following placement, the sod shall be rolled with a smooth roller to establish contact with the soil.

8-02.4 Measurement

The seventh paragraph is revised to read:

> Fine compost, medium compost and coarse compost will be measured by the cubic yard in the haul conveyance at the point of delivery.

8-02.5 Payment

The following new paragraph is inserted above the paragraph beginning with “Payment shall be increased to 90-percent……”:

> Plant establishment milestones are achieved when plants meet conditions described in Section 8-02.3(13).

The following is inserted after the bid item "Fine Compost":

> “Medium Compost”, per cubic yard.

The paragraph for the bid item "Weed Control" is revised to read:

> “Weed and Pest Control”, will be paid in accordance with Section 1-09.6.

The following new paragraph is inserted after the bid item "Soil Amendment":

> The unit Contract price per cubic yard for “Soil Amendment” shall be full pay for furnishing and incorporating the soil amendment into the existing soil.

The following new paragraph is inserted after the bid item "Bark or Wood Chip Mulch":

> The unit Contract price per cubic yard for “Bark or Wood Chip Mulch” shall be full pay for furnishing and spreading the mulch onto the existing soil.

SECTION 8-03, IRRIGATION SYSTEMS
January 4, 2010

8-03.1 Description

In this section, "staked" is revised to read "approved by the Engineer."

8-03.3 Construction Requirements

The second paragraph is revised to read:

> Potable water supplies shall be protected against cross connections in accordance with applicable Washington State Department of Health rules and regulations and approval by the local health authority.

8-03.3(1) Layout of Irrigation System

This section is revised to read:

> The Contractor shall stake the irrigation system following the schematic design shown in the Plans. Approval must be obtained from the Engineer. Alterations and changes in the layout may be expected in order to conform to ground conditions and to obtain full and adequate coverage of plant material with water. However, no changes in the system as planned shall be made without prior authorization by the Engineer.

This section is supplemented with the following new sub-section:

8-03.3(1)A Locating Irrigation Sleeves

Existing underground irrigation sleeve ends shall be located by potholing. Irrigation sleeves placed during general construction prior to installation of the irrigation system shall be marked at both ends with a 2x4x24-inch wood stake extending 6-inches out of the soil and painted blue on the exposed end.

8-03.3(2) Excavation

In the first paragraph, the fourth sentence is revised to read:

Trenches through rock or other material unsuitable for trench bottoms and sides shall be excavated 6-inches below the required depth and shall be backfilled to the top of the pipe with sand or other suitable material free from rocks or stones. Backfill material shall not contain rocks 2-inches or greater in diameter or other materials that can damage pipe.

The second paragraph is revised to read:

The Contractor shall exercise care when excavating pipe trenches near existing trees to minimize damage to tree roots. Where roots are 1-1/2-inches or greater in diameter, the trench shall be hand excavated and tunneled under the roots. When large roots are exposed, they shall be wrapped with heavy, moist material, such as burlap or canvas, for protection and to prevent excessive drying. The material must be kept moist until the trench is backfilled. Trenches dug by machines adjacent to trees having roots less than 1-1/2-inches in diameter shall have severed roots cleanly cut. Trenches having exposed tree roots shall be backfilled within 24-hours unless adequately protected by moist material as approved by the Engineer. All material and fastenings used to cover the roots shall be removed before backfilling.

The third paragraph is revised to read:

Detectable marking tape shall be placed in all trenches 6-inches directly above, parallel to, and along the entire length of all nonmetallic water pipes, and all nonmetallic and aluminum sleeves, conduits and casing pipe. The width of the tape and installation depth shall be as recommended by the manufacturer for the depth of installation or as shown in the Plans.

8-03.3(3) Piping

This section is revised to read:

All water lines shall be a minimum of 18-inches below finished grade measured from the top of the pipe or as shown in the Plans. All live water mains to be constructed under existing pavement shall be placed in steel casing jacked under pavement as shown in the Plans. All PVC or polyethylene pipe installed under areas to be paved shall be placed in irrigation sleeves. Irrigation sleeves shall extend a minimum of 2-feet beyond the limits of pavement. All jacking operations shall be performed in accordance with an approved jacking plan. Where possible; mains and laterals or section piping shall be placed in the same trench. All lines shall be placed a minimum of 3-feet from the edge of concrete sidewalks, curbs, guardrail, walls, fences, or traffic barriers. Pipe pulling will not be allowed for installation and placement of irrigation pipe.

Mainlines and lateral lines shall be defined as follows:

Mainlines: All supply pipe and fittings between the water meter and the irrigation control valves.

Lateral Lines: All supply pipe and fittings between the irrigation control valves and the connections to the irrigation heads. Swing joints, thick walled PVC or polyethylene pipe, flexible risers, rigid pipe risers, and associated fittings are not considered part of the lateral line but incidental components of the irrigation heads.

8-03.3(4) Jointing

In the second paragraph, the third sentence is revised to read:

Threaded galvanized steel joints shall be constructed using either a nonhardening, nonseizing multipurpose sealant or Teflon tape or paste as recommended by the pipe manufacturer, or as shown in the Plans.

In the last sentence of the second paragraph, "will" is revised to read "shall".

In the fourth sentence of the third paragraph, "will" is revised to read "shall" and "at" is revised to read "of".

In the fifth paragraph, the first sentence is revised to read:

On PVC or polyethylene-to-metal connections, work the metal connection first.

In the fifth paragraph, the third sentence is revised to read:

Connections between metal and PVC or polyethylene are to be threaded utilizing female threaded PVC adapters with threaded schedule 80-PVC nipple only.

In the sixth paragraph, the second sentence is revised to read:

The ends of the polyethylene pipe shall be cut square, reamed smooth inside and out, and inserted to the full depth of the fitting.

8-03.3(5) Installation

The following new paragraph is inserted after the third paragraph:

All automatic control valves, flow control valves, and pressure reducing valves shall be installed in appropriate sized valve boxes. Manual control valves shall be installed in an appropriate sized valve box and where appropriate, upstream of the automatic control valves. Manual and automatic valves installed together shall be in an appropriate sized box with 3-inches of clearance on all sides.

The fourth paragraph is revised to read:

Final position of valve boxes, capped sleeves, and quick coupler valves shall be between ½-inch and 1-inch above finished grade or mulch, or as shown in the Plans.

The following new paragraph is inserted after the fourth paragraph:

Quick coupler valves and hose bibs shall be installed in valve boxes, either separately or within a control valve assembly box upstream of the control valves. Valves, quick couplers, and hose bibs shall have 3-inches of clearance on all sides within the valve box.

In the fifth paragraph "an" is revised to read "a minimum".

The following new paragraph is inserted after the fifth paragraph:

Automatic controller pedestals or container cabinets shall be installed on a concrete base as shown in the Plans or in accordance with the manufacturer's recommendations. Provide three 1-inch diameter galvanized metal or PVC electrical wire conduits through the base and 3-inches minimum beyond the edge or side of the base both inside and outside of the pedestal.

8-03.3(6) Electrical Wire Installation

This section is revised to read:

All electrical work shall conform to the National Electric Code, NEMA Specifications and in accordance with Section 8-20. Electrical wiring between the automatic controller and automatic valves shall be direct burial and may share a common neutral. Separate control conductors shall be run from the automatic controller to each valve. When more than one automatic controller is required, a separate common neutral shall be provided for each controller and the automatic valves which it controls. Electrical wire shall be installed in the trench adjacent to or above the irrigation pipe, but no less than 12-inches deep. Plastic tape or nylon tie wraps shall be used to bundle wires together at 10-foot intervals. If it is necessary to run electrical wire in a separate trench from the irrigation pipe, the wire shall be placed at a minimum depth of 18-inches and be "snaked" from side to side in the trench. Each circuit shall be identified at both ends and at all splices with a permanent marker identifying zone and/or station.

Wiring placed under pavement and walls, or through walls, shall be placed in an electrical conduit or within an irrigation sleeve. Electrical conduit shall not be less than 1-inch in diameter, and shall meet conduit specifications for PVC conduit as required in Section 9-29.1.

Splices will be permitted only in approved electrical junction boxes, valve boxes, pole bases, or within control equipment boxes or pedestals. A minimum of 18-inches of excess conductor shall be left at all splices, terminals and control valves to facilitate inspection and future splicing. The excess wire shall be neatly coiled to fit easily into the boxes.

All 120-volt electrical conductors and conduit shall be installed by a certified electrician including all wire splices and wire terminations.

All wiring shall be tested in accordance with Section 8-20.3(11).

Continuity ground and functionality testing shall be performed for all 24-volt direct burial circuits. The Megger test, confirming insulation resistance of not less than 2 megohms to ground in accordance with Section 8-20.3(11), is required.

8-03.3(7) Flushing and Testing

In the first paragraph "correct" is revised to read "as accurate" and "ordered" is revised to read "required".

The third paragraph is revised to read:

> **Main Line Flushing**
>
> All main supply lines shall receive two fully open flushing's to remove debris that may have entered the line during construction: The first before placement of valves and the second after placement of valves and prior to testing.

The fourth paragraph is revised to read:

> **Main Line Testing**
>
> All main supply lines shall be purged of air and tested with a minimum static water pressure of 150-psi for 60-minutes without introduction of additional service or pumping pressure. Testing shall be done with one pressure gauge installed on the line, in the location required by the Engineer. For systems using a pump, an additional pressure gauge shall be installed at the pump when required by the Engineer. Lines that show loss of pressure exceeding 5-psi at the ends of specified test periods will be rejected.

The fifth paragraph is deleted.

In the sixth paragraph, "any" is revised to read "all".

In the seventh paragraph, the second sentence is revised to read:

> The operating line pressure shall be maintained for 30-minutes with valves closed and without introduction of additional service or pumping pressure.

In the eighth paragraph, the fourth and fifth sentences are revised to read:

> The Contractor shall then conduct a thorough inspection of all sprinkler heads, emitters, etc., located downstream of the break or disruption of service, and make all needed repairs to ensure that the entire irrigation system is operating properly.

8-03.3(8) Adjusting System

In the first paragraph, the last sentence is revised to read:

> Unless otherwise specified, sprinkler spray patterns will not be permitted to apply water to pavement, walks, or Structures.

8-03.3(11) System Operation

In the first paragraph, the last sentence is revised to read:

> The final inspection of the irrigation system will coincide with the end of the Contract or the end of first-year plant establishment, which ever is later.

In the second paragraph "ordered" is revised to read "required".

In the third paragraph, the last sentence is revised to read:

Potable water shall not flow through the cross-connection control device to any downstream component until tested and approved for use by the local health authority in accordance with Section 8-03.3(12).

The fourth paragraph is revised to read:

In the spring, when the drip irrigation system is in full operation, the Contractor shall make a full inspection of all emitters, and irrigation heads. This shall involve visual inspection of each emitter and irrigation head under operating conditions. All adjustments, flushing, or replacements to the system shall be made at this time to ensure the proper operation of all emitters and irrigation heads.

8-03.3(12) Cross Connection Control Device Installation

In the first sentence of the first paragraph "serving utility" is revised to read "local health authority".

8-03.3(13) Irrigation Water Service

The first paragraph is revised to read:

All water meter(s) shall be installed by the serving utility. The Contracting Agency shall arrange for a water meter installation(s) for the irrigation system at the locations and sizes as shown in the Plans at no cost to the Contractor. It shall be the Contractor's responsibility to contact the Engineer to schedule the water meter installation. The Contractor shall provide a minimum of 60-calendar days notice to the Engineer prior to the desired water meter installation date.

In the second paragraph, "will" is revised to read "shall".

8-03.3(14) Irrigation Electrical Service

The first paragraph is revised to read:

The Contracting Agency shall arrange for electrical service connection(s) for operation of the automatic electrical controller(s) at the locations as shown in the Plans. The Contractor shall splice and run conduit and wire from the electrical service connection(s), or service cabinet to the automatic electrical controller and connect the conductors to the circuit(s) per the controller manufacturer's diagrams or recommendations.

In the second paragraph, "conduit" is revised to read "conduits".

SECTION 8-08, RUMBLE STRIPS
April 5, 2010

8-08.3 Construction Requirements

In the fourth paragraph, the first and second sentences are combined to read:

When shown in the Plans, the rumble strips shall be fog sealed in accordance with the requirements of Section 5-02 following the completion of the shoulder rumble strip.

SECTION 8-09, RAISED PAVEMENT MARKERS
August 2, 2010

8-09.3(1) Surface Preparation
In the first paragraph, the second procedure is revised to read:

> When markers are placed on new cement concrete pavement, any curing compound shall be removed in accordance with the requirements of this section. All liquid membrane-forming compounds shall be removed from the Portland cement concrete pavement to which Raised Pavement Markers are to bonded, Curing compound removal shall not be started until the pavement has attained sufficient flexural strength for opening for traffic to be allowed on it. The Contractor shall submit a proposed removal method to the Project Engineer and shall not begin the removal process until the Project Engineer has approved the removal method.

SECTION 8-10, GUIDE POSTS
August 2, 2010

8-10.3 Construction Requirements
The second paragraph is supplemented with the following:

> When guide posts are placed on new cement concrete pavement, any curing compound shall be removed. All liquid membrane-forming compounds shall be removed from the Portland cement concrete pavement to which guide post are to be bonded, Curing compound removal shall not be started until the pavement has attained sufficient flexural strength for traffic to be allowed on it. The Contractor shall submit a proposed removal method to the Project Engineer and shall not begin the removal process until the Project Engineer has approved the removal method. The final guide post lengths will be determined or verified by the Engineer at the request of the Contractor.

SECTION 8-11, GUARDRAIL
August 2, 2010

8-11.3(1)A Erection of Posts
The second paragraph is supplemented with the following sentence:

> New installations of guardrail shall have steel posts or as otherwise shown in the Plans.

8-11.3(1)D Terminal and Anchor Installation
The fifth paragraph is supplemented with the following sentence:

> For new terminal installations steel posts shall be used unless shown otherwise in the Plans.

SECTION 8-14, CEMENT CONCRETE SIDEWALKS
April 5, 2010

8-14.3(5) Curb Ramp Detectable Warning Surface Retrofit
This section including heading is revised to read:

8-14.3(5) Detectable Warning Surface

Detectable warning surfaces shall consist of truncated domes as shown in the Plans. Where a detectable warning surface is to be applied, the Contractor shall attach the detectable warning surface to the pavement surface according to the manufacturer's recommendations. The detectable warning surface shall be located as shown in the Plans.

The Contractor shall use one of the detectable warning surface products listed in the Qualified Products List or submit another product for approval by the Project Engineer. If the Plans require, the detectable warning surface shall be capable of being bonded to a cement concrete surface or to an asphalt concrete surface. Vertical edges of the detectable warning surface shall be flush with the adjoining surface to the extent possible (otherwise not be more than 1/4-inch above the surface of the pavement) after installation.

8-14.4 Measurement

The second sentence in the first paragraph is revised to read:

Cement concrete curb ramp type ______ will be measured per each for the complete curb ramp type installed and includes the installation of the detectable warning surface.

The second paragraph is revised to read:

Detectable warning surface will be measured by the square foot of detectable warning surface material installed as shown in the Plans.

8-14.5 Payment

The pay item "Cement Conc. Curb Ramp Type_____" is supplemented with the following new paragraph:

The unit Contract price per each for "Cement Concrete Curb Ramp Type____", shall be full pay for installing the curb ramp as specified including the "Detectable Warning Surface".

The pay item "Curb Ramp Detectable Warning Surface Retrofit" is revised to read "Detectable Warning Surface".

SECTION 8-15, RIPRAP
January 4, 2010

8-15.2 Materials

The referenced sections for the following items are revised to read:

Heavy Loose Riprap	9-13
Light Loose Riprap	9-13
Hand Placed Riprap	9-13
Sack Riprap	9-13
Quarry Spalls	9-13

SECTION 8-17, IMPACT ATTENUATOR SYSTEMS
April 5, 2010

8-17.4 Measurement
The first paragraph is supplemented with the following new sentence:

> Only the maximum number of temporary impact attenuators installed at any one time within the project limits will be measured for payment.

8-17.5 Payment
In the second paragraph following the bid item “Resetting Impact Attenuator”, the first sentence is revised to read:

> If an impact attenuator is damaged by a third party, repairs shall be made in accordance with Section 1-07.13(4) under the Bid item “Reimbursement For Third Party Damage”.

SECTION 8-20, ILLUMINATION, TRAFFIC SIGNAL SYSTEMS, AND ELECTRICAL
August 2, 2010

8-20.1 Description
In the first paragraph, item number 3 is revised to read:

3. Intelligent Transportation Systems (ITS)

8-20.3(4) Foundations
In the 12th paragraph, item number 2 is revised to read:

2. The top heavy-hex nuts for type ASTM F1554 grade 105 anchor bolts shall be tightened by the Turn-Of-Nut Tightening Method to minimum rotation of ¼-turn (90 degrees) and a maximum rotation of ⅓-turn (120 degrees) past snug tight. Permanent marks shall be set on the base plate and nuts to indicate nut rotation past snug tight.

In the 12th paragraph, the following is inserted after item number 2:

3. The top hex nuts for type ASTM F1554 grade 55 anchor bolts shall be tightened by the Turn-of-Nut Tightening Method to minimum rotation of 1/8-turn (45 degrees) and a maximum rotation of 1/6-turn (60 degrees) past snug tight. Permanent marks shall be set on the base plate and nuts to indicate nut rotation past snug tight.

8-20.3(5) Conduit
In the fifth sentence of the fourth paragraph, “conforms” is revised to read “conforming”.

8-20.3(6) Junction Boxes, Cable Vaults, and Pull boxes
In item number 2 of the second paragraph, “top course” is deleted and “per” is revised to read “in accordance with”.

8-20.3(8) Wiring
The following new two paragraphs are inserted after the first table:

Splices and taps on underground circuits shall be made with solderless crimp connectors meeting the requirements of Section 9-29.12.

Only one conductor or one multi conductor cable per wire entrance will be allowed in any rigid mold splice.

In the eleventh paragraph item number 5 is revised to read:

5. Video detection camera lead-in cable - the numbers of the phases the camera served.

In the eleventh paragraph the following is added after item number 5:

6. For ITS cameras – the number of the camera indicated in the Contract and the number of the associated cabinet as indicated on the Plans.

7. Communication cable -- labeled as Comm.

This section is supplemented with the following new paragraph:

Installation of coaxial or coaxial/Siamese cable or data cables with a 600 VAC rating will be allowed in the same raceway with 480 VAC illumination cable.

8-20.4 Measurement

The first sentence is revised to read:

No specific unit of measurement will apply to the lump sum items for illumination system, intelligent transportation system (ITS), or traffic signal systems, but measurement will be for the sum total of all items for a complete system to be furnished and installed.

The second paragraph is revised to read:

Conduit of the kind and diameter specified will be measured, through the junction boxes, by the linear foot of conduit placed, unless the conduit is included in an illumination system, signal system, Intelligent Transportation (ITS) or other type of electrical system lump sum Bid item.

8-20.5 Payment

All references to “Intelligent Transportation System” are revised to read “ITS”.

The paragraph after the bid item, “Conduit Pipe___In. Diam.” per linear foot, is revised to read:

The unit Contract price per linear foot for “Conduit Pipe____ In. Diam.” shall be full pay for furnishing all pipe, pipe connections, elbows, bends, caps, reducers, conduits, unions, junction boxes and fittings; for placing the pipe in accordance with the above provisions, including all excavation, jacking or drilling required, backfilling of any voids around casing, conduits, pits or the trenches, restoration of native vegetation disturbed by the operation, chipping of pavement, and bedding of the pipe; and all other Work necessary for the construction of the conduit, except that when conduit is included on any project as an integral part of an illumination, traffic signal, or ITS systems and the conduit is not shown as a pay item, it shall be included in the lump sum price for the system shown.

SECTION 8-21, PERMANENT SIGNING
August 2, 2010

8-21.3(4) Sign Removal
In the fourth paragraph, the following sentence is inserted after the second sentence:

Where signs are removed from existing overhead sign Structures, the existing vertical sign support braces shall also be removed.

In the fourth paragraph, the third sentence is revised to read:

Aluminum signs, wood signs, wood sign posts, wood structures, metal sign posts, wind beams, and other metal structural members, and all existing fastening hardware connecting such members being removed, shall become the property of the Contractor and shall be removed from the project.

8-21.3(9)F Foundations
In the ninth paragraph, the following new statement is inserted as number 1. Existing numbers 1 through 6 of the ninth paragraph shall be renumbered to 2 through 7.

1. Foundation excavations shall conform to the requirements of Section 2-09.3(3).

In the tenth paragraph, item number 2. is revised to read:

2. Steel reinforcement, including spiral reinforcing, shall conform to Section 9-07.2.

SECTION 8-22, PAVEMENT MARKING
August 2, 2010

8-22.1 Description
In the second paragraph, the last sentence is revised to read:

Traffic letters used in word messages shall be sized as shown in the Plans.

8-22.4 Measurement
In the sixth paragraph “Painted Line” is revised to read “Paint Line”.

SECTION 9-01, PORTLAND CEMENT
April 5, 2010

9-01.2(1) Portland Cement
In the first paragraph, all the text after “shall not exceed 8-percent by weight” is deleted and the paragraph ends.

In the second paragraph, “per” is revised to read “in accordance with”.

SECTION 9-02, BITUMINOUS MATERIALS
August 2, 2010

9-02.1(9) Coal Tar Pitch Emulsion, Cationic Asphalt Emulsion Blend Sealer

This section including title is revised to read:

> **9-02.1(9) Vacant**

SECTION 9-03, AGGREGATES
August 2, 2010

In this Division, all references to "AASHTO TP 61" are revised to read "AASHTO T 335".

9-03.11(2) Streambed Cobbles

The first paragraph is revised to read:

> Streambed cobbles shall be clean, naturally occurring water rounded gravel material. Streambed cobbles shall have a well graded distribution of cobble sizes and conform to one or more of the following gradings as shown in the Plans:

Percent Passing					
Approximate Size Note 1	4″ Cobbles	6″ Cobbles	8″ Cobbles	10″ Cobbles	12″ Cobbles
12″					100
10″				100	70-90
8″			100	70-90	
6″		100	70-90		
5″		70-90			30-60.
4″	100			30-60.	
3″	70-90		30-60.		
2″		30-60.			
1½″	20-50				
¾″	10 max.	10 max.	10 max.	10 max.	10 max.

In the second paragraph, “determine” is revised to read “determined”.

SECTION 9-04, JOINT AND CRACK SEALING MATERIALS
August 2, 2010

9-04.2(1) Hot Poured Joint Sealants

This section is revised to read:

Hot poured joint sealants shall meet the requirements of AASHTO M 324 Type IV except for the following:

1. The Cone Penetration at 25°C shall be 130 maximum.

2. The extension for the bond, non immersed, shall be 100%.

3. The hot poured joint sealant shall have a minimum Cleveland Open Cup Flash Point of 205°C in accordance with AASHTO T 48

Hot poured joint sealants shall be sampled in accordance with ASTM D 5167 and tested in accordance with ASTM D 5329.

9-04.11 Butyl Rubber

This section including title is revised to read:

9-04.11 Butyl Rubber and Nitrile Rubber

Butyl rubber shall conform to ASTM D 2000, M1 BA 610. If the Engineer determines that the area will be exposed to petroleum products Nitrile rubber shall be utilized and conform to ASTM D 2000, M1 BG 610.

SECTION 9-05, DRAINAGE STRUCTURES, CULVERTS, AND CONDUITS January 4, 2010

9-05.12(2) Profile Wall PVC Culvert Pipe, Profile Wall PVC Storm Sewer Pipe, and Profile Wall PVC Sanitary Sewer Pipe

In the fourth paragraph, the word "producer's" is revised to read "Manufacturer's".

9-05.13 Ductile Iron Sewer Pipe

The second and third paragraphs are revised to read:

Ductile iron pipe shall conform to ANSI A 21.51 or AWWA C151 and shall be cement mortar lined and have a 1- mil seal coat per AWWA C104, or a Ceramic Filled Amine cured Novalac Epoxy lining, as indicated on the Plans or in the Special Provisions. The ductile iron pipe shall be Special Thickness Class 50, Minimum Pressure Class 350, or the Class indicated on the Plans or in the Special Provisions.

Nonrestrained joints shall be either rubber gasket type, push on type, or mechanical type meeting the requirements of AWWA C111.

Division 9-05 is supplemented with the following new sections:

9-05.21 Steel Rib Reinforced Polyethylene Culvert Pipe

Steel rib reinforced polyethylene culvert pipe shall meet the requirements of ASTM F2562 Class 1 for steel reinforced thermoplastic ribbed pipe and fittings for pipe 24-inch to 60-inch diameter with silt-tight joints.

Silt-tight joints for steel reinforced polyethylene culvert pipe shall be made with a bell/bell or bell and spigot coupling and incorporate the use of a gasket conforming to the requirements of ASTM F 477. All gaskets shall be installed on the pipe by the manufacturer.

Qualification for each manufacturer of steel reinforced polyethylene culvert pipe requires an approved joint system and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

9-05.22 Steel Rib Reinforced Polyethylene Storm Sewer Pipe

Steel rib reinforced polyethylene storm sewer pipe shall meet the requirements of ASTM F2562 Class 1 for steel reinforced thermoplastic ribbed pipe and fittings. The maximum diameter for steel reinforced polyethylene storm sewer pipe shall be the diameter for which a manufacturer has submitted a qualified joint. Qualified manufacturers and approved joints are listed in the Qualified Products Lists. Fittings shall be rotationally molded, injection molded, or factory welded.

All joints for steel reinforced polyethylene storm sewer pipe shall be made with a bell and spigot coupling and conform to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477. All gaskets shall be installed on the pipe by the manufacturer.

Qualification for each manufacturer of steel reinforced polyethylene storm sewer pipe requires joint system conformance to ASTM D 3212 using elastomeric gaskets conforming to ASTM F 477 and a formal quality control plan for each plant proposed for consideration.

A Manufacturer's Certificate of Compliance shall be required and shall accompany the materials delivered to the project. The certificate shall clearly identify production lots for all materials represented. The Contracting Agency may conduct verification tests of pipe stiffness or other properties as it deems appropriate.

9-05.23 High Density Polyethylene (HDPE) Pipe

HDPE pipe shall be manufactured from resins meeting the requirements of ASTM D3350 with a cell classification of 345464C and a Plastic Pipe Institute (PPI) designation of PE 3408.

The pipes shall have a minimum standard dimension ratio (SDR) of 32.5.

HDPE pipe shall be joined into a continuous length by an approved joining method.

The joints shall not create an increase in the outside diameter of the pipe. The joints shall be fused, snap together or threaded. The joints shall be water tight, rubber gasketed if applicable, and pressure testable to the requirements of ASTM D 3212.

Joints to be welded by butt fusion, shall meet the requirements of ASTM F 2620 and the manufacturer's recommendations. Fusion equipment used in the joining procedure shall be capable of meeting all conditions recommended by the pipe manufacturer, including but not limited to fusion temperature, alignment, and fusion pressure. All field welds shall be made with fusion equipment equipped with a Data Logger. Temperature, fusion pressure and a graphic representation of the fusion cycle shall be part of the

Quality Control records. Electro fusion may be used for field closures as necessary. Joint strength shall be equal or greater than the tensile strength of the pipe.

Fittings shall be manufactured from the same resins and Cell Classification as the pipe unless specified otherwise in the Plans or Specifications. Butt fusion fittings and Flanged or Mechanical joint adapters shall have a manufacturing standard of ASTM D3261. Electro fusion fittings shall have a manufacturing standard of ASTM F1055.

HDPE pipe to be used as liner pipe shall meet the requirements of AASHTO M 326 and this specification.

The supplier shall furnish a Manufacturer's Certification of Compliance stating the materials meet the requirements of ASTM D 3350 with the correct cell classification with the physical properties listed above. The supplier shall certify the dimensions meet the requirements of ASTM F 714 or as indicated in this Specification or the Plans.

At the time of manufacture, each lot of pipe, liner, and fittings shall be inspected for defects and tested for Elevated Temperature Sustain Pressure in accordance with ASTM F 714. The Contractor shall not install any pipe that is more than 2 years old from the date of manufacture.

At the time of delivery, the pipe shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, or deleterious faults.

Pipe shall be marked at 5 foot intervals or less with a coded number which identifies the manufacturer, SDR, size, material, machine, and date on which the pipe was manufactured.

SECTION 9-06, STRUCTURAL STEEL AND RELATED MATERIALS
August 2, 2010

9-06.5(3) High Strength Bolts

The first paragraph is revised to read:

High-strength bolts for structural steel joints shall conform to either AASHTO M 164 Type 1 or 3 or AASHTO M 253 Type 1 or 3, as specified in the Plans or Special Provisions. Tension control bolt assemblies, meeting all requirements of ASTM F 1852 may be substituted where AASHTO M 164 high strength bolts and associated hardware are specified.

The second paragraph is deleted.

The third paragraph is revised to read:

Bolts conforming to AASHTO M 253 and assemblies conforming to ASTM F 1852 shall not be galvanized.

The fourth paragraph is revised to read:

Bolts for unpainted and nongalvanized structures shall conform to either AASHTO M 164 Type 3, AASHTO M 253 Type 3, or ASTM F 1852 Type 3, as specified in the Plans or Special Provisions.

The fifth paragraph is revised to read:

Nuts for high strength bolts shall meet the following requirements:

AASHTO M 164 Bolts	
Type 1 (black)	AASHTO M 291 Grade C, C3, D, DH and DH3
	AASHTO M 292 Grade 2H
Type 3 (black weathering)	AASHTO M 291 Grade C3 and DH3
Type 1 (hot-dip galvanized)	AASHTO M 291 Grade DH
	AASHTO M 292 Grade 2H
AASHTO M 253 Bolts	
Type 1 (black)	AASHTO M 291 Grade DH, DH3
	AASHTO M 292 Grade 2H
Type 3 (black weathering)	AASHTO M 291 Grade DH3

The first sentence in the eighth paragraph is revised to read:

Washers for AASHTO M 164 and AASHTO M 253 bolts shall meet the requirements of AASHTO M 293 and may be circular, beveled, or extra thick as required.

The last sentence in the eleventh paragraph is revised to read:

Approval from the Engineer to use lock-pin and collar fasteners shall be received by the Contractor prior to use.

The number 2 foot note reference in the table is deleted.

The last row of the table is revised to read:

*Manufacturer's Certificate of Compliance — samples not required. 1 Nuts, washers, load indicator devices, and tension control bolt assemblies shall be sampled at the same frequency as the bolts.

SECTION 9-07, REINFORCING STEEL
August 2, 2010

9-07.1(1)A Acceptance of Materials

The following new paragraph is inserted before the first paragraph:

Reinforcing steel rebar manufacturers shall comply with the requirements of AASHTO PP 45, "Standard Recommended Procedure for Qualification of Deformed and Plain Steel Bar Producing Mills" and the National Transportation Product Evaluation Program (NTPEP) Work Plan for Reinforcing Steel (rebar) Manufacturers. Reinforcing steel rebar manufacturers shall participate in the NTPEP Audit Program for Reinforcing Steel (rebar) Manufacturers and be listed on the NTPEP audit program website displaying that they are NTPEP compliant.

9-07.5(1) Epoxy Coated Dowel Bars (For Cement Concrete Pavement)

This section's title is revised to read:

9-07.5(1) Epoxy Coated Dowel Bars (For Cement Concrete Pavement Rehabilitation)

The following is inserted after the third sentence of the first paragraph:

> The Contractor shall furnish a written certification that properly identifies the material, the number of each batch of coating material used, quantity represented, date of manufacture, name and address of manufacturer, and a statement that the supplied coating material meets the requirements of ASTM A 934.

SECTION 9-08, PAINTS AND RELATED MATERIALS
January 4, 2010

9-08.1(2)C Inorganic Zinc Rich Primer

In the first paragraph, the reference to "Type II" is revised to read "Type I".

9-08.1(2)D Organic Zinc Rich Primer

This section is revised to read:

> Organic zinc rich primer shall be a high performance two-component epoxy conforming to SSPC Paint 20 Type II.

SECTION 9-14, EROSION CONTROL AND ROADSIDE PLANTING
August 2, 2010

Section 9-14 is deleted in its entirety and replaced with the following:

9-14.1 Soil

9-14.1(1) Topsoil Type A

Topsoil Type A shall be as specified in the Special Provisions.

9-14.1(2) Topsoil Type B

Topsoil Type B shall be native topsoil taken from within the project limits either from the area where roadway excavation is to be performed or from strippings from borrow, pit, or quarry sites, or from other designated sources. The general limits of the material to be utilized for topsoil will be indicated in the Plans or in the Special Provisions. The Engineer will make the final determination of the areas where the most suitable material exists within these general limits. The Contractor shall reserve this material for the specified use. Material for Topsoil Type B shall not be taken from a depth greater than 1 foot from the existing ground unless otherwise designated by the Engineer.

In the production of Topsoil Type B, all vegetative matter less than 4 feet in height, shall become a part of the topsoil. Prior to topsoil removal, the Contractor shall reduce the native vegetation to a height not exceeding 1 foot. Noxious weeds, as designated by authorized State and County officials, shall not be incorporated in the topsoil, and shall be removed and disposed of as designated elsewhere or as approved by the Engineer.

9-14.1(3) Topsoil Type C

Topsoil Type C shall be native topsoil meeting the requirements of Topsoil Type B but obtained from a source provided by the Contractor outside of the Contracting Agency owned right of way.

9-14.2 Seed

Grasses, legumes, or cover crop seed of the type specified shall conform to the standards for “Certified” grade seed or better as outlined by the State of Washington Department of Agriculture “Rules for Seed Certification,” latest edition. Seed shall be furnished in standard containers on which shall be shown the following information:

1. Common and botanical names of seed
2. Lot number
3. Net weight
4 Pure live seed

All seed vendors must have a business license issued by the Washington State Department of Licensing with a “seed dealer” endorsement. Upon request, the Contractor shall furnish the Engineer with copies of the applicable licenses and endorsements.

Upon request, the Contractor shall furnish to the Engineer duplicate copies of a statement signed by the vendor certifying that each lot of seed has been tested by a recognized seed testing laboratory within six months before the date of delivery on the project. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

9-14.3 Fertilizer

Fertilizer shall be a standard commercial grade of organic or inorganic fertilizer of the kind and quality specified. It may be separate or in a mixture containing the percentage of total nitrogen, available phosphoric acid, water-soluble potash, or sulfur in the amounts specified. All fertilizers shall be furnished in standard unopened containers with weight, name of plant nutrients, and manufacturer’s guaranteed statement of analysis clearly marked, all in accordance with State and Federal laws.

Fertilizer shall be supplied in one of the following forms:

1 A dry free-flowing granular fertilizer, suitable for application by agricultural fertilizer spreader.

2 A soluble form that will permit complete suspension of insoluble particles in water, suitable for application by power sprayer.

3 A homogeneous pellet, suitable for application through a ferti-blast gun.

4 A tablet or other form of controlled release with a minimum of a six month release period.

5 A liquid suitable for application by a power sprayer or hydroseeder.

9-14.4 Mulch and Amendments

All amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's guaranteed chemical analysis and name. In lieu of containers, amendments may be furnished in bulk. A manufacturer's certificate of compliance shall accompany each delivery. Compost and other organic amendments shall be accompanied with all applicable health certificates and permits.

9-14.4(1) Straw

Straw shall be in an air dried condition free of noxious weeds, seeds, and other materials detrimental to plant life. Hay is not acceptable.

All straw material shall be Certified Weed Free Straw using North American Weed Management Association (NAWMA) standards or the Washington Wilderness Hay and Mulch (WWHAM) program run by the Washington State Noxious Weed Control Board. Information can be found at http://www.nwcb.wa.gov/http://www.nwcb.wa.gov/

In lieu of Certified Weed Free Straw, the Contractor shall provide documentation that the material is steam or heat treated to kill seeds, or shall provide U.S., Washington, or other State's Department of Agriculture laboratory test reports, dated within 90 days prior to the date of application, showing there are no viable seeds in the straw.

Straw mulch shall be suitable for spreading with mulch blower equipment.

9-14.4(2) Hydraulically Applied Erosion Control Products (HECPs)

All HECPs shall be biodegradable and in a dry condition free of noxious weeds, seeds, chemical printing ink, germination inhibitors, herbicide residue, chlorine bleach, rock, metal, plastic, and other materials detrimental to plant life. Up to 5 percent by weight may be photodegradable material.

The HECP shall be suitable for spreading with a hydroseeder.

All HECPs shall be furnished premixed by the manufacturer with Type A or Type B Tackifier as specified in 9-14.4(7). Under no circumstances will field mixing of additives or components be acceptable.

The Contractor shall provide test results, dated within three years prior to the date of application, from an independent, accredited laboratory, as approved by the Engineer, showing the product meets the following requirements:

Properties	Test Method	Requirements
Acute Toxicity	EPA-821-R-02-012 Methods for Measuring Acute Toxicity of Effluents. Test leachate from recommended application rate receiving 2 inches of rainfall per hour using static test for No-Observed-Adverse-Effect-Concentration (NOEC)	Four replicates are required with No statistically significant reduction in survival in 100% leachate for a Daphnid at 48 hours and *Oncorhynchus mykiss* (rainbow trout) at 96 hours.
Solvents	EPA 8260B	Benzene - < 0.03 mg/kg Methylene chloride – < 0.02 mg/kg Naphthalene – < 5 mg/kg Tetrachloroethylene – < 0.05 mg/kg Toluene – < 7 mg/kg Trichloroethylene – < 0.03 mg/kg Xylenes – < 9 mg/kg
Heavy Metals	EPA 6020A Total Metals	Antimony – < 4 mg/kg Arsenic – < 6 mg/kg Barium – < 80 mg/kg Boron – < 100 mg/kg Cadmium – < 2 mg/kg Chromium – < 2 mg/kg Copper – < 5 mg/kg Lead – < 5 mg/kg Mercury – < 2 mg/kg Nickel – < 2 mg/kg Selenium – < 10 mg/kg Strontium – < 30 mg/kg Zinc – < 5 mg/kg
Water Holding Capacity	ASTM D 7367	900 percent minimum
Organic Matter Content	ASTM D 586	90 percent minimum
Moisture Content	ASTM D 644	15 percent maximum
Seed Germination Enhancement	ASTM D 7322	HECP Type 1: 420 percent minimum HECP Type 2: 400 percent minimum HECP Type 3: 200 percent minimum

If the HECP contains cotton or straw, the Contractor shall provide documentation that the material has been steam or heat treated to kill seeds, or shall provide U.S., Washington, or other State's Department of Agriculture laboratory test reports, dated within 90 days prior to the date of application, showing there are no viable seeds in the mulch.

The HECP shall be manufactured in such a manner that when agitated in slurry tanks with water, the fibers will become uniformly suspended, without clumping, to form a homogeneous slurry. When hydraulically applied, the material shall form a strong moisture-holding mat that allows the continuous absorption and infiltration of water.

The HECP shall contain a dye to facilitate placement and inspection of the material. Dye shall be non-toxic to plants, animals, and aquatic life and shall not stain concrete or painted surfaces.

The HECP shall be furnished with a Material Safety Data Sheet (MSDS) that demonstrates that the product is not harmful to plants, animals, and aquatic life.

9-14.4(2)A HECP Type 1 Mulch

HECP Type 1 Mulch shall demonstrate the ability to adhere to the soil and create a blanket-like mass within two hours of application and shall bond with the soil surface to create a continuous, porous, absorbent, and flexible erosion resistant blanket that allows for seed germination and plant growth and conforms to the requirements in Table [1] HECP Type 1 Mulch Test Requirements.

The Contractor shall provide test results documenting the mulch meets the requirements in Table [1] HECP Type 1 Mulch Test Requirements.

Prior to January 1, 2012, the Contractor shall supply independent ASTM D 6459 test results from one of the following testing facilities:

National Transportation Product Evaluation Program (NTPEP)
Utah State University's Utah Water Research Laboratory
Texas Transportation Institute
San Diego State University's Soil Erosion Research Laboratory
TRI Environmental, Inc

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

Table [1] HECP Type 1 Mulch Test Requirements

Properties	Test Method	Requirements
Performance in Protecting Slopes from Rainfall-Induced Erosion	ASTM D 6459 - Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle	C Factor = 0.01 maximum using Revised Universal Soil Loss Equation (RUSLE)

9-14.4(2)B HECP Type 2 Mulch

Within 48 hours of application, the HECP Type 2 Mulch shall bond with the soil surface to create a continuous, absorbent, flexible erosion resistant blanket that allows for seed germination and plant growth and conform to the requirements in Table [2] HECP Type 2 Mulch Test Requirements.

The Contractor shall provide test results documenting the mulch meets the requirements in Table [2] HECP Type 2 Mulch Test Requirements.

Prior to January 1, 2012, the Contractor shall supply independent ASTM D 6459 test results from one of the following testing facilities:

National Transportation Product Evaluation Program (NTPEP)
Utah State University's Utah Water Research Laboratory
Texas Transportation Institute
San Diego State University's Soil Erosion Research Laboratory
TRI Environmental, Inc

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

Table 2 HECP Type 2 Mulch Test Requirements

Properties	Test Method	Requirements
Performance in Protecting Slopes from Rainfall-Induced Erosion	ASTM D 6459 - Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle	C Factor = 0.05 maximum using Revised Universal Soil Loss Equation (RUSLE)

9-14.4(2)C HECP Type 3 Mulch

The Contractor shall provide test results documenting the mulch meets the requirements in Table 3 HECP Type 3 Mulch Test Requirements.

Prior to January 1, 2012, the Contractor shall supply independent ASTM D 6459 test results from one of the following testing facilities:

National Transportation Product Evaluation Program (NTPEP)
Utah State University's Utah Water Research Laboratory
Texas Transportation Institute
San Diego State University's Soil Erosion Research Laboratory
TRI Environmental, Inc

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

Table 3 HECP Type 3 Mulch Test Requirements

Properties	Test Method	Requirements
Performance in Protecting Slopes from Rainfall-Induced Erosion	ASTM D 6459 - Test in one soil type. Soil tested shall be sandy loam as defined by the National Resources Conservation Service (NRCS) Soil Texture Triangle	C Factor = 0.15 maximum using Revised Universal Soil Loss Equation (RUSLE)

9-14.4(3) Bark or Wood Chips

Bark or wood chip mulch shall be derived from Douglas fir, pine, or hemlock species. It shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust shall not be used as mulch.

Bark or wood chips, when tested, shall be according to WSDOT Test Method T 123 prior to placement and shall meet the following loose volume gradation:

	Percent Passing	
Sieve Size	**Minimum**	**Maximum**
2"	95	100
No. 4	0	30

9-14.4(4) Wood Strand Mulch

Wood strand mulch shall be a blend of angular, loose, long, thin wood pieces that are frayed, with a high length-to-width ratio and shall be derived from native conifer or deciduous trees. A minimum of 95 percent of the wood strand shall have lengths between 2 and 10 inches. At least 50 percent of the length of each strand shall have a width and thickness between 1/16 and ½ inch. No single strand shall have a width or thickness greater than ½ inch.

The mulch shall not contain salt, preservatives, glue, resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust or wood chips or shavings will not be acceptable. Products shall be tested according to WSDOT Test Method 125 prior to acceptance.

9-14.4(5) Lime

Agriculture lime shall be of standard manufacture, flour grade or in pelletized form, meeting the requirements of ASTM C 602.

9-14.4(6) Gypsum

Gypsum shall consist of Calcium Sulfate (CaSO42H2O) in a pelletized or granular form. 100 percent shall pass through a No. 8 sieve.

9-14.4(7) Tackifier

Tackifiers are used as a tie-down for soil, compost, seed, and/or mulch. Tackifier shall contain no growth or germination inhibiting materials, and shall not reduce infiltration rates. Tackifier shall hydrate in water and readily blend with other slurry materials and conform to the requirements in Table 4 Tackifier Test Requirements.

The Contractor shall provide test results documenting the tackifier meets the requirements in Table 4 Tackifier Test Requirements.

Before January 1, 2012, the Contractor shall supply independent ASTM D 6459 test results from one of the following testing facilities:

National Transportation Product Evaluation Program (NTPEP)
Utah State University's Utah Water Research Laboratory
Texas Transportation Institute
San Diego State University's Soil Erosion Research Laboratory
TRI Environmental, Inc

Effective January 1, 2012, the Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP).

Table 4 Tackifier Test Requirements

Properties	Test Method	Requirements
Heavy Metals Solvents Acute Toxicity	Test at manufacturer's recommended application rate	See Table in Section 9-14.4(2)
Performance in Protecting Slopes from Rainfall-Induced Erosion	Modified ASTM D 6459 on 3(H):1(V) slope with 2 inches of rainfall evenly distributed over a period of 100 minutes. Test in one soil type. Soil tested shall be	C Factor = 0.15 maximum using Revised Universal Soil Loss Equation (RUSLE)

	sandy loam as defined by the National Resources Conservation Service (NRCS) Soil Texture Triangle	

9-14.4(7)A Organic Tackifier

Organic tackifier shall be derived from natural plant sources and shall have an MSDS that demonstrates to the satisfaction of the Engineer that the product is not harmful to plants, animals, and aquatic life.

9-14.4(7)B Synthetic Tackifier

Synthetic tackifier shall have an MSDS that demonstrates to the satisfaction of the Engineer that the product is not harmful to plants, animals, and aquatic life.

9-14.4(8) Compost

Compost products shall be the result of the biological degradation and transformation of plant-derived materials under controlled conditions designed to promote aerobic decomposition. Compost shall be stable with regard to oxygen consumption and carbon dioxide generation. Compost shall be mature with regard to its suitability for serving as a soil amendment or an erosion control BMP as defined below. The compost shall have a moisture content that has no visible free water or dust produced when handling the material.

Compost production and quality shall comply with Chapter 173-350 WAC.

Compost products shall meet the following physical criteria:

1. Compost material shall be tested in accordance with U.S. Composting Council Testing Methods for the Examination of Compost and Composting (TMECC) 02.02-B, “Sample Sieving for Aggregate Size Classification”.

   Fine compost shall meet the following gradation:

	Percent Passing	
Sieve Size	Minimum	Maximum
2”	100	
1”	95	100
5/8”	90	100
1/4”	75	100

Maximum particle length of 6 inches.

   Medium compost shall meet the following gradation:

	Percent Passing	
Sieve Size	Minimum	Maximum
2”	100	
1”	95	100
5/8”	90	100
1/4”	75	85

Maximum particle length of 6 inches.

Medium compost shall have a carbon to nitrogen ratio (C:N) between 18:1 and 30:1. The carbon to nitrogen ratio shall be calculated using the dry weight of "Organic Carbon" using TMECC 04.01A divided by the dry weight of "Total N" using TMECC 04.02D.

Coarse compost shall meet the following gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
3"	100	
1"	90	100
3/4"	70	100
1/4"	40	60

Maximum particle length of 6 inches.

2. The pH shall be between 6.0 and 8.5 when tested in accordance with U.S. Composting Council TMECC 04.11-A, "1:5 Slurry pH".

3. Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0 percent by weight as determined by U.S. Composting Council TMECC 03.08-A "Classification of Inerts by Sieve Size".

4. Minimum organic matter shall be 40 percent by dry weight basis as determined by U.S. Composting Council TMECC 05.07A "Loss-On-Ignition Organic Matter Method (LOI)".

5. Soluble salt contents shall be less than 4.0 mmhos/cm when tested in accordance with U.S. Composting Council TMECC 04.10 "Electrical Conductivity".

6. Maturity shall be greater than 80 percent in accordance with U.S. Composting Council TMECC 05.05-A, "Germination and Root Elongation".

7. Stability shall be 7 mg CO2–C/g OM/day or below in accordance with U.S. Composting Council TMECC 05.08-B "Carbon Dioxide Evolution Rate".

8. The compost product shall originate a minimum of 65 percent by volume from recycled plant waste as defined in WAC 173-350 as "Type 1 Feedstocks." A maximum of 35 percent by volume of "Type 2 Feedstocks," source-separated food waste, and/or biosolids may be substituted for recycled plant waste. The Contractor shall provide a list of feedstock sources by percentage in the final compost product.

9. The Engineer may evaluate compost for maturity using U.S. Composting Council TMECC 05.08-E "Solvita® Maturity Index". Fine compost shall score a number 6 or above on the Solvita® Compost Maturity Test. Coarse compost shall score a 5 or above on the Solvita® Compost Maturity Test.

9-14.4(8)A Compost Submittal Requirements

The Contractor shall submit the following information to the Engineer for approval:

1. The Qualified Products List printed page or a Request for Approval of Material(DOT Form 350-071EF).

2. A copy of the Solid Waste Handling Permit issued to the manufacturer by the Jurisdictional Health Department in accordance with WAC 173-350 (Minimum Functional Standards for Solid Waste Handling).

3. The Contractor shall verify in writing, and provide lab analyses, that the material complies with the processes, testing, and standards specified in WAC 173-350 and these Specifications. An independent Seal of Testing Assurance (STA) Program certified laboratory shall perform the analysis.

4. A copy of the manufacturer's Seal of Testing Assurance (STA) certification as issued by the U.S. Composting Council.

9-14.4(8)B Compost Acceptance

Fourteen days prior to application, the Contractor shall submit a sample of the compost approved for use, and a STA test report dated within 90 calendar days of the application, and the list of feed stocks by volume for each compost type to the Engineer for review.

The Contractor shall use only compost that has been tested within 90 calendar days of application and meets the requirements in Section 9-14.4(8). Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall not be used.

9-14.4(9) Vacant

9-14.4(10) Vacant

9-14.5 Erosion Control Devices

9-14.5(1) Polyacrylamide (PAM)

Polyacrylamide (PAM) products shall meet ANSI/NSF Standard 60 for drinking water treatment with an AMD content not to exceed 0.05 percent. PAM shall be anionic, linear, and not cross-linked. The minimum average molecular weight shall be greater than 5 mg/mole and minimum 30 percent charge density. The product shall contain at least 80 percent active ingredients and have a moisture content not exceeding 10 percent by weight. PAM shall be delivered in a dry granular or powder form.

9-14.5(2) Erosion Control Blanket

Temporary erosion control blanket shall be made of natural plant fibers. The Contractor shall supply independent test results from the National Transportation Product Evaluation Program (NTPEP) meeting the requirements in the following table:

Properties	ASTM Test Method	Requirements
Protecting Slopes from Rainfall-Induced Erosion	D 6459 - Test in one soil type. Soil tested shall be sandy loam as defined by the NRCS Soil Texture Triangle	Maximum C factor of 0.15 using Revised Universal Soil Loss Equation (RUSLE)
Dry Weight per Unit Area	D 6475	0.36 lb/sq. yd. minimum
Performance in	D 6460 Test in one soil	1.0 lb/sq. ft.

Protecting Earthen Channels from Stormwater-Induced Erosion	type. Soil tested shall be loam as defined by the NRCS Soil Texture Triangle	minimum
Seed Germination Enhancement	D 7322	200 percent minimum

Netting, if present, shall be biodegradable with a life span not to exceed one year.

Permanent erosion control blanket shall meet the following requirements:

Properties	**ASTM Test Method**	**Requirements**
UV Stability	D 4355	Minimum 80 percent strength retained after 500 hours in a xenon arc device
Protecting Slopes from Rainfall-Induced Erosion	D 6459 with 0.12 inch average raindrop size.* Test in one soil type. Soil tested shall be loam as defined by the NRCS Soil Texture Triangle **	Maximum C factor of 0.15 using Revised Universal Soil Loss Equation (RUSLE)
Dry Weight per Unit Area	D 6475	0.50 lb/sq. yd. minimum
Performance in Protecting Earthen Channels from Stormwater-Induced Erosion	D 6460 Test in one soil type. Soil tested shall be loam as defined by the NRCS Soil Texture Triangle**	2.0 lb/sq. ft. minimum
Seed Germination Enhancement	D 7322	200 percent minimum

9-14.5(2)A Erosion Control Blanket Approval

The Contractor shall select erosion control blanket products that bear the Quality and Data Oversight and Review (QDOR) seal from the Erosion Control and Technology Council (ECTC). All materials selected shall be currently listed on the QDOR products list available at www.ectc.org/qdor

9-14.5(3) Clear Plastic Covering

Clear plastic covering shall meet the requirements of ASTM D 4397 for polyethylene sheeting having a minimum thickness of 6 mils.

9-14.5(4) Geotextile-Encased Check Dam

The geotextile-encased check dam shall be a urethane foam core encased in geotextile material. The minimum length of the unit shall be 7 feet.

The foam core shall be a minimum of 8 inches in height, and have a minimum base width of 16 inches. The geotextile material shall overhang the foam by at least 6 inches at each end, and shall have apron type flaps that extend a minimum of 24 inches on each side of the check dam. The geotextile material shall meet the requirements in Section 9-33.

9-14.5(5) Wattles

Wattles shall consist of cylinders of biodegradable plant material such as weed-free straw, coir, compost, wood chips, excelsior, or wood fiber or shavings encased within biodegradable netting. Wattles shall be a minimum of 5 inches in diameter. Netting material shall be clean, evenly woven, and free of encrusted concrete or other contaminating materials such as preservatives. Netting material shall be free from cuts, tears, or weak places and shall have a minimum lifespan of 6 months.

Compost filler shall be coarse compost and shall meet the material requirements as specified in Section 9-14.4(8). If wood chips are used they shall meet the material requirements as specified in Section 9-14.4(3). If wood shavings are used, 80 percent of the fibers shall have a minimum length of 6 inches between 0.030 and 0.50 inches wide, and between 0.017 and 0.13 inches thick.

Wood stakes for wattles shall be made from untreated Douglas fir, hemlock, or pine species. Wood stakes shall be 2 inch by 2 inch nominal dimension and 36 inches in length.

9-14.5(6) Compost Socks

Compost socks shall consist of extra heavy weight biodegradable fabric, with a minimum strand thickness of 5 mils. The fabric shall be filled with Coarse Compost. Compost socks shall be at least 8 inches in diameter. The fabric shall be clean, evenly woven, and free of encrusted concrete or other contaminating materials and shall be free from cuts, tears, broken or missing yarns, and be free of thin, open, or weak areas and shall be free of any type of preservative.

Coarse compost filler shall meet the material requirements as specified in Section 9-14.4(8).

Wood stakes for compost socks shall be made from untreated Douglas fir, hemlock, or pine species. Wood stakes shall be 2 inch by 2 inch nominal dimension and 36 inches in length,

9-14.5(7) Coir Log

Coir logs shall be made of 100 percent durable coconut (coir) fiber uniformly compacted within woven netting made of bristle coir twine with minimum strength of 80 lbs tensile strength. The netting shall have nominal 2 inch by 2 inch openings. Log segments shall have a maximum length of 20 feet, with a minimum diameter as shown in the Plans. Logs shall have a minimum density of 7 lbs/cf.

Stakes shall be untreated Douglas fir, hemlock, or pine species. Wood stakes shall have a notch to secure the rope ties. Rope ties shall be of 1/4 inch diameter commercially available hemp rope.

9-14.5(8) High Visibility Fencing

High visibility fence shall be UV stabilized, orange, high-density polyethylene or polypropylene mesh, and shall be at least 4-feet in height.

Support posts shall be wood or steel in accordance with Standard Plan I-10.10-00. The posts shall have sufficient strength and durability to support the fence through the life of the project.

9-14.6 Plant Materials

9-14.6(1) Description

Bareroot plants are grown in the ground and harvested without soil or growing medium around their roots.

Container plants are grown in pots or flats that prevent root growth beyond the sides and bottom of the container.

Balled and burlapped plants are grown in the ground and harvested with soil around a core of undisturbed roots. This rootball is wrapped in burlap and tied or placed in a wire basket or other supportive structure.

Cuttings are live plant material without a previously developed root system. Source plants for cuttings shall be dormant when cuttings are taken and all cuts shall be made with a sharp instrument. Cuttings may be collected. If cuttings are collected, the requirement to be nursery grown or held in nursery conditions does not apply. Written permission shall be obtained from property owners and provided to the Engineer before cuttings are collected. The Contractor shall collect cuttings in accordance with applicable sensitive area ordinances. Cuttings shall meet the following requirements:

A. Live branch cuttings shall have flexible top growth with terminal buds and may have side branches. The rooting end shall be cut at an approximate 45 degree angle.

B. Live stake cuttings shall have a straight top cut immediately above a bud. The lower, rooting end shall be cut at an approximate 45 degree angle. Live stakes are cut from one to two year old wood. Live stake cuttings shall be cut and installed with the bark intact with no branches or stems attached, and be ½ to 1½ inch in diameter.

C. Live pole cuttings shall have a minimum 2 inch diameter and no more than three branches which shall be pruned back to the first bud from the main stem.

Rhizomes shall be a prostrate or subterranean stem, usually rooting at the nodes and becoming erect at the apex. Rhizomes shall have a minimum of two growth points. Tubers shall be a thickened and short subterranean branch having numerous buds or eyes.

9-14.6(2) Quality

At the time of delivery all plant material furnished shall meet the grades established by the latest edition of the American Standard for Nursery Stock, (ASNS) ANSI Z60.1 and shall conform to the size and acceptable conditions as listed in the Contract, and shall be free of all foreign plant material.

All plant material shall comply with State and Federal laws with respect to inspection for plant diseases and insect infestation.

All plant material shall be purchased from a nursery licensed to sell plants in Washington State.

Live woody or herbaceous plant material, except cuttings, rhizomes, and tubers, shall be vigorous, well formed, with well developed fibrous root systems, free from dead branches, and from damage caused by an absence or an excess of heat or moisture, insects, disease, mechanical or other causes detrimental to good plant development. Evergreen plants shall be well foliated and of good color. Deciduous trees that have solitary leaders shall have only the lateral branches thinned by pruning. All conifer trees shall have only one leader (growing apex) and one terminal bud, and shall not be sheared or shaped. Trees having a damaged or missing leader, multiple leaders, or Y-crotches shall be rejected.

Root balls of plant materials shall be solidly held together by a fibrous root system and shall be composed only of the soil in which the plant has been actually growing. Balled and burlapped rootballs shall be securely wrapped with jute burlap or other packing material not injurious to the plant life. Root balls shall be free of weed or foreign plant growth.

Plant materials shall be nursery grown stock. Plant material, with the exception of cuttings, gathered from native stands shall be held under nursery conditions for a minimum of one full growing season, shall be free of all foreign plant material, and meet all of the requirements of these Specifications, the Plans, and the Special Provisions.

Container grown plants shall be plants transplanted into a container and grown in that container sufficiently long for new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container, without having roots that circle the pot. Plant material which is root bound, as determined by the Engineer, shall be rejected. Container plants shall be free of weed or foreign plant growth.

Container sizes for plant material of a larger grade than provided for in the container grown Specifications of the ASNS shall be determined by the volume of the root ball specified in the ASNS for the same size plant material.

All bare root plant materials shall have a heavy fibrous root system and be dormant at the time of planting.

Average height to spread proportions and branching shall be in accordance with the applicable sections, illustrations, and accompanying notes of the ASNS.

Plants specified or identified as “Street Tree Grade” shall be trees with straight trunks, full and symmetrical branching, central leader, and be developed, grown, and propagated with a full branching crown. A “Street Tree Grade” designation requires the highest grade of nursery shade or ornamental tree production which shall be supplied.

Street trees with improperly pruned, broken, or damaged branches, trunk, or root structure shall be rejected. In all cases, whether supplied balled and burlapped or in a container, the root crown (top of root structure) of the tree shall be at the top of the finish soil level. Trees supplied and delivered in a nursery fabric bag will not be accepted.

Plants which have been determined by the Engineer to have suffered damage for the following reasons will be rejected:

1. Girdling of the roots, stem, or a major branch.

2. Deformities of the stem or major branches.

3. Lack of symmetry.

4. Dead or defoliated tops or branches.

5. Defects, injury, and condition which renders the plant unsuitable for its intended use.

Plants that are grafted shall have roots of the same genus as the specified plant.

9-14.6(3) Handling and Shipping

Handling and shipping shall be done in a manner that is not detrimental to the plants. The nursery shall furnish a notice of shipment in triplicate at the time of shipment of each truck load or other lot of plant material. The original copy shall be delivered to the Project Engineer, the duplicate to the consignee and the triplicate shall accompany the shipment to be furnished to the Inspector at the job site. The notice shall contain the following information:

1. Name of shipper.

2. Date of shipment.

3. Name of commodity. (Including all names as specified in the Contract.)

4. Consignee and delivery point.

5. State Contract number.

6. Point from which shipped.

7. Quantity contained.

8. Size. (Height, runner length, caliper, etc. as required.)

9. Signature of shipper by authorized representative.

To acclimate plant materials to Northwest conditions, all plant materials used on a project shall be grown continuously outdoors north of the 42nd Latitude (Oregon-California border) from not later than August 1 of the year prior to the time of planting.

All container grown plants shall be handled by the container.

All balled and burlapped plants shall be handled by the ball.

Plant material shall be packed for shipment in accordance with prevailing practice for the type of plant being shipped, and shall be protected at all times against drying, sun, wind, heat, freezing, and similar detrimental conditions both during shipment and during related handling. Where necessary, plant material shall be temporarily heeled in. When transported in closed vehicles, plants shall receive adequate ventilation to prevent sweating. When transported in open vehicles, plants shall be protected by tarpaulins or other suitable cover material.

9-14.6(4) Tagging

Plants delivered as a single unit of 25 or less of the same size, species, and variety, shall be clearly marked and tagged. Plants delivered in large quantities of more than 25 shall be segregated as to variety, grade, and size; and one plant in each 25, or fraction thereof, of each variety, grade, and size shall be tagged.

9-14.6(5) Inspection

The Contracting Agency will make an inspection of plant material at the source when requested by the Engineer. However, such preliminary approval shall not be considered as final acceptance for payment. Final inspection and approval (or rejection) will only occur when the plant material has been delivered to the Project site. The Contractor shall notify the Engineer, not less than 48 hours in advance, of plant material delivery to the project.

9-14.6(6) Substitution of Plants

No substitution of plant material, species or variety, will be permitted unless evidence is submitted in writing to the Engineer that a specified plant cannot be obtained and has been unobtainable since the Award of the Contract. If substitution is permitted, it can be made only with written approval by the Engineer. The nearest variety, size, and grade, as approved by the Engineer, shall then be furnished.

Container or balled and burlapped plant material may be substituted for bare root plant material. Container grown plant material may be substituted for balled and burlapped plant materials. When substitution is allowed, use current ASNS standards to determine the correct rootball volume (container or balled and burlapped) of the substituted material that corresponds to that of the specified material. These substitutions shall be approved by the Engineer and be at no cost to the Contracting Agency.

9-14.6(7) Temporary Storage

Plants stored under temporary conditions prior to installation shall be the responsibility of the Contractor.

Plants stored on the project shall be protected at all times from extreme weather conditions by insulating the roots, root balls, or containers with sawdust, soil, compost, bark or wood chips, or other approved material and shall be kept moist at all times prior to planting.

Cuttings shall continually be shaded and protected from wind. Cuttings shall be protected from drying at all times and shall be heeled into moist soil or other insulating material or placed in water if not installed within eight hours of cutting. Cuttings to be stored for later installation shall be bundled, laid horizontally, and completely buried under 6 inches of water, moist soil or placed in cold storage at a temperature of 34°F and 90 percent humidity. Cuttings that are not planted within 24 hours of cutting shall be soaked in water for 24 hours prior to planting. Cuttings taken when the temperature is higher than 50°F shall not be stored for later use. Cuttings that already have developed roots shall not be used.

9-14.6(8) Sod

The available grass mixtures on the current market shall be submitted to the Engineer for selection and approval.

The sod shall be field grown one calendar year or older, have a well developed root structure, and be free of all weeds, disease, and insect damage.

Prior to cutting, the sod shall be green, in an active and vigorous state of growth, and mowed to a height not exceeding 1 inch.

The sod shall be cut with a minimum of 1inch of soil adhering.

9-14.7 Stakes, Guys, and Wrapping

Stakes shall be installed as shown in the Plans.

Commercial plant ties may be used in lieu of hose and wire guying upon approval of the Engineer. The minimum size of wire used for guying shall be 12 gauge, soft drawn.

Hose for guying shall be nylon, rubber, or reinforced plastic and shall have an inside diameter of at least 1 inch.

Tree wrap shall be a crinkled waterproof paper weighing not less than 4.0 pounds per 100 square feet and shall be made up of two sheets cemented together with asphalt.

SECTION 9-15, IRRIGATION SYSTEM

January 4, 2010

The first paragraph is supplemented with the following:

When the water supply for the irrigation system is from a non-potable source, irrigation components shall have lavender indicators supplied by the equipment manufacturer.

9-15.3 Automatic Controllers

This section is revised to read:

The automatic controller shall be an electronic timing device for automatically opening and closing control valves for predetermined periods of time. The automatic controller shall be enclosed in a weatherproof, painted, metal housing fabricated from 16 gauge sheet aluminum alloy 6061-T6 or 16 gauge sheet steel or unpainted, non-rusting industrial grade stainless steel. The pedestal shall have a completely removable locking faceplate to allow easy access to wiring.

The automatic controller housing shall have hasp and lock or locking device. All locks or locking devices shall be master keyed and three sets of keys provided to the Engineer. The controller shall be compatible with and capable of operating the irrigation system as designed and constructed and shall include the following operating features:

1. Each controller station shall be adjustable for setting to remain open for any desired period of time, from five minutes or less to at least 99 minutes.
2. Adjustments shall be provided whereby any number of days may be omitted and whereby any one or more positions on the controller can be skipped.

When adjustments are made, they shall continue automatically within a 14-day cycle until the operator desires to make new adjustments.

3. Controls shall allow any position to be operated manually, both on or off, whenever desired, without disrupting the 14 day cycle.
4. Controls shall provide for resetting the start of the irrigation cycle at any time and advancing from one position to another.
5. Controllers shall contain a power on-off switch and fuse assembly.
6. Output shall be 24 volt AC with battery back up for memory retention of the 14 day cycle.
7. Both normally-open or normally-closed rain sensor compatibility.

9-15.4 Irrigation Heads

This section is supplemented with the following new paragraph:

All instructions, special wrenches, clamps, tools, and equipment supplied by the manufacturer necessary for the installation and maintenance of the irrigation heads shall be turned over to the Engineer upon completion and acceptance of the project.

9-15.5 Valve Boxes and Protective Sleeves

This section including title is revised to read:

9-15.5 Valve Boxes

Valve boxes shall conform to the Plans and be extendible to obtain the depth required. All manual drain valves and manual control valves shall be installed in valve box with a vandal resistant lid as shown in the Plans.

9-15.7(1) Manual Control Valves

The third and fourth sentences are revised to read:

The Contractor shall furnish three suitable operating keys. Valves shall have removable bonnet and stem assemblies with adjustable packing glands and shall house long acme threaded stems to ensure full opening and closing.

9-15.7(2) Automatic Control Valves

In the second paragraph, the first and second sentences are revised to read:

Valves shall be of a normally closed design and shall be operated by an electronic solenoid having a maximum rating of 6.5 watts utilizing 24 volt AC power. Electronic solenoids shall have a stainless steel plunger and be directly attached to the valve bonnets or body with all control parts fully encapsulated.

In the fifth sentence of the second paragraph, "electric" is revised to read "electrical".

9-15.7(3) Automatic Control Valves With Pressure Regulator

This section is revised to read:

Automatic control valves with pressure regulators shall be similar to automatic control valves described in Section 9-15.7(2) and shall reduce the inlet pressure to a constant pressure regardless of supply fluctuations. The regulator must be fully adjustable.

9-15.8 Quick Coupling Equipment

In the first paragraph, the first and second sentences are revised to read:

> Quick coupler valves shall have a service rating of not less than 125-psi for non-shock cold water. The body of the valves shall be of cast Copper Alloy No. C84400 Leaded Semi-Red Brass conforming to ASTM B 584.

In the fifth sentence of the first paragraph, "will" is revised to read "shall".

9-15.9 Drain Valves

This section is revised to read:

> Drain valves may be a ½-inch or ¾-inch PVC or metal gate valve manufactured for irrigation systems. Valves shall be designed for underground installation with suitable cross wheel for operation with a standard key, and shall have a service rating of not less than 150-psi non-shock cold water. The Contractor shall furnish three standard operating keys per Contract. Drain valves shall be installed in a valve box with a vandal resistant lid as shown in the Plans.
>
> Drain valves on potable water systems shall only be allowed on the downstream side of approved cross connection control devices.

9-15.10 Hose Bibs

The first sentence is revised to read:

> Hose bibs shall be angle type, constructed of bronze or brass, threaded to accommodate a ¾-inch hose connection, and shall be key operated.

9-15.11 Cross Connection Control Devices

This section is revised to read:

> Atmospheric vacuum breaker assemblies (AVBAs), pressure vacuum breaker assemblies (PVBAs), double check valve assemblies (DCVAs), and reduced pressure backflow devices (RPBDs), shall be of a manufacturer and product model approved for use by the Washington State Department of Health, Olympia, Washington or a Department of Health certified agency.

9-15.12 Check Valves

The last sentence is revised to read:

> Valves shall have angled seats, Buna-N seals and threaded connections, and shall be installed in 8-inch round plastic valve boxes with vandal resistant lids.

9-15.14 Three-Way Valves

The last sentence is revised to read:

> When handles are included as an integral part of the valves, the Contractor shall remove the handles and give them to the Engineer for ultimate distribution to the Maintenance Division.

9-15.15 Flow Control Valves

The third sentence is revised to read:

Valves shall be factory set to the flows as shown in the Plans.

9-15.17 Electrical Wire and Splices

This section is revised to read:

Electrical wire used between the automatic controller and automatic control valves shall be solid or stranded copper, minimum size AWG 14. Insulation shall be Type USE Chemically Cross Linked Polyethylene or Type UF, and shall be listed by a National recognized Testing Laboratory. Each conductor shall be color coded and marked at each end and at all splices with zone or station number identification.

Low voltage splices shall be made with a direct bury splice kit using a twist-on wire connector and inserted in a waterproof polypropylene tube filled with a silicone electrical insulating gel, or heat shrinkable insulating tubing. Heat shrinking insulating tubing shall consist of a mastic lined heavy wall polyolefin cable sleeve.

9-15.18 Detectable Marking Tape

The first paragraph is revised to read:

Detectable marking tape shall consist of inert polyethylene plastic that is impervious to all known alkalis, acids, chemical reagents, and solvents likely to be encountered in the soil, with a metallic foil core to provide for the most positive detection and pipeline location.

In the second paragraph, the first and second sentences are revised to read:

The tape shall be color coded and shall be imprinted continuously over its entire length in permanent black ink indicating the type of line buried below and shall also have the word “Caution” prominently shown.

The last paragraph is revised to read:

The width of the tape shall be as recommended by the manufacturer based on depth of installation.

SECTION 9-16, FENCE AND GUARDRAIL
August 2, 2010

9-16.3(2) Posts and Blocks

This section in its entirety is revised to read:

Posts and blocks may be of creosote, pentachlorophenol, waterborne chromate copper arsenate (CCA), ammoniacal copper arsenate (ACA), or ammoniacal copper zinc arsenate (ACZA), treated timber or galvanized steel (galvanized steel posts only –no blocks). Blocks made from alternate materials that meet the NCHRP Report 350 or MASH criteria may be used in accordance with the manufacturer’s recommendations. Wood posts and blocks may be surface four sides (S4S) or rough sawn.

Posts and blocks shall be of the size, length and type as shown in the Plans and meet the requirements of the below Specifications.

Timber posts and blocks shall conform to the grade specified in Section 9-09.2. Timber posts and blocks shall be fabricated as specified in the Plans before being treated. Timber posts and blocks shall be treated by the empty cell process to provide a minimum retention, depending on the treatment used, according to the following:

Creosote oil	10.0	lbs.	pcf
Pentachlorophenol	0.50	lbs.	pcf
ACA	0.50	lbs.	pcf
ACZA	0.50	lbs.	pcf
CCA	0.50	lbs	pcf

Treatment shall be in accordance with Section 9-09.3.

Galvanized steel posts, and base plates, where used, shall conform to either ASTM A36 or ASTM A992, and shall be galvanized in accordance with AASHTO M 111. Welding shall conform to Section 6-03.3(25). All fabrication shall be completed prior to galvanizing.

Steel posts for weathering steel beam guardrail shall be in accordance with one of the following two methods:

1 Galvanized Powder Coated Steel Posts: These posts shall conform to ASTM A36 or ASTM A992 and galvanized in accordance with AASHTO M 111. Powder Coating Galvanized Surfaces done in accordance with Sections: 6-07.3(11)B, 9-08.2. and 9-08.1(8). Only the top thirty inches on any post length shall be powder coated.

2. Galvanized Weathering Steel Posts: These posts shall conform to ASTM A588 steel and be galvanized in accordance with AASHTO M 111. Thirty inches, on any post length, shall not be galvanized for exposure above ground.

SECTION 9-22, MONUMENT CASES
January 4, 2010

9-22.1 Monument Cases, Covers, and Risers
In the first sentence, "Class 30B" is revised to read "Class 35B".

SECTION 9-23, CONCRETE CURING MATERIALS AND ADMIXTURES
August 2, 2010

9-23.1 Sheet Materials for Curing Concrete
In the first paragraph, “AASHTO M 171” is revised to read “ASTM C 171”.

9-23.2 Liquid Membrane Forming Concrete Curing Compounds
The first paragraph is revised to read:

Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C 309 Type 1 or 2, Class A or B, except that the water retention when tested in accordance with WSDOT Test Method 814 shall be 2.50 grams for all applications.

SECTION 9-29, ILLUMINATION, SIGNAL, ELECTRICAL
August 2, 2010

In this division, all references to "hot-dipped" are revised to read "hot-dip".

9-29.1(2)A Expansion Fittings, Deflection Fittings, and Combination Expansion/Deflection Fittings

The following new paragraph is inserted after the first paragraph:

> Expansion fittings for use with PVC shall allow for 4-inches of movement minimum (2-inches in each direction). Expansion fittings for PVC conduit shall be PVC and have threaded terminal adaptor or coupling end and shall meet the requirements listed in Section 9-29.1(4)A.

9-29.4 Messenger Cable, Fittings

This section is supplemented with the following:

> Messenger cable shall be ⅜-inch, 7-wire strand messenger cables conforming to ASTM A 475, extra-high-strength grade, 15,400 pounds minimum breaking strength, Class A galvanized.
>
> Strain insulators shall be wet process, porcelain, conforming to EEI-NEMA Class 54-2 standards for 12,000 pound ultimate strength.
>
> Down guy assembly shall consist of an eight-way steel expanding anchor, having a minimum area of 300 square inches, made of pressed steel, coated with asphalt or similar preservative, and fitted with a ¾-inch minimum guy eye anchor rod 8-feet long. As an alternate to expanding anchors, screw type anchors with two 8-inch helix, 3½-inch-pitch, 1-inch by 7 foot guy anchor rod, and rated for 7,000 pound maximum torque may be installed.
>
> All pole hardware, bolts, plate rods, hangers, clips, wire guards, and pole bands shall be hot-dipped galvanized in conformance with the requirements of AASHTO M 232.

9-29.6(5) Foundation Hardware

The first paragraph is revised to read:

> Anchor bolts for Type PPB, PS, I, FB, and RM signal standards shall conform to the requirements of ASTM F1554, grade 55. Nuts shall meet the requirements of AASHTO M 291, grade A. Washers shall meet the requirements of ASTM F 844 or ASTM F 436.

9-29.7 Luminaire Fusing and Electrical Connections at Light Standard Bases, Cantilever Bases and Sign Bridge Bases

The content of this section is revised and moved to the following new sub-sections:

9-29.7(1) Unfused Quick-Disconnect

Unfused quick-disconnect connector kits shall conform to the following requirements:

1. The copper pin and copper receptacle shall be a crimped type of connection or a stainless steel set screw and lug connection to the cable. The receptacle shall establish contact pressure with the pin through the use of a tinned copper

or copper beryllium sleeve spring and shall be equipped with a disposable mounting pin. The receptacle shall be fully annealed. Both the copper pin and receptacle shall have a centrally located recessed locking area adapted to be complementarily filled and retained by the rubber housing.

2. The plug and receptacle housing shall be made of water resistant synthetic rubber which is capable of burial in the ground or installation in sunlight. Each housing shall provide a section to form a water-seal around the cable, have an interior arrangement to suitably and complementarily receive and retain the copper pin or receptacle, and a section to provide a water-seal between the two housings at the point of disconnection.

3. The kit shall provide waterproof in-line connector protection with three cutoff sections on both the line and load side to accommodate various wire sizes. All connections shall be as described in item “1” above. Upon disconnect, the connector shall remain in the load side of the kit.

9-29.7(2) Fused Quick-Disconnect

Fused quick-disconnect kits shall provide waterproof in-line fuse protection. The kit shall provide three cutoff sections on both lines and load side to accommodate various wire sizes. All connections shall be as described in item “1” above. Upon disconnect, the fuse shall remain in the load side of the kit.

Fuses furnished for all lighting circuits shall be capable of handling the operating voltage of the circuit involved and shall have the following characteristics:

1. Fuses shall be capable of indefinitely supporting 110 percent of the rated load.

2. Fuses shall be capable of supporting 135 percent of the rated load for approximately 1 hour.

3. A load of 200 percent of rated load shall effectively cause instantaneous blowing of the fuse.

4. Fuses shall be rated as listed below and shall be sized to fit the fuse containers furnished on this project, according to the manufacturer’s recommendations therefore.

5. Fuses shall be listed by a nationally recognized testing laboratory.

Luminaire	**Service Voltage**		
Size	**480V**	**240V**	**120V**
1,000W	10A	15A	30A
750W	5A	10A	20A
700W	5A	10A	20A
400W	5A	10A	15A
310W	5A	5A	10A
250W	5A	5A	10A
200W	4A	5A	10A
175W	4A	5A	10A
150W	3A	4A	5A

100W	2A	3A	4A
70W	2A	2A	2A
50W	2A	2A	2A

9-29.9 Ballast, Transformers

This sections content is deleted and replaced with:

Heat-generating components shall be mounted to use the portion of the luminaire upon which they are mounted as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the fixture temperature to 160°F.

Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors, except those in starting aids, shall be metal cased and hermetically sealed.

No capacitor, transformer, or other device shall employ the class of compounds identified as polychlorinated biphenyls (PCB) as dielectric, coolants, or for any other purpose.

This section is supplemented with the following new sub-sections:

9-29.9(1) Ballast

Each ballast shall have a name plate attached permanently to the case listing all electrical data.

A Manufacturer's Certificate of Compliance in accordance with Section 1-06.3 meeting the manufacturers and these Specification requirements, shall be submitted by the Contractor with each type of luminaire ballast.

Ballasts shall be designed for continuous operation at ambient air temperatures from 20°F without reduction in ballast life. Ballasts shall have a design life of not less than 100,000 hours. Ballasts shall be designed to operate for at least 180 cycles of 12 hours on and 12 hours off, with the lamp circuit in an open or short-circuited condition and without measurable reduction in the operating requirements. All ballasts shall be high power factor (90%).

Ballasts shall be tested in accordance with the requirements of current ANSI C 82.6, Methods of Measurement of High-Intensity-Discharge Lamp Ballasts. Starting aids for ballasts of a given lamp wattage shall be interchangeable between ballasts of the same wattage and manufacturer without adjustment.

Ballast assemblies shall consist of separate components, each of which shall be capable of being easily replaced. A starting aid will be considered as a single component. Each component shall be provided with screw terminals, NEMA tab connectors or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they connect.

Ballasts for high-pressure sodium lamps shall have a ballast characteristic curve which will intersect both of the lamp-voltage limit lines between the wattage limit lines and remain between the wattage limit lines throughout the full range of lamp voltage. This requirement shall be met not only at the rated input voltage of the ballast, but also the lowest and highest input voltage for which the ballast is rated. Throughout the lifetime of the lamp, the ballast curve shall fall within the specified limits of lamp voltage and wattage.

All luminaires ballasts shall be located within the luminaire housing. The only exception shall be ballasts to be mounted on lowering assemblies and shall be external to, and attached to the fixture assembly.

Ballast Characteristics for High Pressure Sodium (HPS) and Metal Halide (MH) Sources shall be:

Source	Line Volt.	Lamp Wattage	Ballast Type	Input Voltage Variation	Lamp Wattage Variation
HPS	any	70 400	Mag. Reg. Lag	10%	18%
HPS	any	750 1000	Auto Reg. Lead CWA	10%	30%
MH	any	175 400	Mag. Reg. Lag	10%	18%
MH	any	1000	Auto Reg. Lead CWA	10%	30%

9-29.9(2) Transformers

The transformers to be furnished shall be indoor/outdoor dry type transformers rated as shown in the Plans. The transformer coils, buss bar, and all connections shall be copper. Transformers, 7.5 KVA and larger shall be supplied with two full capacity taps, one at 5% and one at 10% below the normal full capacity.

9-29.10 Luminaires

This section is revised to read:

All luminaires shall have their components secured to the luminaire frame with ANSI, 300 series chrome-nickel grade stainless steel, zinc dichromate coated steel or ceramic coated steel hardware. The luminaire slip-fitter bolts shall be either stainless steel, hot-dip galvanized steel, zinc dichromate coated steel, or ceramic coated steel. All internal luminaire assemblies shall be assembled on or fabricated from either stainless steel or galvanized steel. The housing, complete with integral ballast, shall be weathertight.

The temperature rating of all wiring internal to the luminaire housing, excluding the pole and bracket cable, shall equal or exceed 200°F .

All luminaires shall be provided with markers for positive identification of light source type and wattage. Markers shall be 3-inches square with Gothic bold, black 2-inch legend on colored background. Background color shall be gold for high pressure sodium, and red for metal halide light sources. Legends shall be sealed with transparent film resistant to dust, weather, and ultraviolet exposure.

Legends shall correspond to the following code:

Lamp	Wattage Legend
70	7
100	10
150	15
175	17
200	20
250	25
310	31
400	40
700	70
750	75
1,000	XI

9-29.10(1) Cobra Head Luminaires

This sections content including title is revised to read:

9-29.10(1) Conventional Roadway Luminaires

A. Conventional highway luminaires shall be IES Type III medium distribution cut off cobra head configuration with horizontal lamp, rated at 24,000 hours minimum.

B. The ballast shall be mounted on a separate exterior door, which shall be hinged to the luminaire and secured in the closed position to the luminaire housing by means of an automatic type of latch (a combination hex/slot stainless steel screw fastener may supplement the automatic type latch).

C. The reflector of all luminaires shall be of a snap-in design or be secured with screws. The reflector shall be manufactured of polished aluminum or molded from prismatically formed borosilicate glass. The refractor or lens shall be mounted in a doorframe assembly which shall be hinged to the luminaire and secured in the closed position to the luminaire by means of automatic latch. The refractor or lens and doorframe assembly, when closed, shall exert pressure against a gasket seat. The refractor lens shall not allow any light output above 90 degrees nadir. Gaskets shall be composed of material capable of withstanding temperatures involved and shall be securely held in place.

D. Each housing shall be provided with a four bolt slipfitter capable of mounting on a 2-inch pipe tenon and capable of being adjusted within 5 degrees from the axis of the tenon. The clamping bracket(s) and the cap screws of the slipfitter shall not bottom out on the housing bosses when adjusted within the ±5 degree range.

No part of the slipfitter mounting brackets on the luminaires shall develop a permanent set in excess of 0.2-inch when the cap screws used for mounting are tightened to a torque of 32 pounds feet.

E. Refractors shall be formed from heat resistant, high impact, molded borosilicate glass. Flat lens shall be formed from heat resistant, high impact borosilicate or tempered glass.

F. High pressure sodium conventional roadway luminaires shall be capable of accepting a 150, 200, 250, 310, or 400 watt lamp complete with ballast.

G. Housings shall be fabricated from aluminum. Painted housings shall be painted flat gray, Federal Standard 595 color chip No. 26280. Housings that are painted shall withstand a 1,000-hour salt spray test as specified in ASTM B 117.

H. All luminaires to be mounted on horizontal mast arms, shall be capable of withstanding cyclic loading in:

1. A vertical plane at a minimum peak acceleration level of 3.0 g's peak-to-peak sinusoidal loading (same as 1.5 g's peak) with the internal ballast removed, for a minimum of 2 million cycles without failure of any luminaire parts, and;

2. A horizontal plane perpendicular to the direction of the mast arm at a minimum peak acceleration level of 1.5 g's peak to peak sinusoidal loading (same as 0.75 g's peak) with the internal ballast installed, for a minimum of 2 million cycles without failure of any luminaire parts.

I. All luminaires shall have leveling reference points for both transverse and longitudinal adjustment. Luminaires shall have slip-fitters capable of adjusting through a 5-degree axis for the required leveling procedure.

9-29.10(2) Decorative Luminaires

In the first paragraph, "150 - 400" is revised to read "50 - 400".

In the second paragraph, "box shaped" is deleted.

In the third paragraph, the first sentence is deleted. The second sentence is revised to read:

> The ballast housing shall be adequately constructed to contain ballasts for 50 - 400 watt alternate high intensity discharge sources.

The fourth paragraph is revised to read:

> Each housing shall consist of an integral reflector, containing a mogul based high intensity discharge lamp, and a one piece heat and shock resistant, clear tempered lens mounted in a gasketed, hinged frame. The reflector shall be a snap-in design or secured with screws. The reflector assembly shall have a lamp vibration damper. The reflector shall be manufactured of polished aluminum or molded from prismatically formed borosilicate glass. The housing shall have a heat resistant finish. The lens frame shall be secured to the housing with ANSI, 300 series chrome-nickel grade stainless steel, zinc dichromate coated steel or ceramic coated steel hardware.

The last sentence in the fifth paragraph is deleted.

The sixth paragraph is deleted.

The seventh paragraph is revised to read:

> The finish shall meet the requirements of ASTM B 117 with the exception that the finish shall be salt spray resistant after 300 hours exposure .

The first sentence in the eight paragraph is deleted.

9-29.10(3) High Mast Luminaires and Post Top Luminaires

This sections content including title is deleted and replaced with:

9-29.10(3) Vacant

9-29.10(5) Sign Lighting Luminaires

This section is revised to read:

Sign lighting luminaires shall be the Induction Bulb type.

9-29.10(5)A Sign Lighting Luminaires - Mercury Vapor

This section including title is revised to read:

9-29.10(5)A Sign Lighting Luminaires – Isolation Switch

The isolation switch shall be installed in a terminal cabinet in accordance with Section 9-29.25 with the exception that the cabinet shall be NEMA 3R and stainless steel. The terminal cabinet shall be installed in accordance to the Standard Plans. The switch shall be either single pole, single throw, or double pole single throw as necessary to open all conductors to the luminaires other than neutral and ground conductors. The switch shall contain 600 volt alternating current (VAC) terminal strips on the load side with solderless lugs as required for each load carrying conductor plus four spare lugs per strip.

9-29.10(5)B Sign Lighting Fixtures - Induction

The first sentence is revised to read:

Sign lighting luminaires shall have a cast aluminum housing and door assembly with a polyester paint finish.

In the second sentence of the sixth paragraph, "87" is revised to read "85".

In the last sentence of the sixth paragraph, "Class a" is revised to read "Class A".

The first sentence of the last paragraph is revised to read:

A Manufacturer's Certificate of Compliance, conforming to Section 1-06.3 “Manufacturer's Certificates of Compliance” and a copy of the high frequency generator test methods and results shall be submitted by the manufacturer with each lot of sign lighting fixtures.

9-29.12 Electrical Splice Materials

This section is revised to read:

Circuit splicing materials shall meet the following specifications.

9-29.12(1) Illumination Circuit Splices

This section is revised to read:

Illumination circuit splices shall be split bolt vice type connectors or solderless crimped connections to securely join the wires both mechanically and electrically as defined in Section 8-20.3(8).

This section is supplemented with the following new sub-sections:

9-29.12(1)A Heat Shrink Splice Enclosure

Heat shrink insulating materials shall be the moisture blocking mastic type meeting Mil Spec I 230053

9-29.12(1)B Molded Splice Enclosure

Epoxy resin cast type insulation shall employ a clear rigid plastic mold or a clear mylar sheet bonded to butyrate webbing forming a flexible mold. The material used shall be compatible with the insulation material of the insulated conductor or cable. The component materials of the resin insulation shall be packaged ready for convenient mixing without removing from the package.

9-29.12(2) Traffic Signal Splice Material

This section is revised to read:

Induction loop splices and magnetometer splices shall include an uninsulated barrel type crimped connector capable of being soldered. The insulating material shall be a heat shrink type meeting requirements of Section 9-29.12(1)A, an epoxy resin cast type with clear rigid plastic mold meeting the requirements of Section 9-29.12(1)B, or a re-enterable type with silicone type filling compound that remains flexible and enclosed in a re-enterable rigid mold that snaps together.

9-29.15 Flashing Beacon Control

In the first paragraph, the first word “Flashers” is revised to read “Line voltage flashers”.

9-29.16 Vehicular Signal Heads

This sections title is revised to read:

9-29.16 Vehicular Signal Heads, Displays and Housing

The first sentence is revised to read:

Each signal head shall be of the adjustable, vertical type with the number and type of displays detailed in the Contract; shall provide an indication in one direction only; shall be adjustable through 360 degrees about a vertical axis; and shall be mounted at the location and in the manner shown in the Plans.

This following new paragraph is inserted after the first paragraph:

Back plates shall be constructed of 5-inch wide .050-inch thick corrosion resistant flat black finish, louvered aluminum or polycarbonate attached with stainless steel hardware. A 1-inch wide strip of yellow retro reflective, type IV prismatic sheeting, in accordance with Section 9-28.12, shall be applied around the perimeter of each backplate.

9-29.16(1) Optically Programmed, Adjustable Face, 12-inch Traffic Signal

This section including title is revised to read:

9-29.16(1) Optically Programmed Adjustable Face, and Programmable, Array 12-inch Traffic Signal

The signal shall permit the visibility zone of the indication to be determined optically and require no hoods or louvers. The projected indication may be selectively visible or veiled anywhere within the optical axis. No indication shall result from external illumination, nor shall one light unit illuminate a second. The display shall operate from 85 VAC to 130 VAC.

9-29.16(1)A Optical Systems

The following new title is inserted above the first paragraph:

9-29.16(1)A1 Conventional Optical System

This section is supplemented with the following new sub-section:

9-29.16(1)A2 LED Programmable Array

1. LED array with programmable visibility from a portable hand held device from ground level,

2. Lens shall be clear, unless color lenses specified.

The LED array shall be 22 watt maximum and shall operate directly from 120 volt AC.

The LED array shall provide an accessible imaging surface at focus on the optical axis for objects 900 to 1,200-feet distant, and permit an effective veiling mask to be variously applied as determined by the desired visibility zone.

The optical system shall accommodate projection of diverse, selected indicia to separate portions of the roadway such that only one indication will be simultaneously apparent to any viewer after optically limiting procedures have been accomplished. The projected indication shall conform to ITE transmittance and chromaticity standards.

9-29.16(1)B Construction

The title for this section is revised to read:

9-29.16(1)B Housing Construction

The fourth paragraph is deleted.

9-29.16(1)D Electrical

The title for this section is revised to read:

9-29.16(1)D Housing Electrical

The following new title is inserted above the first paragraph:

9-29.16(1)D1 Electrical Conventional

This section is supplemented with the following new sub-section:

9-29.16(1)D2 Electrical LED

The LED array shall be accessible from the front of the housing. Each multi section assembly shall include a terminal block for clip or screw attachment of lead wires.

9-29.16(1)E Photo Controls

The following new title is inserted above the first paragraph:

9-29.16(1)E1 Conventional Photo Controls

This section is supplemented with the following new sub-section:

9-29.16(1)E2 LED Photo Controls

Each signal section shall include integral means for automatically regulating the display intensity for day and night operation.

9-29.16(2)A Optical Units

This section is revised to read as follows:

Light Emitting Diode (LED) light sources are required for all displays. The Contractor shall provide test results from a Nationally Recognized Testing Laboratory documenting that the LED display conforms to the current ITE Specification for; Vehicle Traffic Control Signal Heads, Light Emitting Diode Circular Signal Supplement VTCSH ST-052 or Vehicle Traffic Signal Heads, Light Emitting Diode Vehicle Arrow Traffic Signal Supplement ITE VTSCH ST-054, and the following requirements:

1. The LED traffic signal module shall be operationally compatible with controllers and conflict monitors on this project and the LED lamp unit shall contain a disconnect that will show an open switch to the conflict monitor when less than 60% of the LEDs in the unit are operational.

2. LED shall have a 50 degree min. viewing angle and the following:

3. Wattage (Maximum): 12-inch red, yellow and green ball displays - 25 W 12-inch red, yellow and green arrow displays - 15W 8-inch red, yellow and green ball displays - 15W

4. Voltage: The operation voltages shall be between 85 VAC and 130VAC.

5. The LED display shall be a module type and shall replace the lens, socket, bail, reflector and be directly connected to the terminal strip in the signal head.

6. Label: Each optical unit shall be listed by and bear the label of a nationally recognized testing laboratory. In addition, the manufacturer's name, trademark, serial number and other necessary identification shall be permanently marked on the backside of the LED signal module and the installation date shall be indicated on a separate label with an indelible ink marker.

9-29.16(2)B Signal Housing

The first sentence in the first paragraph is revised to read:

The signal head housing, or case, shall consist of an assembly of separate sections, expandable type for vertical mounting, substantially secured together in a weathertight manner.

In the third paragraph “may” is revised to read “shall”.

9-29.16(2)D Back Plates

This section’s content including title is deleted and replaced with:

9-29.16(2)D Vacant

9-29.16(2)E Painting Signal Heads

In the first sentence “Federal Standard 595B” is revised to read “Federal Standard 595-14056”.

9-29.16(3) Polycarbonate Traffic Signal Heads

This section is supplemented with the following paragraph:

Polycarbonate employed in traffic signal fabrication shall tolerate an elongation prior to break in excess of 90 percent. The green color shall be molded throughout the head assembly. The optical system shall be Light Emitting Diodes as defined in 9-29.16(2)A. The entire optical system shall be sealed by a single neoprene gasket. The signal head shall be formed to be used with standard signal head mounting accessories as shown in 9-29.17. All hinge pins, latch assemblies and reflector assemblies shall conform to 9-29.16(2)B.

9-29.16(3)A 8-inch Polycarbonate Traffic Signal Heads

This section and title are deleted.

9-29.16(3)B 12-inch Polycarbonate Traffic Signal Heads

This section and title are deleted.

Section 9-29.16 is supplemented with the following new sub-section:

9-29.16(4) Traffic Signal Cover

The covers shall be manufactured from a durable fabric material, black in color with a mesh front and designed to fit the signal head configuration properly. The covers shall have an attachment method that will hold the cover securely to the signal in heavy wind. The covers shall be provided with a drain to expel any accumulated water.

9-29.18 Vehicle Detector

The first paragraph is revised to read:

Induction loop detectors and magnetometer detectors shall comply with current NEMA Specifications when installed with NEMA control assemblies and shall comply with the current California Department of Transportation document entitled “Transportation Electrical Equipment Specifications,” specified in Section 9-29.13(7) when installed with Type 170, Type 2070 or NEMA control assemblies.

9-29.19 Pedestrian Push Buttons

This section is revised to read:

Where noted in the Contract, pedestrian push buttons of tamper-resistant construction shall be furnished and installed. They shall consist of a 2-inch nominal diameter plunger. The switch shall be a three bladed beryllium copper spring rated at 10 amperes, 125 volts.

The pedestrian push-button assembly shall be constructed and mounted as detailed in the Contract.

9-29.25 Amplifier, Transformer, and Terminal Cabinets

The first sentence in the first paragraph is revised to read:

Amplifier and terminal cabinets shall conform to NEMA 4 requirements. Transformer cabinets shall be NEMA 3R.

Item number 3 in the first paragraph is revised to read:

3. Cabinet doors shall have a stainless steel piano hinge or shall meet the requirements for the alternate hinge detailed for type B modified service cabinets. Doors less than 3 feet in height shall have two hinges. Doors from 3 feet to 4 feet 8 inches in height shall have 3 hinges. Spacing of hinges for doors greater than 4 feet 8 inches in height shall not exceed 14 inches center to center. The door shall also be provided with a three point latch and a spring loaded construction core lock capable of accepting a Best six pin CX series core. The locking mechanism shall provide a tapered bolt. The Contractor shall supply construction cores with two master keys. The keys shall be delivered to the Engineer. Three point latches are not required for terminal cabinets.

SECTION 9-30, WATER DISTRIBUTION MATERIALS
January 4, 2010

9-30.1(1) Ductile Iron Pipe

In the first paragraph, number 1. and 2. are revised to read:

1. Ductile iron pipe shall meet the requirements of AWWA C151. Ductile iron pipe shall have a cement mortar lining, and a 1 mil thick seal coat meeting the requirements of AWWA C104. Ductile iron pipe to be joined using bolted flanged joints shall be Special Thickness Class 53. All other ductile iron pipe shall be Special Thickness Class 50, minimum Pressure Class 350, or the class indicated on the Plans or in the Special Provisions.

2. Nonrestrained joints shall be either rubber gasket type, push on type, or mechanical type meeting the requirements of AWWA C111.

9-30.1(2) Polyethylene Encasement

This section is revised to read:

Polyethylene encasement shall be tube-form, high density cross-laminated polyethylene film, or linear low density polyethylene film, meeting the requirements of ANSI/AWWA C105. Color shall be natural or black.

SECTION 9-33, CONSTRUCTION GEOSYNTHETIC
April 5, 2010

9-33.4(3) Acceptance Samples
The third paragraph is revised to read:

Samples from the geosynthetic roll will be taken to confirm the material meets the property values specified. Samples will be randomly taken at the job site by the Contractor in accordance with WSDOT T 914 in the presence of the Project Engineer.

The first sentence in the sixth paragraph is revised to read:

For each geosynthetic roll that is tested and fails the Project Engineer will select two additional rolls from the same lot for sampling and retesting. The Contractor shall sample the rolls in accordance with WSDOT T 914 in the presence of the Project Engineer.

SECTION 9-35, TEMPORARY TRAFFIC CONTROL MATERIALS
January 4, 2010

9-35.0 General Requirements
In the first paragraph, the item "Truck Mounted Attenuator" is revised to read "Transportable Attenuator".

In the second paragraph, the third sentence is revised to read:

Unless otherwise noted, Requests for Approval of Material (RAM) and Qualified Products List (QPL) submittals are not required.

9-35.12 Truck-Mounted Attenuator
This section including title is revised to read:

9-35.12 Transportable Attenuator
Transportable attenuators are Truck-Mounted Attenuators (TMA) or Trailer-Mounted Attenuators (TMA-trailer). The transportable attenuator shall be mounted on, or attached to a host vehicle with a minimum weight of 15,000 pounds and a maximum weight in accordance with the manufacturer's recommendations. Ballast used to obtain the minimum weight requirement, or any other object that is placed on the vehicle shall be securely anchored such that it will be retained on the vehicle during an impact. The Contractor shall provide certification that the transportable attenuator complies with NCHRP 350 Test level 3 requirements. Lighter host vehicles proposed by the Contractor are subject to the approval of the Engineer. The Contractor shall provide the Engineer with roll-ahead distance calculations and crash test reports illustrating that the proposed host vehicle is appropriate for the attenuator and the site conditions.

The transportable attenuator shall have a chevron pattern on the rear of the unit. The standard chevron pattern shall consist of 4-inch yellow stripes, alternating non-reflective black and retro-reflective yellow sheeting, slanted at 45 degrees in an inverted "V" with the "V" at the center of the unit.

This section is supplemented with the following new sub-sections:

9-35.12(1) Truck-Mounted Attenuator

The TMA may be selected from the approved units listed on the QPL or submitted using a RAM.

The TMA shall have an adjustable height so that it can be placed at the correct elevation during usage and to a safe height for transporting. If needed, the Contractor shall install additional lights to provide fully visible brake lights at all times.

9-35.12(2) Trailer-Mounted Attenuator

The TMA-trailer may be selected from the approved units listed on the QPL or submitted using a RAM.

If needed, the Contractor shall install additional lights to provide fully visible brake lights at all times.

9-35.12(3) Submittal Requirements

For transportable attenuators listed on the QPL, the Contractor shall submit the QPL printed page or a QPL Acceptance Code entered on the RAM (WSDOT Form 350-071EF) for the product proposed for use to the Engineer for approval. The Contractor shall submit a RAM for transportable attenuators not listed on the QPL.

SPECIAL PROVISIONS

The following Special Provisions are made a part of this contract and supersede any conflicting provisions of the 2010 Standard Specifications for Road, Bridge and Municipal Construction, and the foregoing Amendments to the Standard Specifications.

Several types of Special Provisions are included in this contract; General, Region, Bridges and Structures, and Project Specific. Special Provisions types are differentiated as follows:

(date)	General Special Provision
(******)	Notes a revision to a General Special Provision and also notes a Project Specific Special Provision.
(Regions[1] date)	Region Special Provision
(BSP date)	Bridges and Structures Special Provision

General Special Provisions are similar to Standard Specifications in that they typically apply to many projects, usually in more than one Region. Usually, the only difference from one project to another is the inclusion of variable project data, inserted as a "fill-in".

Region Special Provisions are commonly applicable within the designated Region. Region designations are as follows:

Regions[1]	
ER	Eastern Region
NCR	North Central Region
NWR	Northwest Region
OR	Olympic Region
SCR	South Central Region
SWR	Southwest Region
WSF	Washington State Ferries Division

Bridges and Structures Special Provisions are similar to Standard Specifications in that they typically apply to many projects, usually in more than one Region. Usually, the only difference from one project to another is the inclusion of variable project data, inserted as a "fill-in".

Project Specific Special Provisions normally appear only in the contract for which they were developed.

DIVISION 1
GENERAL REQUIREMENTS

DESCRIPTION OF WORK

(March 13, 1995)
This contract provides for the improvement of *** Interstate 5 Columbia River Bridge, MP OR 308.0 to WA 0.3, Columbia River Mile 106.5, Columbia River Bridge Vicinity Pile Driving, by installing piles, pile instrumentation, pile testing, removing piles, and installing noise attenuation systems *** and other work, all in accordance with the attached Contract Plans, these Contract Provisions, and the Standard Specifications.

BID PROCEDURES AND CONDITIONS

(March 13, 1995)
Examination Of Plans, Specifications And Site Of Work
Section 1-02.4 is supplemented with the following:

The soils information used for study and design of this project is available for review by the bidder at the following address:

*** Columbia River Crossing
700 Washington St., Suite 300
Vancouver, WA 98660
Phone: 360-737-2726***

(October 12, 2009)
Public Opening Of Proposal
Section 1-02.12 is supplemented with the following:

Date Of Opening Bids
Sealed bids are to be received at one of the following locations prior to the time Specified:

1. At Post Office Box 47360, Olympia, Washington 98504-7360 until 11:00:59 A.M. of the bid opening date. The Department of Transportation will consider notification of bid receipt by the Post Office as the actual receipt of the bid.

2. In the Department of Transportation Bid Room (SA19), located at the Transportation Building, 310 Maple Park Avenue SE, Room SA19, Olympia WA 98501-2361, until 11:00:59 A.M. of the bid opening date. Bids delivered in person will be received only in the Bid Room SA19 on the bid opening date.

3. Electronically via Expedite software and BidX.com, until 11:00:59 am Pacific time. Bids delivered in person or electronically via Expedite software and BidX.com will be received only in the Bid Room on the bid opening date.

The bid opening date for this project is ____.
Bids received will be publicly opened and read after 11:00:59 A. M. on this date.

AWARD AND EXECUTION OF CONTRACT

Award Of Contract

The first sentence of Section 1-03.2 is revised to read:

(April 7, 2008)
It is the Contracting Agency's intent to award the contract within 24 hours of the bid opening.

CONTROL OF WORK

Conformity With And Deviations From Plans And Stakes

Section 1-05.4 is supplemented with the following:

(******)

Contractor Surveying - Structure

Copies of the Contracting Agency provided primary survey control data are available for the bidder's inspection at the office of the Project Engineer. Except for the survey control data to be furnished by the Contracting Agency, surveying required for setting and maintaining the necessary pile locations shall be the Contractor's responsibility.

Detailed survey records shall be maintained, including but not limited to, a description of the work performed on each shift, the methods utilized, and the control points used. The record shall be adequate to allow the survey to be reproduced. A copy of each day's record shall be provided to the Engineer at the end of the project.

The meaning of words and terms used in this provision shall be as listed in "Definitions of Surveying and Associated Terms" current edition, published by the American Congress on Surveying and Mapping and the American Society of Civil Engineers.

The survey work by the Contractor shall include but not be limited to the following:

1. Verify the primary horizontal and vertical control furnished by the Contracting Agency, and expand into secondary control as needed for the project. Provide descriptions of said secondary control to the Engineer. Said descriptions shall include but not be limited to, physical descriptions of monuments set, reference points and their descriptions, coordinates, and elevations. If closure adjustments are made, then a description of this process shall be provided.
2. Establish the location of piles prior to pile driving.
3. Establish the final location of piles after pile driving and before pile removal.

The Contractor shall provide the Contracting Agency copies of any calculations and data when requested by the Engineer.

To facilitate the establishment of these pile locations, the Contracting Agency will provide the Contractor with the following primary survey and control information:

1. Descriptions of at least two primary control points used for the horizontal and vertical control.
2. Horizontal coordinates for the centerline of each pile.

The Contractor shall give the Contracting Agency three working days notification to allow adequate time to provide the data outlined in Items 1 and 2 above. The Contractor shall ensure a surveying accuracy within the following tolerances:

	Vertical	Horizontal
1. Pile Location, prior to driving		±3.00 feet
2. Pile Location, after driving	±0.02 feet	±0.02 feet

Payment

Payment will be made in accordance with Section 1-04.1 for the following bid item when included in the proposal:

"Structure Surveying", lump sum.

The lump sum contract price for "Structure Surveying" shall be full pay for all labor, equipment, materials, and supervision utilized to perform the work specified, including any resurveying, checking, correction of errors, replacement of missing or damaged stakes, and coordination efforts.

LEGAL RELATIONS AND RESPONSIBILITIES TO THE PUBLIC

Laws To Be Observed

Section 1-07.1 is supplemented with the following:

(******)
State Laws

The work provided for in this contract requires the use of labor, materials, and equipment in both the State of Washington and the State of Oregon. The Contractor shall be obligated to comply with all applicable laws of the State of Washington. It is advised that the Contractor shall be required by the State of Oregon to comply with its laws with respect to that portion of work to be done and materials to be furnished within the State of Oregon. The Contractor should familiarize itself with the laws of both states, particularly those concerning public contracts, permits and licenses, laborers, material suppliers, industrial accident insurance, and taxes, including both income and sales taxes. For this contract, the dividing line between the State of Washington and the State of Oregon is defined in the Plans. The Contractor is advised to contact other state agencies, including the Washington Stated Department of Revenue, the Washington State Department of Employment Security, the Oregon State Department of Revenue, the Oregon State Bureau of Labor and Industries, and the Oregon State Employment Division, relative to their acceptance of this boundary.

(******)
The Contractor shall assume that noise restrictions in Federal, State and local laws and regulations apply except as specifically indicated below:

Pile Driving: Pile driving shall be limited to the hours between ½ hour after sunrise and ½ hour before sunset on weekdays, weekends, and holidays.

State Taxes

Section 1-07.2 is supplemented with the following:

(******)
For this project, portions of the work on this contract are to be performed upon lands whose ownership obligates the Contractor to pay Sales tax. The provisions of Section 1-07.2(1) apply.

Environmental Regulations

Section 1-07.5 is supplemented with the following:

(September 20, 2010)
Environmental Commitments

The following Provisions summarize the requirements, in addition to those required elsewhere in the Contract, imposed upon the Contracting Agency by the various documents referenced in the Special Provision PERMITS AND LICENSES. Throughout the work, the Contractor shall comply with the following requirements:

(******)
The Contractor shall coordinate all work with the Contracting Agency environmental monitoring personnel. During the work the Contracting Agency will perform hydroacoustic monitoring, turbidity monitoring and monitoring marine mammals.

The Contractor shall coordinate and schedule a preconstruction meeting with the Contracting Agency inspectors and environmental monitoring personnel, and coordinate a communication process between the pile driving operator and Contracting Agency environmental monitoring personnel, so as to ensure all monitoring devices established by the Contracting Agency are in place and properly functioning before pile driving commences. At the request of the Contracting Agency environmental monitoring personnel, the Contractor shall turn the bubble curtains on and/or off during the pile driving to ensure a range of data is collected by the Contracting Agency.

As directed by the Engineer, Contracting Agency environmental monitoring personnel or inspector, the Contractor shall temporarily stop pile driving operations should marine mammals enter the pile driving disturbance area defined by the Contracting Agency. The Contracting Agency environmental agency personnel will allow pile driving to resume after marine mammals have passed through the disturbance area, or if no additional marine mammal presence is observed after 30 minutes of the initial observation.

(August 3, 2009)
A mixing zone is established within which the turbidity standard is waived during actual in-water work. The mixing zone is established to only temporarily allow exceeding the turbidity criteria (such as a few hours or days) and is not authorization to exceed the turbidity standard for the entire duration of the construction. The mixing zone shall not exceed *** 300 *** feet downstream from the construction area.

(August 3, 2009)
Materials placed below OHW or MHHW may not consist of trash, debris, car bodies, asphalt, or other potentially contaminating materials.

(August 3, 2009)
Payment
All costs to comply with this special provision for the environmental commitments and requirements are incidental to the contract and are the responsibility of the Contractor. The Contractor shall include all related costs in the associated bid prices of the contract.

Air Quality
Section 1-07.5(4) is supplemented with the following:

(SWR March 19, 2008)

The Contractor shall satisfy the local air pollution agency. For this project, the local air pollution agency is *** Southwest Clean Air Agency ***. In addition, air quality rules of the State Department of Ecology may govern the work.

(******)
Air quality rules of the Department of Environmental Quality shall govern work performed in the State of Oregon.

Permits And Licenses
Section 1-07.6 is supplemented with the following:

(******)
The Contracting Agency has obtained the below-listed permit(s) for this project. A copy of the permit(s) can be found online at the following web site location.

http://www.wsdot.wa.gov/biz/contaa/wsdotpro/GEO-TECH%20REPORTS/DEFAULT.HTM

All contacts with the permitting agency concerning the below-listed permit(s) shall be through the Engineer. The Contractor shall obtain additional permits as necessary. All costs to obtain and comply with additional permits shall be included in the applicable bid items for the work involved.

Hydraulic Project Approval – WDFW – Permit #122114-1
Nationwide Section 10 – USACE – NWP-2008-414
Fill Removal Permit – OR DSL – 45957-GA
Short Term Access – OR DSL – 45949-AA
Aquatic Lands Use Authorization – WA DNR – 23-086667

United States Coast Guard

(March 13, 1995)
The Contractor shall comply with all United States Coast Guard requirements.

The Contractor shall contact the Coast Guard at least 2 weeks in advance of all work in or near the navigable portion of the waterway and request that a Local Notice to Mariners be issued for the waterway at this site.

The Contractor shall contact the Coast Guard for requirements related to the mooring of barges, placement of log booms, and all other equipment that could be a hazard to waterway users.

Provisions shall be made for the removal, on 2 hours notice, of all equipment that would block or partially block, the navigable portion of the waterway.

The Coast Guard contact is:

Bridge Specialist
Aids to Navigation Branch
Thirteenth Coast Guard District
915 Second Avenue
Seattle, WA 98174-1067

Telephone: (206) 220-7270

All costs incurred in contacting the Coast Guard and in complying with all the requirements specified herein shall be included in the contract prices for the items of work involved.

All costs in connection with delays in the construction caused by the Contractor's failure to contact the Coast Guard shall be at the Contractor's expense.

Load Limits

Section 1-07.7 is supplemented with the following:

(March 13, 1995)
Whenever the Contractor obtains materials from a source other than that provided by the Contracting Agency, or provides a source for materials not designated to come from a source provided by the State and the location of the source necessitates hauling on other than State Highways, the Contractor shall, at the Contractor's expense, make all arrangements for the use of the haul routes.

Temporary Water Pollution/Erosion Control

Spill Prevention, Control and Countermeasures Plan

Section 1-07.15(1) is supplemented with the following:

(******)
The Contractor shall address the following items in the SPCC Plan in addition to the requirements of Section 1-07.15(1):

Mixing, Transfers, & Storage

1. All oil, fuel or chemical storage tanks or containers shall be diked and located on impervious surfaces so as to prevent spill from escaping.

2. All liquid products shall be stored and mixed on impervious surfaces in a secure water tight environment and provide containment to handle the maximum volume of liquid products on site at any given time.

3. Proper security shall be maintained to prevent vandalism.

4. Drip pans or other protective devices shall be required for all transfer operations.

Spills

Paint and solvent spills shall be treated as oil spills and shall be prevented from reaching storm drains or other discharges. No cleaning solvents or chemicals used for tool or equipment cleaning may be discharged to the ground or water.

Maintenance of Equipment

Fuel hoses, oil drums, oil or fuel transfer valves and fittings, etc, shall be checked regularly for drips or leaks and shall be maintained and stored properly to prevent spills into State waters.

Disposal

Spilled waste, chemicals or petroleum products shall be transported off site for disposal at a facility approved by the Department of Ecology or Department of Environmental Quality in Washington and Oregon, respectively. The materials shall not be discharged to any sanitary sewer without approval of the local sewer authority.

Reporting and Cleanup

The Contractor's designated person for managing and implementing the SPCC Plan shall report hazardous material spills as follows:

Spills into State water (including ponds, ditches, seasonally dry streams, and wetlands) – Immediately call all of the following:

National Response Center	1-800-424-8802
WA State Div. of Emergency Management (24 hr)	1-800-258-5990
Ecology Southwest Regional Office	360-407-6300
OR Emergency Response System (24hr)	1-800-452-0311
DEQ Environmental Cleanup	503-229-6931

Spill to Soil (Including encounters of pre-existing contamination):

Ecology Southwest Regional Office 360-407-6300

Report immediately if threatening to health or environment (i.e., explosive, flammable, toxic vapors, shallow groundwater, nearby creek), otherwise within 90 days

OR Emergency Response System (24hr) 1-800-452-0311

Report immediately if threatening to health or environment (i.e., explosive, flammable, toxic vapors, shallow groundwater, nearby creek), otherwise if spill is in excess of 42 Gallons.

Underground Storage Tank (confirmed release of material)

Ecology Southwest Regional Office 360-407-6300

Report within 24 hours

PROSECUTION AND PROGRESS

Prosecution of Work

The first sentence of Section 1-08.4 is revised to read:

(******)

The Contractor shall commence onsite work on or before February 7, 2011, and shall notify the Engineer in writing a minimum of ten calendar days in advance of the date on which the Contractor intends to begin work. The Contractor shall complete in-water work no later than February 28, 2011.

Time For Completion

Section 1-08.5 is supplemented with the following:

(******)
This project shall be physically completed within 15 working days.

Contract time shall begin on the first working day the Contractor starts onsite work or February 7, 2011, whichever occurs first.

DIVISION 6
STRUCTURES

GENERAL REQUIREMENTS FOR STRUCTURES

Foundation Data
Section 6-01.2 is supplemented with the following:

(******)
The log of test boring pages are reproductions of the original Log of Test Boring for the test holes shown in the Plans. A copy of the log of test boring can be found online at the following web site location.

http://www.wsdot.wa.gov/biz/contaa/wsdotpro/GEO-TECH%20REPORTS/DEFAULT.HTM

The Contractor should review the soils information prepared for this project. Copies of the soils information are available for review by prospective bidders at the location specified in Section 1-02.4 as supplemented in these Special Provisions.

Navigable Streams
Section 6-01.7 is supplemented with the following:

(June 26, 2000)
Temporary Navigation Lights
Description
This work consists of furnishing, installing, and maintaining temporary navigation lights as required by the United States Coast Guard, and removing them at the completion of the Contract.

Construction Requirements
The navigation lights shall be battery powered and shall remain the property of the Contractor at the completion of the Contract unless otherwise specified. The Contractor shall maintain the temporary navigation lights for the duration of the Contract.

Payment
All costs in connection with furnishing, installing, maintaining, and removing the temporary navigation lights as specified, and as shown in the Plans, shall be included in the *** unit contract price per each for “Furnishing and Driving Steel Test Pile. ***

PILING

Description

Section 6-05.1 is supplemented with the following:

(******)
This work also includes furnishing and installing noise attenuation systems and performing pile driving testing.

Materials

Section 6-05.2 is supplemented with the following:

(******)
The piling shall have a nominal wall thickness for structural purposes of ½-inch for 24-inch diameter piles and 1-inch for 48-inch diameter piles.

(******)
Bubble Curtain
The bubble curtain system shall consist of one or more compressors with power source, primary and secondary feed lines, distribution manifold (air receiver) with shut off valves, flow regulating valves, bubbler manifolds (bubbler), air pressure gauges and flow meters, appurtenant fittings and deployment gear. See the Plans for schematic layout.

Bubble Curtain Systems
The bubble curtain air supply systems shall be designed by (or under the direct supervision of) a Professional Engineer qualified to design compressed air systems, licensed under Title 18 RCW, State of Washington, in the branch of Mechanical Engineering. The drawings and calculations shall bear the stamp or seal, original signature, date of signature, and registration number of the Professional Engineer.

The bubble curtain systems shall conform to the following:

1. Piling shall be completely engulfed in bubbles over the full depth of the water column at all times when an impact pile driver is in use.

2. Air shall be delivered from bubbler ring assemblies at intervals shown on the Plans.

3. The lowest bubble ring shall be in contact with the mudline for the full circumference of the ring. No portion of the bubble ring shall be below the mudline.

4. Bubble rings shall completely surround the pile. Bubble ring minimum dimensions shall be as shown on the Plans.

5. Bubble rings shall be constructed of 2 1/2 inches (minimum) nominal diameter aluminum pipe with 1/16-inch diameter bubble release holes in 4 rows in the axial direction spaced as indicated on the Plans. Bubble rings shall be durable enough to withstand repeated deployment during pile driving and shall be constructed to facilitate underwater setup, knockdown, and reuse on the next pile. Material shall be as specified on the Plans.

6. One or more compressors shall be provided to supply air in sufficient volume and pressure to self-purge water from bubble rings and maintain the required bubble flux for the duration of pile driving. Compressors shall be of a type that prevents the introduction of oil or fine oil mist by the compressed air into the water. The presence of oil film or sheen on the water surface in the vicinity of the operating bubble ring will indicate that the Contractor has failed to meet this requirement. The Contractor shall immediately stop work until the source of oil film or sheen is identified and corrected.

7. Bubble ring feed lines (secondary feed lines) shall be sized taking into account back-pressure at the exit point, in-line friction losses and losses through fittings.

8. The 4 feet – 8 1/8 inch diameter bubble ring system shall provide a bubble flux of 490 cubic feet per minute per bubble ring. The total volume of air per layer is the product of the bubble flux and the circumference of the ring as follows:

   V_t = 33 ft^3/min/ft * (Circumference of the aeration ring in ft)

9. The 6 feet - 8 inch diameter bubble ring system shall provide a bubble flux of 700 cubic feet per minute per bubble ring. The total volume of air per layer is the product of the bubble flux and the circumference of the ring as follows:

   V_t = 33 ft^3/min/ft * (Circumference of the aeration ring in ft)

10. The bubble ring manifold shall incorporate a shut-off valve, flow meter, a throttling globe valve with a pressure gauge for each bubble ring supply as shown and detailed on the Plans.

11. Prior to first use of the bubble curtain during pile driving, the fully assembled system shall be test-operated to demonstrate proper function and to train personnel in the proper balancing of the air flow to the bubble rings. The test shall also confirm the calculated pressures and flow rates at each bubble ring. The Contractor shall submit an inspection/performance report to the Engineer within 72 hours following the performance test.

12. Resilient pile guides shall be used to prevent contact between the pile and the bubble system. The pile guide shall be constructed of material that minimizes the transfer of vibration.

Confined Bubble Curtain

The confinement shall extend from the substrate to an elevation above the maximum water level expected during pile installation such that no water shall be expelled from the noise attenuation system when in use.

Unconfined Bubble Curtain

The weights shall be attached to the bottom ring to ensure the 100% mudline contact. No parts of the ring or other objects shall prevent the full mudline contact.

Removal of Bubble Curtain Equipment

The State will take possession of all bubble curtain equipment as shown on the plans. This shall include the HDPE pipe, pressure vessel, all valves, flow meters, pressure gages, air hoses, connectors, lifting devices and bubbler rings. All parts and pieces that have been submerged in water shall be thoroughly rinsed and flushed with fresh water. The hoses shall be disconnected from the valve manifolds and the bubbler rings and be neatly coiled. The pressure vessel and the valve manifold shall be drained and sprayed with a preservative.

For removal the Contractor shall supply two water tight reusable crates with bottom vents to remove and transport the bubble curtain equipment as well as protect the equipment from moisture damage. One crate shall store the unconfined system bubble rings and the other crate shall be used to store the pressure vessel, valve assemblies, and hoses. Both crates shall have provisions for moving and lifting by forklifts. The HDPE pipe and associated bubble rings are not intended to be stored in a crate.

All bubble curtain equipment shall be delivered to:

Washington State Department of Transportation Glass Yard
Glass Yard is a parcel bounded by Highland Park Way SW, W Marginal Way SW and 2nd Avenue SW – enter from 2nd Avenue SW
Seattle, WA 98106
Contact: Rick Rodda (425) 739-3700

The Contractor shall give a minimum of 48 hours notice prior to delivery and specific location for delivery within the Glass Yard. Delivery to the Glass Yard shall be between the hours of 8:00am and 4:00pm Monday through Friday, except holidays.

Steel Piling

Section 9-10.5 is supplemented with the following:

(******)
Furnishing St. Piling

For this project, the Section 6-05.3(5) prohibition against spiral welded steel pile casings does not apply, and the steel pipe piling may be either longitudinal seam or helical (spiral) seam submerged-arc welded pipe, provided that the requirements of this Special Provision are met.

Steel pipe piling shall conform to ASTM A 252 Grade 3. The chemical composition shall conform to Table 3.1 in the AWS D1.1/D1.1M, latest edition, Structural Welding Code.

The Contractor shall submit a manufacturer’s certification of compliance, conforming to Section 1-06.3 and accompanied by certified mill test reports, including chemical analysis and carbon equivalence, for each heat of steel used to fabricate the steel pipe piling.

Construction Requirements

Piling Terms

Section 6-05.3(1) is supplemented with the following:

(******)
Case Pile Wave Analysis Program
The Case Pile Wave Analysis Program (CAPWAP) is a computer program developed to take input data from pile driving analyzers to perform dynamic pile analysis.

Manufacture of Steel Piles

Section 6-05.3(5) is supplemented with the following:

(BSP April 5, 2010)
Furnishing St. Piling
Welding for ASTM A 252 pipe shall conform to AWS D1.1/D1.1M, latest edition, Structural Welding Code, except that all weld filler metal shall be low hydrogen material selected from Table 4.1 in AASHTO/AWS D1.5M/D1.5:2008 Bridge Welding Code. All seams and splices shall be complete penetration welds.

Welding and joint geometry for the seam shall be qualified in accordance with AWS D1.1/D1.1M, latest edition, Structural Welding Code. The Contractor may submit documentation of prior qualification to the Engineer to satisfy this requirement.
Dimensional tolerances for wall thickness, diameter and weight shall conform to the material specification that the steel pipe piling is manufactured under, except that the radial offset in the weld seams, height of the weld seam, and misalignment of the weld beads, shall not exceed the limits specified in API 5L, latest edition, Sections 9.13.1, 9.13.2, and 9.13.3, respectively. The wall thickness shall not be less than 95 percent of the specified nominal thickness. The ends of the steel pipe piles shall conform to dimensional tolerance and fit-up requirements of Section 5.22.3.1 of the AWS D1.1/D1.1M, latest edition, Structural Welding Code.

Skelp splices shall not be located within 12 inches of a girth shop or field weld. All skelp splices shall be 100 percent radiographically or ultrasonically inspected in accordance with either API 5L Annex E Section E.4 or E.5, or Table 6.2 and Chapter 6 Part E, F or G in AWS D1.1/D1.1M, latest edition, Structural Welding Code. Additionally, at least five percent of the pipe seam at each end, and one pipe diameter length of seam centered on any skelp splice intersection, shall be inspected as specified above. Repairs shall conform to Section 5.26 of the AWS D1.1/D1.1M, latest edition, Structural Welding Code, using approved repair and weld procedures. All seams and splices shall be 100 percent visually inspected in accordance with the acceptance criteria in Table 6.1 of the AWS D1.1/D1.1M, latest edition, Structural Welding Code.

Each length of steel pipe pile shall be marked with paint stencil, no closer than six inches to the end of the pipe, with the name of the manufacturer, material specification and grade of pipe, steel heat number, nominal pipe diameter, and wall thickness.

Splicing Steel Casings and Steel Piles

Section 6-05.3(6) is supplemented with the following:

(BSP April 5, 2010)
Furnishing St. Piling
Welding procedure submittals for shop and field girth splices shall be accompanied by certified mill test reports, including chemical analysis and carbon equivalence. Welding procedure submittals shall include the joint geometry.

Ends of steel pipe piling shall be prepared for splicing in accordance with AWS D1.1/D1.1M, latest edition, Structural Welding Code.

All splices shall be complete penetration groove welds using continuous backing rings of 1/4 inch minimum thickness. Tack welds shall be located in the root of the complete penetration groove weld.

Shop splices shall be 100 percent visually and ultrasonically inspected in accordance with Tables 6.1 and 6.2 acceptance criteria in AWS D1.1/D1.1M, latest edition, Structural Welding Code. Repairs for shop and field splices shall conform to Section 5.26 of AWS D1.1/D1.1M, latest edition, Structural Welding Code, using approved repair and weld procedures.

Field splice welds and welders shall be further qualified, tested and inspected as follows:

1. Welder qualification shall be performed on sample full girth sections of steel pipe pile to be used, in the same position and using the same weld joint as for production pile splicing. At the Contractor’s option, these tests may be performed on the test piles during test pile installation.

2. Weld qualification tests shall be conducted in the presence of the Contractor’s CWI and a representative of the Contracting Agency.

3. Field welded test joints for welder qualification shall be inspected as specified above for shop splices.

4. Production pile field splices shall be inspected as specified above for shop splices, within the limits designated for UT inspection as shown in the Plans. All welds shall be 100 percent visually inspected. The Engineer and the Contractor’s CWI reserve the right to request UT inspection of splices in any pile location.

Field weld inspection and weld repairs shall be the responsibility of the Contractor. Quality control for field welding shall be conducted by an AWS Certified Welding Inspector (CWI). The Contractor shall not begin pile splicing operations until receiving the CWI’s approval of the joint fit-up. The CWI shall inspect 100 percent of all field welds in accordance with the criteria and requirements specified above. All field splices shall have received the CWI’s approval prior to Engineer acceptance.

The CWI shall prepare a report documenting the results of the non destructive quality control inspection of all field welds, and shall submit the report to the Engineer within five working days of the completion of the final pile splice in the project or as otherwise requested by the Engineer.

Pile Tips and Shoes

Section 6-05.3(8) is supplemented with the following:

(******)
For this project, steel pile tips as specified below shall be used on steel piles where shown in the Plans. The Contractor shall submit manufacturer's catalog cut, certificates of compliance and details of the attachment to the Engineer for approval one week prior to the installation of any tips.

The steel pile tips shall be inside cutting type where the outside surface of the pile is flush with the outer edge of the tip. The steel pile tips shall be of the inside fit type and shall conform to the requirements of ASTM A27 65/35 heat-treated steel denoted in the Qualified Products List. If pile tips other than those denoted in the Qualified Products List are proposed, the Contractor shall submit shop drawings of the proposed pile tip along with design calculations, Specifications, material chemistry and installation requirements, to the Engineer for approval.

Steel pile tips shall be fastened to the piles in accordance with the pile tip manufacturer's recommendations where applicable. The steel pile tips shall be flush mounted such that the outside of the steel pile tip and/or weld bead does not protrude more that 1/16-inch beyond the nominal outside diameter of the steel pile. The inside diameter of the tip shall be at least ¾-inch less than the nominal diameter of the steel pile.

Tips manufactured for ¾-inch wall thickness piles may be used for 1 inch wall thickness piles by attachment utilizing one of the following methods:

1. By splicing 1 foot long (maximum) piece of the ¾-inch thick wall pipe pile onto the end of the one inch thick wall pipe pile. Splice shall be made with a full penetration weld and the tip attached to the ¾-inch thick wall pipe pile in accordance with the pile tip manufacture's recommendations. Materials and welding shall be in accordance with the Special Provision ***Splicing Steel Casings and Steel Piles***.
2. By machining the inside of the one inch thick wall pipe pile to produce a zone at the end of the pile ¾-inch thick and long enough to allow installation of the tip per the pile tip manufacture's recommendations.

Pile Driving Equipment

Pile Driving Equipment Minimum Requirements

Section 6-05.3(9)B is supplemented with the following:

(******)
For this project, no jetting and pre-boring shall be allowed.

Driving Piles

Section 6-05.3(11) is supplemented with the following:

(******)
Where shown in the plans, steel piles shall be installed with a vibratory pile hammer to the maximum penetration practicable, but not deeper than 7 feet above the

minimum pile tip elevation specified in the Plans, and then driven with a conventional impact hammer to the ultimate bearing capacity shown in the Plans based on results of wave equation analysis performed by the Contractor. Bearing requirements indicated in the Plans, shall be met. The Contractor shall submit a wave equation analysis for all impact pile driving systems used to drive the piles.

(******)

Dynamic Pile Testing

The Contractor shall furnishing all materials, labor, tools, equipment, services and incidentals necessary to perform Dynamic Pile Testing using the Pile Driving Analyzer (PDA) and Case Pile Wave Analysis Program (CAPWAP) on the piles as indicated in the Plans.

CAPWAP analyses shall be required to evaluate the bearing and uplift capacity of all piles tested by the PDA. Two CAPWAP analyses shall be required for each test pile: (1) at the end of the initial driving, and (2) at restrike after the 48-hour setup period.

Installation, monitoring, and presentation of the results of the PDA and CAPWAP shall be performed by a qualified PDA subcontractor whose name and qualifications shall be submitted to the Engineer for approval at least 7 calendar days before pile driving is to begin. All personnel who operate the PDA and analyze the output data shall have a minimum of 3 years of experience and shall have operated the PDA and analyzed the data on at least 5 projects during each of those 3 years. Four qualified PDA subcontractors are as follows:

Robert Miner Dynamic Testing
Box 340
Manchester, WA 98353
(360) 871-5480
(360) 871-5483 Fax

GRL and Associates
4535 Renaissance Parkway
Cleveland, OH 44128
(216) 831-6131
(216) 831-0916

GeoDesign Inc.
10700 Meridian Avenue North #210
Seattle, WA 98133
(206) 838-9900
(206) 838-9901 Fax

Lachel Felice & Associates
11411 NE 124th St, Ste 275
Kirkland, WA 98034
(425) 820-0800
(425) 820-9892

The piles shall be made available to the PDA subcontractor for installation of instruments before and after placing the piles in the leads. In cooperation with the PDA subcontractor, the Contractor shall cease and resume driving as needed to obtain the required measurements. PDA testing shall be performed during driving of all steel test piles, including after all test pile in-lead splices. Additionally, restriking of all test piles shall occur at least 48 hours after the test piles are initially driven, as specified in the earlier section.

The Contractor shall monitor the PDA throughout pile driving operations to confirm proper hammer to pile energy transfer, and to ensure that the piles are not overstressed or damaged during pile driving. The Contractor shall notify the Engineer immediately if the PDA readings indicate non-axial driving or possible pile damage.

For each pile tested using the PDA, the PDA subcontractor shall provide a summary of the PDA results which shall include the hammer blows per minute, transferred energy, and the force and stress at the pile top. These results shall be provided at 1 foot intervals of pile penetration over the last 5 feet of driving. In addition, the pile shall be monitored with the PDA for damage and the occurrence of non axial driving. All PDA results provided by the PDA subcontractor shall be correlated to pile tip elevation and blows per foot as recorded by the Engineer.

Preliminary PDA results shall be made available to the Engineer immediately after the pile is driven.

All PDA results shall be presented in a formal, written, dynamic analysis report, including the results of the CAPWAP analyses. The report shall include an explanation of all symbols used, any background information needed to understand the data, any adjustments made to the field data to obtain the data tabulated in the report, an interpretation of the data, and typical plots of force and velocity versus time obtained near the end of driving. The report shall be submitted to the Engineer within 5 working days of completion of each analyzed pile.

Achieving Minimum Tip Elevation and Bearing
Section 6-05.3(11)D is supplemented with the following:

(******)
The test piles shall be driven to ultimate bearing capacity.

The Contractor shall size the hammer to accommodate the maximum driving resistance and not result in premature refusal or pile damage.

The water elevation within the hollow pile shall be maintained at or above the water elevation outside of the pile. Water shall not be removed from the pile unless indicated. The piles will be examined for damage visually for the full length of pile above the mudline.

After the piles have been driven to bearing capacity, the Contractor shall wait 48 hours and then re-strike the test piles shown in the Plans.

Measurement

Section 6-05.4 is supplemented with the following:

(******)
Dynamic pile testing will be measured per each for each dynamic pile test performed at a pile including initial reading and restrike.

Installing confined bubble curtain systems will be measured per each by the number of impact driven piles on which the confined bubble curtain system is used.

Installing unconfined bubble curtain systems will be measured per each by the number of impact driven piles on which the unconfined bubble curtain system is used.

Payment

Section 6-05.5 is supplemented with the following:

(******)
"Furnishing and Driving (type) Test Pile", per each.
For this project, the unit contract price per each for "Furnishing and Driving (type) Test Pile" shall be full pay for furnishing and driving test piles to the ultimate bearing capacity or penetration required by the Engineer, furnishing and installing a pile tip, and vibratory driving when vibratory is specified. This price shall also include all costs in connection with moving all pile driving equipment or other necessary equipment to perform the work in the Plans and as specified.

"Dynamic Pile Testing", per each.
The unit contract price for "Dynamic Pile Testing", per each, shall be full pay for performing the work as specified, including data collection, using the Pile Driving Analyzer (PDA), using the Case Pile Wave Analysis Program (CAPWAP) and provide reports as specified.

"Furnish Confined Bubble Curtain System", lump sum.
"Furnish Unconfined Bubble Curtain System", lump sum.
The lump sum contract price for "Furnish ____ Bubble Curtain System" shall be full pay for performing the work as specified, including transporting, designing, fabricating, furnishing, and removing the systems as specified.

"Install Confined Bubble Curtain System", per each location.
"Install Unconfined Bubble Curtain System" per each location.
The unit contract price per each for "Install ____ Bubble Curtain System" shall be full pay for performing the work as specified, including installing and operating the bubble curtain systems.

DIVISION 8
MISCELLANEOUS CONSTRUCTION

(******)

PILE REMOVAL AND CLEANUP

Construction Requirements

Following completion of load testing and test pile inspections, the Contractor shall remove and dispose of or salvage items as listed below. The Contractor shall dispose of all items in accordance with Section 2-02.3.

The Contractor shall remove all 24-inch and 48-inch diameter steel pipe piles installed in this project.

Submittal

The Contractor shall submit to the Engineer for approval a Demolition Plan with working drawings and a Safety Plan five working days prior to pile removal. The Demolition Plan shall demonstrate that the methods and equipment to be used are adequate for the intended purpose and will provide satisfactory results. It shall provide for debris containment, and containment and immediate retrieval of deleterious material that may inadvertently fall in the water.

Steel Pile Removal

The steel piling shall be removed using a vibratory extractor as the preferred method. Piles shall be removed with a force that is coaxial with the vertical axis of the pile. Piles shall be removed one at a time. Concurrent multiple pile removal is not allowed, unless done in different locations with different equipment. The steel pile shall be cut off 2 feet below the mudline if they cannot be removed by methods in the approved Demolition Plan.

Payment

Payment will be made in accordance with Section 1-04.1, for the following bid item:

"Pile Removal and Cleanup", lump sum.
The lump sum contract price for "Pile Removal and Cleanup" shall be full pay for performing the work as specified.

STANDARD PLANS
August 2, 2010

The State of Washington Standard Plans for Road, Bridge and Municipal Construction M21-01 transmitted under Publications Transmittal No. PT 09-013, effective August 2, 2010 is made a part of this contract.

The Standard Plans are revised as follows:

<u>B-10.20 and B10.40</u>
Substitute “step” in lieu of “handhold” on plan

<u>C-3, C-3B, C-3C</u>
Note 1 is revised as follows: replace reference F-2b with F-10.42

<u>C-14a</u>
SECTION B, callout – 1½” PVC CONDUIT (TYP.) is revised to read: 1¼” PVC CONDUIT (TYP.)
callout (mark) 8 #9 ~ 36” (TYP.) is revised to read: callout (mark) 8 #8 ~ 36” (TYP.)
EPOXY BAR EXPANSION JOINT DETAIL, callout (mark) W #9 (epoxy coated symbol) ~ 36” (TYP.) is revised to read: callout (mark) 8 #8 (epoxy coated symbol) ~ 36” (TYP.)

<u>D-3a</u>
Deleted

<u>D-3b</u>

Key Note 7,reference D-3a is revised to D-3.10
TYPICAL SECTION, lower left corner, reference D-3a is revised to D-3.10

D-3c
Key Note 7,reference D-3a is revised to D-3.10
TYPICAL SECTION, lower left corner, references (2x) D-3a are revised to D-3.10

F-40.10
Deleted

F-40.18
Deleted

F-40.20
Deleted

F-42.10
Deleted

G-24.40
Existing callout - CORNER BOLT (TYP.)
New callout - CORNER BOLT OR SHOULDER BOLT (TYP.)

G-24.60
ELEVATION, upper left corner, callout W6x12 STEEL SIGN POST (TYP.) is revised to read: W6x9 (TP-A) W6x12 (TP-B) STEEL SIGN POST (TYP.)

J-1f
Note 2, reference to J-7d is revised to J-15.15

J-3b
Sheet 2 of 2, Plan View of Service Cabinet, Boxed Note,
“SEE STANDARD PLAN J-6C…” is revised to read:
“SEE STANDARD PLAN J-10.10…”

J-6c
Deleted

J-7c
Note 3, reference to J-7d is revised to J-15.15

J-7d
Deleted

J-16a
Deleted

J-16b
Key Note 1, reference to J-16a is revised to J-40.36

J-16c
Key Note 1, reference to J-16a is revised to J-40.36

K-80.30

In the NARROW BASE, END view, the reference to Std. Plan C-8e is revised to Std. Plan K-80.35

L-20.10, Sheet 1

Delete all references to tension cable and substitute tension wire.
Add knuckled selvage is required on the top edge of the fence fabric.

L-20.10, Sheet 2

Delete all references to tension cable and substitute tension wire.
All rope thimbles, wire rope clips and seizing are not required.

L-30.10, Sheet 1

Delete all references to tension cable and substitute tension wire.

L-30.10, Sheet 2

Delete all references to tension cable and substitute tension wire.
All rope thimbles, wire rope clips and seizing are not required.

M-1.60

COLLECTOR DISTRIBUTOR ROAD OFF- CONNECTION, taper dimensions of 225' MIN. is changed to 300' MIN.

M-65.10

PERSPECTIVE VIEW, add dim. "SEE NOTE 1" to right side of PERSPECTIVE VIEW.
To clarify that the requirement must be met on both sides of the roadway

The following are the Standard Plan numbers applicable at the time this project was advertised. The date shown with each plan number is the publication approval date shown in the lower right-hand corner of that plan. Standard Plans showing different dates shall not be used in this contract.

A-10.10-00........8/07/07	A-30.35-00......10/12/07	A-50.20-01…....9/22/09
A-10.20-00......10/05/07	A-40.00-00........8/11/09	A-50.30-00…..11/17/08
A-10.30-00......10/05/07	A-40.10-01........8/11/09	A-50.40-00…..11/17/08
A-20.10-00........8/31/07	A-40.15-00........8/11/09	A-60.10-01......10/14/09
A-30.10-00......11/08/07	A-40.20-00........9/20/07	A-60.20-01........8/11/09
A-30.15-00......11/08/07	A-40.50-00......11/08/07	A-60.30-00......11/08/07
A-30.30-00......11/08/07	A-50.10-00…..11/17/08	A-60.40-00........8/31/07

B-5.20-00..........6/01/06	B-30.50-00........6/01/06	B-75.20-01.......6/10/08
B-5.40-00..........6/01/06	B-30.70-01........8/31/07	B-75.50-01.......6/10/08
B-5.60-00..........6/01/06	B-30.80-00........6/08/06	B-75.60-00.......6/08/06
B-10.20-00........6/01/06	B-30.90-01........9/20/07	B-80.20-00.......6/08/06
B-10.40-00........6/01/06	B-35.20-00........6/08/06	B-80.40-00.......6/01/06
B-10.60-00........6/08/06	B-35.40-00........6/08/06	B-82.20-00.......6/01/06
B-15.20-00........6/01/06	B-40.20-00........6/01/06	B-85.10-01.......6/10/08
B-15.40-00........6/01/06	B-40.40-01........6/16/10	B-85.20-00.......6/01/06
B-15.60-00........6/01/06	B-45.20-00........6/01/06	B-85.30-00.......6/01/06
B-20.20-01......11/21/06	B-45.40-00........6/01/06	B-85.40-00.......6/08/06
B-20.40-02........6/10/08	B-50.20-00........6/01/06	B-85.50-01.......6/10/08

B-20.60-02........6/10/08
B-25.20-00........6/08/06
B-25.60-00........6/01/06
B-30.10-00........6/08/06
B-30.20-01......11/21/06
B-30.30-00........6/01/06
B-30.40-00........6/01/06
B-55.20-00........6/01/06
B-60.20-00........6/08/06
B-60.40-00........6/01/06
B-65.20-00........6/01/06
B-65.40-00........6/01/06
B-70.20-00........6/01/06
B-70.60-00........6/01/06
B-90.10-00.......6/08/06
B-90.20-00.......6/08/06
B-90.30-00.......6/08/06
B-90.40-00.......6/08/06
B-90.50-00.......6/08/06
B-95.20-01.......2/03/09
B-95.40-00.......6/08/06

1

C-1...................2/10/09
C-1a................10/14/09
C-1b...............6/3/10
C-1c.................5/30/97
C-1d...............10/31/03
C-2...................1/06/00
C-2a.................6/21/06
C-2b.................6/21/06
C-2c.................6/21/06
C-2d.................6/21/06
C-2e.................6/21/06
C-2f..................3/14/97
C-2g.................7/27/01
C-2h.................3/28/97
C-2i..................3/28/97
C-2j..................6/12/98
C-2k.................7/27/01
C-2n.................7/27/01
C-2o.................7/13/01
C-2p...............10/31/03
C-3.................10/04/05
C-3a...............10/04/05
C-3b...............10/04/05
C-3c.................6/21/06
C-4b.................6/08/06
C-4b.................6/08/06
C-4e.................2/20/03
C-4f..................6/30/04
C-5.................10/14/09
C-6...................5/30/97
C-6a...............10/14/09
C-6c.................1/06/00
C-6d.................5/30/97
C-6f..................7/25/97
C-7.................10/31/03
C-7a...............10/31/03
C-8...................2/10/09
C-8a.................7/25/97
C-8b.................2/10/09
C-8e.................2/21/07
C-8f..................6/30/04
C-10.................6/3/10
C-13...................7/3/08
C-13a.................7/3/08
C-13b...............7/3/08
C-13c................7/3/08
C-14a................7/3/08
C-14b...............7/26/02
C-14c................7/3/08
C-14d................7/3/08
C-14e................7/3/08
C-14h..............2/10/09
C-14i................2/10/09
C-14j..............12/02/03
C-14k................2/10/09
C-15a................7/3/08
C-15b................7/3/08
C-16a..............6/3/10
C-16b..............6/3/10
C-20.14-01......10/14/09
C-20.15-00......10/14/09
C-20.18-00......10/14/09
C-20.19-00......10/14/09
C-20.40-01......10/14/09
C-20.42-01......10/14/09
C-22.14-01........6/3/10
C-22.16-01........6/3/10
C-22.40-02......6/16/10
C-23.60-01......10/14/09
C-25.18-01........9/20/07
C-25.20-04......10/14/09
C-25.22-03......10/14/09
C-25.26-01......10/14/09
C-25.80-01........7/3/08
C-28.40-00........2/06/07
C-40.14-01........6/3/10
C-40.16-01........6/3/10
C-40.18-01......10/14/09
C-90.10-00........7/3/08

2

D-2.02-00........11/10/05
D-2.04-00........11/10/05
D-2.06-01........1/06/09
D-2.08-00........11/10/05
D-2.10-00........11/10/05
D-2.12-00........11/10/05
D-2.14-00........11/10/05
D-2.16-00........11/10/05
D-2.18-00........11/10/05
D-2.20-00........11/10/05
D-2.30-00........11/10/05
D-2.32-00........11/10/05
D-2.34-01........1/06/09
D-2.36-02........1/06/09
D-2.38-00........11/10/05
D-2.40-00........11/10/05
D-2.44-00........11/10/05
D-2.46-00........11/10/05
D-2.48-00........11/10/05
D-2.60-00........11/10/05
D-2.62-00........11/10/05
D-2.64-01........1/06/09
D-2.66-00........11/10/05
D-2.68-00........11/10/05
D-2.78-00........11/10/05
D-2.80-00........11/10/05
D-2.82-00........11/10/05
D-2.84-00........11/10/05
D-2.86-00........11/10/05
D-2.88-00........11/10/05
D-2.92-00........11/10/05
D-3...................6/16/10
D-3.11-00……6/16/10
D-3b................6/30/04
D-3c................6/30/04
D-4................12/11/98
D-6..................6/19/98
D-10.10-01......12/02/08
D-10.15-01......12/02/08
D-10.20-00.........7/8/08
D-10.25-00.........7/8/08
D-10.30-00.........7/8/08
D-10.35-00.........7/8/08
D-10.40-01......12/02/08
D-10.45-01......12/02/08
D-15.10-01......12/02/08
D-15.20-01........1/06/09
D-15.30-01......12/02/08

D-2.42-00........11/10/05	D-3.10-00……6/16/10	

1

E-1....................2/21/07	E-4....................8/27/03	
E-2....................5/29/98	E-4a.................8/27/03	

2

F-10.12-01........6/3/10	F-10.62-01........9/05/07	F-40.14-01........6/3/10
F-10.16-00.......12/20/06	F-10.64-02........7/3/08	F-40.15-01........6/3/10
F-10.40-01...........7/3/08	F-30.10-01........6/3/10	F-40.16-01........6/3/10
F-10.42-00.........1/23/07	F-40.12-01........6/3/10	F-45.10-00........6/3/10
F-80.10-01........6/3/10		

3

G-10.10-00........9/20/07	G-24.60-00.....11/08/07	G-70.20-00......10/5/07
G-20.10-00........9/20/07	G-25.10-01......1/06/09	G-70.30-00......10/5/07
G-22.10-01..........7/3/08	G-30.10-00.....11/08/07	G-90.10-00…..1/06/09
G-24.10-00......11/08/07	G-50.10-00.....11/08/07	G-90.20-00…..1/06/09
G-24.20-00......11/08/07	G-60.10-00.......8/31/07	G-90.30-00…..1/06/09
G-24.30-00......11/08/07	G-60.20-00.......8/31/07	G-90.40-01…..10/14/09
G-24.40-01......12/02/08	G-60.30-00.......8/31/07	G-95.10-00.....11/08/07
G-24.50-00.....11/08/07	G-70.10-00......10/5/07	G-95.20-01......7/10/08
		G-95.30-01......7/10/08

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H-10.10-00..........7/3/08	H-32.10-00.......9/20/07	H-70.10-00......9/05/07
H-10.15-00..........7/3/08	H-60.10-01.........7/3/08	H-70.20-00......9/05/07
H-30.10-00......10/12/07	H-60.20-01.........7/3/08	H-70.30-01......11/17/08

5

I-10.10-01.........8/11/09	I-30.40-00.......10/12/07	I-50.20-00..........8/31/07
I-30.10-01.........8/11/09	I-30.50-00.......11/14/07	I-60.10-00..........8/31/07
I-30.15-00.........8/11/09	I-40.10-00.........9/20/07	I-60.20-00..........8/31/07
I-30.20-00.........9/20/07	I-40.20-00.........9/20/07	I-80.10-01..........8/11/09
I-30.30-00.........9/20/07	I-50.10-00.........9/20/07	

6

J-1f....................6/23/00	J-20.................9/02/05	J-28.40-01.......10/14/09
J-3.....................8/01/97	J-20.10-00......10/14/09	J-28.42-00.......8/07/07
J-3b...................3/04/05	J-20.15-00......10/14/09	J-28.45-00.......8/07/07
J-3c...................6/24/02	J-20.16-00......10/14/09	J-28.50-01.......6/16/10
J-3d.................11/05/03	J-20.20-00......10/14/09	J-28.60-00.......8/07/07
J-7c...................6/19/98	J-20.26-00......10/14/09	J-28.70-00.......11/08/07
J-8a...................5/20/04	J-21.10-01......6/3/10	J-40.10-01…...10/14/09
J-8b..................5/20/04	J-21.15-00......10/14/09	J-40.30-01……6/3/10
J-8c...................5/20/04	J-21.16-00......10/14/09	J-40.36-00…….6/3/10
J-8d..................5/20/04	J-21.17-00......10/14/09	J-40.37-00…….6/3/10
J-9a..................4/24/98	J-21.20-00......10/14/09	J-60.13-00…....6/16/10
J-10..................7/18/97	J-22.15-00......10/14/09	J-60.14-00……6/16/10
J-10.10-00……6/16/10	J-22.16-01......6/3/10	J-75.10-00……2/10/09
J-11b.................9/02/05	J-26.10-00…..6/16/10	J-75.20-00……2/10/09
J-12..................2/10/09	J-26.15-00…..6/16/10	J-75.30-00…….2/10/09
J-15.15-00……6/16/10	J-28.10-00......8/07/07	J-75.40-00……10/14/09
J-16b................2/10/09	J-28.22-00.......8/07/07	J-75.45-00……10/14/09
J-16c.................2/10/09	J-28.24-00.......8/07/07	J-90.10-00…….2/10/09
J-18.................2/10/09	J-28.26-01......12/02/08	J-90.20-00…….2/10/09
J-19................2/10/09	J-28.30-01......10/14/09	

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K-10.20-01......10/12/07	K-26.40-01......10/12/07	K-40.60-00.......2/15/07
K-10.40-00........2/15/07	K-30.20-00........2/15/07	K-40.80-00.......2/15/07
K-20.20-01......10/12/07	K-30.40-01......10/12/07	K-55.20-00.......2/15/07
K-20.40-00........2/15/07	K-32.20-00........2/15/07	K-60.20-02.........7/3/08
K-20.60-00........2/15/07	K-32.40-00........2/15/07	K-60.40-00.......2/15/07
K-22.20-01......10/12/07	K-32.60-00........2/15/07	K-70.20-00.......2/15/07
K-24.20-00........2/15/07	K-32.80-00........2/15/07	K-80.10-00.......2/21/07
K-24.40-01......10/12/07	K-34.20-00........2/15/07	K-80.20-00.....12/20/06
K-24.60-00........2/15/07	K-36.20-00........2/15/07	K-80.30-00.......2/21/07
K-24.80-01......10/12/07	K-40.20-00........2/15/07	K-80.35-00.......2/21/07
K-26.20-00........2/15/07	K-40.40-00........2/15/07	K-80.37-00.......2/21/07

L-10.10-00........2/21/07	L-40.10-00........2/21/07	L-70.10-01.......5/21/08
L-20.10-00........2/07/07	L-40.15-00........2/21/07	L-70.20-01.......5/21/08
L-30.10-00........2/07/07	L-40.20-00........2/21/07	

M-1.20-01.........1/30/07	M-7.50-01.........1/30/07	M-24.60-02.......2/06/07
M-1.40-01.........1/30/07	M-9.50-01.........1/30/07	M-40.10-01......6/3/10
M-1.60-01.........1/30/07	M-9.60-00…….2/10/09	M-40.20-00...10/12/07
M-1.80-02.........8/31/07	M-11.10-01.......1/30/07	M-40.30-00......9/20/07
M-2.20-01.........1/30/07	M-15.10-01.......2/06/07	M-40.40-00......9/20/07
M-2.40-01.........1/30/07	M-17.10-02.........7/3/08	M-40.50-00......9/20/07
M-2.60-01.........1/30/07	M-20.10-01.......1/30/07	M-40.60-00......9/20/07
M-3.10-02.........2/10/09	M-20.20-01.......1/30/07	M-60.10-00......9/05/07
M-3.20-01.........1/30/07	M-20.30-02.....10/14/09	M-60.20-01......2/03/09
M-3.30-02.........2/10/09	M-20.40-01.......1/30/07	M-65.10-01......5/21/08
M-3.40-02.........2/10/09	M-20.50-01.......1/30/07	M-80.10-00......6/10/08
M-3.50-01.........1/30/07	M-24.20-01.......5/31/06	M-80.20-00......6/10/08
M-5.10-01.........1/30/07	M-24.40-01.......5/31/06	M-80.30-00......6/10/08

Columbia River CROSSING

Memorandum

1 August 2011

TO: Steve Morrow
Sharon Rainsberry

FROM: James Coleman, David Evans and Associates, Inc.

SUBJECT: **Columbia River Crossing Test Pile Project Vibratory Extraction Sound Levels**

COPY: Jim Laughlin, WSDOT

Vibratory Extraction Analysis

This memorandum summarizes the results of hydroacoustic monitoring on the vibratory extraction of piles during the Columbia River Crossing Test Pile Project. A detailed discussion of monitoring procedures and the data processing methodology used in this analysis can be found in the *Columbia River Crossing Test Pile Project Hydroacoustic Monitoring Final Report.* The final report also includes the definitions of the derived qualities referred to in this memorandum. Two 24-inch and four 48-inch piles were extracted using an APE King Kong model 400 vibratory hammer between 14 and 21 February 2011. No noise mitigation measures were used during pile extraction. Hydroacoustic measurements were taken at ranges of approximately 10 meters, 200 meters, 400 meters, 800 meters, and also 800 meters in the opposite direction from the pile being extracted.

A RMS pressure level and Cumulative SEL level was calculated for each vibratory extraction. No frequency weightings were used during calculations. RMS pressure levels were calculated for each 30-second block of vibration and averaged together to represent the RMS pressure level of the entire vibratory extraction. Cumulative SEL was calculating by directly integrating the square of the sound pressure over the duration of the vibratory extraction. Both Cumulative SEL values and RMS sound pressure levels are presented as decibels (re: 1μPa).

Observed Sound Levels for Vibratory Extraction

A typical time series of the RMS sound pressure level for vibratory extraction is shown in figure-1. A summary of the average RMS pressure level, measured Cumulative SEL, and approximate time for the extraction are shown in table-1. The average RMS pressure level for extraction was 173 dB, and did not appear to vary with pile size. The 173 dB observed for extraction was slightly less than the 176 dB average observed during installation as found in the *Columbia River Crossing Test Pile Project Hydroacoustic Monitoring Final Report*. The variance of the pressure levels was also less, with extraction values ranging 167-176 dB while installation values ranged 157-181 dB.

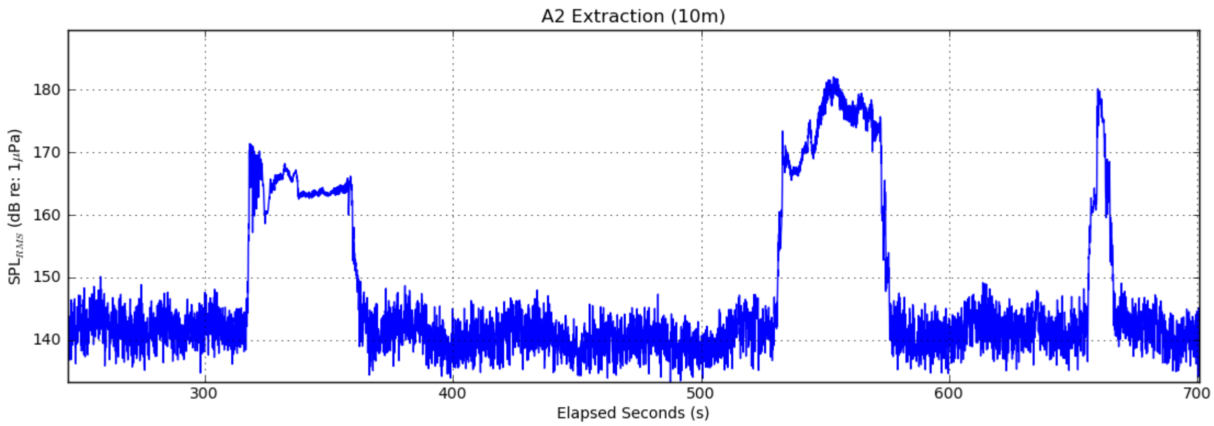

FIGURE TIME SERIES OF RMS SOUND PRESSURE LEVELS AT 10-METERS FOR VIBRATORY EXTRACTION OF PILE B-2. THREE SEPARATE VIBRATION EVENTS OCCUR DURING THE EXTRACTION.

Time required for vibratory extraction varied widely, from 1 minute to over 110 minutes. Unlike the RMS pressure level, the extraction time varied with pile size. Extraction time was shorter for 24-inch piles (1, 2, and 3 minutes) than 48-inch piles (9,10,110 minutes). The extraction of pile A-3, totaled approximately 110 minutes, which is significantly longer than the next longest extraction of 10 minutes for pile B-2. Extraction began for pile A-3 on 15 February, however after over 65 minutes of active vibration the pile had not moved. Extraction for the same pile was attempted again on 18 February. After over 15 minutes of vibration the pile still had not moved. The pile was then impact driven another foot in an attempt to loosen the pile and extraction was attempted again. Extraction was complete after approximately 30 minutes of vibration following the impact driving. The average time for vibratory extraction, approximately 20 minutes, was much longer than the average time of 3 minutes used to drive the pile with vibration, due primarily to the significant time required to extract pile A3. If pile A3 is considered an outlier and not included, the average extraction time, 5 minutes, is only slightly longer than the time for the vibratory drive used to set the pile.

TABLE 1. OBSERVED SOUND LEVELS FOR VIBRATORY EXTRACTION.

Pile	Date	Size (inches)	SPL_{RMS} (dB) (10m)	Approximate Time (minutes)	Cumulative SEL (dB)
A1	14-Feb	24	167	3	190
A2	17-Feb	24	176	2	193
A3	15-Feb	48	173	65	210
A3	18-Feb	48	170	45	206
A4	18-Feb	48	174	9	203
B1	21-Feb	24	171	1	188
B2	21-Feb	48	172	10	199

The measured Cumulative SEL values shown in table-1 deviate in some instances by up to a couple decibels from the Cumulative SEL that would be expected given the average RMS pressure level and drive duration. These differences are attributable to the different approach used in calculating each quantity; RMS values were calculated using 30-second averages to be consistent with previous studies, while Cumulative SEL was derived from direct integration.

Observed Transmission Loss for Vibratory Extraction

The coefficient of transmission loss for vibratory extraction was calculated using the transmission loss equation and actual observed ranges as outlined in the *Columbia River Crossing Test Pile Project Hydroacoustic Monitoring Final Report*. Transmission loss calculated from both RMS pressure and Cumulative SEL were similar to one another, as expected, and in line with the practical spreading model at all ranges except 200 meters. High levels of ambient noise were observed at the 200 meter station during five of the seven vibratory extractions. The high noise levels affected the calculation of RMS pressure and Cumulative SEL, resulting in higher overall sound levels and a lower than anticipated transmission loss at 200 meters. The cause of the high ambient noise is unknown.

TABLE 2. TRANSMISSION LOSS FOR VIBRATORY EXTRACTION.

Coefficient of Transmission Loss				
	RMS Pressure		Cumulative SEL	
Range (m)	Average	1σ	Average	1σ
200.0	12.9	1.2	13.1	2.9
400.0	15.3	2.0	15.8	1.7
800.0	14.7	1.5	14.9	1.4
-800.0	14.8	0.9	15.8	1.3

Spectral Density of Vibratory Extraction

Power spectral densities were calculated for each vibratory extraction at each monitored range. Vibratory extraction produced broadband energy. The majority of the energy occurred in frequencies below 1,000 Hz, with energy levels gradually falling off at higher frequencies. Transmission loss was expected to be spectrally flat, however was consistently observed to be greatest between 100 and 1,000 Hz, and flat above 1,000 Hz. The cause of the increased propagation loss at frequencies between 100 and 1,000Hz is unknown.

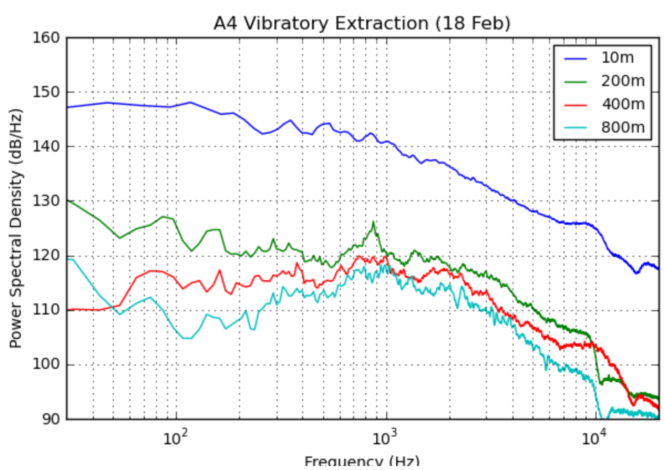

FIGURE 1. SPECTRAL DENSITY OF VIBRATORY EXTRACTION WITH RANGE.