APPENDIX B

HUMAN HEALTH SCO AND CSL DEVELOPMENT

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LIST OF ACRONYMS AND ABBREVIATIONS

BSAF	biota-sediment accumulation factors
bw	body weight
CLARC	Cleanup Levels and Risk Calculations
cm^2	square centimeter
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPF	cancer potency factor
COC	constituent of concern
CSL	Cleanup Screening Level
DF	diet fractions
DMMP	Dredged Material Management Program
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
ELCR	Excess Lifetime Cancer Risk
EPA	U.S. Environmental Protection Agency
ERDC	USACE Environmental Research Development Center
ESA	Endangered Species Act
g	gram
g/day	gram per day
HI	hazard index
HQ	hazard quotient
g/g	gram per gram
kg	kilogram
km^2	square kilometer
Koc	organic carbon-water partitioning coefficient
mg/kg	milligram per kilogram
MLLW	mean lower low water
MTCA	Model Toxics Control Act
OC	organic carbon
ODEQ	Oregon Department of Environmental Quality
ORD	EPA Office of Research and Development
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PQL	practical quantitation limit

RBC	risk-based concentration
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
RSET	Regional Sediment Evaluation Team
SCL	sediment cleanup level
SCO	Sediment Cleanup Objective
SCUM II	Sediment Cleanup Users Manual II
Site	I&J Waterway Site
SMS	Sediment Management Standards
SUF	site use factor
TCDD	tetrachlorodibenzodioxin
TEF	toxic equivalency factor
TEQ	toxic equivalents quotient
TTL	target tissue level
USACE	U.S. Army Corps of Engineers
UTL	upper tolerance limit
WAC	Washington Administrative Code
WES	Waterway Experiment Station

1 INTRODUCTION

This appendix presents the development of human health risk-based concentrations (RBCs) for the I&J Waterway Site (Site). These human health RBCs contribute to the selection of the final Sediment Cleanup Objective (SCO) and Cleanup Screening Level (CSL) described in Section 4 of the Remedial Investigation (RI). This appendix also describes the methods used to develop natural background, regional background, and practical quantitation limits (PQLs), which also contribute to selection of the final SCO and CSL.

Sediment sites are regulated by the Sediment Management Standards (SMS; Washington Administrative Code [WAC] 173-204). The revised SMS rule was implemented on September 1, 2013 (Ecology 2013a) and includes specific requirements for the protection of both human health and the environment. The new SMS rule includes specific procedures to determine human health risk-based SCOs and CSLs to address the bioaccumulative (seafood consumption) and direct contact exposure pathways (WAC 173-204-560). Under the new SMS rule, the derivation of human health sediment RBCs is a component of the overall sediment cleanup level (SCL) development. The SMS permits site risk-based cleanup standards within a range of 1 in 100,000 (1×10^{-5}) to 1 in 1 million (1×10^{-6}) excess lifetime cancer risk (ELCR) levels for all individual carcinogens, and a total ELCR risk of 1×10^{-5} for all carcinogens (total risk from multiple contaminants). For non-carcinogenic chemicals, a hazard quotient (HQ) of 1 is used to develop cleanup standards. If a site has multiple non-carcinogens with similar types of toxicity, the cleanup standards may be adjusted downwards in accordance with WAC 173-340-708, or other approved methods to ensure protectiveness at a hazard index (HI) of 1.

The human health risk-based SCO is the lowest sediment RBC developed from the 1×10^{-6} ELCR[1] threshold and/or a HQ of 1.[2] The human health risk-based CSL is the lowest sediment RBC corresponding to a 1×10^{-5} ELCR threshold and/or a HQ of 1.[2] The final SCO and CSL are determined based on the highest of the 1) lowest appropriate RBCs for protection of human health, benthic organisms (WAC 173-204-320 and WAC 173-204-562 for SCO and CSL, respectively), or ecological receptors; 2) background; and 3) PQLs.

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[1] Or $1x10^{-5}$ for multiple carcinogens

[2] Or an HI of 1 for multiple non-carcinogens

The SCO defines the lower bound of a sediment cleanup level and the CSL defines the upper bound. The SCL may be adjusted upward from the SCO, if the SCO is not technically possible to achieve considering net environmental effects on the aquatic environment, natural resources, and habitat. However, the SCL may not be adjusted upward above the CSL (WAC 173-204-560).

As described in the new SMS rule and draft Sediment Cleanup Users Manual II (SCUM II) (Ecology 2013b) guidance document, the steps for developing human health risk-based CSL and SCO for I&J Waterway are as follows:

- Identify Site bioaccumulative chemicals requiring RBC development (Ecology 2013b).
- Identify potential exposure pathways and the reasonable maximum exposure (RME) scenario (WAC 173-204-561(2)).
- Calculate carcinogenic sediment RBCs at $1x10^{-6}$ (SCO) and $1x10^{-5}$ (CSL) and non-carcinogenic RBCs using a HQ of 1.[1]
- Determine natural background.
- Determine the PQL.
- Develop regional background levels.

This document is generally organized according to these steps and includes the following sections:

- Section 2 identifies Site bioaccumulative chemicals requiring development of bioaccumulative exposure pathway (seafood consumption) RBC.
- Section 3 identifies complete Site exposure pathways and discusses RME scenarios.
- Section 4 includes components of SCO development. This section provides equations for calculating RBCs for the exposure scenarios and discusses natural background and PQLs.
- Section 5 includes components of CSL development. This section discusses RBCs and PQLs and develops preliminary regional background values for carcinogenic polycyclic aromatic hydrocarbons (cPAH) toxic equivalents quotient (TEQ) and total dioxin/furan TEQ.

2 IDENTIFICATION OF SITE BIOACCUMULATIVE CHEMICALS OF POTENTIAL CONCERN

I&J Waterway sediment samples collected in 2005/2006, 2012, and 2013 were used to determine Site bioaccumulative chemicals requiring RBC development. Bioaccumulative chemicals detected in at least one Site surface sediment sample included arsenic, cadmium, lead, mercury, total polychlorinated biphenyls (PCB) Aroclors, polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol, and total dioxin/furan TEQ. The frequency of detection, temporal and spatial chemical concentration patterns, and current and historical Site activities were considered to determine which of these chemicals could be considered Site related.

Bioaccumulative chemicals that could be potentially Site related include a number of PAHs, which were developed into RBCs for cPAHs. The other bioaccumulative chemicals are not considered Site-related because they are not specifically associated with historical or current Site uses and/or have low detection frequencies. Dioxin/furan was not retained as a constituent of concern (COC) because congener profiles suggest no Site-associated release/activity and Site sediments are similar to Bellingham Bay profiles. As shown in Appendix E, dioxin/furan congener profiles from sediment at the Site are similar to sediment samples collected by the U.S. Army Corps of Engineers (USACE) in 2012 that extend to the end of the I&J Waterway, up to approximately 2,000 feet from the Site into Bellingham Bay. Congener patterns in Site sediment resemble profiles associated with typical urban inputs, such as automobile and diesel emissions (Attachments 1 and 2 of Appendix E), which is typical in urban areas with stormwater runoff from commercial and industrial areas. Areas with elevated dioxin/furan concentrations that are co-located with Site COCs will be addressed as part of Site remediation.

2.1 cPAHs

PAHs are a group of structurally similar planar compounds. Seven of the 16 PAHs tested under SMS have been identified as probable human carcinogens (cPAH). Evaluation of cPAH under the Model Toxics Control Act (MTCA) occurs by multiplying the individual cPAH by their respective benzo(a)pyrene toxic equivalency factors (TEF; CalEPA 2005) and summing these TEQs into a total cPAH TEQ (WAC 173-340-708(e)). While non-carcinogenic PAHs co-occur with the cPAH at the Site, the cPAH exhibit higher potential risk to human health than do the non-carcinogenic PAHs. For this reason, Site remediation to risk-based bioaccumulative cleanup levels developed for cPAHs will be protective of risk from other bioaccumulative non-carcinogenic PAHs.

3 EXPOSURE PATHWAYS AND REASONABLE MAXIMUM EXPOSURE SCENARIOS

RBCs have been calculated for Site exposure pathways for both carcinogenic and non-carcinogenic risk, as applicable. This section describes the exposure pathways used to calculate the RBCs.

Two likely exposure pathways were identified for the Site based on current and potential future Site uses:

- Ingestion of fish and shellfish that have bioaccumulated chemicals from the Site.
- Direct contact (incidental sediment ingestion and dermal contact) with chemicals in Site sediments during recreational beach use.

The RME scenario refers to the highest exposure for human health risk that is reasonably expected to occur at a site under current and potential future land use (WAC 173-204-561(2)(b)). Three RME scenarios were developed to address these exposure pathways:

- Tribal seafood ingestion of fish and shellfish (seafood consumption)
- Adult direct contact and incidental ingestion RME clamming
- Child direct contact and incidental ingestion RME beach play

These RME scenarios were developed for the Study Area based on Washington State Department of Ecology (Ecology) guidance (Ecology 2013b). The pathways are considered complete and are shown in the Conceptual Site Model (Figure 7-2).

3.1 Seafood Consumption Scenario

Development of the sediment cPAH RBC that would be protective of tribal RME seafood consumption from the Site was calculated using Ecology's default equation (Ecology 2013b), and a combination of Ecology's default input parameters (e.g., exposure frequency, exposure duration) and Site-specific input parameters (e.g., seafood ingestion rates, site use factors). The RBC developed is the concentration in sediment at and below which chemicals would not be expected to accumulate in seafood tissue to levels presenting potential unacceptable ELCR to human consumers under RME conditions. The equation and Site-specific parameters used for calculating the seafood consumption cPAH RBC are presented in Section 4.1.1.

3.2 Sediment Direct Contact and Incidental Ingestion Scenario

The direct contact and incidental ingestion exposure pathways were evaluated through the adult clamming and the child beach play scenarios. These scenarios were used to derive RBCs for adult and child recreational activities in the intertidal area of the Site (-4 feet to 11 feet mean lower low water [MLLW]). RBCs protective of the direct contact and incidental ingestion scenarios were calculated using Ecology's default equations (Ecology 2013b), and a combination of Ecology's default input parameters (e.g., body weight, exposure duration) and Site-specific input parameters (e.g., exposure frequency). RBCs were developed for cPAHs in addition to other SMS chemicals if toxicity data (cancer potency factor [CPF] and/or reference dose [RfD]) were available in Ecology's Cleanup Levels and Risk Calculations (CLARC) database (Ecology 2013b). For a given chemical, carcinogenic and/or non-carcinogenic RBCs were developed based on the chemical's toxicological mechanisms of action. The direct contact and incidental ingestion equations and Site-specific parameters used for calculating the RBCs are presented in Section 4.1.2.

3.3 Ecological Receptors

Ecological risk from bioaccumulative chemicals is also considered in the development of SCO and CSL for a site (Ecology 2013b). Higher trophic-level aquatic dependent organisms such as Great Blue Heron (*Ardea herodias*) or Harbor Seals (*Phoca vituluna*) could potentially forage on prey species that have bioaccumulated chemicals from the Site. PAHs were the only chemicals identified as Site-related bioaccumulative chemicals of potential concern. The other bioaccumulative chemicals (arsenic, cadmium, lead, mercury, PCB, pentachlorophenol, and total dioxin/furan) were excluded from further ecological evaluation based on frequency of detection, temporal and spatial chemical concentration patterns, and knowledge of current and historical Site activities.

The Site mean concentrations of the bioaccumulative metals cadmium and lead in surface sediments were at or below natural background (Ecology 2013b) concentrations, while arsenic and mercury concentrations were slightly above natural background. Arsenic and mercury are not associated with any known Site release/activity and elevated areas are co-located with Site COCs that will be addressed as part of Site remediation. These chemicals are therefore not considered Site bioaccumulative chemicals of concern.

Pentachlorophenol and PCB had low detection frequencies in Site samples, there is no known Site-related release/activity, and samples with detections are located in areas targeted for remediation of Site COCs. These chemicals are therefore not considered Site bioaccumulative chemicals of concern.

Dioxin/furan tends to be present in higher concentrations throughout Bellingham Bay and in other urban areas in Puget Sound. As discussed previously, dioxin/furan was not retained as a COC because congener profiles suggest no Site-associated release/activity and Site sediments are similar to Bellingham Bay profiles. Areas with elevated dioxin/furan concentrations that are co-located with Site COCs will be addressed as part of Site remediation.

The cPAH RBC developed for human health is anticipated to be adequately protective of aquatic dependent wildlife that may be exposed to bioaccumulative chemicals (through foraging) at the Site, which may include otters or seals. Human and aquatic-dependent wildlife bioaccumulative chemical target tissue levels (TTLs) have been developed and are presented in several documents, including the SCUM II (Table 2-2; Ecology 2013b), the *Sediment Evaluation Framework for the Pacific Northwest* (RSET 2009), and the *Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment* (ODEQ 2007). The TTLs represent the prey tissue concentrations considered protective of human health and aquatic dependent wildlife. The compilation of available TTLs are included in Table B-1. Comparison of the human and aquatic-life dependent wildlife TTLs demonstrates that RBCs developed for human health would also be protective of aquatic-dependent wildlife. The available human TTLs for metals, PAHs, PCB, pentachlorophenol, and dioxin/furan TEQ are generally several orders of magnitude less than the aquatic dependent wildlife TTLs (for those chemicals where both are presented)[3], indicating that the sediment concentrations

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[3] The fluoranthene nearshore Endangered Species Act (ESA) aquatic-dependent wildlife TTL is slightly lower than the human TTL presented in the *Sediment Evaluation Framework for the Pacific Northwest* (RSET 2009). However, the RSET (2009) population-level aquatic dependent wildlife TTL is greater than the human TTL. Because individual ESA species are not receptors of concern at the I&J Waterway Site, the population-level TTLs are a more appropriate benchmark for comparison to the human health TTLs. Further, the aquatic-

corresponding to the human TTL would be inclusively protective of aquatic-dependent wildlife. While no aquatic life dependent cPAH TTL is available to compare to the human TTL, Ecology has not identified cPAH or benzo(a)pyrene (as a surrogate) as a chemical that may pose a risk to aquatic dependent receptors at levels lower than may present an unacceptable risk to human health (Ecology 2013b). Elevated concentrations of non-carcinogen PAH and other bioaccumulative chemicals collocated with cPAH in Site sediments will be addressed with remedies developed for cPAH. For these reasons, it is expected that the cPAH RBC developed for the human health RME seafood consumption scenario will also be protective of exposure of aquatic dependent wildlife foraging at the Site.

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dependent TTLs were based on mink, which is not present in the I&J Waterway Site. RSET (2009) also presents population-level TTLs for sea otter and harbor seal, two aquatic dependent wildlife species that have a greater potential to use the I&J Waterway Site. The RSET (2009) TTLs for otter and seal are greater than the mink TTL.

4 SCO DEVELOPMENT

For a given chemical, the SCO is determined based on the highest of the following:

- The lowest appropriate RBCs for protection of human health for the 1×10^{-6} ELCR threshold and/or a HQ of 1, benthic organisms (WAC 173-204-320 for SCO), or ecological receptors
- Background
- PQLs

4.1 Risk-based Levels

Carcinogenic ELCR and non-carcinogenic health effects were evaluated separately because of differences in assumptions about the mechanism of these toxic effects. The toxicity values used to evaluate exposure to chemicals with non-carcinogenic and carcinogenic effects are RfDs and the CPFs, respectively. All toxicity values were taken from the CLARC database (Ecology 2012) unless otherwise specified.

Carcinogenic chemicals are assumed to have no threshold for carcinogenicity. Carcinogenic risks are presented as the chance of contracting cancer over a 75-year lifetime due to Site-related exposure. These risks are considered by the U.S. Environmental Protection Agency (EPA) to be excess cancer risks that are in addition to the national rates of cancer for the general population. Carcinogenic-based sediment screening values were calculated using 1x10^{-6} cancer risk, consistent with SMS guidance for developing human health-based SCO.

Chemicals exhibiting non-carcinogenic health effects are considered threshold chemicals, indicating that a critical chemical dose must be exceeded before adverse health effects occur. The potential for non-carcinogenic health effects to occur from exposure to a chemical is represented by the ratio of the estimated chemical intake to the RfD, and is expressed as a HQ. Exposures resulting in a HQ less than or equal to 1 are unlikely to result in non-carcinogenic adverse health effects.

4.1.1 Seafood Consumption Risk Levels

The cPAH TEQ sediment RBC for the seafood consumption pathway was calculated using Equations 1 through 1.4 shown in the following paragraphs. The individual PAHs comprising the cPAH TEQ have unique biota sediment accumulation factors (BSAF) and relative potencies and are present in Site sediments in varying concentrations. To calculate a cPAH TEQ RBC for the Site, the default equation (Ecology 2013b) was re-arranged to first calculate the current total cPAH TEQ ELCR from the mean[4] individual cPAH concentrations. The current mean Site sediment concentrations were then multiplied by the target ELCR ($1\text{x}10^{-6}$ for the SCO) and divided by the current total cPAH TEQ ELCR. This resulted in individual PAH sediment values with ELCRs that sum to the target ELCR ($1\text{x}10^{-6}$). The protective sediment concentrations for the individual PAH were then adjusted by their respective TEFs and summed to express the protective sediment concentration in terms of cPAH TEQ.

Equation 1

$$RBC_{cPAH\ TEQ} = \sum_{a=1}^{g} \left[\left(\frac{Csed_a \times ELCR_{Target}}{ELCR_{cPAH\ TEQ}} \right) \times TEF_a \right]$$

Equation 1.1

$$ELCR_{cPAH\ TEQ} = \sum_{a=1}^{g} ELCR_a$$

Equation 1.2

$$ELCR_a = CPFo_a \times CDI_a$$

Equation 1.3

$$CDI_a = \sum_{k=1}^{m} \left(\frac{C_{a,k} \times FCR_k \times EF \times ED \times FDF_k \times SUF_k \times UCF}{AT_{cr} \times BW} \right)$$

Equation 1.4

$$C_{a,k} = SL_k \times BSAF_{a,k} \times CsedOC_a$$

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[4] The cPAH averages were calculated from all waterway samples with the exception of sample IJ12-11, which was located outside of the Site. The cPAH averages were calculated after first averaging parent and field duplicates. Average benzo(b)fluoranthene and benzo(k)fluoranthene concentrations were calculated from samples collected in 2005/2006.

Where:

AT_{cr} = Cancer averaging time (days)

$BSAF_{a,k}$ = Biota sediment accumulation factor of a^{th} individual cPAH for k^{th} seafood type (grams organic carbon [g-OC]/grams lipid [g-lipid])

BW = Body weight (kilograms [kg])

$C_{a,k}$ = Tissue concentration of at^{h} individual cPAH in k^{th} seafood type (milligrams per kilogram [mg/kg])

$Csed_{a}$ = Average Site concentration of a^{th} individual cPAH (mg/kg)

$CsedOC_{a}$ = Average Site organic carbon normalized concentration a^{th} individual cPAH (mg/kg-OC)

CDI_{a} = Chronic daily intake of a^{th} individual cPAH (mg/kg-day)

$CPFo_{a}$ = Oral cancer potency factor of a^{th} individual cPAH $(mg/kg\text{-}day)^{-1}$

$ELCR_{a}$ = Excess lifetime cancer risk for a^{th} individual cPAH (unitless)

$ELCR_{cPAH\ TEQ}$ = Current Site cPAH TEQ excess lifetime cancer risk (unitless)

$ELCR_{Target}$ = Target total excess lifetime cancer risk ($1x10^{-6}$, unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

FCR_{k} = Consumption rate of k^{th} seafood type (g/day)

FDF_{k} = Diet fraction of k^{th} seafood type (proportion)

$RBC_{cPAH\ TEQ}$ = Sediment cPAH TEQ risk-based concentration (mg/kg)

SL_{k} = Lipid fraction of k^{th} seafood type (gram per gram [g/g])

SUF_{k} = Site use factor of k^{th} seafood type (proportion)

TEF_{a} = Toxicity equivalency factor of a^{th} individual cPAH (unitless)

UCF = Conversion factor (0.001 kg/g)

Values for each of the listed parameters are presented in Table B-2a and B-2b. The cPAH TEQ RBC is presented in Table B-4.

4.1.1.1 Site-specific Parameters

The Site-specific parameters used in the seafood consumption risk equation are described below. The Ecology default values for all other parameters were used. All parameters used are included in Tables B-2a and B-2b.

4.1.1.1.1 Seafood Consumption Rates, Diet Fraction, and Site Use Factors

Fish and shellfish consumption rates for shellfish, crabs, and bottomfish were 38.5 grams per day (g/day), 23.4 g/day, 38.5 g/day, and 7.8 g/day, respectively, based on the 90th percentile rates from the Tulalip Tribe Seafood Consumption study and an average Tulalip tribal member adult body weight[5] of 81.8 kg (Toy et al. 1996) for use in developing the cPAH TEQ RBC. The consumption rates used for the I&J Waterway Site were 45 g/day for clam, 27.3 g/day for crabs, and 9.1 g/day for fish. Mobile crabs and bottomfish that could be potentially caught in I&J Waterway were assumed to have a 10-square kilometer (km^2) unconstrained home range. The I&J Waterway Site consists of 0.016-km^2 area, or 0.2% of the 10-km^2 home range. Crab and fish would therefore be expected to utilize I&J Waterway for only a small portion of the time, given the relatively small area of the Site compared to the home range. The RBC was developed for the Site using crab and fish site use factors (SUF) of 0.01 and the Ecology default diet fractions (DF) of 1.

I&J Waterway has a small beach (approximately 250 feet by 155 feet; -4 feet MLLW to the vegetated berm) at the head of the Waterway. While it is possible that the relatively small intertidal area could support a limited clam population, shellfish densities are low along the eastern shore of Bellingham Bay and geoduck do not occur in I&J Waterway (discussed in Section 3.2.2 of the RI). Because of the constrained clam habitat in I&J Waterway, a clam DF of 0.1 was used. Clams are sessile organisms and therefore a SUF of 1.0 was used.

4.1.1.1.2 Cancer Potency Factors

To be consistent with the MTCA cPAH TEQ approach, the individual cPAH CPFs were calculated by adjusting the benzo(a)pyrene CPF (7.3 $[mg/kg\text{-}day]^{-1}$) by the individual cPAH TEF. The cPAH-specific CPFs are included in Chart 1.

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[5] Weighted average of female and male adult tribal members.

Chart 1
Model Toxics Control Act cPAH Toxicity Equivalency Factor and Adjusted Cancer Potency Factor

Chemical	CAS Number	TEF	CPF (mg/kg-day)$^{-1}$
Benz[a]anthracene	56-55-3	0.1	0.73
Benzo[a]pyrene	50-32-8	1	7.3
Benzo[b]fluoranthene	205-99-2	0.1	0.73
Benzo[k]fluoranthene	207-08-9	0.1	0.73
Chrysene	218-01-9	0.01	0.073
Dibenz[a,h]anthracene	53-70-3	0.1	0.73
Indeno[1,2,3-cd]pyrene	193-39-5	0.1	0.73

Notes:
CPF = Cancer potency factor
mg/kg-day = milligrams per kilogram per day
TEF = toxic equivalency factor

4.1.1.1.3 Biota-Sediment Accumulation Factors

The extent of aquatic biota non-polar chemical bioaccumulation from sediment is typically expressed using BSAF. BSAF is the ratio between the concentration of a nonpolar organic chemical in the total extractable lipids of an organism (normalized to the lipid fraction), to the concentration in sediment normalized to the organic carbon content of sediment.

The BSAF that were used to model clam, crab, and bottomfish tissue concentrations were developed using BSAF data from the following two sources:

- EPA Office of Research and Development (ORD) BSAF database of synoptic tissue and sediment data from a subset of national Superfund sites
- USACE Environmental Research Development Center (ERDC) BSAF database (USACE 2013b) of literature-reported studies

Selection of records within these databases was based on the following guidelines:

- ERDC data must have variance estimate to be selected
- Basis must be known
- Conversion between wet or dry weight basis is assumed to be 80 percent tissue moisture or 60 percent sediment moisture content

The clam BSAF used for this analysis were derived from the clam and oyster species included in the databases, including hard clam (*Mercenaria mercenaria* and *Pitar morrhuana*), macoma clam (*Macoma nasuta*), venus clam (*Venerupis philippinarum*), asian clam (*Potamocorbula amurensis*), and eastern oyster (*Crossostrea virginica*). The brackish water clam (*Rangia cuneata*) BSAF were excluded due to potential data quality issues. An outlier evaluation was conducted using the distribution platform in JMP software. An outlier boxplot evaluation was conducted and outliers from both the high and low tails were identified. Outliers were removed from the dataset. The final dataset included 160 individual clam and oyster BSAF. The individual cPAH BSAF values were derived as the mean value from all clam and oyster species. Each final cPAH BSAF was based on the mean of a minimum of 11 individual values. Sufficient individual BSAF values for benzo(b)fluoranthene and benzo(k)fluoranthene were not available in the ORD or ERDC databases, so the evaluation of these BSAF values were selected on the basis of the organic carbon-water partitioning coefficient (Koc) values reported by EPA (2003). The cPAH compound with the closest matching Koc for benzo(b)fluoranthene and benzo(k)fluoranthene was benzo(a)pyrene. Therefore, the BSAF for these compounds were set equal to the BSAF for benzo(a)pyrene. The Koc and literature-derived BSAF are provided in Table B-2b.

The databases did not include whole-body BSAF for bottomfish species inhabiting Bellingham Bay. As an alternative, whole-body BSAF for other demersal fish were used, including brown bullhead (*Ictalurus nebulosus*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), and white sucker (*Catostomus commersoni*). An outlier evaluation was conducted using the distribution platform in JMP software. An outlier boxplot evaluation was conducted and outliers from both the high and low tails were identified. Outliers were removed from the dataset. The final dataset included 80 individual BSAF for cPAH. The individual cPAH chemical-specific BSAF values were derived as the mean value from all bottomfish specifies. Each final chemical BSAF was based on the mean of a minimum of 10 individual bottomfish values.

No Pacific crab species BSAF data were available from the databases. Limited (one to six BSAF per chemical) BSAF are available for other crustacean species, including crayfish and fiddler crab. Due to limited available data and potential data quality issues, these BSAF were not used. The individual cPAH BSAF developed for bottomfish were used as a surrogate. Similar to bottomfish, crabs have enzymes capable of metabolizing PAH; however, they metabolize PAH less efficiently than bottomfish (Stegeman and Lech 1991). A safety factor of 5 was applied to the bottomfish BSAF to account for this uncertainty.

4.1.1.1.4 Seafood Lipid Content

Lipid data for marine/estuarine mollusks, bottom feeding fish, and crab were obtained from the tissue lipid summary provided by the USACE Waterway Experiment Station (WES) BSAF database. The WES database summarizes lipid data for different species groups (e.g., bottom feeding fish, marine crustaceans, and marine mollusks). The lipid data selected were based on average whole-body wet weight measurements that were reviewed for data quality and designated as useable by WES. The average percent lipid content for marine/estuarine mollusks, marine crustaceans, and bottom feeding fish were 1.42, 2.45, and 3.84, respectively. These values were used for modeling clam, crab, and bottomfish tissue cPAH concentrations using Equation 1.4.

4.1.1.1.5 Sediment Fraction Organic Carbon

The sediment fraction organic carbon used was the mean of Site surface samples with the exception of sample IJ12-11, which was located outside of the Site. The Site mean was calculated after first averaging the parent and field duplicate samples. The Site mean fraction organic carbon was 0.028 g/g.

4.1.2 Incidental Ingestion and Dermal Contact Risk Levels

For the incidental ingestion and dermal contact pathways, Equations 2 and 3 (Ecology 2013b) were used to calculate the carcinogenic and non-carcinogenic sediment RBCs, respectively.

Equation 2

$$RBC_{cancer} = \left(\frac{CR \times BW \times AT_{cr}}{EF \times ED \times \left[\left(\frac{IR \times AB \times CPFo}{UCF} \right) + \left(\frac{SA \times AF \times ABS \times CPFd}{UCF} \right) \right]} \right)$$

Where:

AB = Gastrointestinal absorption fraction (unitless)

ABS = Dermal absorption fraction (unitless)

AF = Sediment to skin adherence factor (mg/kg^2-day)

AT_{cr} = Cancer averaging time (days)

BW = Body weight (kg)

CPFo = Oral cancer potency factor (mg/kg-day^{-1})

CPFd = Dermal cancer potency factor (mg/kg-day^{-1})

CR = Cancer risk (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

IR = Ingestion rate (mg/day)

RBC_{cancer} = Risk-based concentration for carcinogenic mechanism of toxicity (mg/kg)

SA = Dermal surface area (square centimeter [cm^2])

UCF = Conversion factor (1,000,000 mg/kg)

Equation 3

$$RBC_{Noncancer} = \left(\frac{HQ \times BW \times AT_{nc}}{EF \times ED \times \left[\left(\left(\frac{1}{RfDo} \right) \times \left(\frac{IR \times AB}{UCF} \right) \right) + \left(\left(\frac{1}{RfDd} \right) \times \left(\frac{SA \times AF \times ABS}{UCF} \right) \right) \right]} \right)$$

Where:

AB = Gastrointestinal absorption fraction (unitless)

ABS = Dermal absorption fraction (unitless)

AF = Sediment to skin adherence factor (mg/kg^2-day)

AT_{nc} = Noncancer averaging time (days)

BW = Body weight (kg)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

HQ = Hazard Quotient (1 unitless)

IR = Ingestion rate (mg/day)

$RBC_{noncancer}$ = Risk-based concentration for non-carcinogenic mechanism of toxicity (mg/kg)

RfDd = Dermal reference dose (mg/kg-day)

RfDo = Oral reference dose (mg/kg-day)

SA = Dermal surface area (cm^2)

UCF = Conversion factor (1,000,000 mg/kg)

Values for each of the listed parameters are presented in Table B-3. The benzo(a)pyrene and 2,3,7,8- tetrachlorodibenzodioxin (TCDD) CPFs were used to calculate the direct contact and incidental ingestion RBCs for cPAH TEQ and total dioxin/furan TEQ, respectively. The SCO RBCs are presented in Table B-4.

4.1.2.1 Site-specific Parameters

The Site-specific parameter used in the incidental ingestion and dermal contact risk equations is described below. The Ecology default values were used for the other parameters. All parameters used are included in Table B-3.

4.1.2.1.1 Clamming Exposure Frequency

Section 4.1.1.1.1 above describes the Site habitat limitations prohibiting a clam diet fraction equivalent to the Ecology default value of 1. For the seafood consumption exposure pathway, it was estimated that the I&J Waterway beach could potentially support approximately 0.1 of the clam diet fraction (28.4 g/day, 365 days/year). For the dermal contact and incidental ingestion adult clamming scenario, this assumption was converted to terms of days per year (i.e., the Site could support a clam diet fraction of 1, 36.5 days of the year). This value was conservatively adjusted by two with the assumption that an adult clammer could potentially collect half of their daily take on any given day. A Site-specific exposure frequency of 74 days/year was used for the clamming exposure pathway.

4.2 PQL

SMS allows consideration of the PQL in establishing the SCLs when a COC concentration determined to be protective cannot be reliably detected using state-of-the-art currently available analytical instruments and methods (WAC 173-204-505(15)). In simpler terms, the

PQL is the minimum concentration for an analyte that can be reported with a high degree of certainty. If natural background or the risk-based SCO is below the concentration at which a contaminant can be reliably quantified, then the SCO for that contaminant may default to the analytical PQL. MTCA defines the PQL as the following:

> *…the lowest concentration that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using department approved methods (WAC 173-340-200).*

Table B-4 includes the specific PQLs. These PQLs are based on specific reporting limits at the I&J Waterway Site and recommended PQLs in the SCUM II guidance (Ecology 2013b).

4.3 Natural Background

Natural background values were adopted from the SCUM II Table 11-1 (Ecology 2013b). These natural background concentrations were derived as the 90/90 upper tolerance limit (UTL) of the Dredged Material Management Program (DMMP) OSV Bold Survey data (DMMP 2009) and additional datasets selected by Ecology (collectively referred to as the "BOLD Plus" dataset; Ecology 2013b). Natural background concentrations are included in Table B-4.

5 CSL DEVELOPMENT

For a given chemical, the CSL is based on the highest of the following:

- The lowest appropriate RBCs for protection of human health corresponding to a 1×10^{-5} ELCR threshold and/or a HQ of 1, benthic organisms (WAC 173-204-562 for CSL), or ecological receptors
- Regional background
- PQLs

5.1 Risk-based Levels

The methods for developing human health CSL RBC were similar to methods used to calculate SCO RBCs as described in Section 4, with the exception that a target cancer risk of $1x10^{-5}$ is used for carcinogenic chemicals instead of $1x10^{-6}$. A HQ of 1 is used for development of both the SCO and CSL RBC, and the RBCs for non-carcinogens will therefore be the same for the SCO and CSL. The CSL RBCs are included in Table B-4.

5.2 PQL

The PQLs are described in Section 4.3. The PQLs are the same for the development of both the SCO and CSL.

5.3 Preliminary Regional Background

Ecology recognizes that natural and man-made hazardous substance concentrations can occur at a site in excess of natural background concentrations but are not the result of controllable local Site-related releases. The SMS defines the term "regional background" as concentrations that are consistently present in the environment in the vicinity of a site that are attributable to "diffuse nonpoint sources, such as atmospheric deposition or storm water, not attributable to a specific source or release." SMS allows upward adjustment of cleanup levels to regional background.

Regional background concentrations have not yet been developed for Bellingham Bay by Ecology. For the purposes of this evaluation, preliminary regional background values were developed from data available in Ecology's Environmental Information Management (EIM) database for cPAH TEQs and dioxin/furan TEQs. The MTCA TEFs and one-half the detection limit for undetected chemicals were used for calculating the TEQs.

EIM was queried for all sediment data available for Bellingham Bay. Consistent with Ecology's guidance on temporal relevancy of environmental data, samples collected before 2003 (older than 10 years) were excluded from the dataset. Only samples collected from within the top 0- to 1-foot interval, and further than 1,000 feet from the shoreline, were retained in the dataset. The cPAH TEQs were calculated for only those samples with all cPAH reported. Lab replicates and field duplicates (in that order) were averaged prior to derivation of the background concentration. Following methods described in SCUM II (Ecology 2013b), regional background values were calculated as the 90/90 UTL using ProUCL version 5 software (EPA 2013). Both the cPAH TEQ and dioxin/furan TEQ datasets approximated a normal distribution at a 5% significance level and the normal distribution background statistic was used as the regional background concentration. Tables B-5 and B-6 include the samples used to calculate the cPAH TEQ and dioxin/furan TEQ regional background values, respectively. Figures B-1 and B-2 show the cPAH TEQ and dioxin/furan TEQ sample locations, respectively. Chart 2 includes the preliminary regional background values.

Chart 2

Bellingham Bay Preliminary Regional Background

Chemical	Number of Samples	Preliminary Regional Background (dry weight)	Statistic
cPAH TEQ	38	70 µg/kg	normal distribution 90/90 UTL
Dioxin/Furan TEQ	35	16 ng/kg	normal distribution 90/90 UTL

Notes:
µg/kg = microgram per kilogram
cPAH = carcinogenic polycyclic aromatic hydrocarbons
ng/kg = nanogram per kilogram
TEQ = toxic equivalents quotient
90/90 UTL = 90/90 Upper Tolerance Limit

6 SUMMARY

The human health RBC and background concentrations derived following methods described in this Appendix have been included in the development of the SCO and CSL for the I&J Waterway Site. The human health RBCs, natural and regional background values, and PQLs are included in Table B-4. These values are referenced in Section 4 of the RI in the screening of Site sediments and determination of Site COCs.

7 REFERENCES

CalEPA, 2005. Air Toxics Hot Spots Program Risk Assessment Guidelines, Part II Technical Support Document for Describing Available Cancer Potency Factors. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. May 2005.

DMMP (Dredged Material Management Program), 2009. OSV Bold Summer 2008 Survey. Data Report. The Dredged Material Management Program (DMMP) Agencies: U.S. Army Corps of Engineers, Seattle District, Seattle, Washington; U.S. Environmental Protection Agency, Region 10, Seattle, Washington; Washington State Department of Natural Resources; and Washington State Department of Ecology, Olympia, Washington. June 2009.

Ecology (Washington State Department of Ecology), 2012. CLARC database.

Ecology, 2013a. Sediment Management Standards - Chapter 173-204 WAC. Final Rule. Washington State Department of Ecology. February 22, 2013.

Ecology, 2013b. Draft Sediment Cleanup Users Manual II. Guidance for Implementing the Sediment Management Standards, Chapter 173-204 WAC. Publication No. 12-09-057. December.

EPA (U.S. Environmental Protection Agency), 2013. ProUCL version 5.0. Available from: http://www.epa.gov/osp/hstl/tsc/software.htm#Documentation.

ODEQ (Oregon Department of Environmental Quality), 2007. Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment. 07-LQ-023A. April.

RSET (Regional Sediment Evaluation Team), 2009. Sediment Evaluation Framework for the Pacific Northwest. May.

Stegeman, J.J., Lech, J.J., 1991. Cytochrome P-450 monooxygenase systems in aquatic species: carcinogen metabolism and biomarkers for carcinogen and pollutant exposure. Environmental Health Perspectives; 90: 101-109.

USACE, 2013b. BSAF Database. Prepared by the Engineering Research and Development Center (ERDC). http://el.erdc.usace.army.mil/bsafnew/BSAF.html. Last accessed April 23, 2013.

TABLES

Table B-1
Human and Wildlife Target Tissue Levels (mg/kg wet weight)

	SCUM II[c]		Sediment Evaluation Framework for the Pacific Northwest [d]			Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment[e]				
Bioaccumulative Chemical	**Aquatic-dependent Wildlife**	**Human**	**Nearshore ESA Aquatic-dependent Wildlife**	**Nearshore Population Aquatic-dependent Wildlife**	**Human Health[a]**	**Bird Individuals**	**Bird Populations**	**Mammals Individuals**	**Mammal Population**	**Human Health[b]**
Metals										
Arsenic	2.7	0.00012	2.7	14	0.00008	13	64	7.6	38	0.00076
Cadmium		0.162				8.4	42	5.6	28	0.49
Chromium										
Copper										
Lead	2		2	10		9.3	46	34	170	0.5
Mercury	0.02		0.02	0.03	0.012	0.074	0.15	0.12	0.2	0.049
Nickel										
Silver										
Zinc										
PAH										
2-Methylnaphthalene										
Acenaphthene										
Acenaphthylene										
Anthracene										
Benz(a)anthracene										
Benzo(a)pyrene										
Benzo(g,h,i)perylene										
Benzo[b]fluoranthene										
Benzo[k]fluoranthene										
Benzofluoranthenes (total)										
Chrysene										
Dibenzo(a,h)anthracene										
Fluoranthene	3.8	0.00433	3.8	19	4.8			190	950	20
Fluorene	410	0.00433	410	2,000	4.8					
Indeno(1,2,3-cd)pyrene										
Naphthalene										
Phenanthrene										
Pyrene	3.8	0.00577	3.8	19	3.6			9,500	47,000	15
cPAH TEQ		2.4E-05								
PCB										
Total Aroclors	0.04	8.7E-05	0.04	0.18	0.00006	1.1	3.4	0.88	1.7	0.00057
Phenols										
Pentachlorophenol	8.1	0.00577	8.1	41	0.001			0.18	1.8	0.0096
Dioxin/furans										
Dioxin/furan TEQ	5.00E-07	1.2E-09	5.00E-07	8.50E-06	9.20E-10	8.00E-06	4.00E-05	5.80E-07	1.60E-05	7.60E-09

Notes:

a. TTL3 protective of high-end tribal consumption
b. Lower of carcinogen or non-carcinogen Subsistance Tribal
c. Ecology 2013b
d. RSET 2009
e. ODEQ 2007

ESA = Endangered Species Act
cPAH = carcinogenic polycyclic aromatic hydrocarbon
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyls
SCUM II = Sediment Cleanup Users Manual II
TEQ = toxic equivalents quotient

Table B-2a
Seafood Consumption RBC Equation Parameters

Parameter Abbreviation	Parameter Name	Value	Units	Source
$AT_{C(FC)}$	Averaging Time Carcinogen (fish consumption)	27,375	days	Ecology 2013b default
BSAF	Biota-Sediment Accumulation Factor	See Table B-2b	g-OC/g-lipid	ORD and ERDC databases (see Section 4.1.1.1.3)
$BW_{Adult-FC}$	Body Weight Adult (fish consumption)	81.8	kg	Weighted average (male and female) Tulalip adult body weight (Toy et al., 1996)
CPFo	Cancer Potency Factor (oral)	See Table B-2b	$mg/kg\text{-}day^{-1}$	CLARC (see Section 4.1.1.1.2)
CR	Cancer Risk for Individual Carcinogens	1.00E-06	unitless	Ecology 2013b default
ED_{FC}	Exposure Duration Fish Consumption	70	years	Ecology 2013b default
EF_{FC}	Exposure Frequency Fish Consumption	365	days/year	Ecology 2013b default
$FCR_{(clam)}$	Fish/Shellfish Consumption Rate (clam)	45	grams/day	Whatcom Waterway RI (Hart Crowser 2000) consumption rate adjusted for an 81.8 kg adult
$FCR_{(crab)}$	Fish/Shellfish Consumption Rate (crab)	27.3	grams/day	Whatcom Waterway RI (Hart Crowser 2000) consumption rate adjusted for an 81.8 kg adult
$FCR_{(fish)}$	Fish/Shellfish Consumption Rate (fish)	9.1	grams/day	Whatcom Waterway RI (Hart Crowser 2000) consumption rate adjusted for an 81.8 kg adult
$FDF_{(clam)}$	Fish/Shellfish Diet Fraction (clam)	0.1	proportion	Site specific - limited intertidal clam habitat (see Section 4.1.1.1.1)
$FDF_{(crab)}$	Fish/Shellfish Diet Fraction (crab)	1	proportion	Ecology 2013b default
$FDF_{(fish)}$	Fish/Shellfish Diet Fraction (fish)	1	proportion	Ecology 2013b default
$SUF_{(clam)}$	Site Use Factor (clam)	1	proportion	SCUM II Table 9-1 (Ecology policy, may be adjsuted based on site-specific data)
$SUF_{(crab)}$	Site Use Factor (crab)	0.01	proportion	Site specific. Based on the Site Area (0.016 km^2). Rounded up to 0.01 proportion of 10 km^2 home range.
$SUF_{(fish)}$	Site Use Factor (fish)	0.01	proportion	Site specific. Based on the Site Area (0.016 km^2). Rounded up to 0.01 proportion of 10 km^2 home range.
Sfoc	Fraction of Organic Carbon in Sediment	0.028	gram/gram	Average of site surface samples (excluding IJ12-11). Field Duplicates averaged before calculating site average

Table B-2a
Seafood Consumption RBC Equation Parameters

Parameter Abbreviation	Parameter Name	Value	Units	Source
$SL_{(clam)}$	Fish/Shellfish Lipid Fraction (clam)	0.01419	gram/gram	WES (see Section 4.1.1.1.4)
$SL_{(crab)}$	Fish/Shellfish Lipid Fraction (crab)	0.02447	gram/gram	WES (see Section 4.1.1.1.4)
$SL_{(fish)}$	Fish/Shellfish Lipid Fraction (fish)	0.0384	gram/gram	WES (see Section 4.1.1.1.4)
$UCF_{(CDI\text{-}calculation)}$	Unit Conversion Factor	0.001	kg/gram	

Notes:

CLARC = Cleanup Levels and Risk Calculations

ERDC = USACE Environmental Research Development Center

g = gram

kg = kilogram

kg/g = kilogram per gram

km^2 = square kilometer

mg/kg = milligram per kilogram

OC = organic carbon

ORD = EPA Office of Research and Development

RBC = risk-based concentration

RI = Remedial Investigation

SCUM II = Sediment Cleanup Users Manual II

WES = Waterway Experiment Station

Table B-2b
Seafood Consumption cPAH RBC Chemical-specific Parameters

Chemical	CAS number	TEF	CPF (mg/kg-day)$^{-1}$	Log10 Koc[a]	Clam BSAF (g-OC/g lipid)	Crab BSAF (g-OC/g lipid)	Bottomfish BSAF (g-OC/g lipid)	Average I&J Waterway Surface Sediment (Csed) (mg/kg)
Benz(a)anthracene	56-55-3	0.1	0.73	5.577	0.1727	0.0061	0.0012	0.421
Benzo(a)pyrene	50-32-8	1	7.3	6.003	0.0771	0.0048	0.0010	0.289
Benzo(b)fluoranthene	205-99-2	0.1	0.73	6.16	0.0771	0.0061	0.0012	0.428
Benzo(k)fluoranthene	207-08-9	0.1	0.73	6.184	0.0771	0.0056	0.0011	0.383
Chrysene	218-01-9	0.01	0.073	5.616	0.2651	0.0075	0.0015	0.735
Dibenz(a,h)anthracene	53-70-3	0.1	0.73	6.599	0.0297	0.0065	0.0013	0.065
Indeno(1,2,3-cd)pyrene	193-39-5	0.1	0.73	6.608	0.0421	0.0055	0.0011	0.116

Notes:

a. EPA (2003; Table 3-4). Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures. EPA-600-R-02-013.

BSAF = biota-sediment accumulation factors

cPAH = carcinogenic polycyclic aromatic hydrocarbon

CPF = cancer potency factor

g = gram

Koc = organic carbon - water partitioning coefficient

mg/kg = milligram per kilogram

OC = organic carbon

RBC = risk-based concentration

TEF = toxic equivalency factor

Table B-3
Direct Contact RBC Equation Parameters

Parameter Abbreviation	Parameter Name	Value	Units	Source
AB	Gastrointestinal Absorption Fraction (soil)	1 0.6 for mixtures of dioxins/furans	unitless	Ecology 2013b defaults (WAC 173-340-735 ((Equation 745-5))
ABS	Dermal Absorption Fraction	0.01 for inorganic hazardous substances 0.03 for dioxins/furans 0.1 for other organic hazardous substances	unitless	Ecology 2013b defaults (WAC 173-340-735 ((Equation 745-5))
AF_{Child}	Sediment to Skin Adherence Factor Child	0.2	mg/cm^2-day	Ecology 2013b default
$AF_{Adult\ (CD)}$	Sediment to Skin Adherence Factor Adult Clam Digging	0.6	mg/cm^2-day	Ecology 2013b default
$AT_{C(Inc+Derm)}$	Averaging Time Cancer (incidental ingestion and dermal contact) Child or Adult	27,375	days	Ecology 2013b default
$AT_{NC(Inc+Derm)\ Adult(CD)}$	Averaging Time Non-cancer (incidental ingestion and dermal contact) Adult Clam Digging	25,550	days	Based on a 70-year exposure duration
$AT_{NC(Inc+Derm)\ Child}$	Averaging Time Non-cancer (incidental ingestion and dermal contact) Child	2,190	days	Ecology 2013b default
BW_{Child}	Body weight Child	16	kg	Ecology 2013b default
$BW_{Adult-CD}$	Body weight Adult (clam digging)	70	kg	Ecology 2013b default
CPFd	Cancer Potency Factor (dermal)	chemical specific	mg/kg-day^{-1}	Calculated (CPFo/GI)
CPFo	Cancer Potency Factor (oral)	chemical specific	mg/kg-day^{-1}	CLARC Database
CR	Cancer Risk for individual carcinogens	1.00E-06	unitless	Ecology 2013b default
$ED_{(Inc+Derm)Adult(CD)}$	Exposure Duration (incidental ingestion and dermal contact) Adult Clam Digging	70	years	Ecology 2013b default
$ED_{(Inc+Derm)Child}$	Exposure Duration (incidental ingestion and dermal contact) Child	6	years	Ecology 2013b default
$EF_{(Inc+Derm)Adult\ (CD)}$	Exposure Frequency (incidental ingestion and dermal contact) Adult Clam Digging	74	days/year	I&J Site-specific value based on limited clam habitat (see Section 4.1.2.1.1)
$EF_{(Inc+Derm)Child}$	Exposure Frequency (incidental ingestion and dermal contact) Child	41	days/year	Ecology 2013b default
GI	Gastrointestinal Absorption Fraction	0.2 for inorganic hazardous substances 0.8 for dioxins/furans 0.5 for other organic hazardous substances	unitless	Ecology 2013b defaults (WAC 173-340-745 (Equation 745-5))
HQ	Hazard Quotient	1	unitless	Ecology 2013b default
$IR_{Adult\ (CD)}$	Ingestion Rate (Sediment) Adult Clam Digging	100	mg/day	Ecology 2013b default
IR_{Child}	Ingestion Rate (Sediment) Child	200	mg/day	Ecology 2013b default
RfDd	Reference Dose (dermal)	chemical specific	mg/kg-day	Calculated (RfDo*GI)
RfDo	Reference Dose (oral)	chemical specific	mg/kg-day	CLARC Database[a]
SA_{Adult}	Dermal Surface Area Adult	3,160	cm^2	Ecology 2013b default
SA_{Child}	Dermal Surface Area Child	2,200	cm^2	Ecology 2013b default
$UCF_{(Inc+Derm)}$	Unit Conversion Factor (incidental ingestion and dermal contact)	1,000,000	mg/kg	Ecology 2013b default

Notes:

a. The dioxin/furan RfDo is from the EPA Integrated Risk Information System.
http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=1024

CLARC = Cleanup Levels and Risk Calculations

cm^2 = square centimeter

kg = kilogram

mg/day = milligram per day

mg/cm^2-day = milligram per square centimeter per day

mg/kg-day = milligram per kilogram per day

WAC = Washington Administrative Code

Table B-4
Human Health Risk-Based SCO and CSL

Analyte	CAS Number	Protection of Human Health								Natural Background[d] (mg/kg-dw)	Regional Background (Bellingham Bay) (mg/kg-dw)	Applicable PQL[a] (mg/kg-dw)
		Via Seafood Consumption (bioaccumulative chemicals)		Via Direct Contact								
				Clamming (Adult) (mg/kg-dw)			Beach Play (Child) (mg/kg-dw)					
		Carcinogenic		Carcinogenic		Non-carcinogenic	Carcinogenic		Non-carcinogenic			
		10-6, SCO_{HH}	10-5, SCO_{HH}	10-6, SCO_{HH}	10-5, SCO_{HH}	HQ=1, SCO_{HH} and CSL_{HH}	10-6, SCO_{HH}	10-5, SCO_{HH}	HQ=1, SCO_{HH} and CSL_{HH}	SCO_{NB}	CSL_{RB}	SCO_{PQL} and CSL_{PQL}
Metals												
Arsenic	7440-38-2	--	--	1.3	13	530	5.3	53	190	11	--	20
Cadmium	7440-43-9	--	--	--	--	1,800	--	--	640	1	--	1.7
Chromium	16065-83-1	--	--	--	--	--[c]	--	--	960,000	62	--	87
Copper	7440-50-8	--	--	--	--	71,000	--	--	26,000	44	--	130
Lead	7439-92-1	--	--	--	--	--	--	--	--	21	--	150
Mercury	7439-97-6	--	--	--	--	530	--	--	190	0.2	--	0.14
Nickle	7440-02-0	--	--	--	--	35,000	--	--	13,000	50		47
Silver	7440-22-4	--	--	--	--	8,900	--	--	3,200	0.3	--	2
Zinc	7440-66-6	--	--	--	--	530,000	--	--	190,000	93	--	137
Polycyclic Aromatic Hydrocarbons												
2-Methylnaphthalene	91-57-6	--	--	--	--	2,900	--	--	2,000	--	--	0.223
Acenaphthene	83-32-9	--	--	--	--	43,000	--	--	30,000	--	--	0.167
Acenaphthylene	208-96-8	--	--	--	--	--	--	--	--	--	--	0.433
Anthracene	120-12-7	--	--	--	--	220,000	--	--	150,000	--	--	0.32
Benz(a)anthracene	56-55-3	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	0.433
Benzo(a)pyrene	50-32-8	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	0.533
Benzo(g,h,i)perylene	191-24-2	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	0.223
Benzo[b]fluoranthene	205-99-2	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	--
Benzo[k]fluoranthene	207-08-9	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	--
Benzofluoranthenes (total)		--[b]	--[b]	--[b]	--[b]	--	--	--	--	--	--	1.067
Chrysene	218-01-9	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	0.467
Dibenzo(a,h)anthracene	53-70-3	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	0.077
Fluoranthene	206-44-0	--	--	--	--	29,000	--	--	20,000	--	--	0.567
Fluorene	86-73-7	--	--	--	--	29,000	--	--	20,000	--	--	0.18
Indeno(1,2,3-cd)pyrene	193-39-5	--[b]	--[b]	--[b]	--[b]	--	--[b]	--[b]	--	--	--	0.2
Naphthalene	91-20-3	--	--	--	--	14,000	--	--	9,900	--	--	0.7
Phenanthrene	85-01-8	--	--	--	--	--	--	--	--	--	--	0.5
Pyrene	129-00-0	--	--	--	--	22,000	--	--	15,000	--	--	0.867
Total HPAH		--	--	--	--	--	--	--	--	--	--	--
Total LPAH		--	--	--	--	--	--	--	--	--	--	--
cPAH TEQ (U=1/2)	cPAH TEQ	0.061	0.61	0.11	1.1	--	0.85	8.5	--	0.016	0.070	0.009
Other SVOCs mg/kg												
1,2,4-Trichlorobenzene	120-82-1	--	--	27	270	7,200	210	2,100	4,900	--	--	0.031
1,2-Dichlorobenzene	95-50-1	--	--	--	--	65,000	--	--	45,000	--	--	0.035
1,4-Dichlorobenzene	106-46-7	--	--	--	--	--	--	--	--	--	--	0.037

Table B-4
Human Health Risk-Based SCO and CSL

		Protection of Human Health										
		Via Seafood Consumption (bioaccumulative chemicals)		Via Direct Contact						Natural Background[d] (mg/kg-dw)	Regional Background (Bellingham Bay) (mg/kg-dw)	Applicable PQL[a] (mg/kg-dw)
				Clamming (Adult) (mg/kg-dw)			Beach Play (Child) (mg/kg-dw)					
		Carcinogenic		Carcinogenic		Non-carcinogenic	Carcinogenic		Non-carcinogenic			
Analyte	**CAS Number**	10-6, SCO$_{HH}$	10-5, SCO$_{HH}$	10-6, SCO$_{HH}$	10-5, SCO$_{HH}$	HQ=1, SCO$_{HH}$ and CSL$_{HH}$	10-6, SCO$_{HH}$	10-5, SCO$_{HH}$	HQ=1, SCO$_{HH}$ and CSL$_{HH}$	SCO$_{NB}$	CSL$_{RB}$	SCO$_{PQL}$ and CSL$_{PQL}$
2,4-Dimethylphenol	105-67-9	--	--	--	--	14,000	--	--	9,900	--	--	0.029
2-Methylphenol	95-48-7	--	--	--	--	36,000	--	--	25,000	--	--	0.063
4-Methylphenol	106-44-5	--	--	--	--	3,600	--	--	2,500		--	0.223
Benzoic Acid	65-85-0	--	--	--	--	--[c]	--	--	--[c]	--	--	0.217
Benzyl alcohol	100-51-6	--	--	--	--	72,000	--	--	49,000	--	--	0.057
Bis(2-ethylhexyl)phthalate	117-81-7	--	--	55	550	14,000	440	4,400	9,900	--	--	0.433
Butyl benzyl phthalate	85-68-7	--	--	410	4,100	140,000	3,300	33,000	99,000	--	--	0.021
Dibenzofuran	132-64-9	--	--	--	--	720	--	--	490	--	--	0.18
Diethylphthalate	84-66-2	--	--	--	--	580,000	--	--	400,000	--	--	0.067
Dimethyl phthalate	131-11-3	--	--	--	--	--	--	--	--	--	--	0.024
Di-n-butyl phthalate	84-74-2	--	--	--	--	72,000	--	--	49,000	--	--	0.467
Di-n-octyl phthalate	117-84-0	--	--	--	--	--	--	--	--	--	--	2.067
Hexachlorobenzene	118-74-1	--	--	0.48	4.8	580	3.9	39	400	--	--	0.022
Hexachlorobutadiene	87-68-3	--	--	9.9	99	720	79	790	490	--	--	0.011
N-Nitrosodiphenylamine	86-30-6	--	--	160	1600	--	1,300	13,000	--	--	--	0.028
Pentachlorophenol	87-86-5	--	--	1.9	19	3,600	15	150	2,500	--	--	0.12
Phenol	108-95-2	--	--	--	--	220,000	--	--	150,000		--	0.14
Polychlorinated Biphenyls												
Total PCBs	1336-36-3	--	--	0.39	3.9	--	3.1	31	--	0.0035	--	0.006
Dioxins/Furans												
Total Dioxin/Furan TEQ (U=1/2)	1746-01-6	--	--	0.000019	0.00019	0.0018	0.000087	0.00087	0.00073	0.000004	0.000016	0.000005

Notes:

a. PQLs are based on specific reporting limits at the I&J Waterway Site and recommended PQLs in the SCUM II Guidance (Ecology 2012)

b. Evaluated as cPAH TEQ

c. RBC is greater than 1,000,000 mg/kg

d. Natural Background values are from SCUM II Table 11-1 (Ecology 2013b)

cPAH = carcinogenic polycyclic aromatic hydrocarbon

CSL = Cleanup Screening Level

HPAH = high-molecular-weight polycyclic aromatic hydrocarbon

HQ = hazard quotient

LPAH = low-molecular-weight polycyclic aromatic hydrocarbon

mg/kg-dw = milligram per kilogram dry weight

PCB = polychlorinated biphenyls

PQL = practical quantitation limit

SCO = Sediment Cleanup Objective

SVOC = semi-volatile organic compound

TEQ = toxic equivalents quotient

Table B-5

Selected Surface Sediment Samples Used to Calculate Bellingham Bay cPAH TEQ Regional Background[e]

Study ID	Study Name	X Coordinate	Y Coordinate	Coordinate Type	Sample Name	Field Replicates	Matrix	Sample Date	Start Depth	End Depth	Sample Depth Units	Chemical Name	Result Numeric	Qualifier[f]	Result Units	Basis
NCCA	National Coastal Condition Assessment	1208178.31586	635920.63593	LAT/LONG	WA05-0003-1/25/2007	1	Solid/Sediment	8/1/2006	0	7	cm	Total cPAH TEQ (U = 1/2)	3.46		µg/kg	Dry
PSAMP_LT	The Puget Sound Assessment and Monitoring Program’s Long-Term Temporal Monitoring 1989-Present	1228592.99959	618845.45308	LAT/LONG	1004041-0(4_5_6_fD)[a]	3	Solid/Sediment	4/22/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	34.06	J	µg/kg	Dry
PSAMP_LT	The Puget Sound Assessment and Monitoring Program’s Long-Term Temporal Monitoring 1989-Present	1228592.99959	618845.45308	LAT/LONG	517425(4_5_6_AV)[b]	3	Solid/Sediment	4/21/2005	0	3	cm	Total cPAH TEQ (U = 1/2)	51.35		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1221555.57443	621292.65355	LAT/LONG	6234230	1	Solid/Sediment	6/5/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	33.85		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1226612.72713	625786.59238	LAT/LONG	6234231	1	Solid/Sediment	6/5/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	39.2		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1226901.24173	628525.90609	LAT/LONG	6234232	1	Solid/Sediment	6/5/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	44.23		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1222173.62194	633727.31806	LAT/LONG	6234235	1	Solid/Sediment	6/5/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	41.24		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1227079.83873	637828.80908	LAT/LONG	6234236	1	Solid/Sediment	6/5/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	40.24		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1232752.18758	621121.76373	LAT/LONG	6234241	1	Solid/Sediment	6/6/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	60.96		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1216210.62327	638992.87311	LAT/LONG	6234243	1	Solid/Sediment	6/7/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	19.26		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1222032.89248	640949.65947	LAT/LONG	6234244	1	Solid/Sediment	6/7/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	15.4		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1229684.49980	644147.50807	LAT/LONG	6234245	1	Solid/Sediment	6/7/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	11.16		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1237047.49542	639418.18726	LAT/LONG	6234246	1	Solid/Sediment	6/7/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	71.31		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1237440.93620	642865.54214	LAT/LONG	6234247	1	Solid/Sediment	6/7/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	24.32		µg/kg	Dry
PSAMP_SP	The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present	1216133.90813	634367.20312	LAT/LONG	6234248	1	Solid/Sediment	6/7/2006	0	3	cm	Total cPAH TEQ (U = 1/2)	23.44		µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1212373.65875	638849.19984	LAT/LONG	1006020-01	1	Solid/Sediment	6/8/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	3.20	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1212015.11548	640780.71225	LAT/LONG	1006020-02_B10G016-DUP1[c]	2	Solid/Sediment	6/8/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	5.71	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1228692.34547	645979.57425	LAT/LONG	1006020-03	1	Solid/Sediment	6/10/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	1.59	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1235269.41124	643313.14275	LAT/LONG	1006020-04	1	Solid/Sediment	6/14/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	17.94		µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1235160.90503	644311.77904	LAT/LONG	1006020-06	1	Solid/Sediment	6/15/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	28.1	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1237389.40795	642037.17099	LAT/LONG	1006020-07	1	Solid/Sediment	6/15/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	43.62	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1237985.96609	641724.98503	LAT/LONG	1006020-08	1	Solid/Sediment	6/15/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	42.85	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1234564.35212	638657.41075	LAT/LONG	1006020-10	1	Solid/Sediment	6/9/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	45.06	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1235523.11231	636687.74761	LAT/LONG	1006020-11	1	Solid/Sediment	6/9/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	92.57	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1234340.83350	634396.25684	LAT/LONG	1006020-12	1	Solid/Sediment	6/9/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	97.61	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1227223.26774	633848.93545	LAT/LONG	1006020-13	1	Solid/Sediment	6/10/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	43.04	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1227102.26399	630906.62394	LAT/LONG	1006020-14	1	Solid/Sediment	6/9/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	36.21	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1222022.85501	630217.49058	LAT/LONG	1006020-15	1	Solid/Sediment	6/8/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	32.95	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1229614.78799	644148.68589	LAT/LONG	1006020-16	1	Solid/Sediment	6/11/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	9.31	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1237098.90894	637773.78860	LAT/LONG	1006020-20	1	Solid/Sediment	6/10/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	64.00	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1222032.89248	640949.65947	LAT/LONG	1006020-21	1	Solid/Sediment	6/9/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	8.70	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1237047.49542	639418.18726	LAT/LONG	1006020-22	1	Solid/Sediment	6/11/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	48.11	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1222173.62194	633727.31806	LAT/LONG	1006020-24	1	Solid/Sediment	6/8/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	31.12	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1216133.90813	634367.20312	LAT/LONG	1006020-25	1	Solid/Sediment	6/8/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	16.98	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1227079.83873	637828.80908	LAT/LONG	1006020-26_B10H104-DUP1[d]	2	Solid/Sediment	6/9/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	28.18	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1216210.62327	638992.87311	LAT/LONG	1006020-27	1	Solid/Sediment	6/8/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	9.49	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1237440.93620	642865.54214	LAT/LONG	1006020-29	1	Solid/Sediment	6/15/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	34.34	J	µg/kg	Dry
UWI2010	Urban Waters Initiative, Sediment Quality in Bellingham Bay	1234440.66324	643949.81231	LAT/LONG	1006020-30	1	Solid/Sediment	6/15/2010	0	3	cm	Total cPAH TEQ (U = 1/2)	14.47	J	µg/kg	Dry

Notes:

a. Sample name assigned by Anchor QEA. Result is the average of apparent field duplicate samples 1004041-04, 1004041-05, and 1004041-06.

b. Sample name assigned by Anchor QEA. Result is the average of apparent field duplicate samples 5174254, 5174255, and 5174256.

c. Sample name assigned by Anchor QEA. Result is the average of apparent field duplicate samples 1006020-02 and B10G016-DUP1.

d. Sample name assigned by Anchor QEA. Result is the average of apparent field duplicate samples 1006020-26 and B10H104-DUP1.

e. The normal distribution 90/90 UTL. Background statistic calculated in ProUCL.

f. Qualifier adopted from Environmental Information Management database.

µg/kg = microgram per kilogram

cPAH = carcinogenic polycyclic aromatic hydrocarbon

J = Estimated concentration

TEQ = toxic equivalents quotient

Table B-6

Selected Surface Sediment Samples Used to Calculate Bellingham Bay Dioxin/Furan TEQ Regional Background[a]

Study ID	Study Name	X Coordinate	Y Coordinate	Coordinate Type	Sample Name	Matrix	Sample Date	Start Depth	End Depth	Sample Depth Units	Chemical Name	Result Numeric	Qualifier	Result Units	Basis
Bellinghambay08	Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation	1237078.74000	642566.98992	LAT/LONG	BBDx-SS-02	Solid/Sediment	9/19/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	3.21		ng/kg	Dry
Bellinghambay08	Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation	1237644.31006	638732.05993	LAT/LONG	BBDx-SS-03	Solid/Sediment	9/19/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	14.3		ng/kg	Dry
Bellinghambay08	Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation	1232478.72984	643795.14987	LAT/LONG	BBDx-SS-01	Solid/Sediment	9/19/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	1.5		ng/kg	Dry
Bellinghambay08	Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation	1233722.85990	637137.63989	LAT/LONG	BBDx-SS-04	Solid/Sediment	9/19/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	12.7		ng/kg	Dry
Bellinghambay08	Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation	1229401.50010	636558.87989	LAT/LONG	BBDx-SS-05	Solid/Sediment	9/18/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	12		ng/kg	Dry
Bellinghambay08	Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation	1235086.13014	633754.72999	LAT/LONG	BBDx-SS-06	Solid/Sediment	9/18/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	7.39		ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1234559.23716	638650.42394	LAT/LONG	UWI 29	Solid/Sediment	6/9/2010	0	11	cm	Total Dioxin/furan TEQ (U=1/2)	5.94	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1230908.96067	636212.53643	LAT/LONG	BBDIOX-1A	Solid/Sediment	6/15/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	10.63	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1230681.26657	626984.82785	LAT/LONG	BBDIOX-10	Solid/Sediment	6/9/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	10.73	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1229612.35664	644160.23247	LAT/LONG	UWI 35	Solid/Sediment	6/11/2010	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	1.33	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1232617.69315	641466.44882	LAT/LONG	BBDIOX-5	Solid/Sediment	6/15/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	1.6	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1230370.19206	639143.88457	LAT/LONG	BBDIOX-6	Solid/Sediment	6/11/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	2.65	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1230679.66749	631291.02724	LAT/LONG	BBDIOX-11	Solid/Sediment	6/9/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	6.63	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1227082.41747	637830.03155	LAT/LONG	UWI 277	Solid/Sediment	6/9/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	5.62	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1232833.77900	645804.40766	LAT/LONG	BBDIOX-2	Solid/Sediment	6/10/2010	0	9	cm	Total Dioxin/furan TEQ (U=1/2)	0.54	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1235530.36678	636695.09222	LAT/LONG	UWI 30	Solid/Sediment	6/9/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	17.01	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1225217.01995	644002.56809	LAT/LONG	BBDIOX-3A	Solid/Sediment	6/15/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	0.55	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1227211.08355	633849.39712	LAT/LONG	UWI 32	Solid/Sediment	6/10/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	2.55	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1234345.27237	634385.41672	LAT/LONG	UWI 31	Solid/Sediment	6/9/2010	0	11	cm	Total Dioxin/furan TEQ (U=1/2)	14.22	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1235264.33811	643306.14921	LAT/LONG	UWI 23	Solid/Sediment	6/14/2010	0	11	cm	Total Dioxin/furan TEQ (U=1/2)	1.37	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1237980.77199	641714.35285	LAT/LONG	UWI 27	Solid/Sediment	6/15/2010	0	9	cm	Total Dioxin/furan TEQ (U=1/2)	0.86	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1230694.17764	634137.16492	LAT/LONG	BBDIOX-9	Solid/Sediment	6/10/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	9.87	J	ng/kg	Dry
BELSEDDF	Dioxins and Furans in Surface Sediments of Bellingham Bay	1228065.07200	641858.95492	LAT/LONG	BBDIOX-4	Solid/Sediment	6/11/2010	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	1.48	J	ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1225548.14593	635046.69263	LAT/LONG	BBT06	Solid/Sediment	7/20/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	6.76		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1225548.14003	634045.77731	LAT/LONG	BBT05	Solid/Sediment	7/20/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	7.24		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1225548.13445	633167.78103	LAT/LONG	BBT04	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	7.01		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1225548.12887	632219.54540	LAT/LONG	BBP03	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	6.98		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1223072.12693	629761.17564	LAT/LONG	BBP04	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	5.2		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1225530.53737	627056.92810	LAT/LONG	BBP01	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	5.48		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1228375.30432	629708.45396	LAT/LONG	BBP02	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	8.51		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1233507.04143	635583.44123	LAT/LONG	BBB01	Solid/Sediment	7/20/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	21.97		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1231571.25954	629743.54838	LAT/LONG	BBB02	Solid/Sediment	7/20/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	10.49		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1225542.31392	629750.62711	LAT/LONG	BBZ01	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	6.1		ng/kg	Dry
DMMP_Dioxin_2005-07	DNR Dioxin Study	1218421.27928	624828.32199	LAT/LONG	BBB04	Solid/Sediment	7/19/2007	0	10	cm	Total Dioxin/furan TEQ (U=1/2)	4.34		ng/kg	Dry
WWPRDI08	Whatcom Waterway Pre-Remedial Design Investigation	1238568.30001	640047.70002	LAT/LONG	1B-01-SS	Solid/Sediment	8/20/2008	0	12	cm	Total Dioxin/furan TEQ (U=1/2)	13.5		ng/kg	Dry

Notes:

a. The normal distribution 90/90 UTL. Background statistic calculated in ProUCL.

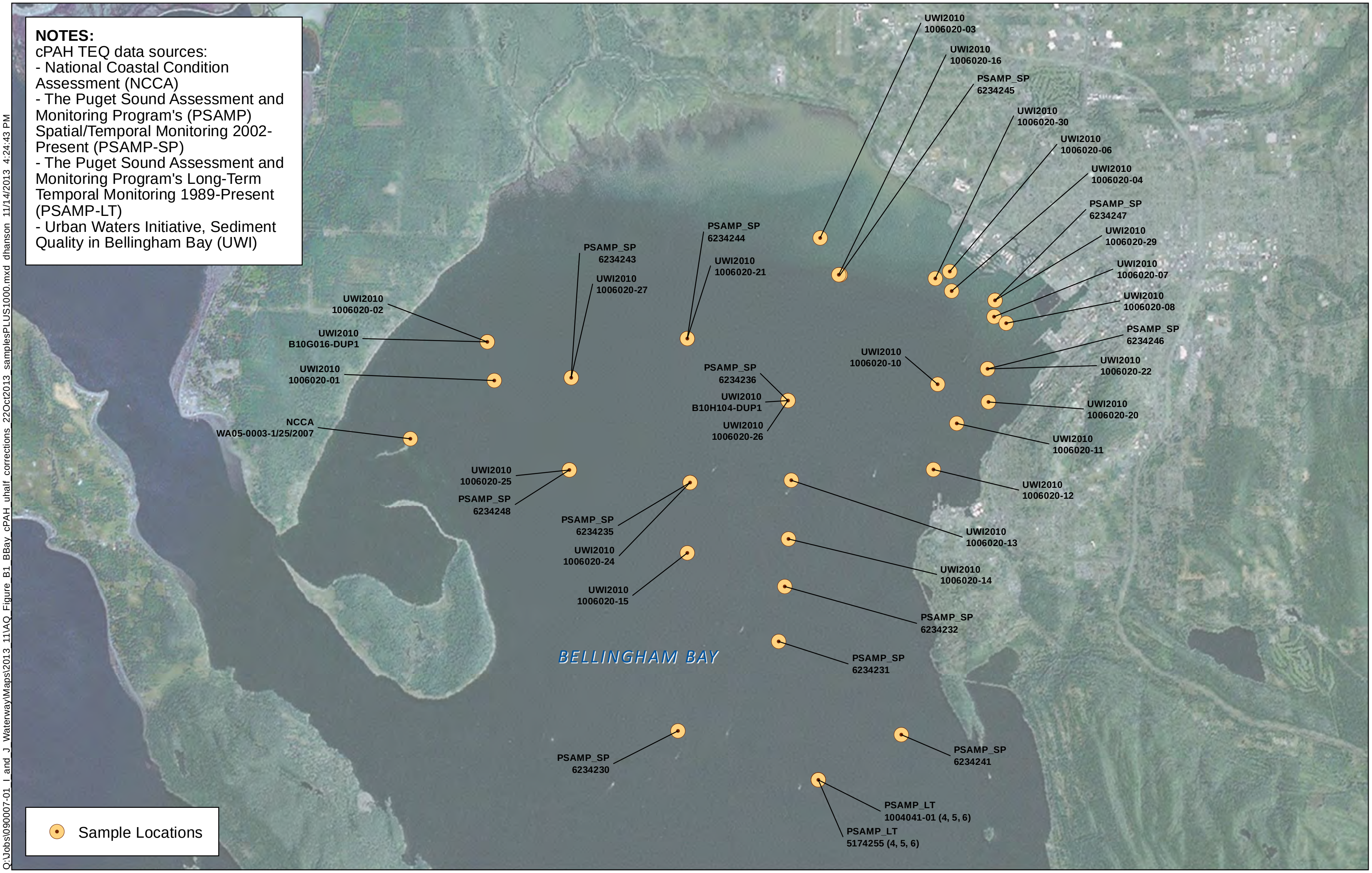
cm = centimeter

J = Estimated concentration

ng/kg = nanogram per kilogram

TEQ = toxic equivalents quotient

FIGURES



NOTES:
cPAH TEQ data sources:
- National Coastal Condition Assessment (NCCA)
- The Puget Sound Assessment and Monitoring Program's (PSAMP) Spatial/Temporal Monitoring 2002-Present (PSAMP-SP)
- The Puget Sound Assessment and Monitoring Program's Long-Term Temporal Monitoring 1989-Present (PSAMP-LT)
- Urban Waters Initiative, Sediment Quality in Bellingham Bay (UWI)

● Sample Locations

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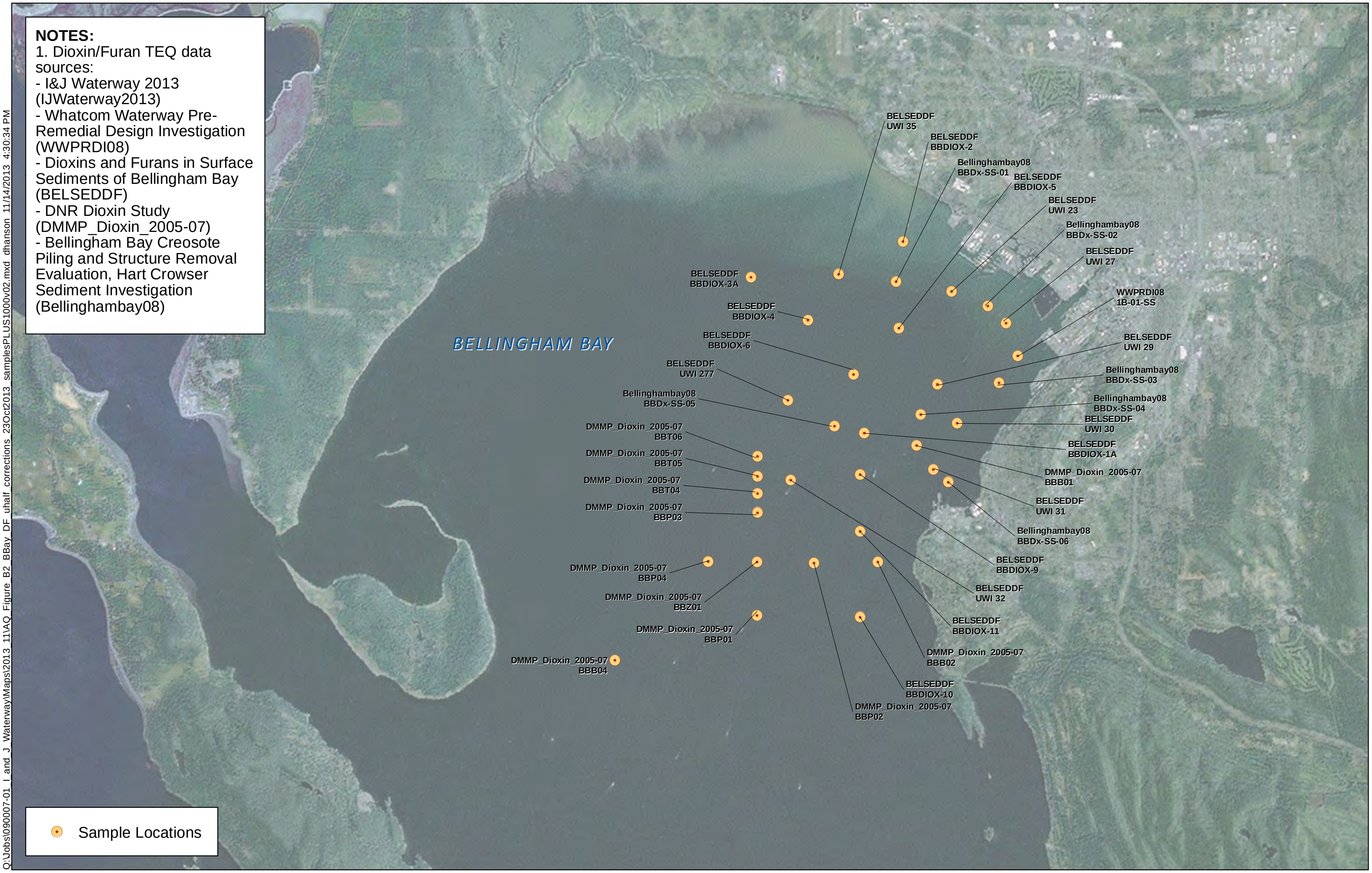
Miles
0 1 2

Figure B-1
cPAH TEQ Regional Background Sample Locations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham, WA



NOTES:

1. Dioxin/Furan TEQ data sources:
- I&J Waterway 2013 (IJWaterway2013)
- Whatcom Waterway Pre-Remedial Design Investigation (WWPRDI08)
- Dioxins and Furans in Surface Sediments of Bellingham Bay (BELSEDDF)
- DNR Dioxin Study (DMMP_Dioxin_2005-07)
- Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation (Bellinghambay08)

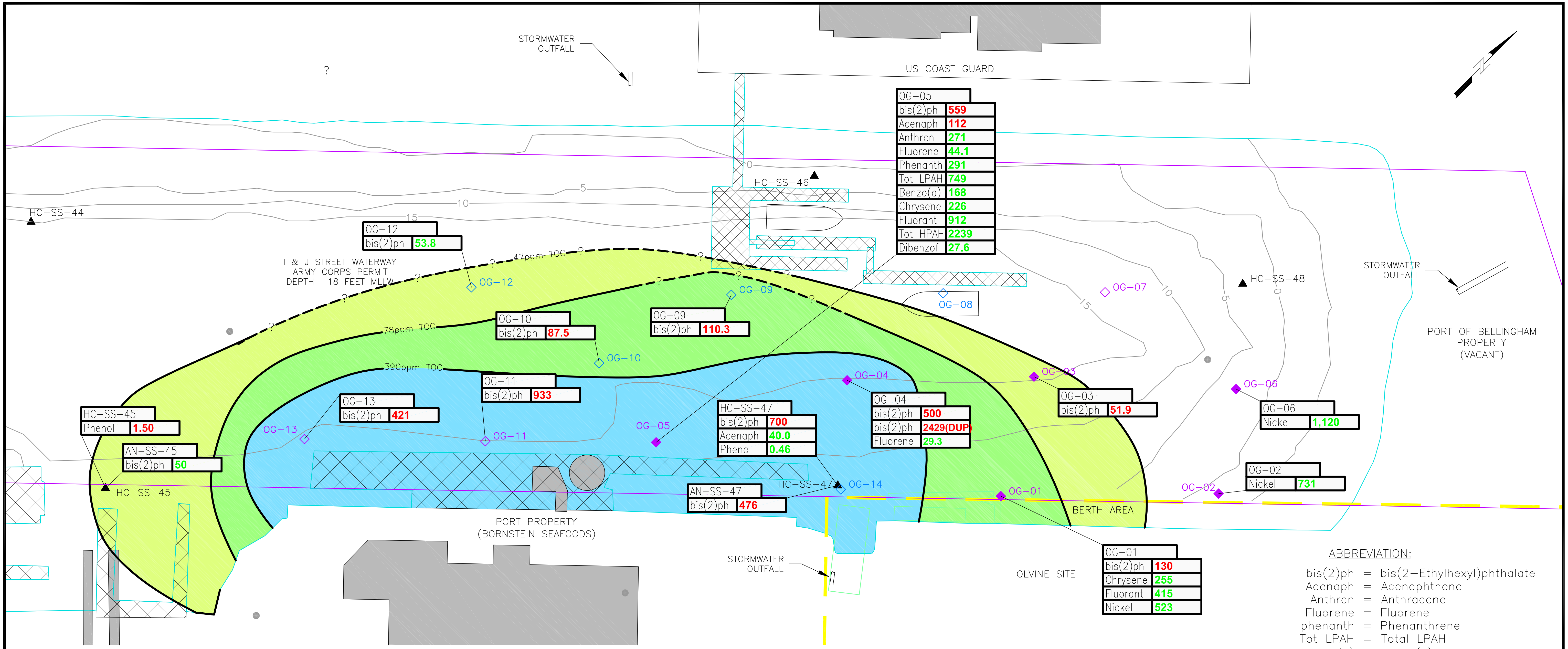
● Sample Locations

Q:\Jobs\090007-01 I and J Waterway\Maps\2013 11\AQ Figure B2 BBay DF uhalf corrections 23Oct2013 samplesPLUS1000v02.mxd dhanson 11/14/2013 4:30:34 PM

ANCHOR QEA

Figure B-2
Dioxin/Furan TEQ Regional Background Sample Locations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham, WA

APPENDIX C
RI/FS WORK PLAN (2005) FIGURE SUMMARIZING PREVIOUS SURFACE SEDIMENT EXCEEDANCES



LEGEND

271	PREVIOUS CHEMICAL DATA DETECTED BETWEEN SQS AND MCUL	▲ HC-SS-47	PREVIOUS SEDIMENT GRAB SAMPLE (HART CROWSER, 1997)
476	PREVIOUS CHEMICAL DATA DETECTED ABOVE MCUL	◆ OG-3	PHASE 2 SURFACE SEDIMENT GRAB SAMPLE
▨	DOCKS OR PIERS	◇ OG-10	PHASE 2 SVOC/TOC ANALYSIS ONLY
■	EXISTING STRUCTURES	🟨	bis(2-Ethylhexyl)phthalate EXCEEDS CHEMICAL SQS CRITERIA (47ppm TOC)
~	EXISTING SHORELINE	🟩	bis(2-Ethylhexyl)phthalate EXCEEDS CHEMICAL MCUL CRITERIA (78ppm TOC)
25	BATHYMETRY (FEET BELOW MLLW PER WHATCOM WATERWAY RI/FS REPORT)	🟦	bis(2-Ethylhexyl)phthalate EXCEEDS 5 TIMES CHEMICAL MCUL CRITERIA (390ppm TOC)
▬ ▬	CURRENT OLIVINE UPLAND SITE BOUNDARY		
—	I & J WATERWAY BOUNDARY		

PARAMETER	SQS	MCUL
Acenaphthene (ppm TOC)	16	57
Anthracene (ppm TOC)	220	1200
Fluorene (ppm TOC)	23	79
Phenanthrene (ppm TOC)	100	480
Total LPAH (ppm TOC)	370	780
Benzo(a)anthracene (ppm TOC)	110	270
Chrysene (ppm TOC)	110	460
Fluoranthene (ppm TOC)	160	1200
Total HPAH (ppm TOC)	960	5300
Dibenzofuran (ppm TOC)	15	58
bis(2-Ethylhexyl)phthalate (ppm TOC)	47	78
Phenol (mg/kg)	0.42	1.2
Nickel (mg/kg) PSDDA SL= 140*		

ABBREVIATION:

bis(2)ph = bis(2-Ethylhexyl)phthalate
Acenaph = Acenaphthene
Anthrcn = Anthracene
Fluorene = Fluorene
phenanth = Phenanthrene
Tot LPAH = Total LPAH
Benzo(a) = Benzo(a)anthracene
Chrysene = Chrysene
Fluorant = Fluoranthene
Tot HPAH = Total HPAH
Dibenzof = Dibenzofuran

NOTES:

PAHs, dibenzofuran, AND/OR phenol SQS EXCEEDANCES WERE DETECTED AT OG-01, OG-04, OG-05, HC-SS-45, AND HC-SS-47.

CONCENTRATIONS ARE SHOWN IN TOC-NORMALIZED UNITS (ppm TOC OR mg/kg O.C.)

EXCEEDENCES OF SQS BIOLOGICAL EFFECTS CRITERIA WERE PREVIOUSLY DETECTED AT STATION AN-SS-45. EXCEEDENCES OF MCUL BIOLOGICAL EFFECTS CRITERIA WERE PREVIOUSLY DETECTED AT STATION AN-SS-47.

*SMS DOES NOT DEFINE A NICKEL NUMERIC SQS OR MCUL. THE NICKEL PSDDA SL WILL BE USED TO ASSESS WHETHER OR NOT TO PERFORM BIOLOGICAL EFFECTS TESTING IN SURFACE SEDIMENT SAMPLES.

RETEC

0 30 60 120
SCALE IN FEET

I & J WATERWAY
RI/FS WORK PLAN
PORTB-18449-100

SUMMARY OF PREVIOUS
SURFACE SEDIMENTS EXCEEDENCES

DATE: 03/04/05
DRWN: A.S./SEA

FIGURE 1-2

File: H:\18449\18449S008.dwg Layout: Layout1 User: astenberg Plotted: Mar 04, 2005 - 10:35am Xref's:

Table C-1 Summary of Valid Historical Analytical Data for Surface Sediments

Station			HC-SS-45	HC-SS-46	HC-SS-47	HC-SS-48	HC-SC-85	AN-SS-84	AN-SS-45	AN-SS-47
Sampling Date			9/4/1996	9/5/1996	9/4/1996	9/5/1996	9/9/1996	10/27/1998	10/27/1998	10/27/1998
Datum			NAD-83	NAD-83	NAD-83	NAD-83	NAD-83	Corresponds approximately to HC-SC-84	Corresponds approximately to HC-SS-45	Corresponds approximately to HC-SS-47
Easting			1239793	1239963	1240107	1240194	1240186			
Northing			644131	644572	644449	644711	644711			
Sample Type			Surface Grab	Surface Grab	Surface Grab	Surface Grab	Surface Grab	Surface Grab	Surface Grab	Surface Grab
Reported elevation			-13.1 ft.	-7.0 ft.	-7.1 ft.	-2.3 ft.	-2.3 ft.	NT	NT	NT
Sampling Interval			0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm	0-10 cm
Consultant	SMS Criteria		Hart Crowser	Hart Crowser	Hart Crowser	Hart Crowser	Hart Crowser	Anchor	Anchor	Anchor
Reference	SQS	MCUL	HC May 1997	HC May 1997	HC May 1997	HC May 1997	HC May 1997	Anchor, 1999	Anchor, 1999	Anchor, 1999
Conventionals										
Total Solids (%)	NV	NV	**40**	**45**	**50**	**50**	**35**	**43.3**	**39.2**	**62.2**
Total Organic Carbon (%)	NV	NV	**3.4**	**2.6**	**4**	**0.82**	**3.1**	**2.6**	**2.8**	**4.2**
Metals	*(mg/kg)*	*(mg/kg)*	*(mg/kg dry)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*
Antimony	NV	NV	NT	NT	NT	NT	NT	NT	NT	NT
Arsenic	57	93	**11 E**	NT	**9.2 E**	**3.2 E**	**9.6 E**	NT	NT	NT
Cadmium	5.1	6.7	**1.6**	NT	**1.3**	< 0.59	**1.3**	**1 U**	**1**	**0.7 J**
Chromium	260	270	**71**	NT	**49**	**17**	**66**	NT	NT	NT
Copper	390	390	**73**	NT	**51**	**16**	**61**	NT	NT	NT
Lead	450	530	**19**	NT	**24**	**11**	**20**	NT	NT	NT
Mercury	0.41	0.59	**0.36**	**0.36**	**0.29**	< 0.13	**0.45**	**0.45**	**0.41**	**0.17 J**
Nickel	NV	NV	NT	NT	NT	NT	NT	NT	NT	NT
Silver	6.1	6.1	< 1.2	NT	< 1.0	< 0.59	< 1.3	NT	NT	NT
Zinc	410	960	**130**	NT	**190**	**51**	**120**	**106**	**138**	**137**
LPAH	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*
2-Methylnaphthalene	38	64	**0.94 E**	NT	**4.00**	**6.83**	**0.68 E**	**1.4**	**3**	3.3 U
Acenaphthene	16	57	**0.47 E**	NT	**40.00**	**2.07 E**	**0.84 E**	0.77 U	**1.1**	3.3 U
Acenaphthylene	66	66	< 1.12	NT	**2.15**	**1.16 E**	< 1.42	0.77 U	**0.75**	3.3 U
Anthracene	220	1,200	**1.56**	NT	**35.00**	**5.98**	**1.16 E**	**1.6**	**6.1**	**4.3**
Fluorene	23	79	**0.94 E**	NT	**7.50**	**4.02**	**1.26 E**	**0.96**	**2.5**	3.3 U
Naphthalene	99	170	**1.53**	NT	**3.75**	**7.44**	**1.13 E**	**2**	**3.6**	3.3 U
Phenanthrene	100	480	**4.41**	NT	**30.00**	**24.39**	**7.74**	**3.8**	**10**	**11**
Total LPAHs	562	780	**8.91**	NT	**118.40**	**45.06**	**12.13**	**11**	**27**	**32**
HPAH	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*
Benzo(a)anthracene	110	270	**5.29**	NT	**42.50**	**18.29**	**4.52**	**2.4**	**13**	**12**
Benzo(a)pyrene	99	210	**3.24**	NT	**13.50**	**20.73**	**3.13**	**1.9**	**8.2**	**10**
Benzo(b)fluoranthene	230	450	**8.53 C**	NT	**35.0 C**	**20.73**	**4.52**	**2.5**	**14**	**17**
Benzo(g,h,i)perylene	31	78	**2.24 E**	NT	**5.75**	**19.51**	**2.26 E**	**1.3**	**3.1**	**4**
Benzo(k)fluoranthene	230	450	**8.53 C**	NT	**35.0 C**	**19.51**	**3.87**	**3**	**12**	**24**
Chrysene	110	460	**8.82**	NT	**47.50**	**29.27**	**8.06**	**3.8**	**19**	**31**
Dibenz(a,h)anthracene	12	33	**1.32 E**	NT	**3.75**	**9.27**	**1.0 E**	0.77 U	**1.8**	3.3 U
Fluoranthene	160	1,200	**10.29**	NT	**125.00**	**47.56**	**12.58**	**8.5**	**24**	**74**
Indeno(1,2,3-cd)pyrene	34	88	**2.24**	NT	**5.75**	**18.29**	**2.16 E**	**1.1**	**3.9**	**5.5**
Pyrene	1,000	1,400	**10.00**	NT	**117.50**	**47.56**	**12.58**	**9.2**	**54**	**100**
Total HPAHs	2,016	5,300	**51.97**	NT	**396.25**	**250.73**	**54.7**	**35.0**	**152.0**	**280.0**
Phthalates	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*
bis(2-Ethylhexyl)phthalate	47	78	**13.24**	NT	**700.00**	**25.61**	**7.1**	**4.6**	**50**	**476**
Butylbenzylphthalate	4.9	64	**0.59 E**	NT	< 1.53	**1.83 E**	< 2.81	**0.88**	**1.3**	3.3 U
Diethylphthalate	61	110	< 2.94	NT	< 2.00	< 6.34	< 3.87	0.77 U	0.71 U	3.3 U
Dimethylphthalate	53	53	< 2.53	NT	**0.73 E**	< 5.37	< 3.16	0.77 U	**0.82**	3.3 U
Di-n-Butylphthalate	220	1,700	< 1.74	NT	< 1.18	**1.34 E**	< 2.16	**1.3**	0.71 U	**18**
Di-n-Octyl phthalate	58	4,500	< 2.12	NT	< 1.43	< 4.51	**4.19**	0.77 U	**0.93 E**	3.3 U
Phenols	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*
Phenol	0.42	1.2	**1.50**	NT	**0.46**	**0.07**	**0.026 E**	0.039 U	0.040 U	0.280 UG
2,4-Dimethylphenol	0.029	0.029	**0.014 E**	NT	**.016 E**	**0.010 E**	**0.0093 E**	0.059 U	0.060 U	0.410 UG
2-Methylphenol	0.063	0.063	**0.009 E**	NT	**0.011 E**	**0.0059 E**	**0.0068 E**	0.039 U	0.040 U	0.280 UG
4-Methylphenol	0.67	0.67	**0.22**	NT	**0.21**	**0.04**	**0.19**	**0.062**	**0.22**	0.140 UG
Pentachlorophenol	0.36	0.69	**0.015 E**	NT	**0.018 E**	**0.010 E**	**0.011 E**	0.099 U	0.099 U	0.410 UG
Misc. Extractables	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*	*(mg/kg)*
Benzyl Alcohol	0.057	0.073	< 0.0057 E	NT	< 0.0077 E	< 0.034	**0.0064 E**	0.099 U	0.099 U	0.690 U
Benzoic Acid	0.65	0.65	< 0.23 E	NT	< 0.29	< 0.089 E	< 0.19 E	0.2 U	0.20 U	1.4 UG
Misc. Extractables	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*
1,2,4-Trichlorobenzene	0.81	1.8	< 1.15	NT	< 0.78	< 2.44	< 1.42	0.77 U	0.71 U	3.3 U
1,2-Dichlorobenzene	2.3	2.3	< 1.35	NT	< 0.90	< 2.93	< 1.68	0.77 U	0.71 U	3.3 U
1,3-Dichlorobenzene	NV	NV	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	3.1	9	< 1.21	NT	< 0.83	< 2.56	< 1.52	0.77 U	0.71 U	3.3 U
Dibenzofuran	15	58	**0.91 E**	NT	**4.50**	**4.88**	**0.94 E**	**1.4**	**3.6**	3.3 U
Hexachlorobenzene	0.38	2.3	< 0.12	NT	< 0.08	< 0.27	< 0.15	0.77 U	0.71 U	3.3 U
Hexachlorobutadiene	3.9	6.2	< 0.12	NT	< 0.08	< 0.27	< 0.15	1.5 U	1.4 U	6.7 U
N-Nitrosodiphenylamine	11	11	< 1.5	NT	< 1.03	< 3.29	< 1.90	0.77 U	0.71 U	3.3 U
PCBs	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*	*(ppm TOC)*
Aroclor 1016	12	65	< 3.82	NT	< 2.5	< 7.93	< 4.52	NT	NT	NT
Aroclor 1221	12	65	< 3.82	NT	< 2.5	< 7.93	< 4.52	NT	NT	NT
Aroclor 1232	12	65	< 3.82	NT	< 2.5	< 7.93	< 4.52	NT	NT	NT
Aroclor 1242	12	65	< 3.82	NT	< 2.5	< 7.93	< 4.52	NT	NT	NT
Aroclor 1248	12	65	< 3.82	NT	< 2.5	< 7.93	< 4.52	NT	NT	NT
Aroclor 1254	12	65	< 3.82	NT	< 2.5	< 7.93	< 4.52	NT	NT	NT
Aroclor 1260	12	65	< 3.82	NT	**3.25**	< 7.93	< 4.52	NT	NT	NT
Total PCBs	12	65	< 3.82	NT	**3.25**	< 7.93	< 4.52	NT	NT	NT

Notes:

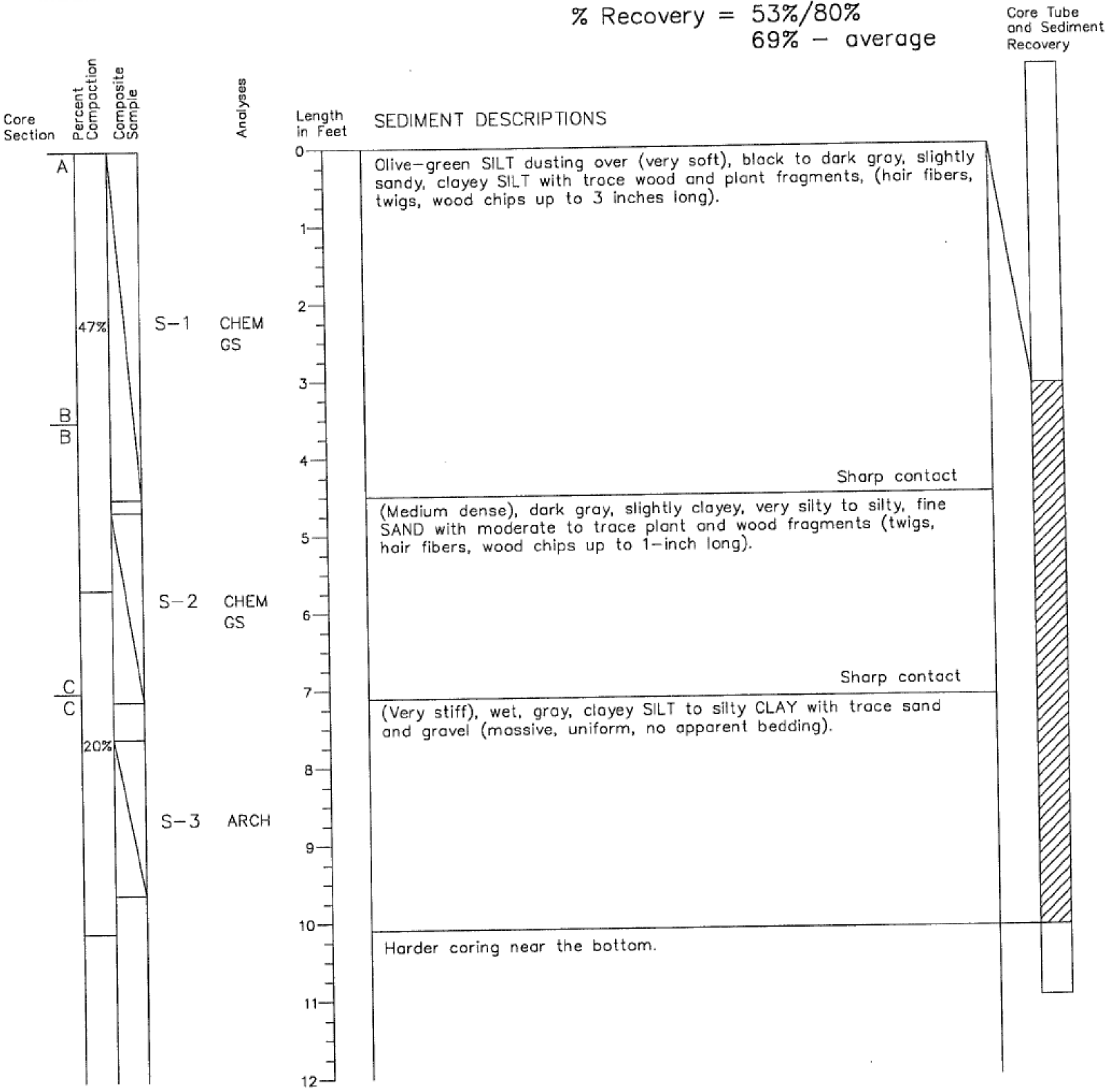
Single underlined values exceed the SQS value.
Double underlined values exceed the MCUL value.
NV - No Value.
NA - Not Analyzed.
D - Indicates value reported in diluted sample.
E - Value above linear range of detector
M - indicates estimated value of analyte found and confirmed by analyst but with low spectral match.

APPENDIX D
SEDIMENT CORE LOGS

Sediment Core Log HC-VC-85

Type of Sample: 4–inch Vibracore
Date/Time: 9/11/96 1015
Recovery Length in Feet: 7.0
Mudline Elevation in Feet: –16.3

Northing: 644,634
Easting: 1,240,185
Drive Depth in Feet: 10.1
Core Tube Length in Feet: 12.0
% Recovery = 53%/80%
69% – average



Olive–green SILT dusting over (very soft), black to dark gray, slightly sandy, clayey SILT with trace wood and plant fragments, (hair fibers, twigs, wood chips up to 3 inches long).

Sharp contact

(Medium dense), dark gray, slightly clayey, very silty to silty, fine SAND with moderate to trace plant and wood fragments (twigs, hair fibers, wood chips up to 1–inch long).

Sharp contact

(Very stiff), wet, gray, clayey SILT to silty CLAY with trace sand and gravel (massive, uniform, no apparent bedding).

Harder coring near the bottom.

Notes:
1. Horizontal control is based on NAD 83 datum (DGPS) – North Zone and vertical control is based on MLLW datum.
2. Composite sample depths and sediment contacts shown above were recalculated to account for percent compaction during driving.
3. Collocated surface samples were collected with van Veen grab sampler.
4. See Figure A–1 for key and legend.

cvd 1/15/97 1=1 hc–pcp
HCVC85

HARTCROWSER
J-4478-05 9/96
Figure A-17

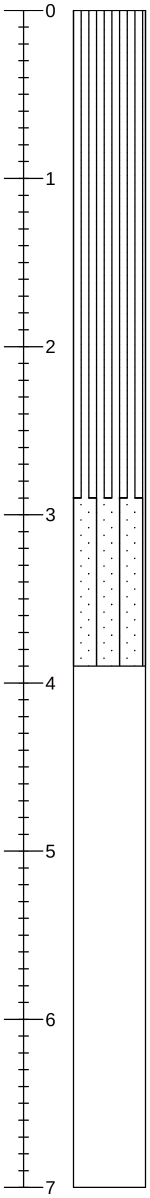
Sediment Core Log

Sheet 1 of 1

IJ13-VC-101

Project: **I&J Waterway RI/FS**	Location: **Bornstein Seafoods, Bellingham, WA**	Tube Length (ft): **8**
Project #: **090007-01.02**	Water Elevation (ft): **5.6**	Penetration Depth (ft): **8**
Client: **Port of Bellingham**	Water Depth (ft): **10.8**	Sample Quality: **Good**
Collection Date: **20 August 2013**	Calculated Mudline Elevation (ft): **-5.2**	Field Recovery (%): **58 %**
Contractor: **RSS**	Northing/LAT: **644336.26** Easting/LONG: **1239977.68**	Process Date: **20 August 2013**
Vessel: **R/V Carolyn Dow**	Horiz. Datum: **WA SP N, NAD 83, ft** Vert. Datum: **MLLW**	Process Method: **Cut Tube**
Operator: **Eric Parker**	Method/Tube ID: **Vibracore/3.75" round**	Logged By: **AC**

Recoverd Depth (ft)	Recovered Interval	Sample	**Sediment Description** Samples and descriptions are in Recovered Depths. Classification Scheme: USCS



IJ13-VC-101-0-2	Soft, wet, black, f-m-sandy, SILT. Moderate shell fragments and substantial organic matter (fish scales and sticks). Slight H2S-like odor. @ 0.2': Grades to moist. @ 1.0': Grades to medium stiff. @ 2.6': 3 cm subangular c-gravel
IJ13-VC-101-2-3.9	@ 2.9': Grades to medium dense, moist, dark gray, slightly silty, f-m SAND, trace c-gravel, trace cobbles (subrounded up to 6 cm). Sand grains are multicolored. Occassional wood fragments. Moderate pockets of stiff, moist, gray, CLAY.
	End of core @ 3.9'

ANCHOR QEA
1605 Cornwall Avenue
Bellingham, WA
360-733-4311

Footnote (1): Attempt 1 of 2; 0-4' easy coring, 4-5' some resistance, 5-8' easy

Footnote (2): Estimated coordinates, sampling location 11 ft from pier face.

Footnote (3): Moist, gray, stiff CLAY present in shoe.

Calculated Recovery
Recovery Length/Penetration Depth:
4.6 ft/8 ft = 58%

Sediment Core Log

Sheet 1 of 1

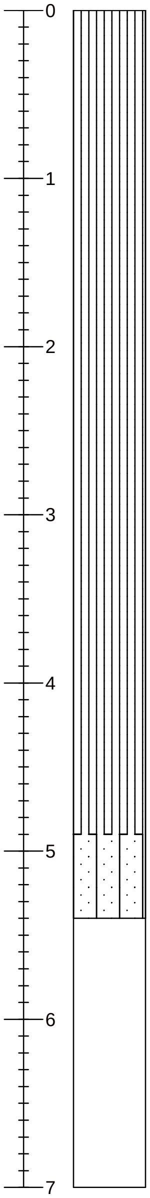
IJ13-VC-102

Project: **I&J Waterway RI/FS**	Location: **Bornstein Seafoods, Bellingham, WA**	Tube Length (ft): **8**
Project #: **090007-01.02**	Water Elevation (ft): **4.4**	Penetration Depth (ft): **8**
Client: **Port of Bellingham**	Water Depth (ft): **11.2**	Sample Quality: **Good**
Collection Date: **20 August 2013**	Calculated Mudline Elevation (ft): **-6.8**	Field Recovery (%): **80 %**
Contractor: **RSS**	Northing/LAT: **644244.9** Easting/LONG: **1239881.59**	Process Date: **20 August 2013**
Vessel: **R/V Carolyn Dow**	Horiz. Datum: **WA SP N, NAD 83, ft** Vert. Datum: **MLLW**	Process Method: **Cut Tube**
Operator: **Eric Parker**	Method/Tube ID: **Vibracore/3.75" round**	Logged By: **AC**

Recoverd Depth (ft) | Recovered Interval | Sample

Sediment Description

Samples and descriptions are in Recovered Depths.
Classification Scheme: USCS



Sample	Sediment Description
IJ13-VC-102-0-2	Soft, wet, black, f-m-sandy, SILT. Moderate shell fragments, occasional wood fragments. Slight H2S-like odor. @ 0.6': 3" wood fragment @ 0.8': Grades to stiff, moist, dark gray, slightly f-sandy, SILT, trace shell fragments.
IJ13-VC-102-2-4	@ 2.6': Grades to moderate organic fibers (brown, decomposed).
IJ13-VC-102-4-5.4	@ 4.9': Grades to medium dense, moist, dark gray, slightly silty, f-m SAND. Sand grains are multicolored and are white, black, red and beige. Moderate shell fragments (bivalve).
	End of core @ 5.4'

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Bellingham, WA
360-733-4311

Footnote (1): Attempt 1 of 1; 0-8' easy drive

Footnote (2): Estimated coordinates, sampling location 12 ft from pier face.

Footnote (3): Moist, gray, stiff CLAY present in shoe.

Calculated Recovery

Recovery Length/Penetration Depth:

6.4 ft/8 ft = 80%

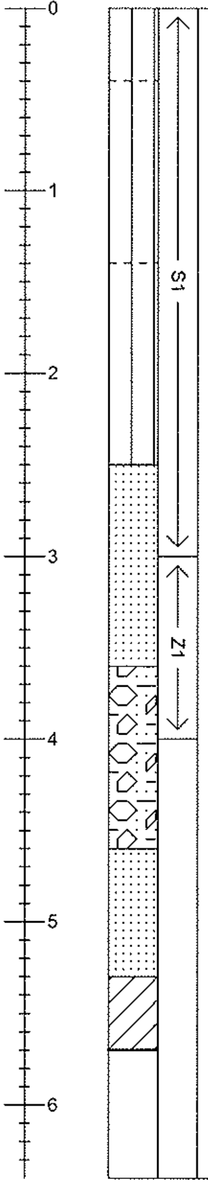
Sediment Core Log

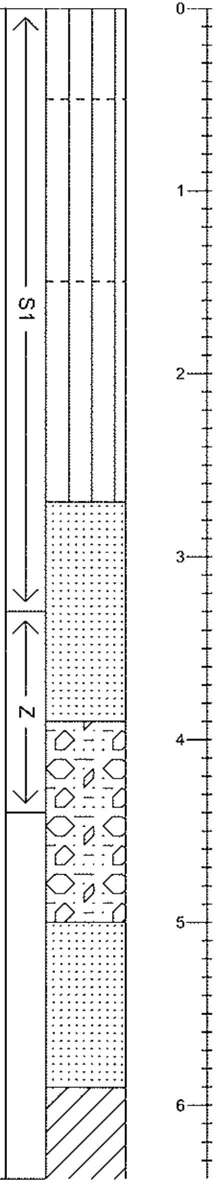
IJ-18

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-0.3**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **16.7**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-17.0**	Recovery in ft (%): **6.4 (91)**
Contractor: **MSS**	N./LAT: **48 45.2970** E./LONG: **122 29.6136**	Process Date: **06/13/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0–0.5	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C3) Bioassay (IJ-C3)	ML: wet, very soft, dark gray (GLEY 1, 4/N) SILT, trace clay. Scattered rootlets and wood fragments. Clay texture is gummy.	Homogenized for sample IJ-C3	S1
0.5–1.4				ML: wet, soft, dark gray (GLEY 1, 4/N) CLAYEY SILT, trace sand and gravel. Clay competancy increases towards basal contact. @ 1.3' subangular gravel up to 1/2" diameter		
1.4–2.5				ML: moist, soft, dark gray (GLEY 1, 4/N) SILT, little sand.		
2.5–3.6	Z1		Archive	SM: moist, medium dense, very dark gray (GLEY 1, 3/N) SAND, little silt. Sand grains are medium, multicolored (red, white, black), and coarsen towards basal contact. Trace shell fragments. Moderate hydrogen sulfide odor.		Z
3.6–4.6				GP: moist, dense, very dark gray (GLEY 1, 3/N) GRAVEL, little sand. Gravel is subrounded to subangular and up to 3" L.		
4.6–5.3				SM: moist, medium dense, very dark gray (7.5YR, 3/1) SAND, few silt. Sand grains are multicolored (red, white, black). Trace wood layers up to 2" thick with wood fragments up to 1" L.		
5.3–5.7				CL: damp, stiff, greenish gray (GLEY 1, 5/GY) CLAY. Clay is of high plasticity, rolls well, and is highly competant.		
				End of core at 5.7. Driven to refusal. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.		





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Remarks: Drive notes: freefall (3.0'), easy (4.8'), very hard (6.6'). refusal (6.4'). Core shoe was 25% full of green-gray clay, trace hydrogen sulfide odor. Core tube scratched.

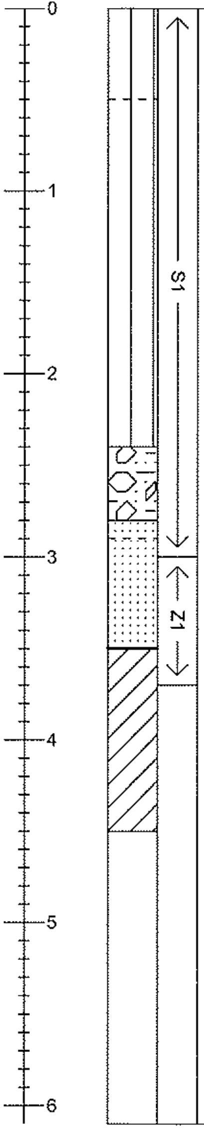
Calculated Recovery
Sample Length/Penetration Length:
6.4 / 7.0 = 91 %

Sediment Core Log
IJ-19

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-1.7**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **13.6**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-15.2**	Recovery in ft (%): **5.2 (74)**
Contractor: **MSS**	N./LAT: **48 45.2963** E./LONG: **122 29.6137**	Process Date: **06/13/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft) | Recov.Interval & Sample # | % Recovery (depth in ft) | Analysis



Analysis

Metals
SVOCs
PCB
TBT bulk
Pesticides
Conventionals
Grain Size
TBT porewater
VOCs
Sulfides
Archive

Dioxins (IJ-C3)
Bioassays (IJ-C3)

Archive

Sediment Description

Classification Scheme: USCS
Contacts are recovered depth

ML: wet, soft, dark gray (GLEY 1, 4/N) SILT, trace sand. Scattered worms, trace rootlets.

ML: moist, medium stiff, dark gray (GLEY 1, 4/N) SILT, trace fine sand. Sand percentage increases to few and coarsens toward basal contact. Slight hydrogen sulfide odor. Trace fish matter (scales) up to 1/2" diameter.

GP: moist, dense, dark gray (GLEY 1, 4/N) SANDY GRAVEL. Gravel is subrounded to subangular and up to 2" L.

SM: moist, dense, very dark gray (GLEY 1, 3/N) SAND, trace gravel. Sand grains are coarse and multicolored. Trace shell fragments.

SM: moist, dense, very dark gray (GLEY 1, 3/N) SAND, few silt, trace gravel. Trace shell fragments. Trace hydrogen sulfide odor.

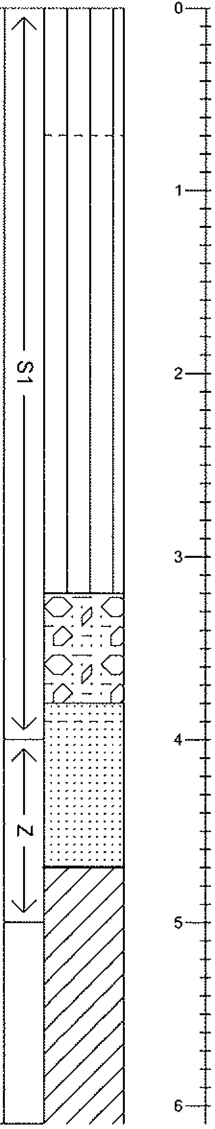
CL: damp, stiff to very stiff, greenish gray (GLEY 1, 5/GY) CLAY. Clay has high plasticity and rolls well. @ 3.8-3.9': substantial subrounded gravel up to 3" L and shell fragments. Scattered sand and smaller gravels.

End of core at 4.5'. Driven to refusal (see remarks). In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.

Comments for Recovered Depths

Homogenized for sample IJ-C3

In-situ Depths (ft) & Graphic Log



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Remarks: **Drive notes: freefall (3.5'), easy (6.1'), refusal (6.1').**

Core shoe 100% full of damp, greenish gray clay.

Refusal likely caused by mechanical rather than lithological refusal.

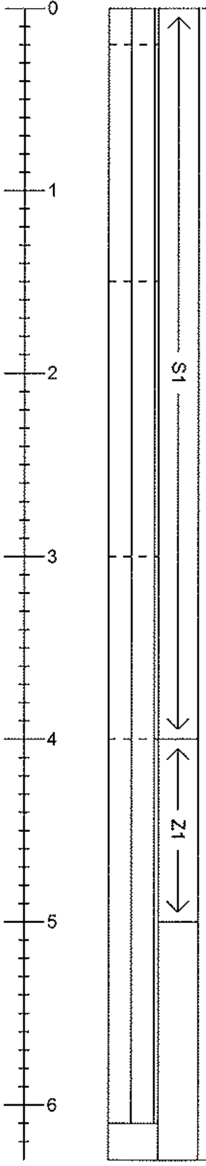
Calculated Recovery
Sample Length/Penetration Length:
5.2 / 7.0 = 74 %

Sediment Core Log

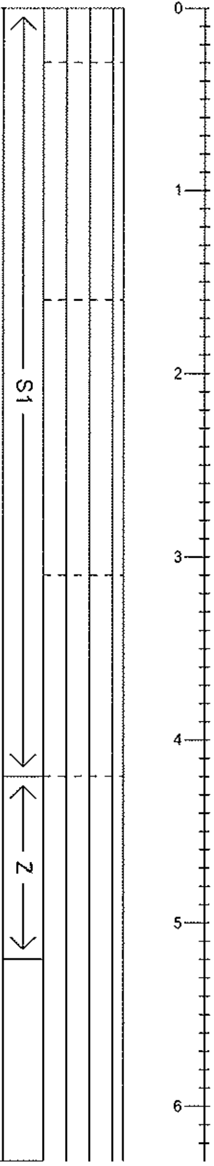
IJ-20

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **+1.3**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **18.4**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-17.1**	Recovery in ft (%): **6.3 (96)**
Contractor: **MSS**	N./LAT: **48 45.3057** E./LONG: **122 29.5848**	Process Date: **06/13/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**



% Recovery (depth in ft)	Analysis	Sediment Description Classification Scheme: USCS Contacts are recovered depth	Comments for Recovered Depths
		ML: wet, very soft, dark gray (GLEY 1, 4/N) SILT, trace fine sand.	
	Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C3) Bioassays (IJ-C3)	ML: moist, soft, very dark gray (GLEY 1, 3/N) SILT. Silt competancy increases toward basal contact. Trace fish matter. Trace to moderate hydrogen sulfide odor.	Homogenized for sample IJ-C3
		ML: moist, soft, very dark gray (GLEY 1, 3/N) SILT, little clay. Silt competancy increases toward basal contact. No hydrogen sulfide odor below 2.0'. @ 2.1' 3" L metal piece (drill bit - like)	Bag @ 2.1' (metal).
		ML: moist, medium stiff, very dark gray (GLEY 1, 3/N) SILT, few sand. Sand grains are medium to coarse. Trace wood and gravel. @ 3.3'-4.5': scattered wood fragments up to 1" L @ 3.5': subrounded gravel up to 2.5" L @ 4.0': subangular gravel up to 2.5" L	
	Archive	ML: moist, medium stiff, very dark gray (GLEY 1, 3/N) CLAYEY SILT, trace gravel. Trace shell fragments and organic matter (wood).	
		End of core at 6.1. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.	Clay tagged in core shoe.



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Remarks: Drive notes: freefall (3.7'), easy (7.0'), no refusal.
Core shoe was 100% full of damp, black clayey silt.

Calculated Recovery
Sample Length/Penetration Length:
6.7 /7.0 = 96 %

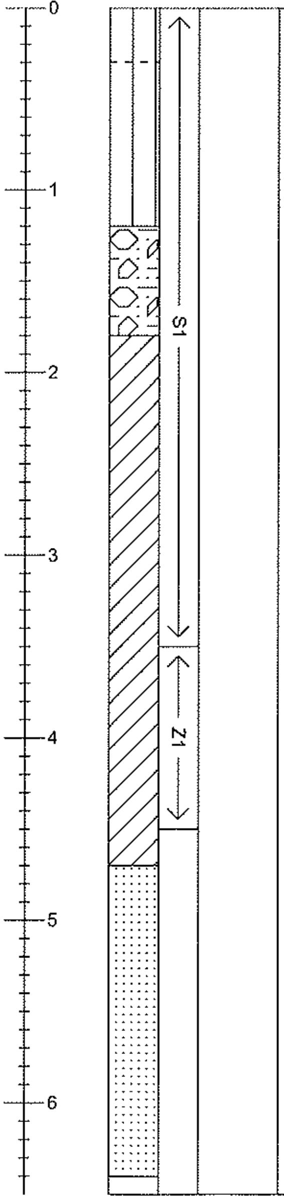
Sediment Core Log

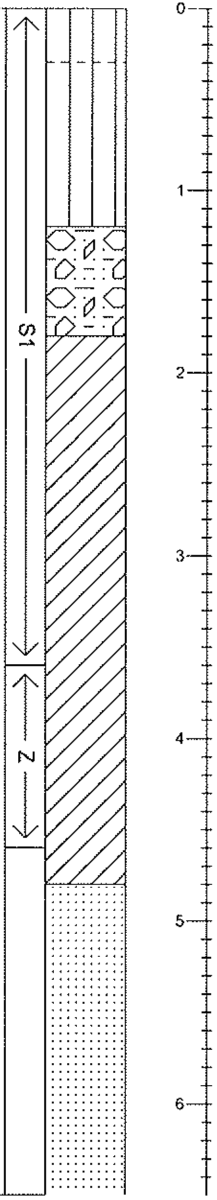
IJ-21

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-3.0**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **14.1**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-17.1**	Recovery in ft (%): **6.8 (97)**
Contractor: **MSS**	N./LAT: **48 45.2904** E./LONG: **122 29.6016**	Process Date: **06/13/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
				ML: wet, very soft, black (GLEY 1, 2.5/N) SILT.		
	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C3) Bioassays (IJ-C3)	ML: moist, soft, black (GLEY 1, 2.5/N) CLAYEY SILT. Trace fish matter (scales and flakes)l and wood fragments. Trace hydrogen sulfide odor. @ 1.1': 1" thick layer of wood fragments	Homogenized for sample IJ-C3	S1
				GP: moist, dense, black (GLEY 1, 2.5/N) GRAVEL, little silt and sand. Gravel is subrounded to subangular and up to 2" in diameter. @ 1.7': 1/2" thick lens of very coarse sand		
				CL: moist, medium stiff, very dark gray (GLEY 1, 3/N) CLAY, trace silt. Clay texture is gummy, rolls easily, and has low plasticity. Trace layers of fish matter (scales and flakes) and wood fragments. @ 3.6': wood fragments up to 1" L. Plastic piece 1.5" L.	Bag @ 3.6' (plastic).	
	Z1		Archive	@ 4.0': Trace flakes of organic matter (fish scales) in a layer of decomposing material.		Z
				SM: moist, medium dense, black (GLEY 1, 2.5/N) SAND, little silt. Moderate to substational wood, trace fish bones. @ 4.7': 1" thick layer of moderate to substantial wood fragments @ 4.9': fish bones up to 3" L @ 5.4': CLAYEY SILT with seams of sand		
				End of core at 6.3'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.		





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Remarks: Drive notes: freefall (1.0'), easy (7.0'), no refusal.
Core shoe was empty.

Calculated Recovery
Sample Length/Penetration Length:
6.8 / 7.0 = 97 %

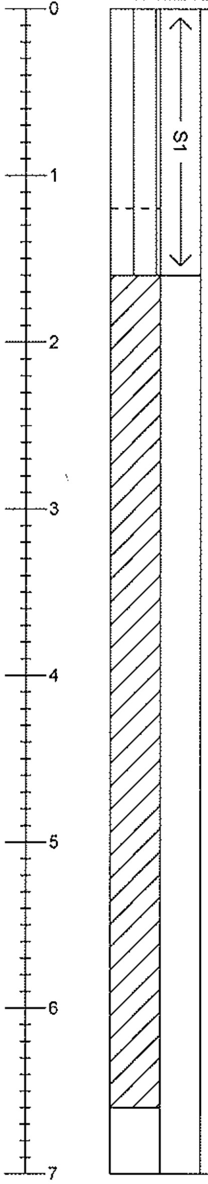
Sediment Core Log

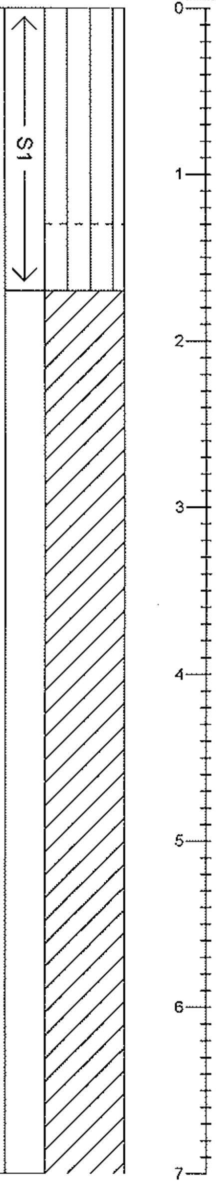
IJ-22

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-2.6**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **16.7**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-19.3**	Recovery in ft (%): **6.6 (93)**
Contractor: **MSS**	N./LAT: **48 45.3023** E./LONG: **122 29.5739**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0–1.0	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C5) Bioassays (IJ-C5)	ML: moist, soft, greenish black (GLEY 1, 2.5/10Y) SILT trace very fine sand. Trace shell fragments up to 3" L. Moderate hydrogen sulfide odor.		S1
1.0–1.6				ML: moist, medium stiff, greenish black (GLEY 1, 2.5/10Y) SILT, few medium-coarse sand. Scattered small shell fragments. Strong hydrogen sulfide odor.	Homogenized for sample IJ-C5	
1.6–6.6				CL: moist, stiff, greenish gray (GLEY 1, 5/GY) CLAY, trace subrounded gravel.		
6.6				End of core at 6.6'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.		





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Remarks: Drive notes: freefall (2.0'), moderate (7.0'), no refusal.
Core shoe was 100% full of green-gray clay.

Calculated Recovery
Sample Length/Penetration Length:
6.6 /7.0 = 93 %

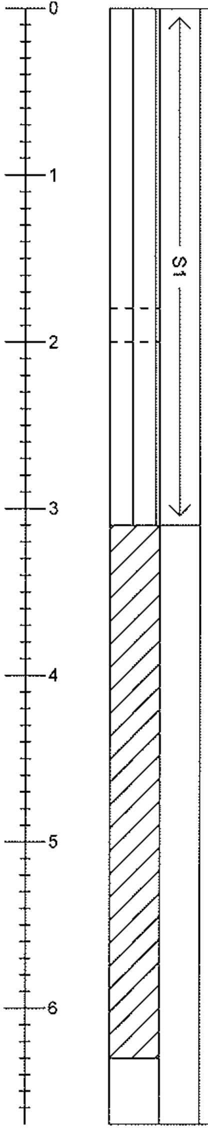
Sediment Core Log

IJ-23

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-1.8**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **15.7**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-17.5**	Recovery in ft (%): **6.7 (96)**
Contractor: **MSS**	N./LAT: **48 45.2721** E./LONG: **122 29.6107**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log



Metals
VOCs
PCB
TBT bulk
Pesticides
Conventionals
Grain Size
TBT porewater
Archive

Dioxins (IJ-C5)
Bioassays (IJ-C5)

ML: moist, very soft, greenish black (GLEY 1, 2.5/10Y) SILT, few sand. Abundant intact mussel shells up to 1.5" L. Trace wood fragments up to 2.5" L. Moderate hydrogen sulfide odor. Grades to substantial shells and fish scales up to 3" L and fish bones up to 1" L. Trace subrounded 2" L gravel and trace wood fragments up to 2" L. Very strong hydrogen sulfide odor.

@ 1.6': piece of 3" L filmy, thin, plastic

ML: moist, medium stiff, greenish black (GLEY 1, 2.5/10Y) SILT, few fine sand. Scattered decomposed fish matter (scales and flakes).

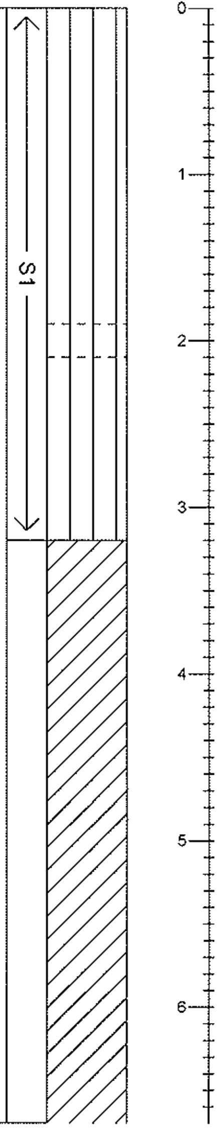
ML: moist, medium stiff, greenish black (GLEY 1, 2.5/10Y) VERY SANDY SILT. Scattered 1/2" to 1" thick layers of decomposed, broken fish matter (scales, bones, flakes).

CL: moist, stiff, greenish gray (GLEY 1, 5/GY) CLAY, trace subrounded gravel up to 1/2" diameter.

End of core at 6.3'.
In-situ depth = Recovered Interval / % Recovery
Method assumes compaction is the same throughout the core.

Homogenized for sample IJ-C5

Bag @ 1.6' (plastic).



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Remarks: Drive notes: freefall (1.0'), easy (4.0'), moderate-hard (7.0'), no refusal. Core shoe was 100% full of green-gray clay. Piece of 3/8" polypropylene line in bottom of core shoe.

Calculated Recovery
Sample Length/Penetration Length:
6.7 / 7.0 = 96 %

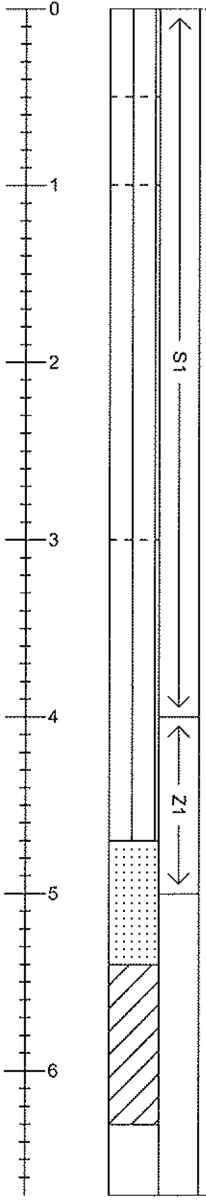
Sediment Core Log

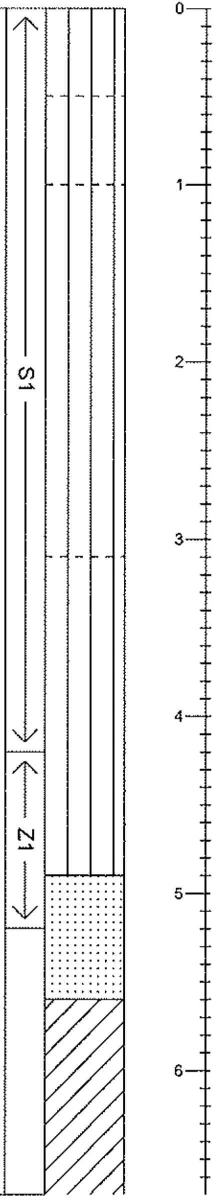
IJ-24

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-0.9**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **16.3**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-17.2**	Recovery in ft (%): **6.6 (96)**
Contractor: **MSS**	N./LAT: **48 45.2894** E./LONG: **122 29.5948**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C5) Bioassays (IJ-C5)	ML: moist, soft, greenish black (GLEY 1, 2.5/10Y) SILT, trace very fine sand. Color is mottled gray-green and black. @ 0.5': 2" L worm		S1
1				ML: moist, soft, black (GLEY 1, 2.5/N) CLAYEY SILT. Silt competancy increases toward basal contact. Few fish matter (fish scales and bones), trace intact mussle shells up to 1" L, and trace shell fragments up to 2 cm.	Homogenized for sample IJ-C5	
2				ML: moist, soft, black (GLEY 1, 2.5/N) CLAYEY SILT, trace fine sand. Silt decreases in competancy toward basal contact. Trace fish matter (scales, bones) increasing to substantial below 2.2' in 2" thick layers. Trace hydrogen sulfide odor.		
3				ML: moist, medium-stiff, black (GLEY 1, 2.5/N) SILT, few sand and trace gravel. Sand grains are medium to coarse and multicolored (gray, white, black). Gravel is subangular, up to 3" diameter, and increases to few below 4.2 feet. Trace rootlets. Trace hydrogen sulfide odor.		
4	Z1		Archive			Z1
5				SM: moist, medium dense, black (GLEY 1, 2.5/N) COARSE SAND, few silt. Moderate to substantial shredded wood fragments.		
6				CL: moist, medium stiff, greenish gray (GLEY 1, 5/GY) CLAY. End of core at 6.3'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.		





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Remarks: **Drive notes: freefall (1.0'), easy (4.0'), moderate-hard (7.0'), no refusal. Core shoe was 100% full of gray-green clay and some woody material.**

Calculated Recovery
Sample Length/Penetration Length:
6.7 / 7.0 = 96 %

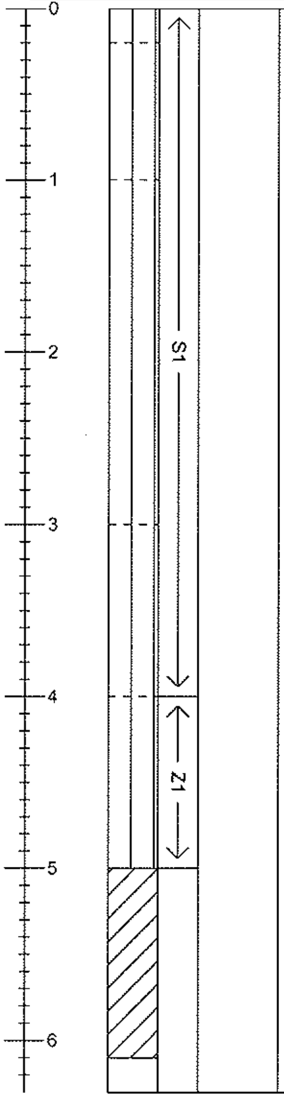
Sediment Core Log

IJ-25

Sheet 1 of 1

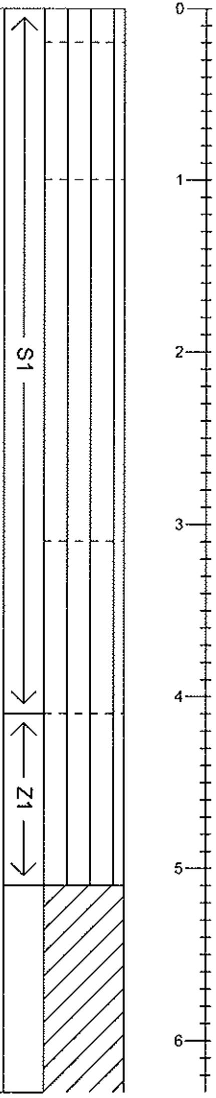
Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **0.01**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **16.9**	Sample Quality: **Good**
Collection Date: **06/12/06**	Mudline Elevation (ft): **-16.9**	Recovery in ft (%): **6.8 (97)**
Contractor: **MSS**	N./LAT: **48 45.3027** E./LONG: **122 29.5741**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft) | Recov.Interval & Sample # | % Recovery (depth in ft)



Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths
	ML: wet, very soft, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT.	
Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater VOCs Sulfides Archive Dioxins (IJ-C5) Bioassays (IJ-C5)	ML: moist, soft, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT. Silt competancy increases toward basal contact. Trace rootlets. Trace hydrogen sulfide odor.	Homogenized for sample IJ-C5
	ML: moist, soft, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT, trace very fine sand. Trace fish matter (scales) below 2.2 feet and trace layers of fish matter. @ 2.0': 2" thick layer of substantial fish matter (scales, bones, shells). Slight hydrogen sulfide odor.	
	ML: moist, medium-stiff, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT, trace medium to coarse sand.	
Archive	ML: moist, medium-stiff, greenish black (GLEY 1, 2.5/10Y) SILT, little medium to coarse sand. Moderate decomposed wood chips and shreds up to 1" L.	
	CL: damp, stiff, greenish gray (GLEY 1, 5/GY) CLAY, trace subrounded gravel up to 1" diameter. Clay is of high plasticity, rolls well, and is highly competant.	
	End of core at 6.1'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.	

In-situ Depths (ft) & Graphic Log



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Remarks: **Drive notes: freefall (4.0'), easy (5.0'), moderate-hard (7.0'), no refusal. Core shoe was 100% full of gray-green clay.**

Calculated Recovery
Sample Length/Penetration Length:
6.8 /7.0 = 97 %

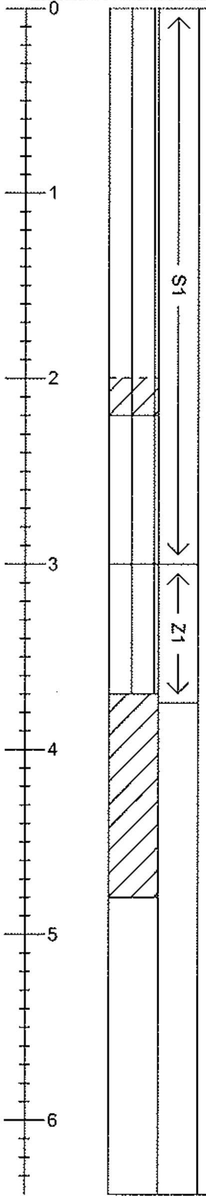
Sediment Core Log

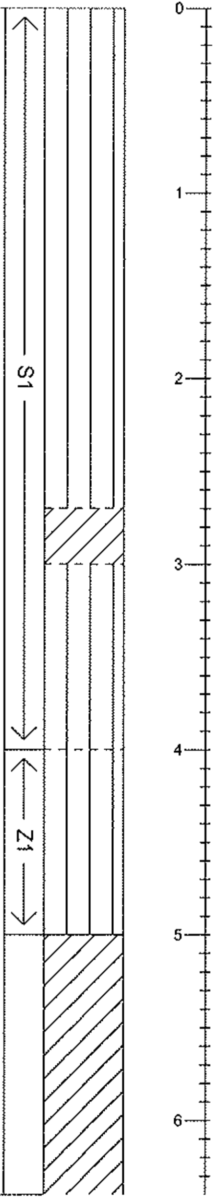
IJ-26

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-3.0**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **17.2**	Sample Quality: **Good**
Collection Date: **06/13/06**	Mudline Elevation (ft): **-14.2**	Recovery in ft (%): **5.2 (75)**
Contractor: **MSS**	N./LAT: **48 45.2519** E./LONG: **122 29.6311**	Process Date: **06/14/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0–2	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater VOCs Sulfides Archive Dioxins (IJ-C6) Bioassays (IJ-C6)	ML: wet, soft, greenish black (GLEY 1, 2.5/10Y) FISHY SILT. Abundant decomposed fish bones and scales up to 4" L, wood splinters and fragments up to 2.5" L, and shells up to 2.5" L. Very strong hydrogen sulfide odor.	Homogenized for sample IJ-C6	S1
				CL: moist, medium stiff, very dark greenish gray (GLEY 1, 5/GY) CLAY, little silt. Clay texture is gummy.		
				ML: moist, medium stiff, greenish gray (GLEY 1, 3/10Y) SILT, little fine to medium sand. Very strong hydrogen sulfide odor.		
3	Z1		Archive	ML: moist, medium-stiff, greenish gray (GLEY 1, 3/10Y) SILT, little, sand and clay. Silt texture increases in competancy toward basal contact. Scattered fish matter (bones) up to 2" L, shells both intact and fragments up to 2" L, and wood fragments up to 3"L. Hydrogen sulfide odor decreases toward basal contact from strong to trace.		
4				CL: moist, stiff, greenish gray (GLEY 1, 5/GY) CLAY. Clay rolls well and is of high plasticity.		Z1
				End of core at 4.8'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.	No sample collected below 3.75' due to clay layer. Strongest hydrogen sulfide odor of all the cores logged.	





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Remarks: Drive notes: freefall (3.5'), easy (6.0'), moderate-hard (7.0'), no refusal. Core shoe was 100% full of gray-green clay.

Calculated Recovery
Sample Length/Penetration Length:
5.2 /7.0 = 75 %

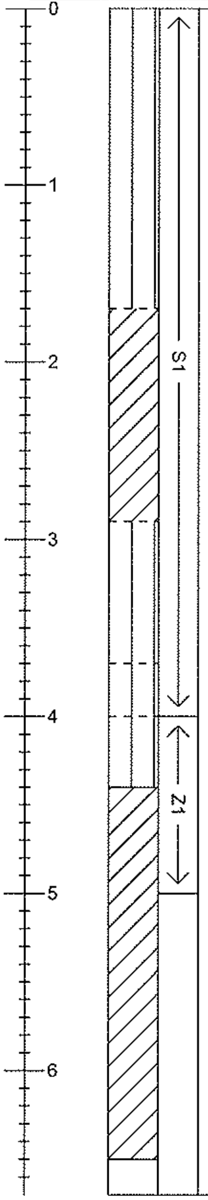
Sediment Core Log

IJ-27

Sheet 1 of 1

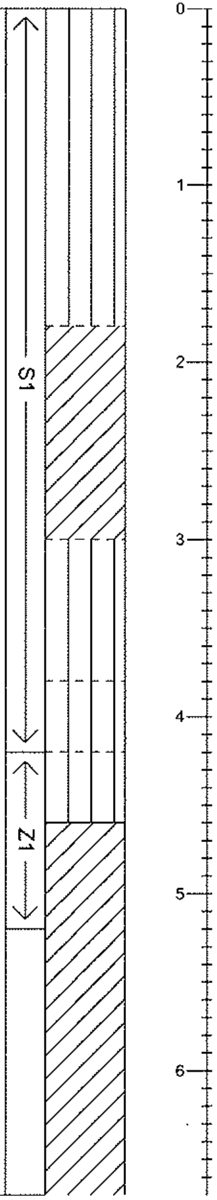
Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-3.0**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **13.4**	Sample Quality: **Good**
Collection Date: **06/13/06**	Mudline Elevation (ft): **-16.4**	Recovery in ft (%): **6.7 (96)**
Contractor: **MSS**	N./LAT: **48 45.2702** E./LONG: **122 29.6068**	Process Date: **06/14/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft) | Recov. Interval & Sample # | % Recovery (depth in ft)



Analysis	Sediment Description Classification Scheme: USCS Contacts are recovered depth	Comments for Recovered Depths
Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive	ML: wet, soft, greenish black (GLEY 1, 2.5/10Y) FISHY SILT, trace subrounded gravel. Abundant decomposed fish scales and wood splinters up to 3.0" L, trace intact mussel shells up to 0.5" L and worms. Moderate hydrogen sulfide odor.	Homogenized for sample IJ-C6
Dioxins (IJ-C6) Bioassays (IJ-C6)	CL: moist, medium stiff, very dark greenish gray (GLEY 1, 5/GY) CLAY, few fine sand and clay. Scattered wood fragments and fish matter (bones). Trace to moderate hydrogen sulfide odor. @ 2.0': angular anthropogenic fragment	
	ML: moist, soft, very dark greenish gray (GLEY 1, 3/10Y) FISHY SILT, little fine sand. Abundant fish matter (bones and scales). Very strong hydrogen sulfide odor.	
	ML: moist, soft, very dark greenish gray (GLEY 1, 3/10Y) SILT, little fine sand. Scattered fish matter (bones, scales, vertebrae). Moderate hydrogen sulfide odor.	
Archive	ML: moist, medium-stiff, very dark greenish gray (GLEY 1, 3/10Y) SILT, few sand and clay. Scattered layer of fish matter (scales).	
	CL: damp, stiff, greenish gray (GLEY 1, 5/GY) CLAY, trace subrounded gravel. Clay is highly competant, of high plasticity, and rolls well.	
	End of core at 6.5'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.	

In-situ Depths (ft) & Graphic Log



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Remarks: **Drive notes: freefall (5.0'), moderate-hard (7.0'), no refusal. Proposed location was under the dock, actual is 6.0' from proposed.**

Calculated Recovery
Sample Length/Penetration Length:
6.7 / 7.0 = 96 %

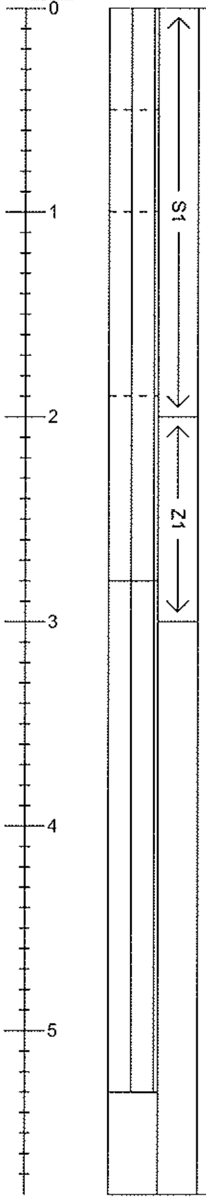
Sediment Core Log

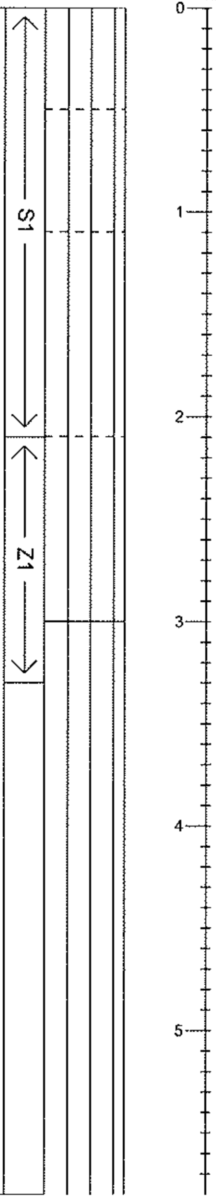
IJ-28

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **+3.0**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **17.0**	Sample Quality: **Good**
Collection Date: **06/13/06**	Mudline Elevation (ft): **-14.0**	Recovery in ft (%): **5.8 (92)**
Contractor: **MSS**	N./LAT: **48 45.2865** E./LONG: **122 29.5820**	Process Date: **06/14/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov.Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C6) Bioassays (IJ-C6)	ML: wet, very soft, greenish black (GLEY 1, 2.5/10Y) FISHY SILT, trace sand. Abundant decomposed fish matter (bones) and mussel shells.	Homogenized for sample IJ-C6	S1
				ML: moist, soft, very dark greenish gray (GLEY 1, 5/GY) SILT, few sand and trace subrounded gravel up to 3" L. Silt competancy increases with depth. Moderate fish matter (scales).		
1				ML: moist, soft, very dark greenish gray (GLEY 1, 3/10Y) SILT, few fine to medium sand. Trace to scattered fish matter (scales), shells, and seams of decomposed wood.		
2	Z1		Archive	ML: moist, soft, very dark greenish gray (GLEY 1, 3/10Y) SILT, few sand and clay, trace subangular gravel up to 0.25" diameter. Moderate shell fragments. Trace hydrogen sulfide odor.		Z1
3				ML: moist, soft, dark greenish gray (GLEY 1, 4/10Y) SILT, little medium to coarse sand. Trace rootlets. Grades to more sand towards basal contact.		
5				End of core at 5.3'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.		





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Remarks: Drive notes: freefall (2.6'), moderate-hard (7.0'), no refusal.

Calculated Recovery
Sample Length/Penetration Length:
5.8 / 7.0 = 92 %

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Sediment Core Log

IJ-29

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-2.1**	Penetration Depth (ft): **6.8**
Client: **Port of Bellingham**	Water Depth (ft): **8.4**	Sample Quality: **Good**
Collection Date: **06/13/06**	Mudline Elevation (ft): **-10.3**	Recovery in ft (%): **6.8 (100)**
Contractor: **MSS**	N./LAT: **48 45.3000** E./LONG: **122 29.5616**	Process Date: **06/14/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0–2	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C6) Bioassays (IJ-C6)	ML: wet, soft, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT, trace fine sand. Silt competancy and sand content increase towards basal contact . Trace shell and wood fragments up to 2" L and scattered worms. Trace hydrogen sulfide odor.	Homogenized for sample IJ-C6	S1
2–6.2	Z1		Archive	ML: wet, soft, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT, few fine sand. Trace rootlets and wood fragments. @ 3.8': seam of wood fragments (lumbered)		Z1
6.2–6.8				ML: moist, medium-stiff, very dark greenish gray (GLEY 1, 3/10Y) CLAYEY SILT, little sand. Color is mottled black and greenish gray.		

End of core at 6.8'.
In-situ depth = Recovered Interval / % Recovery
Method assumes compaction is the same
throughout the core.

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Remarks: Drive notes: easy (6.8'), no refusal.

Calculated Recovery
Sample Length/Penetration Length:
6.8 / 6.8 = 100 %

Sediment Core Log

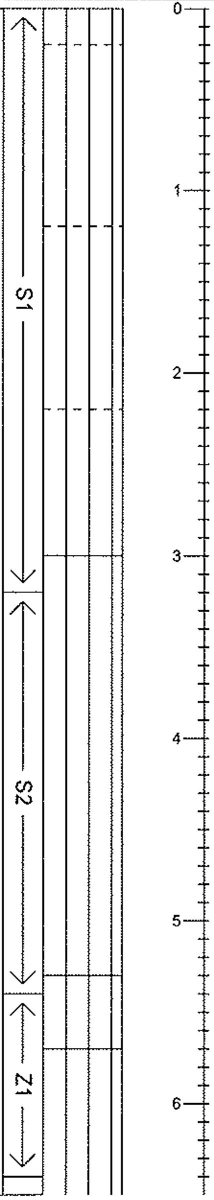
IJ-30

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **-0.5**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **15.3**	Sample Quality: **Good**
Collection Date: **06/14/06**	Mudline Elevation (ft): **-15.8**	Recovery in ft (%): **6.5 (93)**
Contractor: **MSS**	N./LAT: **48 45.3170** E./LONG: **122 29.5745**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths
0	S1		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C4-S1) Bioassays (IJ-C4-S1)	ML: wet, very soft, black (GLEY 1, 2.5/N) SILT, few fine sand. Trace eel grass blades and mussel shell fragments up to 1" L.	Homogenized for sample IJ-C4-S1
1				ML: wet, soft, black (GLEY 1, 2.5/N) SILT, few fine sand. Trace shell fragments up to 0.5" L and rootlets. Silt has increased competancy.	
				ML: moist, soft, very dark gray (GLEY 1, 3/N) CLAYEY SILT, few fine sand. Trace wood fragments.	
2				ML: moist, soft, very dark gray (GLEY 1, 3/N) CLAYEY SILT, few medium sand. Trace rootlets. Trace hydrogen sulfide odor.	
3 4	S2		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C4-S2) Bioassays (IJ-C4-S2)	ML: moist, medium stiff, dark reddish brown (5YR, 2.5/Z) WOODY SILT, little sand. Wood fragments and chips are up to 3" L. Sand grains are medium to coarse, angular, poorly sorted, multicolored (black, white, brownish-green), and non-native looking. Moderate hydrogen sulfide odor. @ 3.8': Strong hydrogen sulfide odor.	Homogenized for sample IJ-C4-S2 Bag @ 4.0' (sand, non-native looking).
5				ML: moist, medium stiff, very dark gray (GLEY 1, 3/N) SILT, few medium sand. Trace hydrodgen sulfide odor.	
6	Z1		Archive	ML: moist, soft, very dark gray (GLEY 1, 3/N) CLAYEY SILT, few medium sand. Trace rootlets.	
				End of core at 6.1'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.	

In-situ Depths (ft) & Graphic Log



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Remarks: **Drive notes: freefall (0-3'), easy (7.0'), no refusal.**

Core shoe was 50 % full of black sandy silt with wood.

Calculated Recovery
Sample Length/Penetration Length:
6.5 / 7.0 = 93 %

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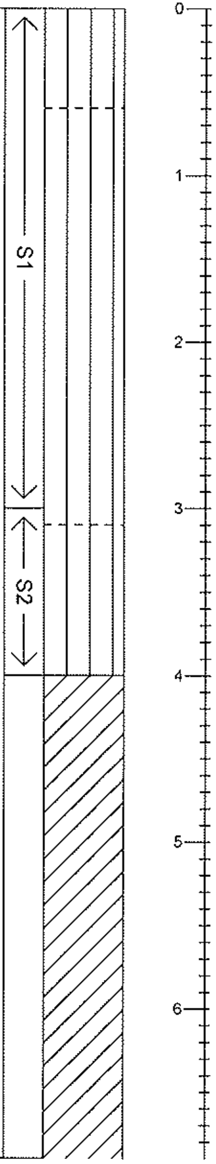
Sediment Core Log

IJ-31

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **+1.0**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **16.8**	Sample Quality: **Good**
Collection Date: **06/14/06**	Mudline Elevation (ft): **-15.8**	Recovery in ft (%): **6.9 (99)**
Contractor: **MSS**	N./LAT: **48 45.3238** E./LONG: **122 29.5602**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft)	Recov. Interval & Sample #	% Recovery (depth in ft)	Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths	*In-situ* Depths (ft) & Graphic Log
0	S1			ML: wet, soft, black (GLEY 1, 2.5/N) SILT. Trace leaf and wood fragments up to 3" L.		0
			Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C4-S1) Bioassays (IJ-C4-S1)	ML: moist, soft, black (GLEY 1, 2.5/N) SILT with 2" diameter pockets of clay. Silt has increased competancy. Trace rootlets. Trace hydrogen sulfide odor. @ 1.2': 2" thick layer of moist, soft, black (GLEY 1, 2.5/N) SILT, few medium sand. Trace wood fragments up to 0.25" L. Moderate hydrogen sulfide odor. @ 2.2': layer of fish scales up to 0.5" L.	Homogenized for sample IJ-C4-S1	1 2
3	S2		Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C4-S2) Bioassays (IJ-C4-S2)	ML: moist, medium stiff, black (GLEY 1, 2.5/N) SILT, few coarse sand and clay, trace sub-angular gravel. Sand is similar to that found in IJ-30. Gravel is up to 1" diameter. Trace dark red (5YR, 2.5/2) wood fragments up to 3" L.	Homogenized for sample IJ-C4-S2	3
4 5 6				CL: damp, stiff, greenish gray (GLEY 1, 5/GY) CLAY. Clay is of high plasticity, rolls well, and is highly competant.		4 5 6
				End of core at 6.5'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.		



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Remarks: Drive notes: freefall (4.5'), moderate (5.0'), hard (7.0'), no refusal. Core shoe was full of stiff, gray, clay.

Calculated Recovery
Sample Length/Penetration Length:
6.9 / 7.0 = 99 %

Sediment Core Log

IJ-32

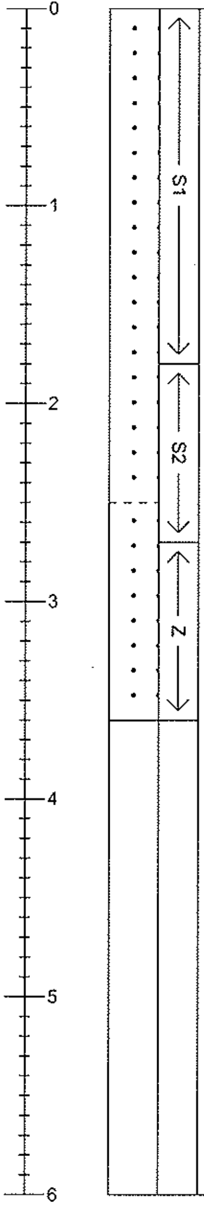
Sheet 1 of 1

Project: **POB I&J Waterway**
Project #: **PORTB-18448-310**
Client: **Port of Bellingham**
Collection Date: **06/14/06**
Contractor: **MSS**
Vessel: **R/V Nancy Anne**
Operator: **Bill Jaworski**

Water Body Type: **Marine**
Water Elevation (ft)/Tide: **+2.6**
Water Depth (ft): **3.7**
Mudline Elevation (ft): **-1.1**
N./LAT: **48 45.3292** E./LONG: **122 29.5429**
Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**
Method/Tube ID: **Vibracorer/3" round Al**

Tube Length (ft): **8.0**
Penetration Depth (ft): **7.0**
Sample Quality: **Good**
Recovery in ft (%): **4.2 (60)**
Process Date: **06/15/06**
Process Method: **Cut tube**
Logged By: **L.McKee, C.Brackett**

Recovered Depth (ft) | Recov. Interval & Sample # | % Recovery (depth in ft) | Analysis



Analysis

Metals
SVOCs
PCB
TBT bulk
Pesticides
Conventionals
Grain Size
TBT porewater
Sulfides
VOCs
Archive
Dioxins (IJ-C4-S1)
Bioassays (IJ-C4-S1)

Metals
SVOCs
PCB
TBT bulk
Pesticides
Conventionals
Grain Size
TBT porewater
Sulfides
VOCs
Archive
Dioxins (IJ-C4-S2)
Bioassays (IJ-C4-S2)

Archive

Sediment Description

Classification Scheme: USCS
Contacts are recovered depth

SP: moist, medium dense, dark gray (GLEY 1, 4/N) FINE SAND, few silt. Jumbled texture. Trace intact clam shells up to 2" L and rootlets. Scattered wood fragments up to 3" L. Moderate to strong hydrogen sulfide odor.
@ 0.0-0.8': Shell fragments with trace intact shells up to 2" L.

SP: moist, medium dense, dark gray (GLEY 1, 4/N) MEDIUM SAND, trace subrounded gravel up to 2" diameter. Scattered shell fragments.

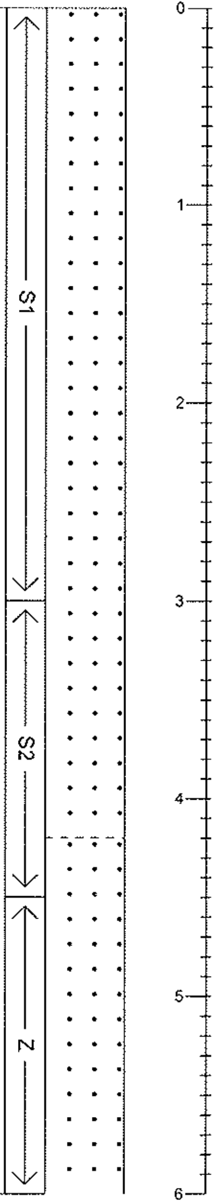
End of core at 3.6'.
In-situ depth = Recovered Interval / % Recovery
Method assumes compaction is the same throughout the core.

Comments for Recovered Depths

Homogenized for sample IJ-C4-S1

Homogenized for sample IJ-C4-S2

In-situ Depths (ft) & Graphic Log



Remarks: **Drive notes: moderate (7.0'), no refusal.**
Core shoe was full of dark gray sand with moderate sulfide odor.

Calculated Recovery
Sample Length/Penetration Length:
4.2 / 7.0 = 60 %

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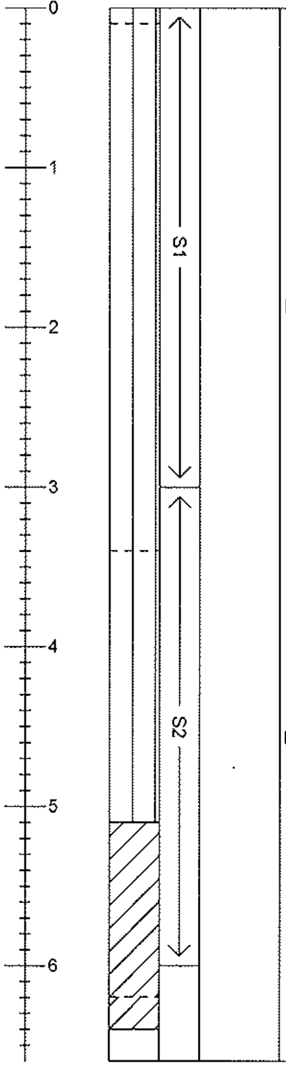
Sediment Core Log

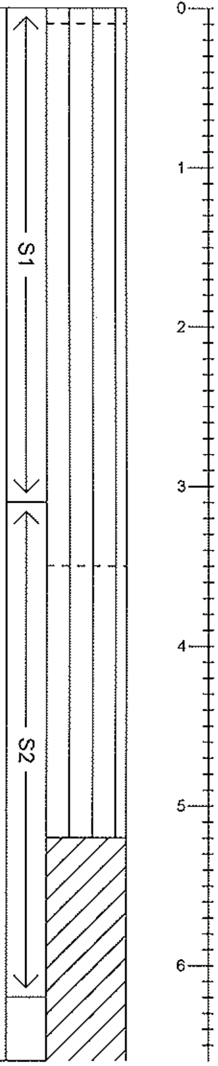
IJ-33

Sheet 1 of 1

Project: **POB I&J Waterway**	Water Body Type: **Marine**	Tube Length (ft): **8.0**
Project #: **PORTB-18448-310**	Water Elevation (ft)/Tide: **+1.2**	Penetration Depth (ft): **7.0**
Client: **Port of Bellingham**	Water Depth (ft): **11.2**	Sample Quality: **Good**
Collection Date: **06/14/06**	Mudline Elevation (ft): **-10.0**	Recovery in ft (%): **6.8 (97)**
Contractor: **MSS**	N./LAT: **48 45.3149** E./LONG: **122 29.5432**	Process Date: **06/15/06**
Vessel: **R/V Nancy Anne**	Horiz. Datum: **NAD 83** Vert. Datum: **MLLW**	Process Method: **Cut tube**
Operator: **Bill Jaworski**	Method/Tube ID: **Vibracorer/3" round Al**	Logged By: **L.McKee, C.Brackett**



Analysis	**Sediment Description** Classification Scheme: USCS Contacts are recovered depth	**Comments** for Recovered Depths
Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C4-S1) Bioassays (IJ-C4-S1)	ML: wet, very soft, greenish black (GLEY 1, 2.5/10Y) SILT. ML: moist, soft, greenish black (GLEY 1, 2.5/10Y) CLAYEY SILT, few fine sand. Trace rootlets and leaf stems. Grades to medium sand below 1.5'. Trace hydrogen sulfide odor.	Homogenized for sample IJ-C4-S1
Metals SVOCs PCB TBT bulk Pesticides Conventionals Grain Size TBT porewater Archive Dioxins (IJ-C4-S2) Bioassays (IJ-C4-S2)	ML: moist, medium stiff, very dark gray (GLEY 1, 3/N) SILT, few fine to medium sand. Sand grains are poorly sorted and angular. Scattered shredded wood up to 2" L. Grades to no wood below 4.2". Sand content increases to little (25%) toward basal contact.	Homogenized for sample IJ-C4-S2
	CL: damp, medium stiff, greenish gray (GLEY 1, 5/GY) CLAY, few sand. Jumbled texture.	
	CL: damp, firm, greenish gray (GLEY 1, 5/GY) CLAY.	
	End of core at 6.4'. In-situ depth = Recovered Interval / % Recovery Method assumes compaction is the same throughout the core.	



The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162
Phone: (206) 624-9349
Fax: (206) 624-2839

Remarks: Drive notes: easy (7.0'), no refusal.

Core shoe was full of gray-green clay.

Calculated Recovery
Sample Length/Penetration Length:
6.8 / 7.0 = 97 %

Sediment Core Processing Log

ANCHOR QEA

Job: USACE: Squalicum and I&J Waterways Station ID: I-1 (S17)

Job No. 080202-01

No. of Sections: 1

Drive Length: 9'

Recovery: 8.4'

% Recovery: 93%

Notes:

Date/Time: 9-8-2011

Core Logged By: JL

Attempt #: 2 of 2

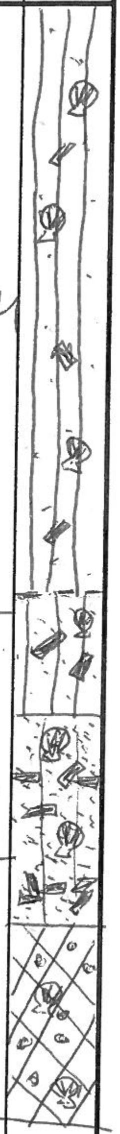
Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core

Diameter of Core (inches) 3.5" Lexan - core extruded

Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	**Classification and Remarks** (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor) In-situ elevation →	~~Recovered Length (ft)~~	~~PID~~	Sample	Summary Sketch	time
0		10	90	Soft, wet, black, slightly f-sandy SILT. Occasional shell and wood fragments. Slight H_2S-like odor	-15.1		I-1-DM		950
		20	80	@4.5' Grades to medium stiff, moist, f-m sandy. Moderate wood fragments (decomposed sticks). Moderate H_2S-like odor. @5' piece of rope (6" long)					
		70	30	~~@5.5' Grades to very f-m sandy~~ Medium dense, damp, dark gray, ~~slightly~~ silty f-m SAND. Substantial wood debris (decomposed sticks and fibers). Moderate shell hash. Moderate H_2S-like odor.			I-1-Z		955
7	10		90	Very stiff, damp to dry, light gray, slightly f-gravelly CLAY. Clay rolls easily. ~~Occasional~~ Moderate shell hash. Strong H_2S-like odor.					
				End of core @8.4'					

10



Page 1 of 1

Sediment Core Processing Log

ANCHOR QEA

Job: USACE: Squalicum and I&J Waterways Station ID: I-2
Job No. 080202-01
No. of Sections: 1
Drive Length: 9'
Recovery: 8.4
% Recovery: 93%
Notes:

Date/Time: 9/8/2011
Core Logged By: JL
Attempt #: 2 of 2
Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core
Diameter of Core (inches) 3.5" Lexan - Core Extruded
Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	Classification and Remarks (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor)	~~Recovered Length (ft)~~	~~PID~~	Sample	Summary Sketch	time
0		10	90	In-situ Elevation → Soft, wet, black, slightly ~~[illegible]~~ vf-f-sandy SILT. Trace biota (pink worms). Occasional wood fragments (sticks). Occasional shell fragments. Slight H_2S-like odor.	-16.3'				
1							I-2-A-DM ~~I-2-DM~~		1110
2									
3									
4							I-2-A-Z ~~I-2-Z~~		1115
5		70	30	Medium dense, moist, dark gray, silty f-c SAND. Moderate wood and shell fragments. Moderate H_2S-like odor.					
6	10		90	Stiff, damp, light gray, slightly f-gravelly CLAY. Clay rolls easily. Moderate shell hash. Strong H_2S-like odor.					
7				End of core @7'					
8				Note: clay in shoe. 1.4' of clay lost from base of core during retrieval.					
10									

Compaction correction does not include the 2.8' clay unit. Compaction was adjusted to 90% for silt and sand.

Page 1 of 1

Sediment Core Processing Log

ANCHOR QEA

Job: USACE: Squalicum and I&J Waterways Station ID: I-3 (519)

Job No. 080202-01
No. of Sections: 1
Drive Length: 8'
Recovery: 6.4'
% Recovery: 80%
Notes:

Date/Time: 9-8-2011
Core Logged By: JL
Attempt #: 1 of 1
Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core
Diameter of Core (inches) 3.5" Lexan - core extruded
Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	Classification and Remarks (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor)	~~Recovered Length (ft)~~ in-situ elevation	~~PID~~	Sample	Summary Sketch	time
0 1		10	90	Soft, wet, black, slightly f-sandy SILT. Trace biota (worms). Occasional shell fragments. Slight H_2S-like odor.			I-3-DM		1200
2 3 4 5	5	80	15	Medium dense, moist to damp, slightly silty f-m SAND. Moderate shell fragments. Trace gravel. Moderate H_2S-like odor. @4': Grades to dense, damp.			I-3-Z		1205
6	80	20		Medium dense to dense, damp, c-sandy GRAVEL. Moderate shell fragments. Moderate H_2S-like odor.					
7 8 10				End of core at 6.4'					

Sediment Core Processing Log

ANCHOR QEA

Job: USACE: Squalicum and I&J Waterways Station ID: I-4 (S20)

Job No. 080202-01

Date/Time: 9-8-2011

No. of Sections: 1

Core Logged By: JL

Drive Length: 9.5'

Attempt #: 3 of 3

Recovery: 7.8'

Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core

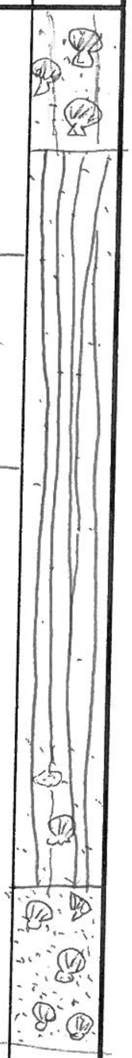
% Recovery: 82%

Diameter of Core (inches) 3.5" Lexan - Core extruded

Notes:

Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

	Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	Classification and Remarks (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor) in-situ Elevation →	~~Recovered Length (ft)~~	~~PID~~	Sample	Summary Sketch	time
0			90	10	Loose, ~~damp~~ moist, dark gray, slightly silty f-c SAND. Occasional pockets of silt. Moderate shell fragments. Moderate H_2S-like odor	-17.7		I-4-A-DM		1515
1			8	92	Medium stiff, moist, dark olive gray, slightly f-sandy, SILT. Occasional shell fragments. Moderate H_2S-like odor.					
2								I-4-A-Z		1520
3			2	98	@3' Grades to trace sand.					
4										
5			10	90	@5.5' Grades to slightly f-m sandy. Moderate shell fragments. Trace pockets of f-m sand.					
6										
7			100		Dense, damp, dark gray f-m SAND. Moderate shell fragments. Moderate H_2S-like odor.					
8					End of core @ 7.8'					
10										



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Sediment Core Processing Log

Job: USACE: Squalicum and I&J Waterways Station ID: I-5 (S21)

Job No. 080202-01
No. of Sections: 1
Drive Length: 10'
Recovery: 9.8'
% Recovery: 98%
Notes:

Date/Time: 9-8-2011
Core Logged By: JL
Attempt #: 1 of 1
Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core
Diameter of Core (inches) 3.5" Lexan - core extruded
Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	**Classification and Remarks** (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor)	~~Recovered Length (ft)~~ insitu elevation	~~PID~~	Sample	Summary Sketch	time
0			100	Soft, wet, black SILT. Moderate ~~shell~~ wood fragments (sticks). Occasional shell fragments. Moderate H2S-like odor.	-16.6				
1							I-5-DM		1330
2				@2.5': Grades to medium stiff, moist.					
3									
4				@4' Grades to trace wood fragments.			I-5-Z		1335
5		5	95	@5': Grades to ~~stiff~~ trace vf-f sand. Strong H2S-like odor.					
6				@6': silt is gummy.					
7									
8				@8.5': Grades to moderate shell fragments.					
10									

~~Grades~~ End of core @ 9.8'

Page 1 of 1

Sediment Core Processing Log

ANCHOR QEA

Job: USACE: Squalicum and I&J Waterways Station ID: I-6 (S22)

Job No. 080202-01

Date/Time: 9-8-2011

No. of Sections: 1

Core Logged By: JL

Drive Length: 10'

Attempt #: 1 of 1

Recovery: 8.4'

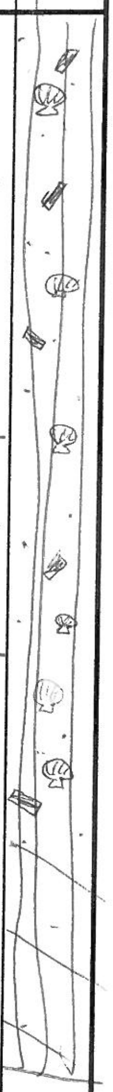
Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core

% Recovery: 84%

Diameter of Core (inches) 3.5" Lexan. Core extruded

Notes:

Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	Classification and Remarks (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor)	~~Recovered Length (ft)~~ in-situ elevation ↓	~~PID~~	Sample	Summary Sketch	time
0		2	98	Soft, wet, black SILT. Trace f-sand. Occasional shell and wood fragments. Trace biota (worms). Moderate H_2S-like odor.	-16.2				
1							I-6-A-DM		1410
2				@2': Grades to medium dense, moist.					
4				@4': Grades to moderate shell fragments. Strong H_2S-like odor.			I-6-A-Z		1415
6				@6': Grades to slightly clayey.					
8				End of Core @7.9'					
10									

Page 1 of 1

Sediment Core Processing Log

ANCHOR QEA

Job: USACE: Squalicum and I&J Waterways Station ID: I-7

Job No. 080202-01

Date/Time: 9-7-2011

No. of Sections: 1

Core Logged By: JL

Drive Length: 10'

Attempt #: 1 of 1

Recovery: 8.4

Type of Core ☐ Mudmole ☒ Vibracore ☐ Diver Core

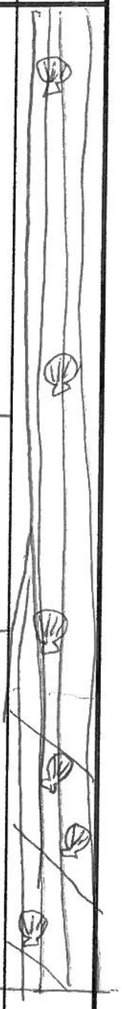
% Recovery: 84%

Diameter of Core (inches) 3.5" Lexan - core extruded

Notes:

Core Quality ☒ Good ☐ Fair ☐ Poor ☐ Disturbed

Recovered Length (ft)	Size % Gravel	Size % Sand	Size % Fines	Classification and Remarks (Density, Moisture, Color, Minor Constituent, MAJOR Constituent, with Additional Constituents, Sheen, Odor)	~~Recovered Length (ft)~~	~~PID~~	Sample	Summary Sketch	time
0				In-situ Elevation ↓					
	—	—	100	Soft, wet, dark gray SILT. Occasional shell fragments. slight H_2S-like odor.	-14.3				
1							I-7-DM		
2				@2': Grades to medium stiff, moist.					1640
3									
4				@4': Grades to moderate shell fragments.			I-7-Z		1645
5	—	—		@5': Grades to ~~slight~~ light olive gray, slightly clayey. Moderate H_2S-like odor.					
6									
7				@7': Strong H_2S-like odor.					
				End of core @7.3'					
8									
9									
10									



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APPENDIX E

DIOXIN AND FURAN CONGENER PROFILES

1 INTRODUCTION

This Appendix summarizes the dioxin/furan (D/F) congener profile comparison for I&J Waterway. The evaluation was conducted to support the conceptual site model by identifying similarities and differences in D/F congener profiles of Site sediment to other sediment samples outside of the Site and to potential sources of sediment contamination. D/Fs are produced as byproducts in a variety of processes, such as waste incineration or automobile emissions, and these different processes produce differing congener compositions. This evaluation was performed by qualitatively comparing congener profiles from I&J Waterway samples to samples collected from Bellingham Bay, sediment samples collected from near the Georgia-Pacific (GP) outfall and within the Aerated Stabilization Basin (ASB), and standard reference profiles from known sources.

The following sections review the method for developing congener profiles, the selection of reference profiles, and conclusions from this analysis.

2 DATA

The congener analysis was performed for all D/F surface and subsurface sediment samples in I&J Waterway and one catch basin solids sample. Specific dioxin-like congeners measured at the site include seven polychlorinated dibenzodioxin (dioxin) and ten polychlorinated dibenzofuran (furan) congeners. The D/F profiles were shown in two ways to better interpret trends in relative congener concentrations:

1. Concentrations of 16 congeners were normalized to the total concentration of all 16 congeners.
2. The toxic equivalency (TEQ) concentrations of the congeners (concentration times the toxic equivalency factor for each congener). The TEQ concentrations are normalized to the total TEQ for all congeners.

For calculating TEQs, 0.5 times the estimated detection limit was used for non-detect.

The samples were presented in groups to more easily interpret trends in the data, as follows:

1. Congener profiles in the 2011 Dredged Material Management Program (DMMP) subsurface sediment core sampling in I&J Waterway federal navigation channel. This sampling included eight samples, one from within the I&J Waterway Site (I-1) and seven outside the Site up to approximately 3,000 feet from the Site (Figure 1), providing a direct comparison of congener profiles within the I&J Waterway Site and Bellingham Bay.
2. All other congener profiles in I&J Waterway:
    a. Surface sediment samples
        i. 2012 sampling: IJ12-01 through IJ12-08 and IJ12-58
        ii. 2013 under-dock sampling: IJ13-SS-101, 151, 102
    b. Subsurface sediment samples
        i. 2005 DMMP composite samples: IJ-C3-S1, IJ-C4-S1, IJ-C4-S2, IJ-C5-S1, IJ-C6-S1
        ii. 2013 Under-dock discrete samples: IJ-13-VC-101, IJ-13-102-2-4, IJ-13-102-4-5.4
    c. 2012 catch-basin solids sample from Hilton Avenue stormwater line: CB-002
3. Congener profiles in sediment near the GP outfall and from within the ASB, which has a distinct D/F signature.

In addition, multiple reference profiles are available for comparison and are provided in an attachment to this Appendix. The analysis performed for the Rayonier sediment site of the Rayonier Mill Off-Property Soil Dioxin Study Final Project Report (Ecology and Environment, Inc., 2011; Attachment 1) in Port Angeles includes profiles from multiple local sources (e.g., local hog-fuel burners) and general sources (e.g., diesel fuel), presented as bulk concentrations normalized to totals and as TEQ concentrations. EPA, 2006, also provides a series of reference profiles from various sources presented as bulk concentrations normalized to totals only (Attachment 2).

3 PROFILE COMPARISON

This section provides a series of qualitative observations based on comparison of congener profiles. Figures 2 and 3 show congener profiles from the 2011 DMMP subsurface sediment core sampling in the federal navigation channel, from within the I&J Waterway Site (I-1) and extending into Bellingham Bay. The profile from within the I&J Waterway Site (I-1) is similar to profiles farther out in the bay (I-2 through I-7). In Figure 2, these profiles generally contain approximately 80% OCDD, with smaller components of 1,2,3,4,6,7,8-HPCDD and OCDF. Figure 3 summarizes congener TEQ normalized to the total TEQ, which shows 1,2,3,4,6,7,8-HPCDD generally between 20 and 30%, with smaller portions of 1,2,3,7,8-PECDD (generally 10 to 20%) and 1,2,3,6,7,8-HXCDD (10 to 15%). These suggest all samples are similar, with no consistent trend moving out into the bay.

Figures 4 and 5 show congener profiles for all other surface sediment and subsurface sediment samples in I&J Waterway as well as the catch basin solids sample. All surface sediment samples consist of approximately 80% OCDD (Figure 4), consistent with 2011 DMMP samples. 2012 DMMP composite subsurface sediment samples also matched this pattern. Subsurface sediment samples from under the Bornstein Seafoods dock (IJ13-VC-101 and 102) and the catch basin sample (CB-002) contained less OCDD than other samples (approximately 65%-75%). For these four samples, the reduced percentage of OCDD resulted in higher contributions from all other congeners, most notably from the furans 1,2,3,4,6,7,8-HPCDF and OCDF.

The TEQ normalized profiles in Figure 5 show similar groupings and distinctions among samples. All surface sediment samples and the DMMP composite subsurface sediment samples contain TEQ contributions from 1,2,3,4,6,7,8-HPCDD of greater than 25%, consistent with 2011 DMMP samples. The subsurface sediment under the dock and catch basin solids sample have contributions of this congener of less than approximately 10% and comparatively higher concentrations in furans and 1,2,3,7,8-PECDD.

Figures 6 and 7 show the profiles from GP and ASB samples, which indicate a different profile than any I&J Waterway sample profiles. In Figure 6, OCDD contributes generally 30% to 50% to total concentrations. GP and ASB samples are also notable for higher dioxin concentrations (in particular 1,2,3,4,6,7,8-HPCDD) and lower furan concentrations. The

TEQ-normalized profiles for GP and ASB samples in Figure 7 indicate large contributions to TEQ concentrations from 2,3,7,8-TCDF, unlike any I&J Waterway profiles.

EPA, 2006 reference profiles (Attachment 1) contain several potential source with OCDD-dominated profiles. These include wood waste combustion, cement kilns, oil-fired electrical generation, pulp and paper mills, diesel truck exhaust, automobile exhaust, and forest fires. Many combustion sources, such as waste incinerators, backyard refuse barrel burning, coal-fired electrical generating facilities, petroleum refineries, and smelters contain higher contributions from furans.

Reference profiles in the Rayonier Mill Off-Property Soil Dioxin Study (Ecology and Environment, Inc., 2011; Attachment 2) indicate similar OCDD-dominated profiles from select hog-fuel boilers, sewage sludge incineration, tire combustion, truck diesel, unleaded gas, residential wood burning, oil-fired burner, forest fire, and pentachlorophenol. For TEQ normalized profiles, profiles with a prominent 1,2,3,7,8-PECDD peak include select hog-fuel boilers, oil-fired boiler, and forest fire. Pentachlorophenol has a prominent 1,2,3,4,6,7,8-HPCDD peak, and truck diesel emissions contain prominent peaks for both of these congeners.

4 CONCLUSIONS

This qualitative analysis was performed for the purpose of making qualitative assessments of potential sources of dioxins/furans in I&J Waterway. Based on this qualitative analysis, several observations can be made, as follows:

- 2012 DMMP samples from within the I&J Waterway Site have similar profiles to samples the federal navigation channel in Bellingham Bay up to 3,000 feet away.
- I&J Waterway surface sediment and subsurface sediment composite samples show similar profiles throughout the site and are very similar to the 2012 DMMP samples.
- Subsurface sediment samples from under the Bornstein dock and the catch basin sample have slightly different profiles from all other sediment samples from the Site. Surface sediment samples from beneath the dock are similar to surface sediment samples from the remainder of the waterway and are different from subsurface samples beneath the dock. This suggests no ongoing contribution from the Hilton Avenue stormwater system. Subsurface sediment samples from under the dock were collected from deeper intervals just above the native clay layer, which are likely associated with some other historical source closer to the time of original dock construction (1947) and original channel dredging (1966). Sediment beneath the dock will be remediated for other COCs that will also address elevated dioxin/furan concentrations.
- I&J Waterway samples do not resemble GP or ASB sediment samples.
- Comparison to reference profiles suggests that I&J Waterway surface sediment and composite subsurface sediment samples are consistent with urban activities, primarily associated with stormwater inputs from sources that could include diesel emissions, historical atmospheric deposition from hog-fuel burning, and other industrial activities. These D/F profiles indicate a general stormwater source not attributable to any site-associated release/activity, consistent with the conceptual site model presented in Section 7.1.

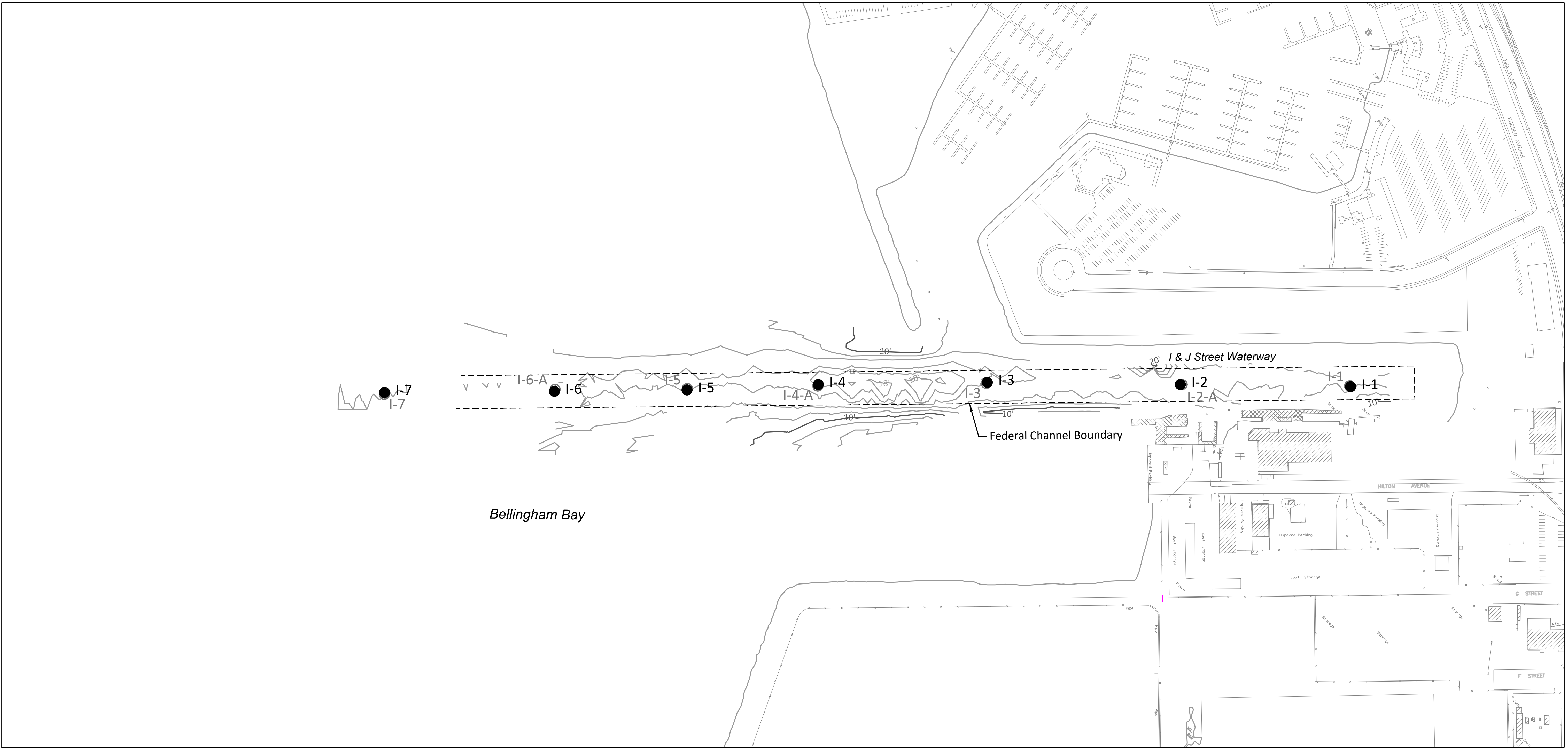
5 REFERENCES

Ecology and Environment, Inc., 2011. *Rayonier Mill Off-Property Soil Dioxin Study Final Project Report, Public Review Draft*. Prepared for Washington State Department of Ecology Toxics Cleanup Program.

EPA, 2006. *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000*. 600/P-03/002F. November 2006.

FIGURES

R:\Jobs\090007-01_I&J_Waterway\Maps\2014_03\Figure 1-I&J Waterway Subsurface Sed Dioxin Testing.dwg Figure 3



Apr 25, 2014 11:42am epipkin

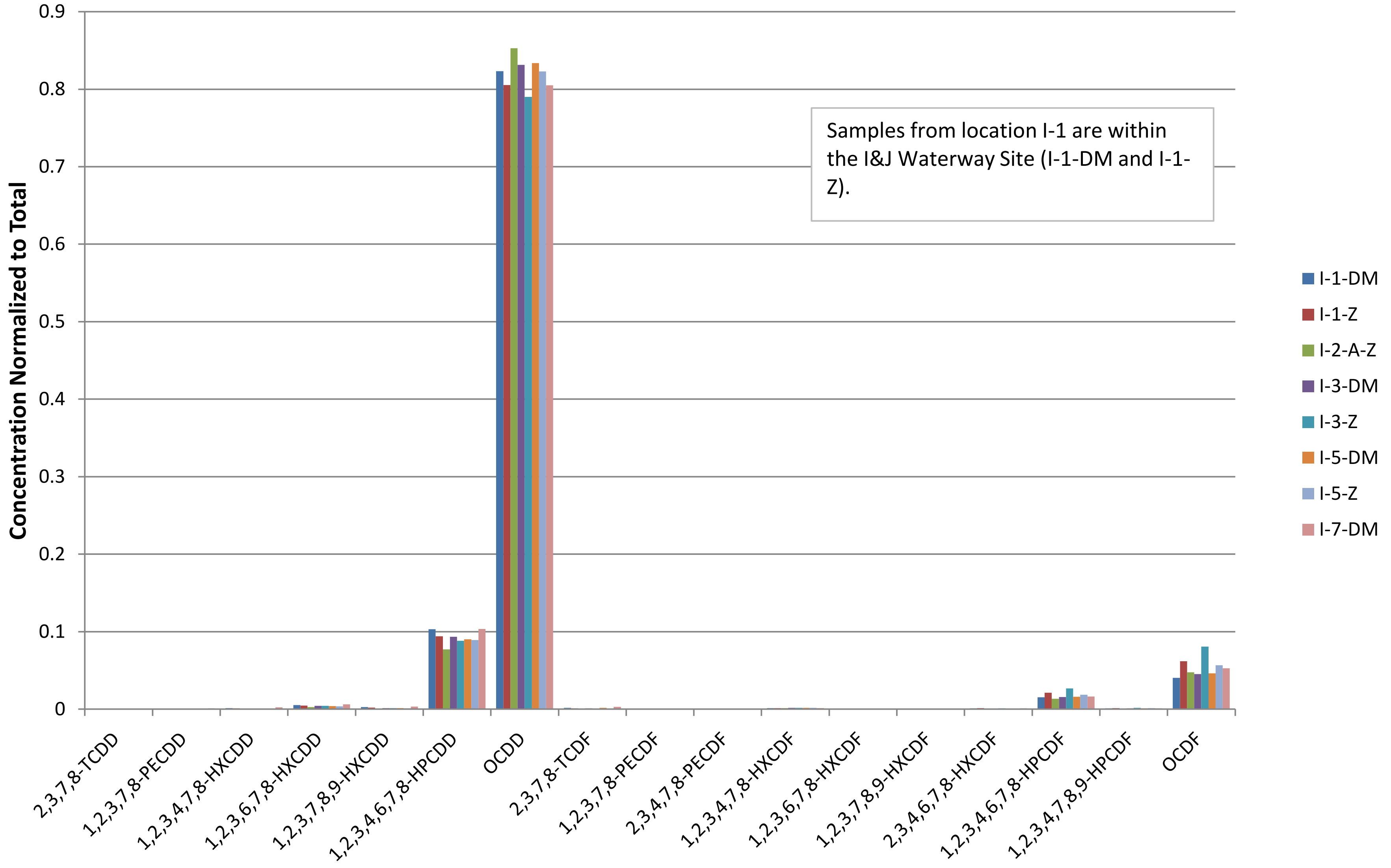
SOURCE: 2010 Bathymetric survey data provided by USACE.
HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

I-4 ⊕	Proposed Subsurface Sediment Sampling Location
I-4-A ●	Actual Subsurface Sediment Sampling Location

0 300
Scale in Feet

Figure 1
I & J Street Waterway Subsurface Sediment Sampling Locations
Dioxin Testing of Bellingham Bay Federal Project
U.S. Army Corps of Engineers



Samples from location I-1 are within the I&J Waterway Site (I-1-DM and I-1-Z).

Figure 2

Relative Congener Concentrations in the I&J Waterway Federal Navigation Channel from 2011 DMMP Sampling
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

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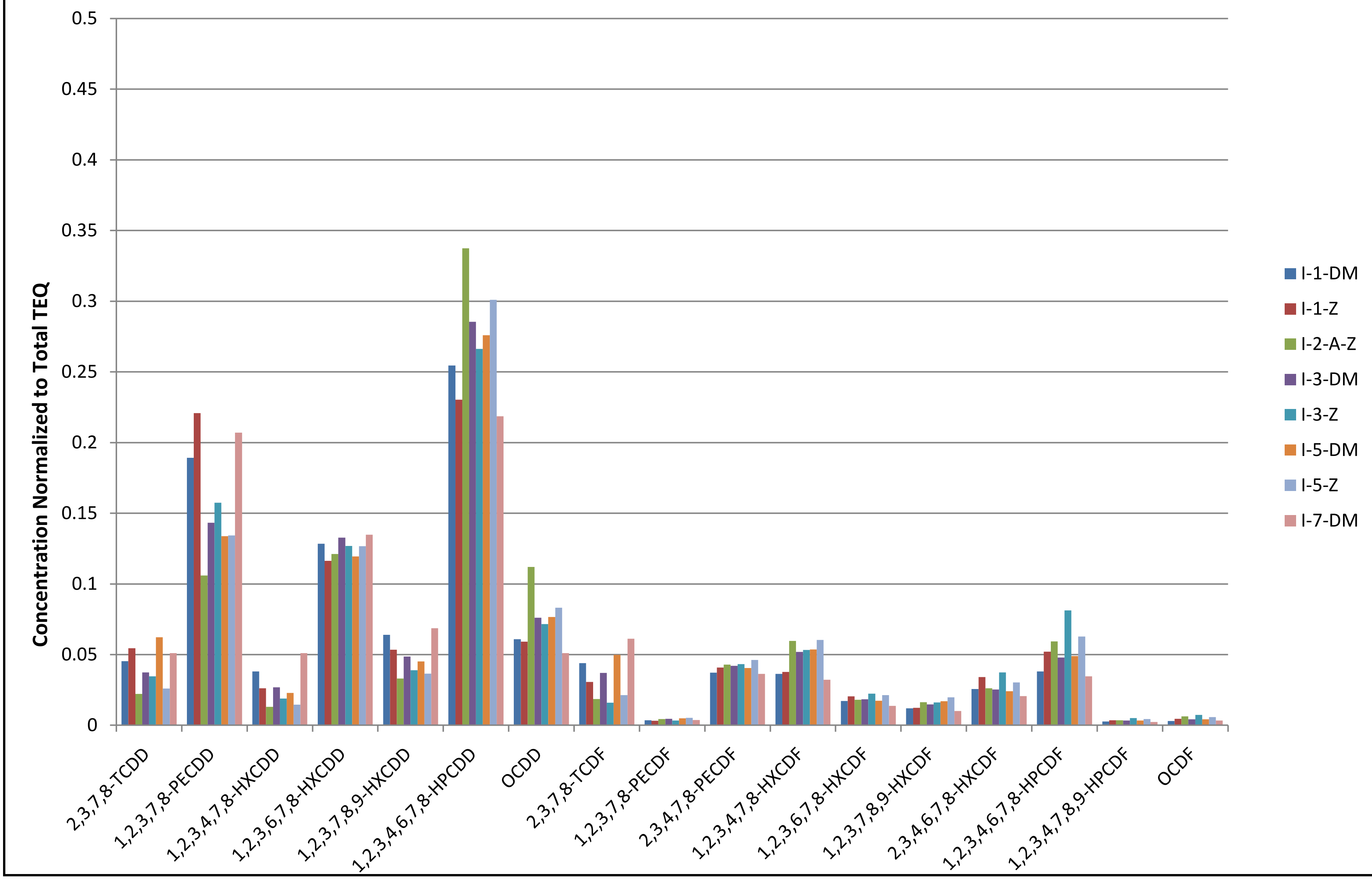

Figure 3
Relative Congener TEQ Concentrations in the I&J Waterway Federal Navigation Channel from 2011 DMMP Sampling
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

ANCHOR QEA

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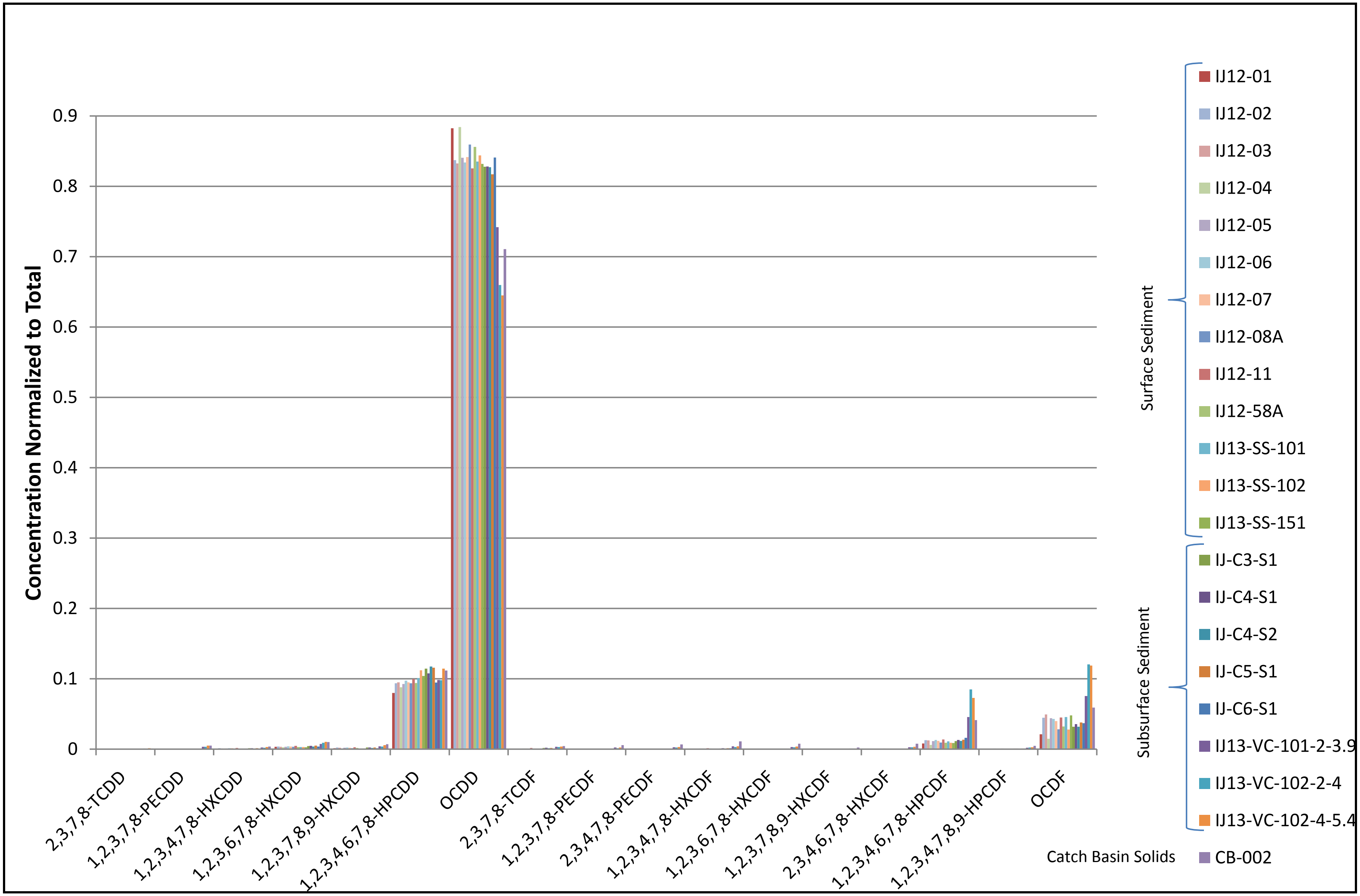


Figure 4

Relative Congener Concentrations in I&J Waterway in Surface Sediment, Subsurface Sediment, and Catch Basin Solids
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

ANCHOR QEA

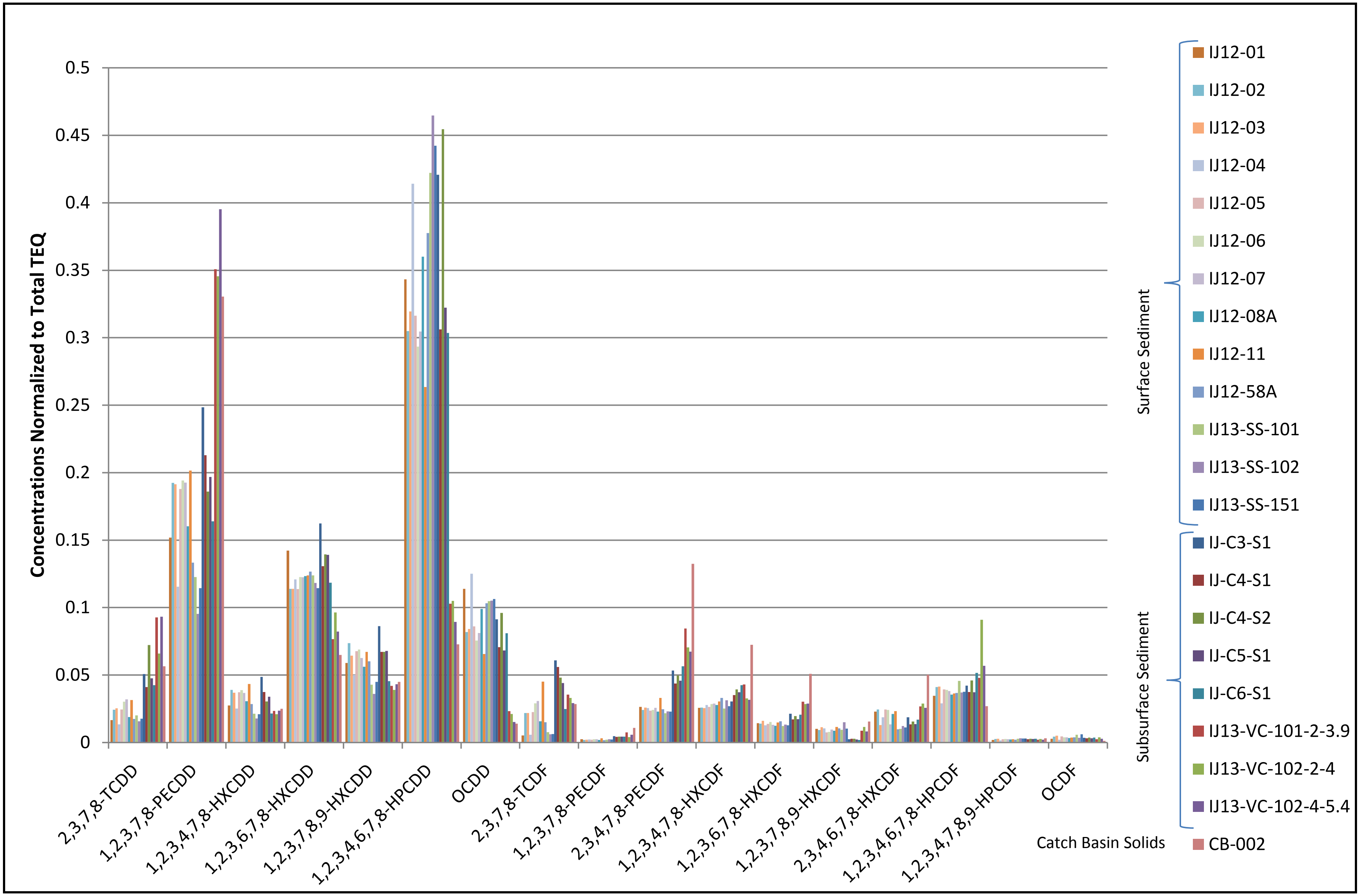
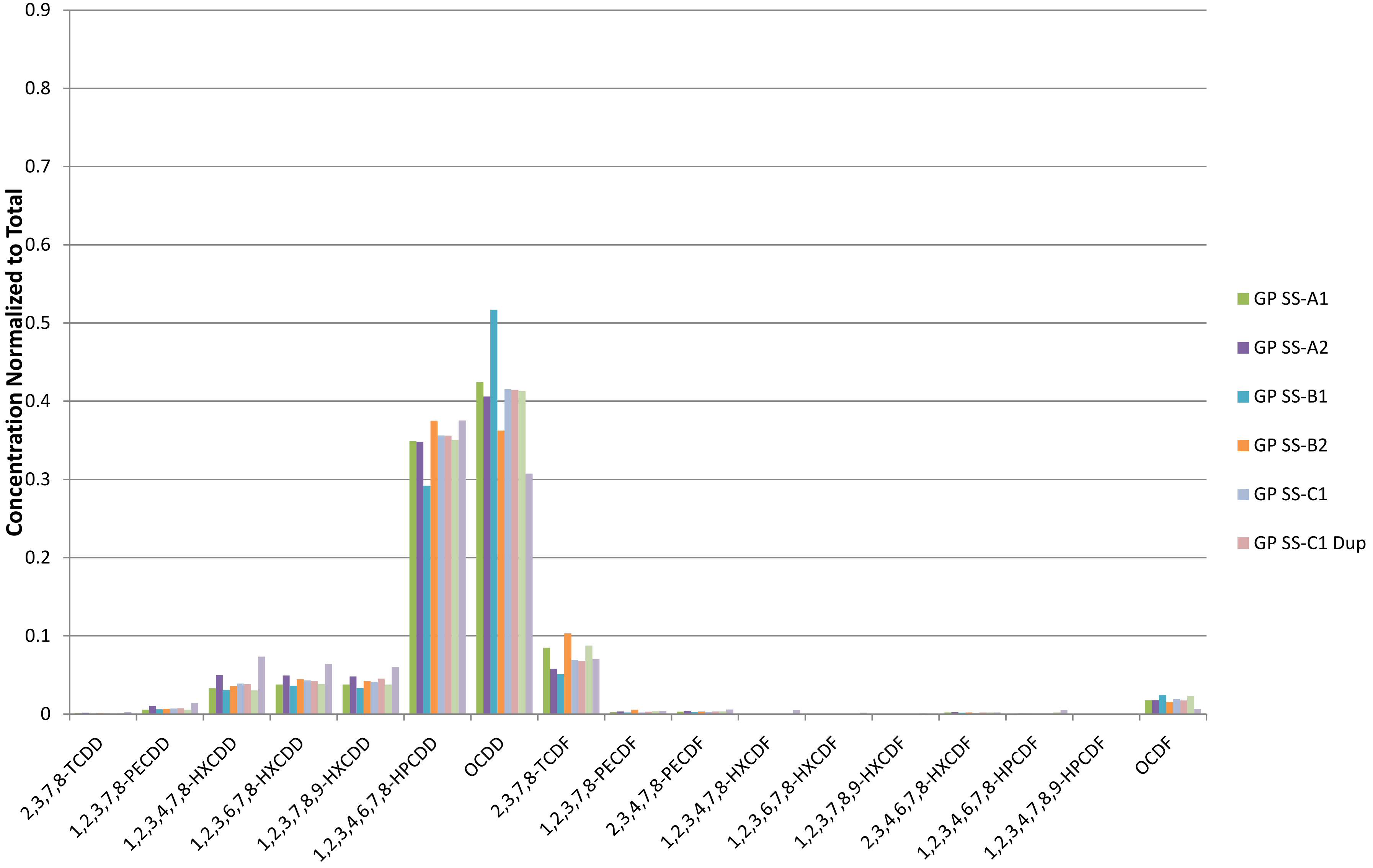


Figure 5

Relative Congener TEQ Concentrations in I&J Waterway in Surface Sediment, Subsurface Sediment, and Catch Basin Solids

Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



ANCHOR QEA

Figure 6
Relative Congener Concentrations in GP and ASB Samples
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

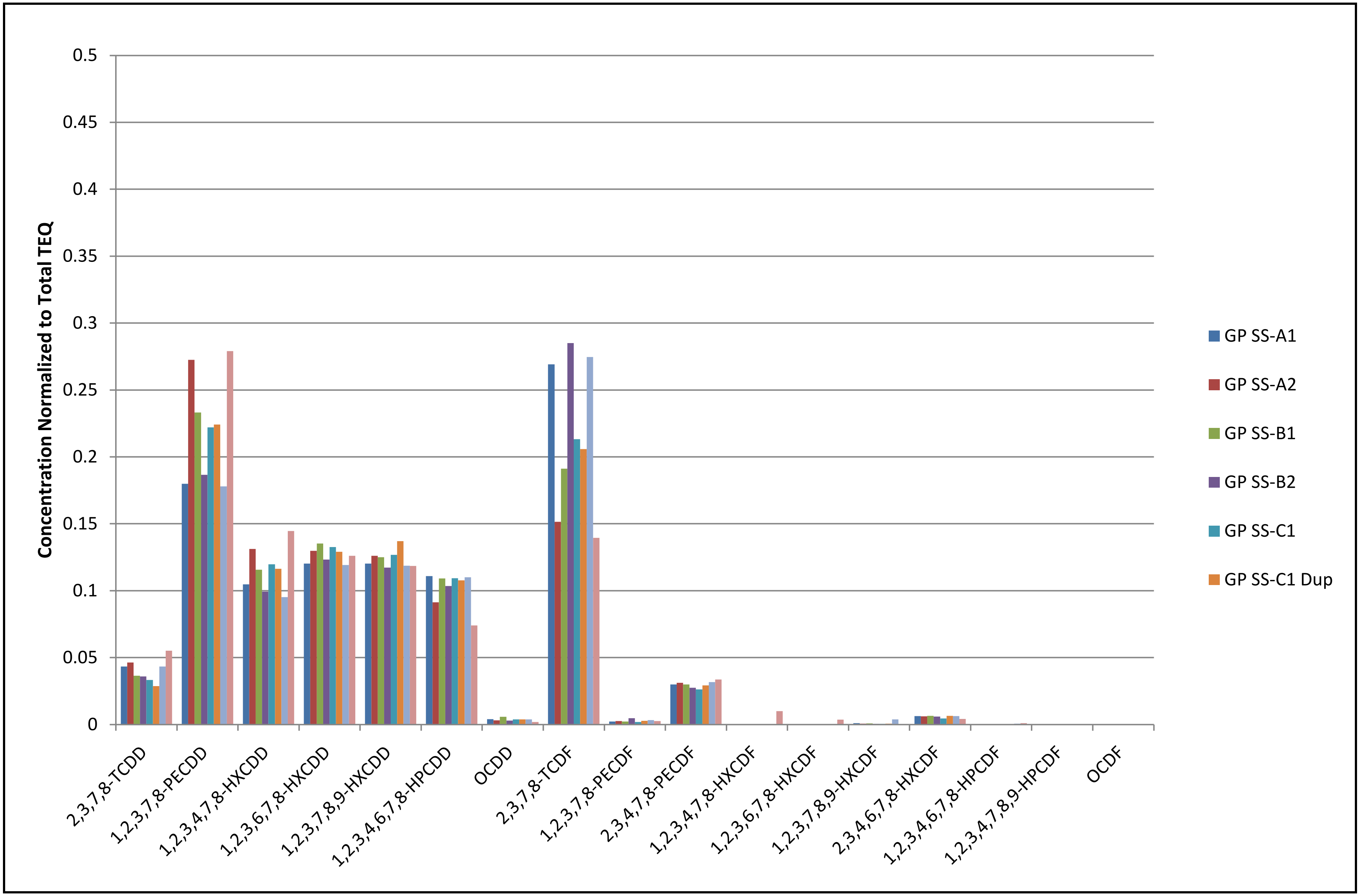


Figure 7

Relative Congener TEQ Concentrations in GP and ASB Samples

Draft RI/FS Report

I&J Waterway Site

Port of Bellingham

ANCHOR QEA

ATTACHMENT 1
ECOLOGY AND ENVIRONMENT, INC., 2011 CONGENER PROFILES

Dioxin/Furan Source Profiles

An inventory of chemical patterns for multiple dioxin/furan sources is presented graphically in this appendix. The data sources used to compile this inventory of dioxin/furan profiles are listed as references below and are identified for each source. Not every potential source for dioxins/furans is included here, but most of the major sources are represented.

The toxicity of dioxins/furans is evaluated based on 17 2,3,7,8-substituted congeners, which are a small subset of the total number of congeners. Source profiles presented here reflect those 17 2,3,7,8-substituted congeners. For each source, two profiles are presented: one based on bulk congener concentrations (blue), and a second one based on calculated TEQ values (red).[22] The set of TEF values used to scale bulk congener concentrations has changed over time. All of the TEQ profiles presented here were developed using the current set of TEFs (WHO-2005; Van den Berg et al. 2006) to calculate TEQs from original bulk concentrations. The TEQ profiles are thus presented on a consistent and equivalent basis.

Both the bulk profiles and the TEQ profiles are normalized (sum over 17 congeners equals 1) so that they reflect chemical patterns and not magnitudes. The Y-axis scale can be understood as fractional contribution to the total; the bar heights thus represent the fractional contributions of individual congeners, and the set of such contributions provides the source profile. (Note that the Y-axis scales vary across sources depending on the maximum congener contributions). The X-axis for all profiles lists the 17 2,3,7,8-substituted congeners in the same order. Dioxin/furan chemical profiles presented in this manner support visual comparisons both within and across sources.

Comparing the bulk (blue) and TEQ (red) profiles for individual sources shows that there are large shifts in the chemical profiles depending on which measure is used. TEF values range over more than 3 orders of magnitude and the rescaling of bulk concentrations by TEFs has a large impact on the profile shape.

Comparing the profiles of one type, either bulk or TEQ, across various sources shows that there are differences in the patterns from one source to another. These differences can be used as one factor in evaluating the likely contributions of various sources to measured dioxin/furan concentrations, for example in unmixing analyses.

The profiles shown here are representative of the listed sources, but variability in the profiles within a single source type should be recognized. One facility may have somewhat different

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[22] For all profile types except two, bulk congener concentrations were used as a starting point and then scaled using TEFs to develop TEQ profiles. The exceptions are the class of residential wood burning profiles and the asphalt plant profile, which were available only as TEQ profiles in EPA 2006 [reference 7 below]. Bulk congener values for those two types of profiles were derived from TEQ profiles [adjusted to reflect WHO 2005 TEFs] by dividing each congener TEQ value by its appropriate WHO 2005 TEF. Because the TEF-scaled values are given as 0 for most OCDF and some OCDD entries in the EPA 2006 profiles for residential wood burning, back calculations of bulk concentrations for those congeners in the residential wood burning profiles may be zero, which may be an artifact of the way in which TEQ profiles are reported in EPA 2006.

profiles over time, especially if there are changes in facility feedstocks, operations, or pollution controls. Different facilities within a source class are also expected to show some degree of variation in profiles. Laboratory analyses of typically low-concentration dioxins and furans also introduce variability in the results. In cases where multiple datasets are available for a single source type, variability in profiles has been demonstrated. Applications of dioxin/furan profiles like those compiled here should take such variability within source class into consideration.

This graphic inventory of dioxin/furan profiles illustrates that bulk and TEQ profiles can differ for a source and that sources have different profiles.

References

1. AmTest Air Quality, Inc., 1995. Source Emission Evaluation for Rayonier, Inc. Port Angeles Mill #6 Boiler EFB Scrubber System, #4 and #5 Package Boiler Stacks, and Recovery Boiler Stack, April 25-28, Volumes 1 and 2. August 3.

2. AmTest Air Quality, 2009. Nippon Paper Industries USA Co., LTD. Port Angeles, Washington. #8 Hogged Fuel Boiler (EU2), Boiler Information Collection Request, July 29-30, 2009. ATAQ Project #2601-001. (A Division of Hoefler Consulting Group). Final Report, December 4.

3. Burkhard, Lawrence P. and Marta T. Lukasewycz, 2008. Toxicity Equivalency Values for Polychlorinated Biphenyl Mixtures. Environmental Toxicology and Chemistry 27, 529-534.

4. DeAbreu, Michael, 2009. Environment Canada, Pollution Data Division, Vancouver, BC. Personal communication with Gregory L. Glass providing data from the Canadian NPRI database. March 5.

5. Foster Wheeler Environmental Corporation, 1997. Current Situation/Site Conceptual Model Report for Rayonier Port Angeles Mill Site, Mt. Pleasant Road Landfill, and 13th and M Street Landfill. October.

6. U.S. Environmental Protection Agency, 2000. Exposure Assessment and Risk Characterization Group, National Center for Environmental Assessment, Office of Research and Development. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (TCDD) and Related Compounds. Part I: Estimating Exposure to Dioxin-Like Compounds. Volume 2: Sources of Dioxin-Like Compounds in the United States. EPA/600/P-00/001Bb. Volume 3: Properties, Environmental Levels, and Background Exposures. EPA/600/P-00/001Bc. September. Draft Final Report.

7. U.S. Environmental Protection Agency, 2006. National Center for Environmental Assessment, Office of Research and Development. An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000. EPA/600/P-03/002F. November.

8. Yake, Bill, Stacie Singleton, and Karol Erickson, 1998. Washington State Department of Ecology. Washington State Dioxin Source Assessment. Publication No. 98-320. Including Appendix D, Data Appendix, Publication No. 98-321. July.

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BULK PROFILE

TEQ PROFILE

Rayonier Hog Fuel Boiler - 1995(a)

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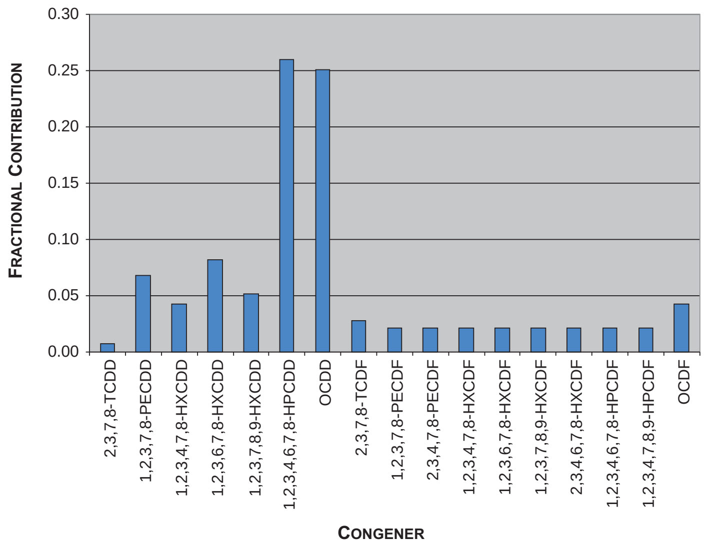

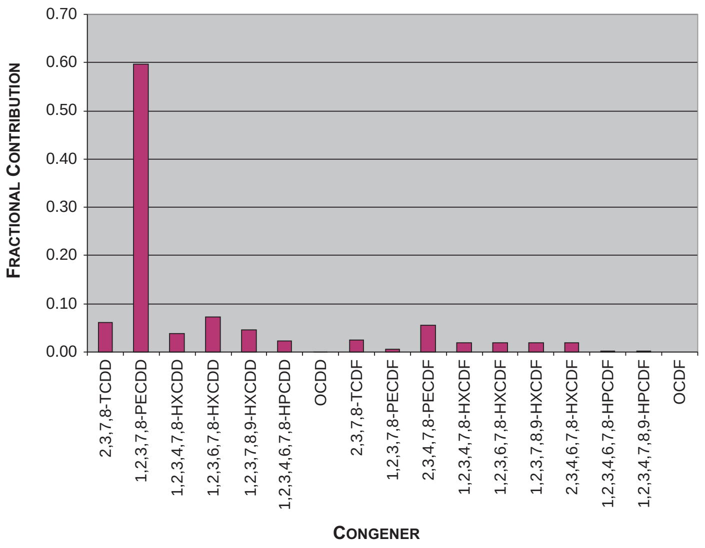

Rayonier Hog Fuel Boiler - 1995(b)

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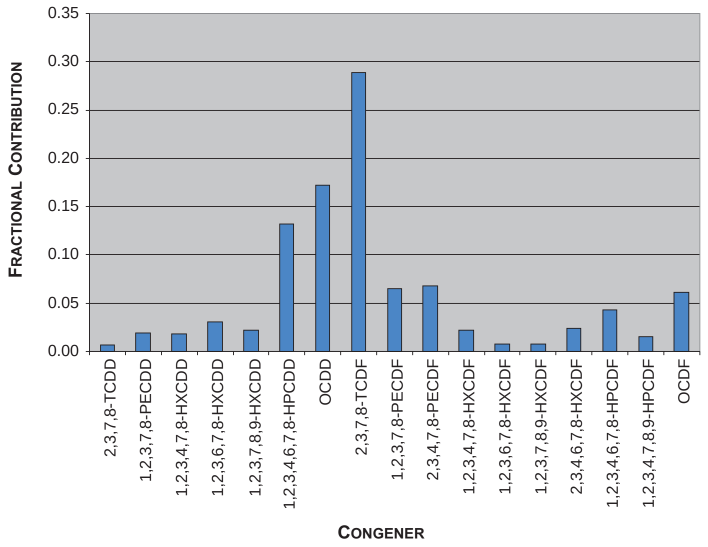

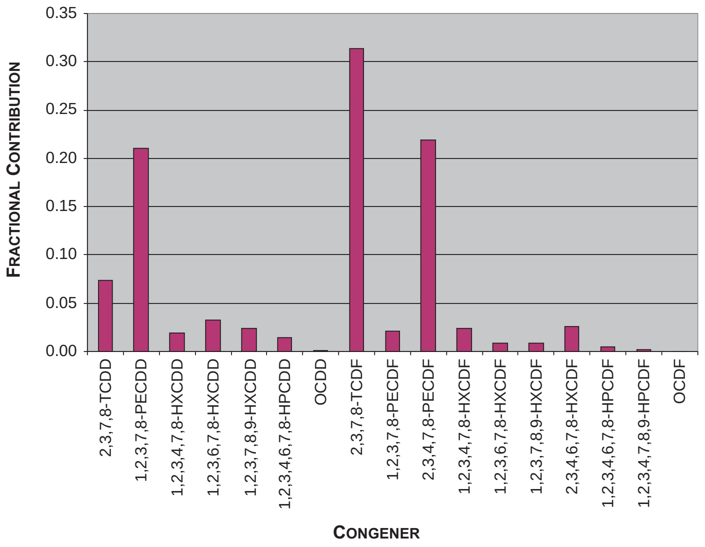

Rayonier Hog Fuel Boiler Ash - 1989

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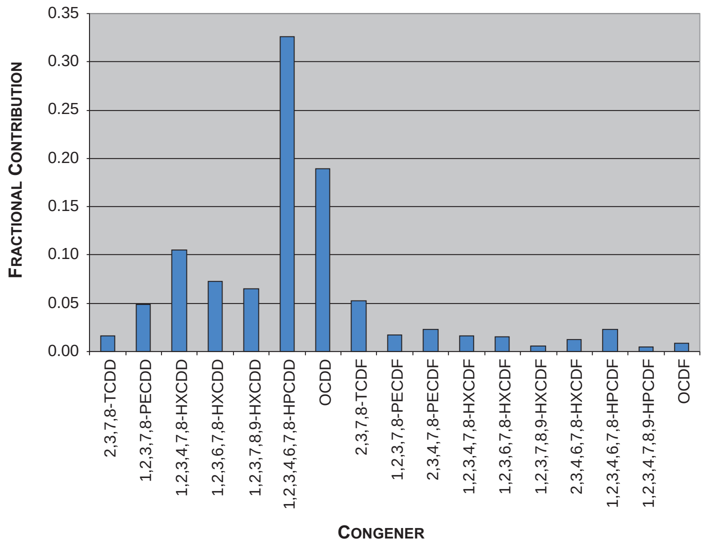

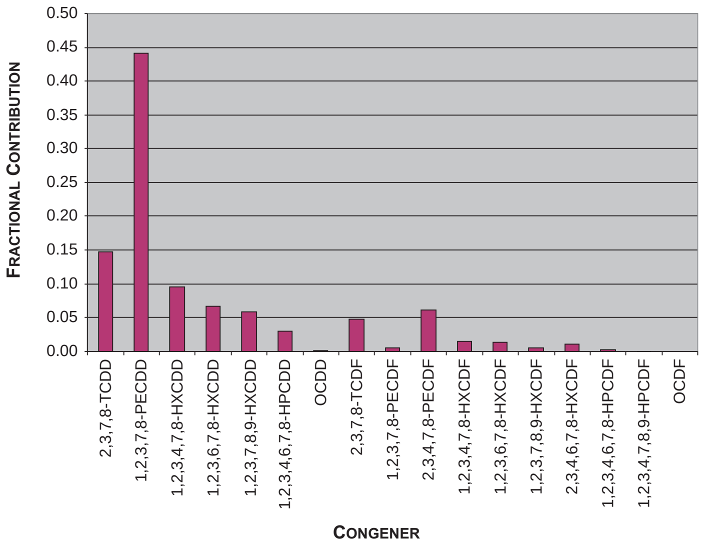

Nippon Hog Fuel Boiler - 2009

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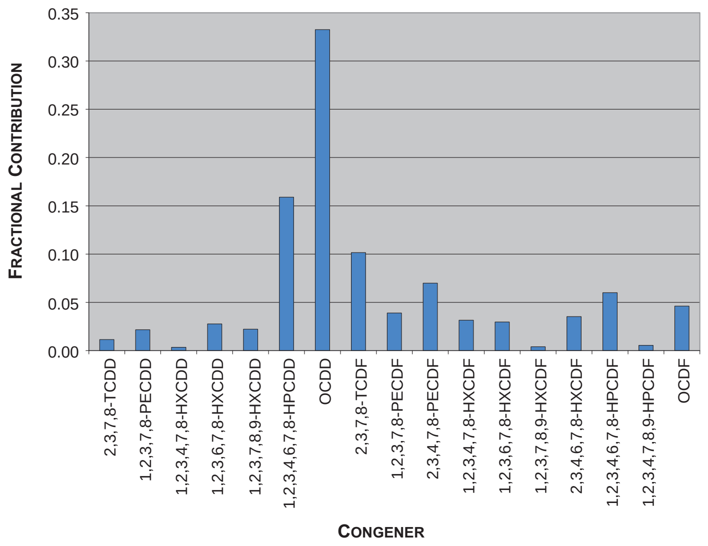

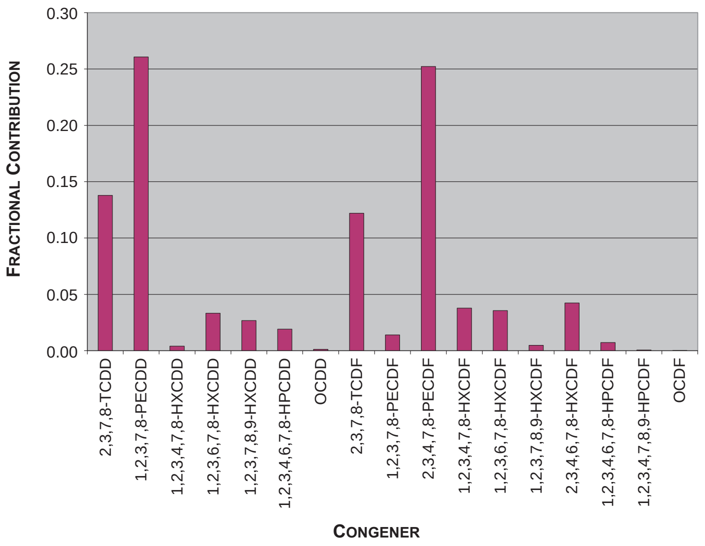

Canadian Hog Fuel Boiler 1 - 2007

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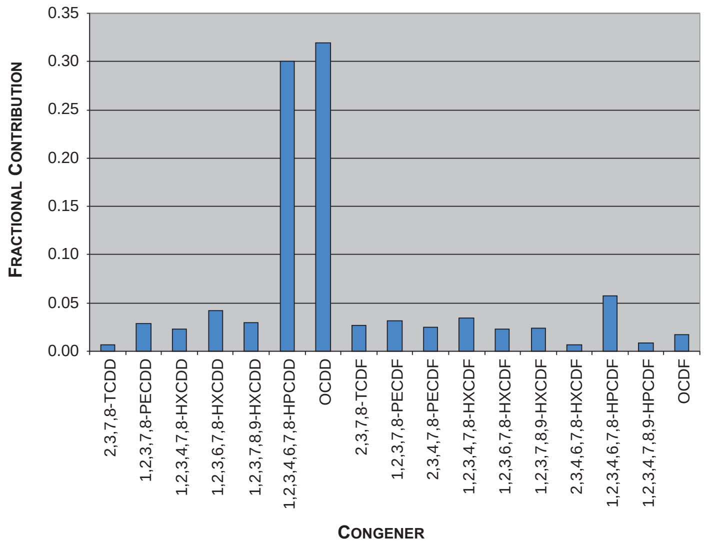

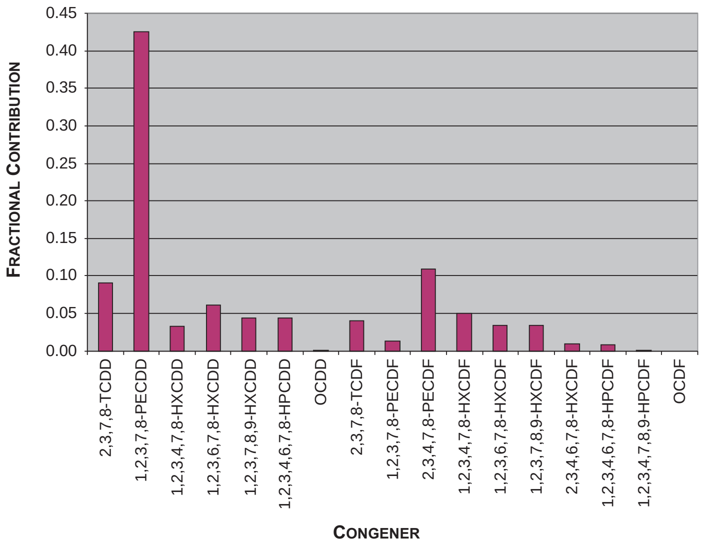

BULK PROFILE **TEQ PROFILE**

Canadian Hog Fuel Boiler 2 - 2007

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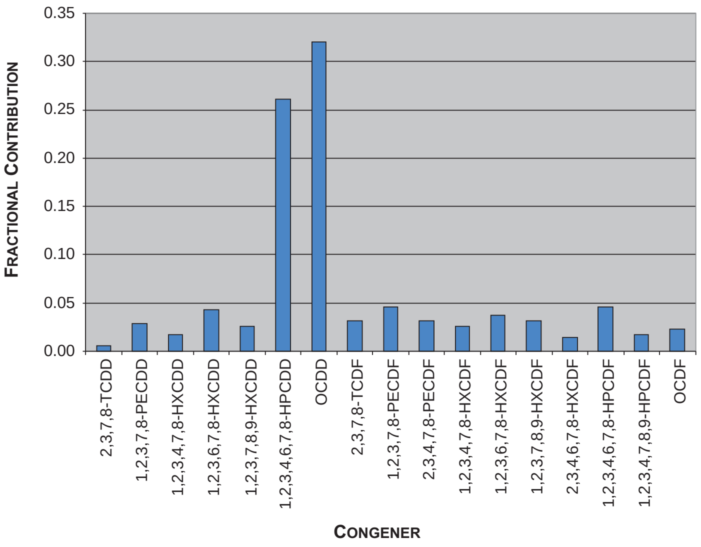

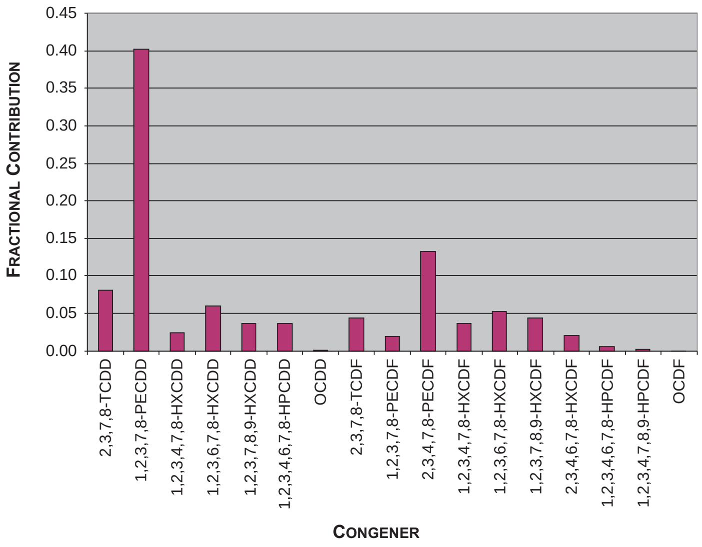

Canadian Hog Fuel Boiler 3 - 2007

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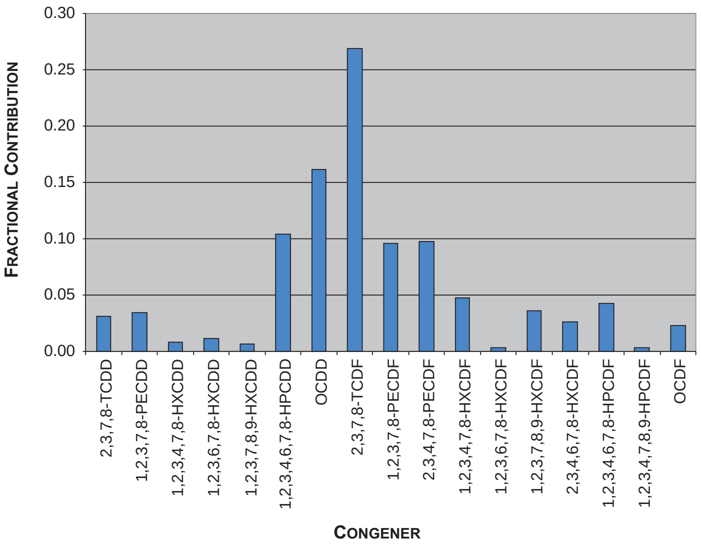

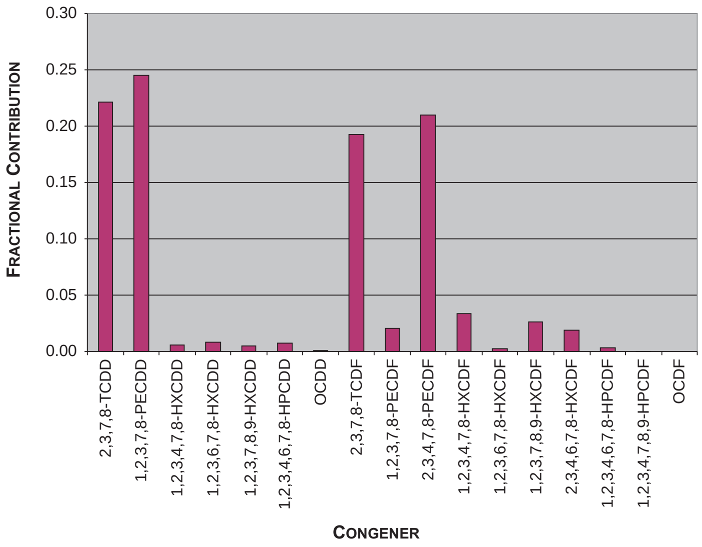

WA Medical Waste Incinerator 1

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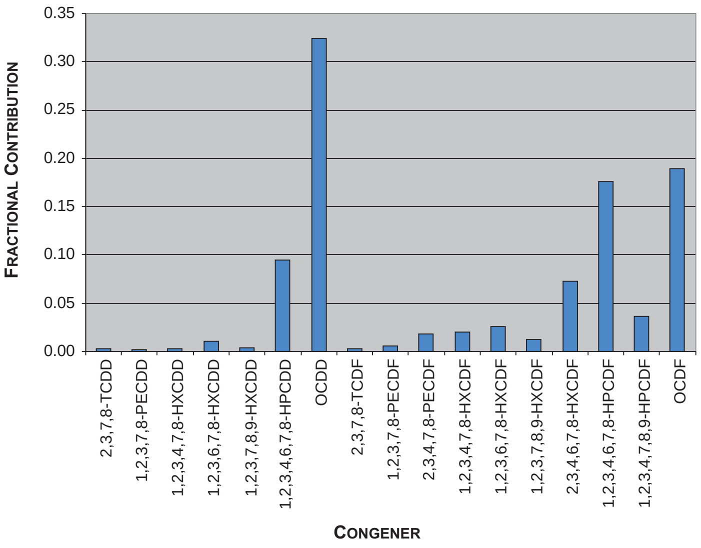

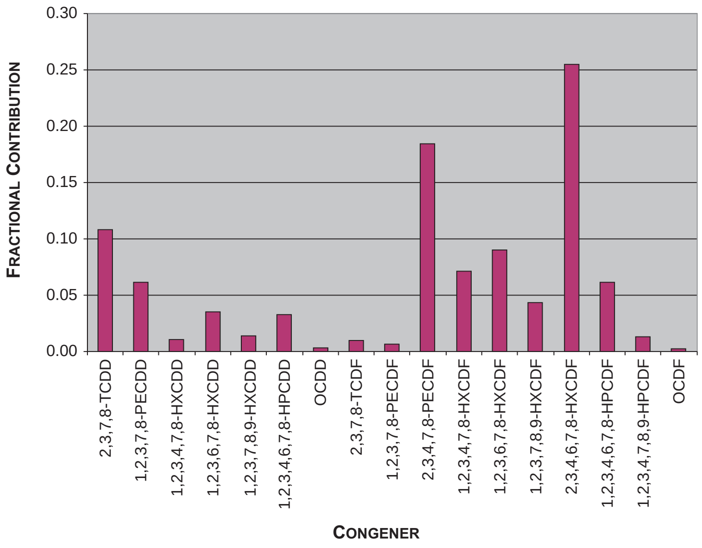

WA Medical Waste Incinerator 2

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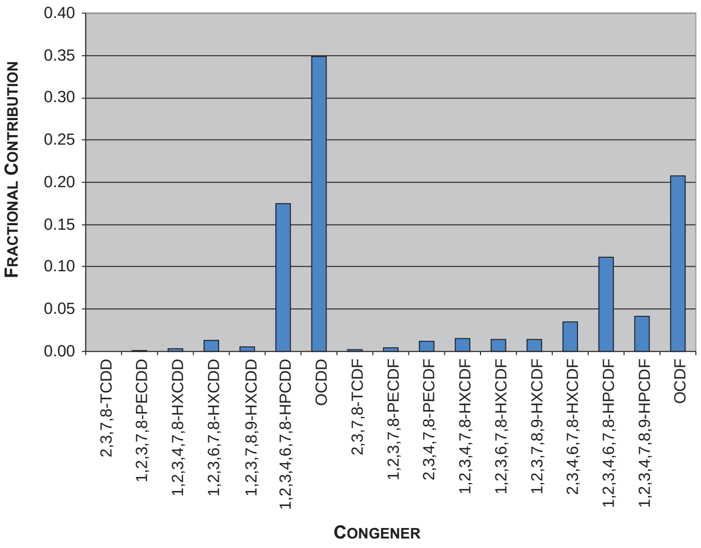

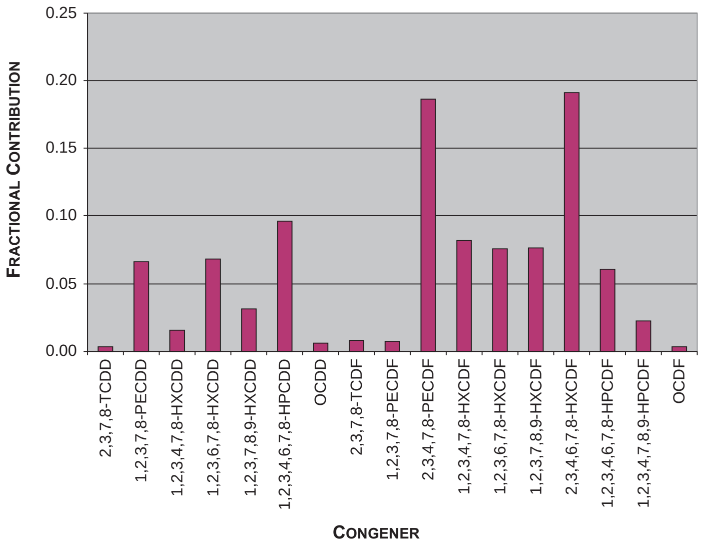

Municipal Waste Incinerator

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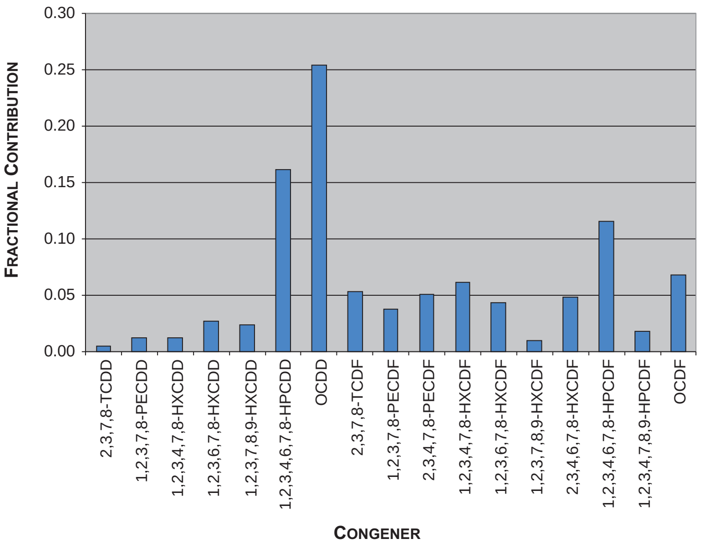

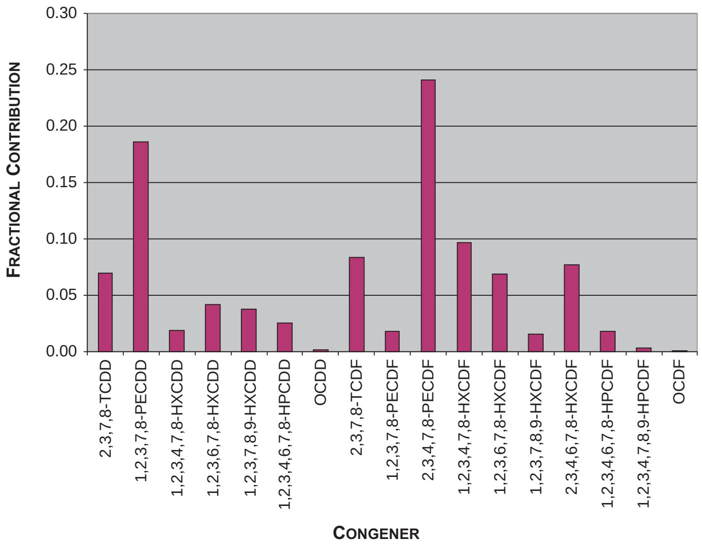

BULK PROFILE **TEQ PROFILE**

Hazardous Waste Incinerator

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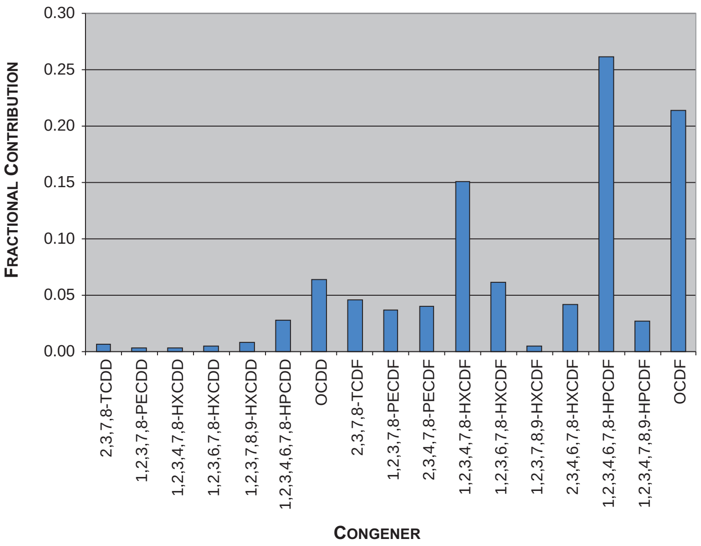

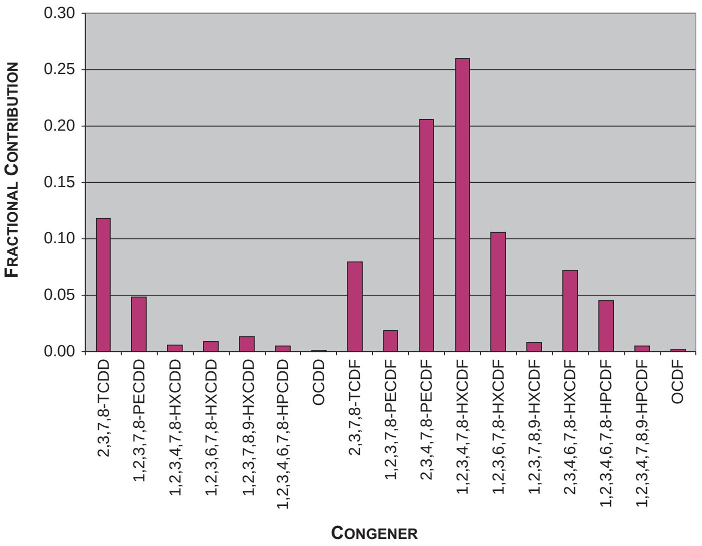

Crematorium

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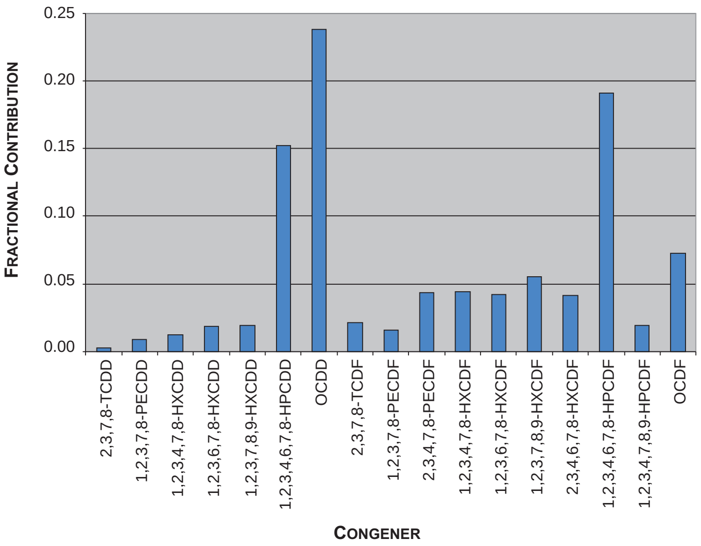

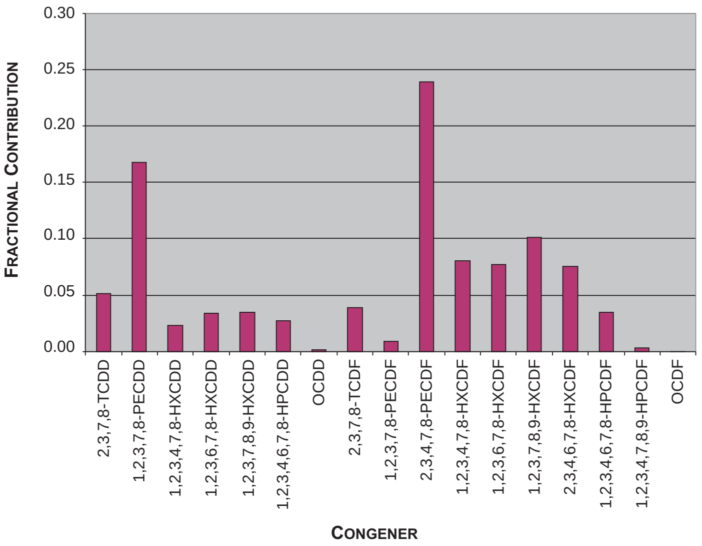

Sewage Sludge Incinerator

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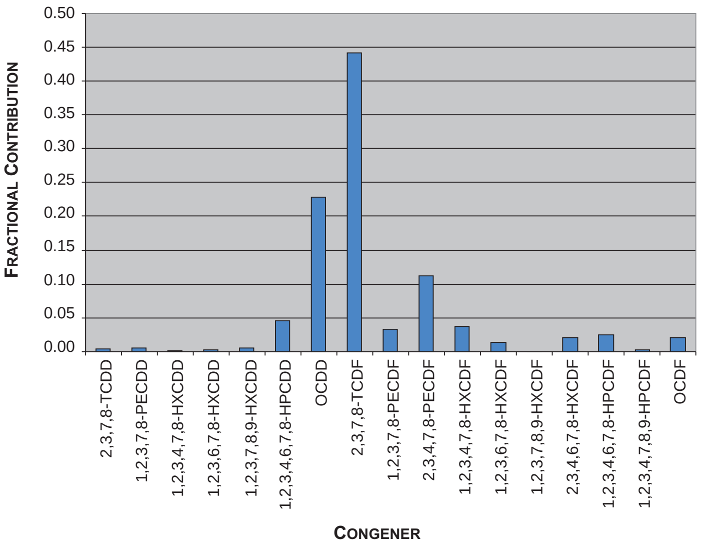

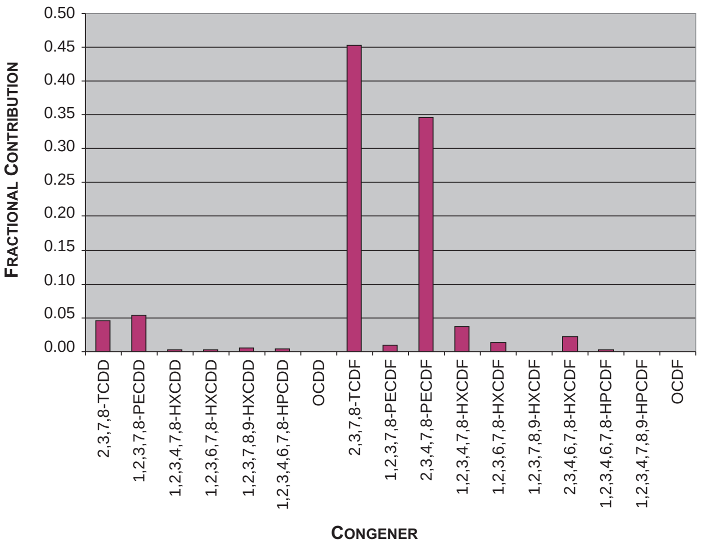

Tire Combustion

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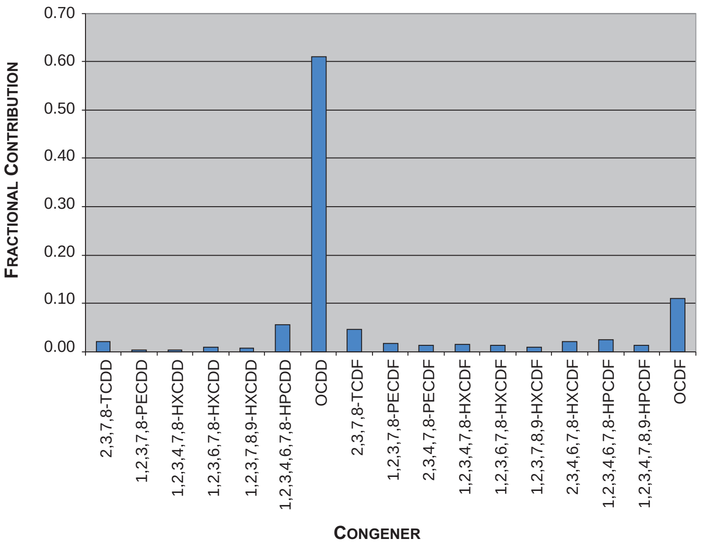

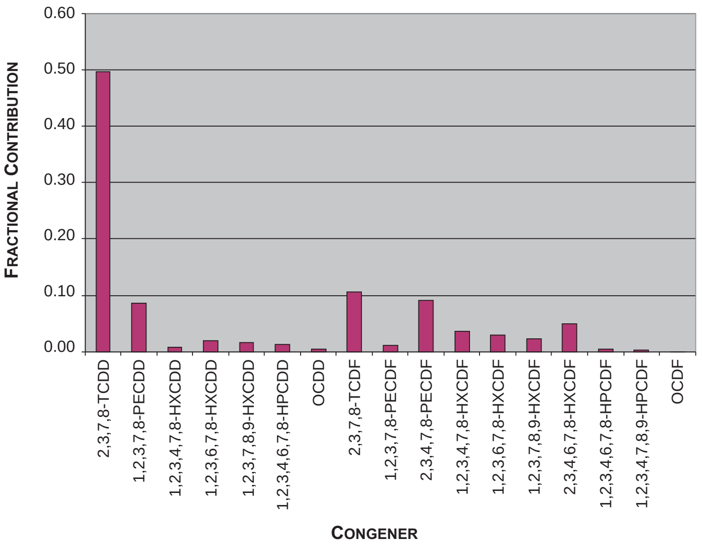

Truck Diesel

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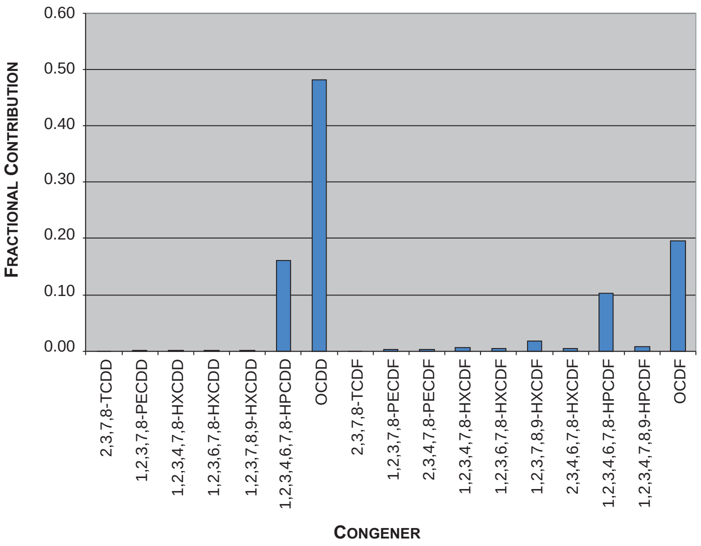

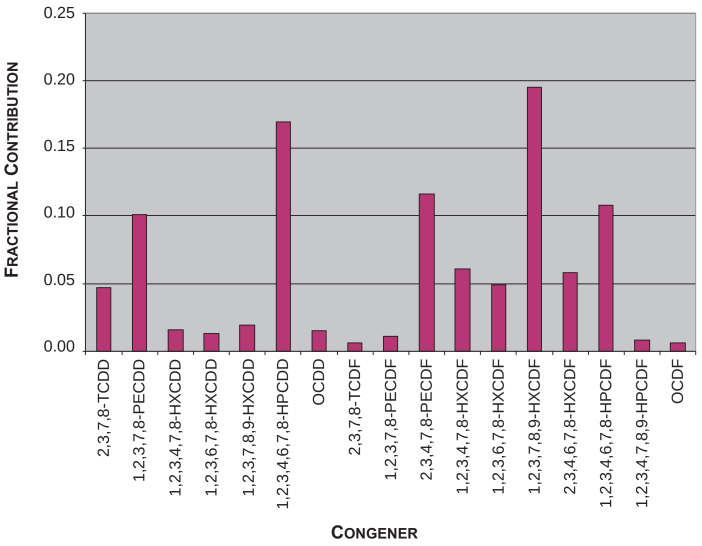

BULK PROFILE **TEQ PROFILE**

Car Leaded Gas

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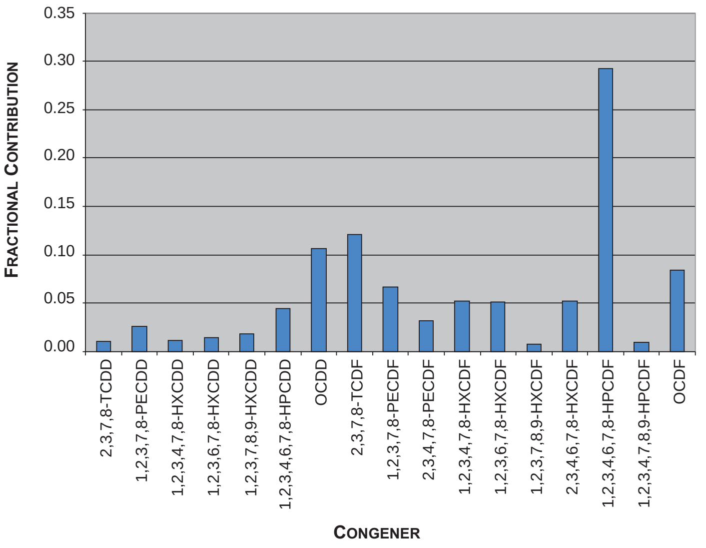

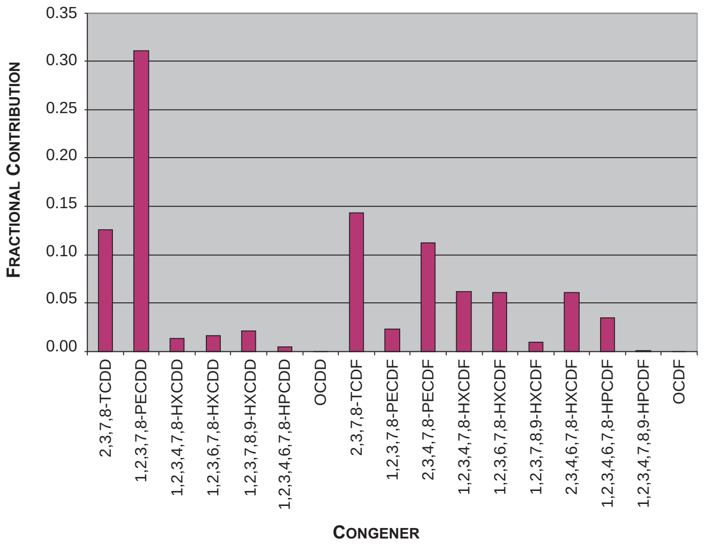

Car Unleaded Gas,
Catalytic Converter

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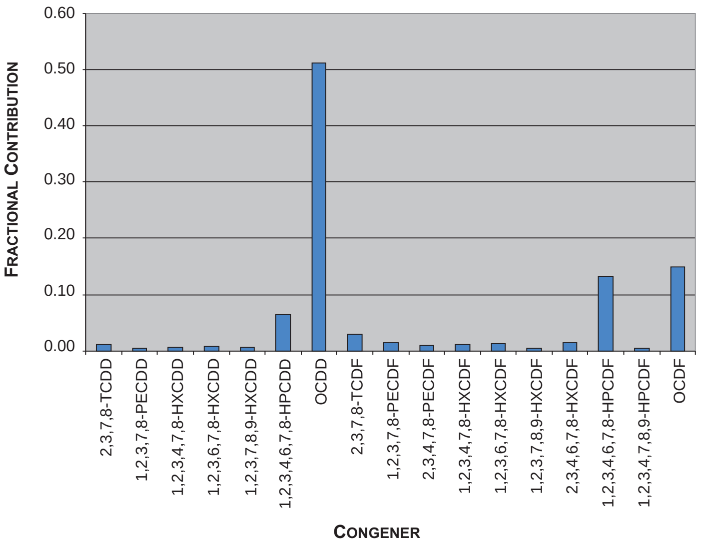

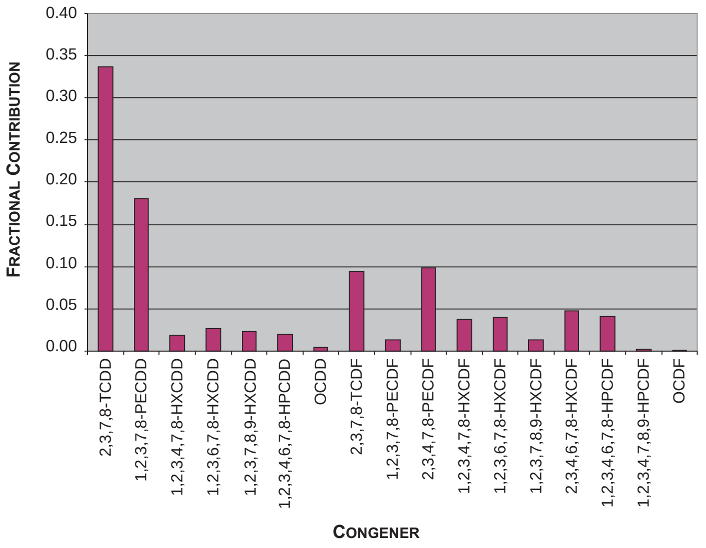

Residential Wood Burning 1

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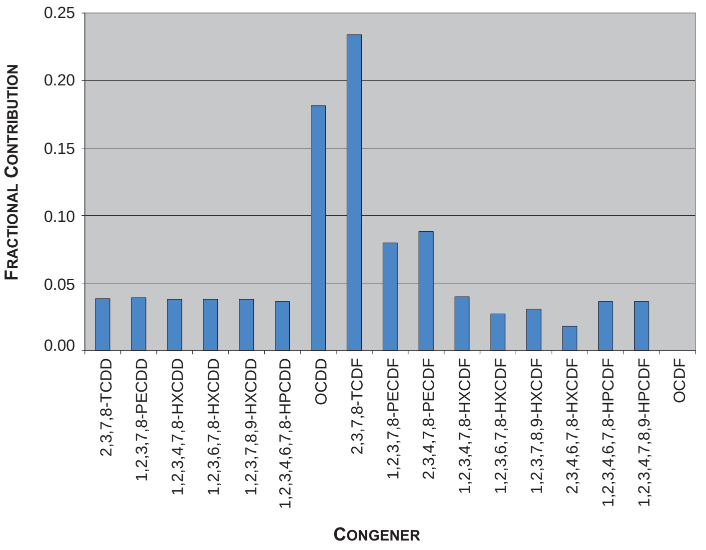

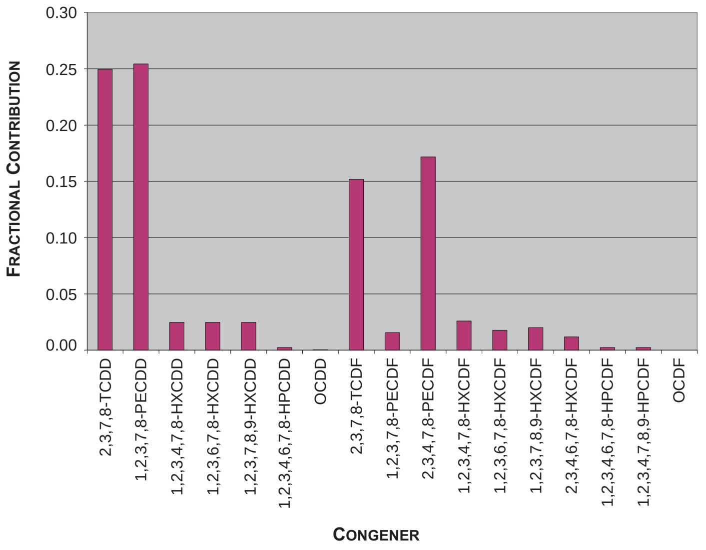

Residential Wood Burning 9

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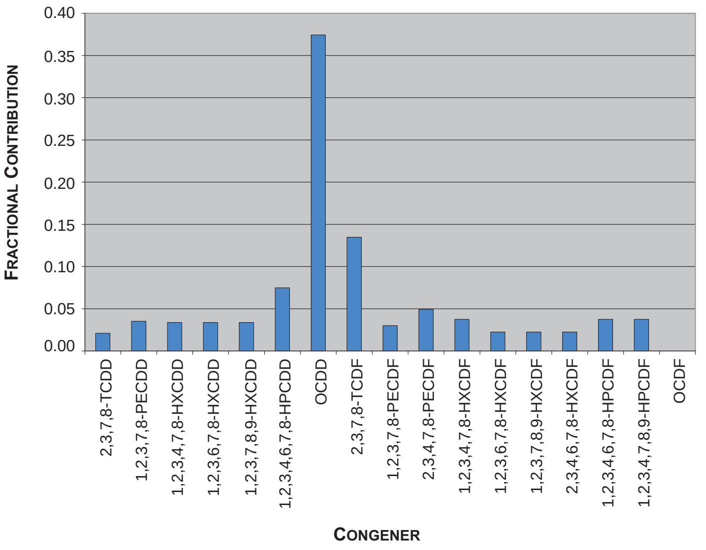

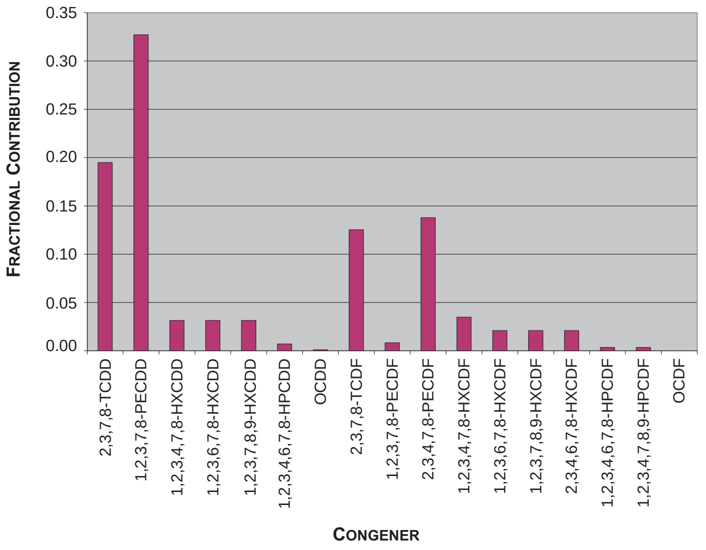

Oil-fired Boiler 1

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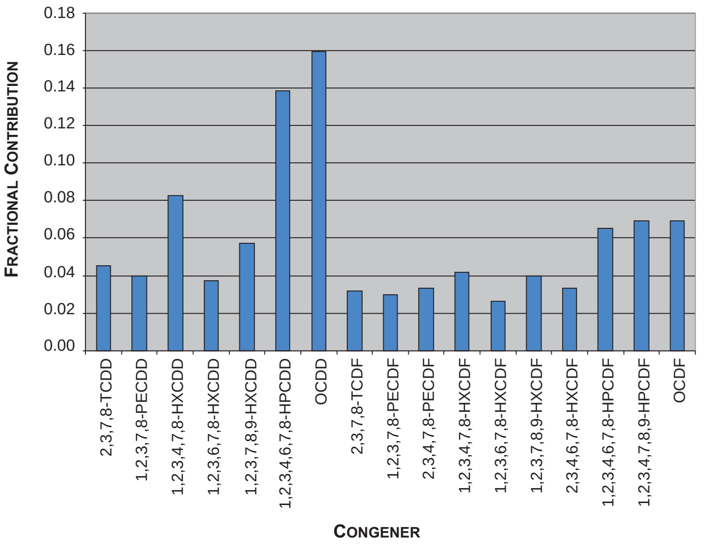

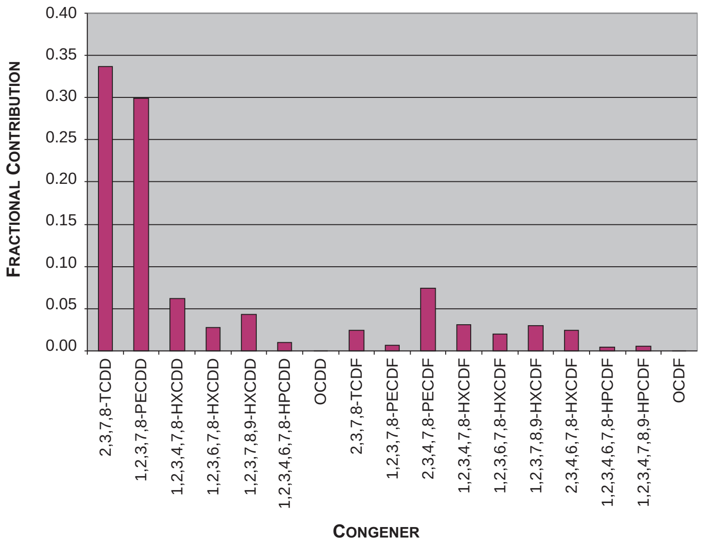

BULK PROFILE

TEQ PROFILE

Oil-fired Boiler 2

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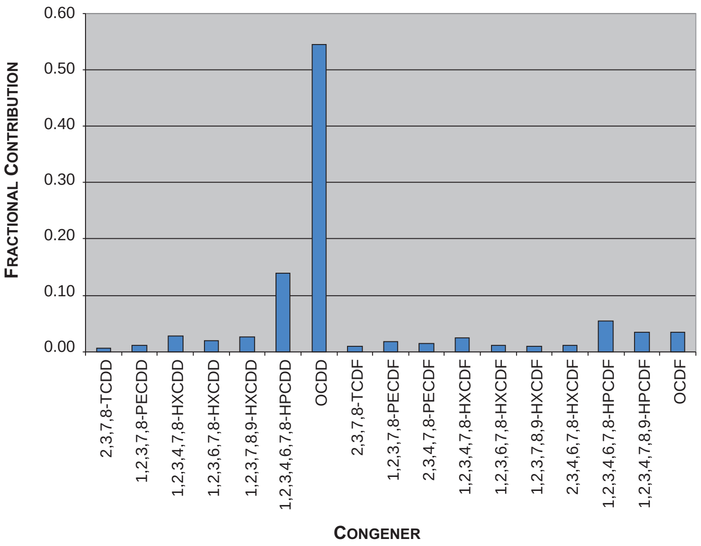
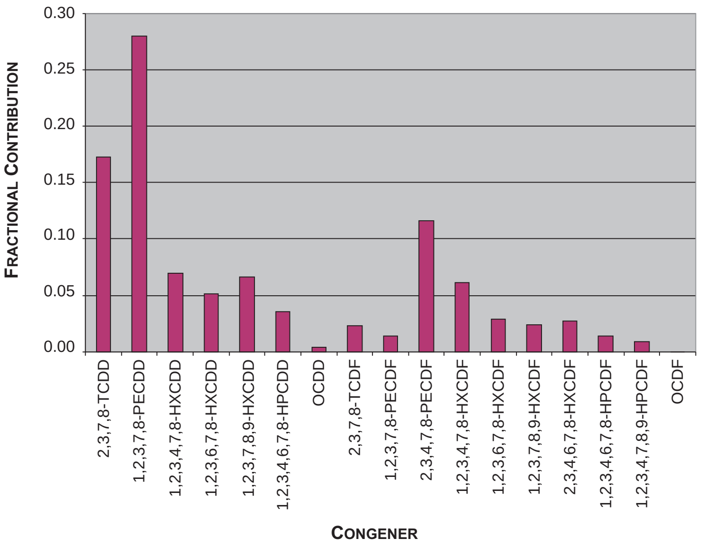
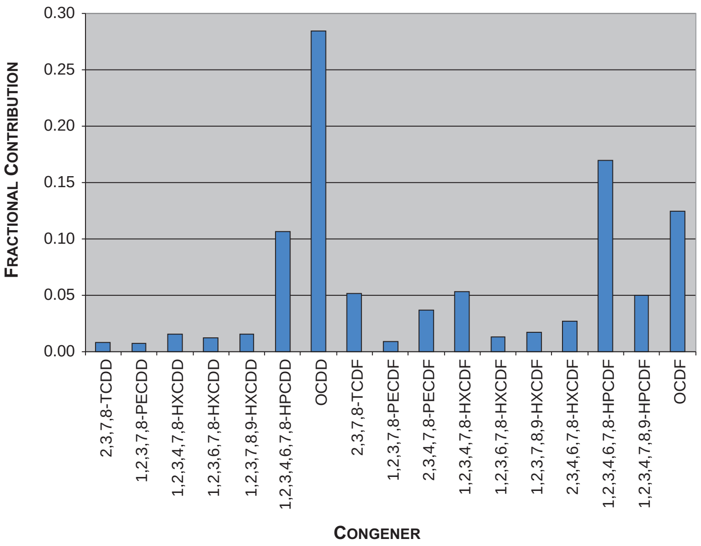
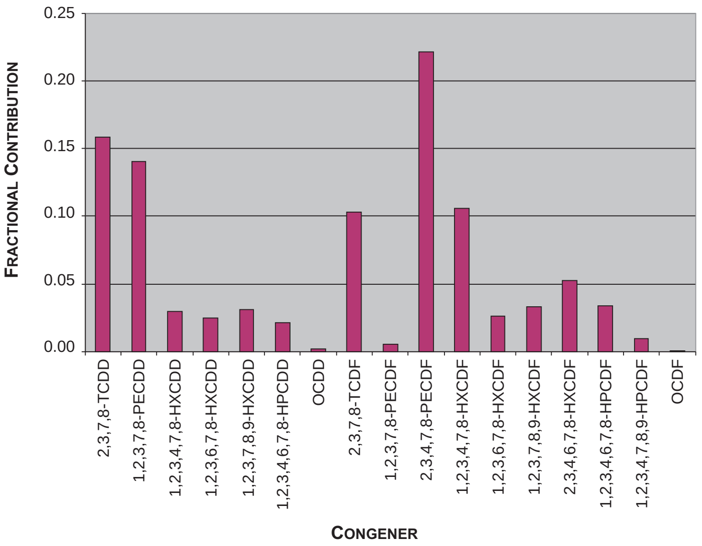




Coal Utility/
Industrial Boiler

Reference No. 7





Cement Kiln

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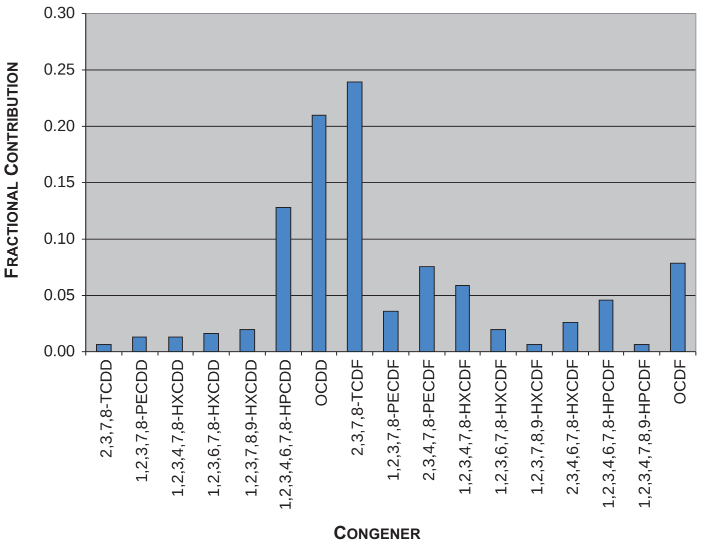

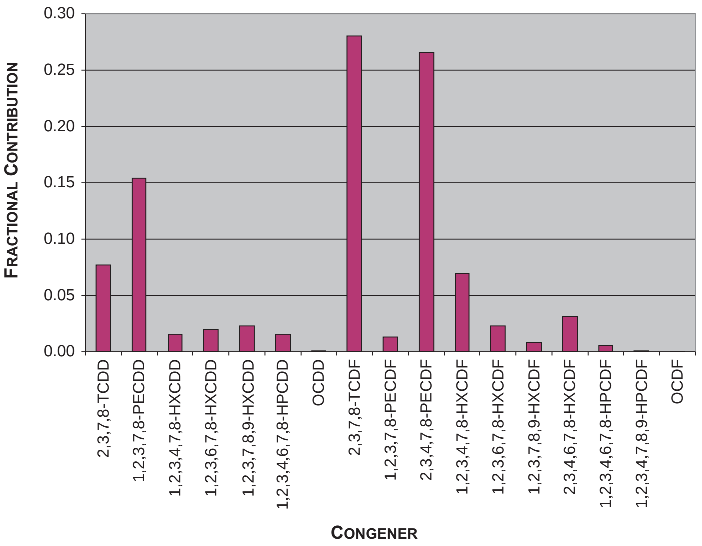

Asphalt Plant

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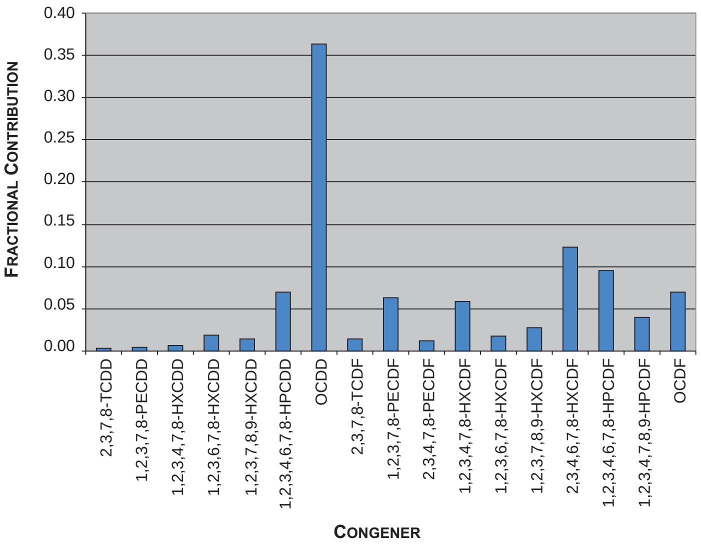

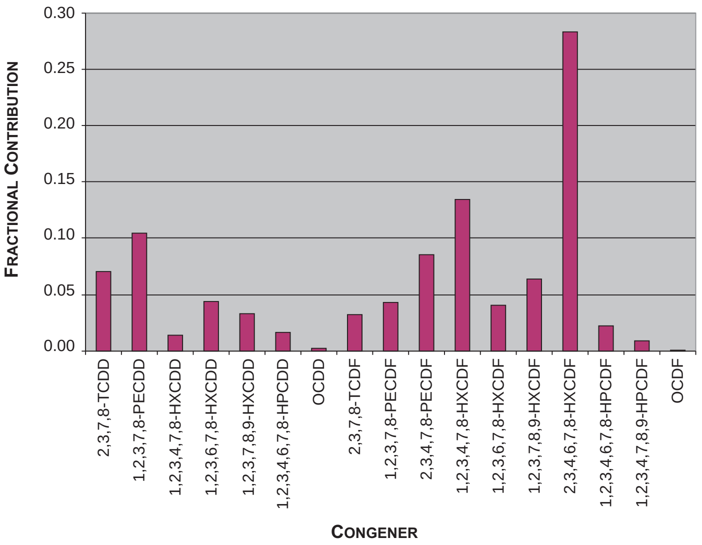

Forest Fire

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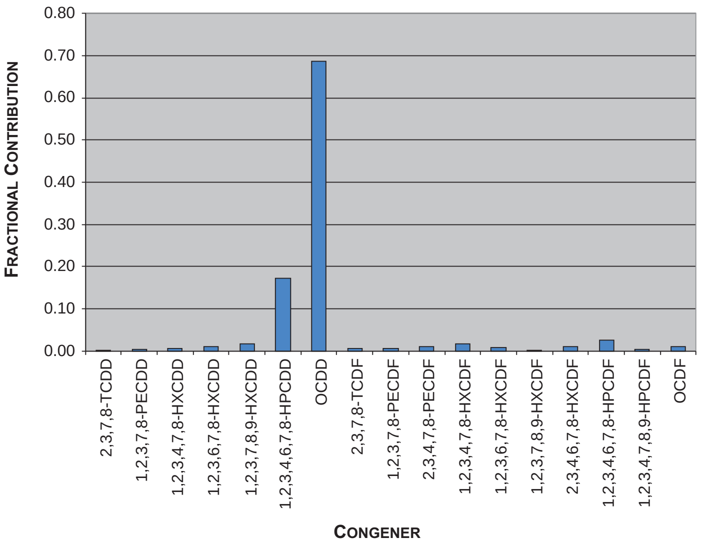

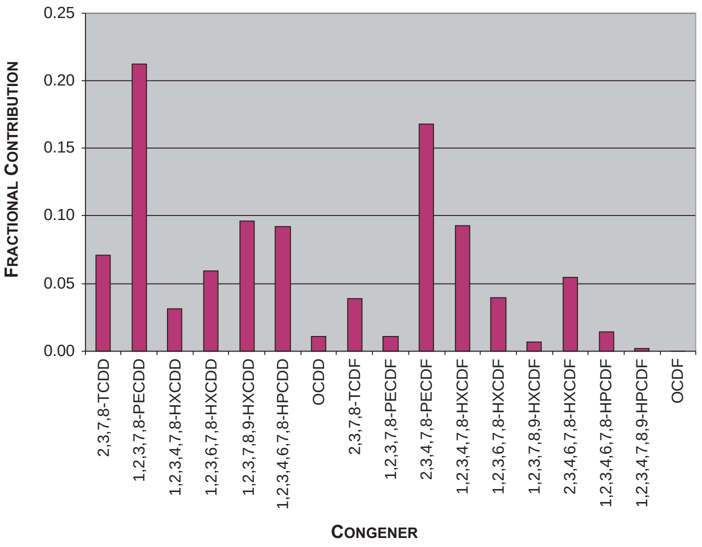

BULK PROFILE **TEQ PROFILE**

Household Burn Barrel

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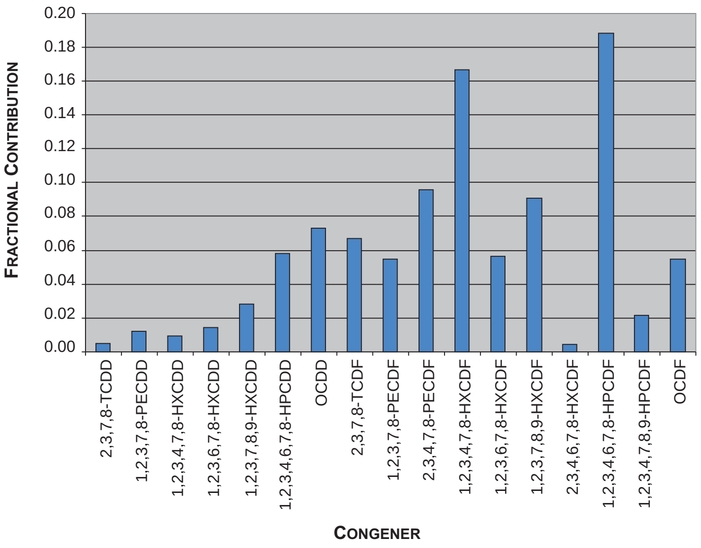

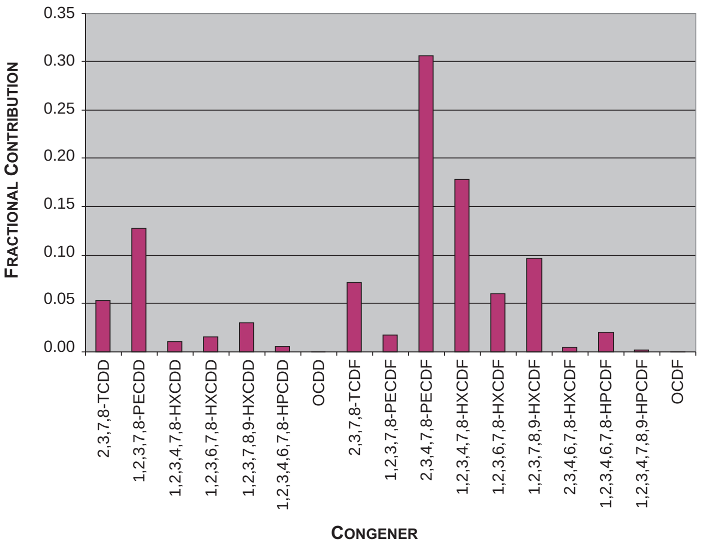

PCB 1248

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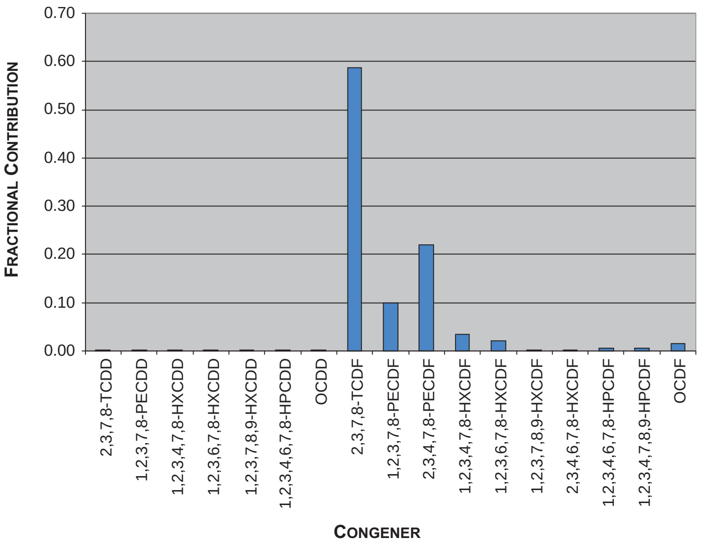
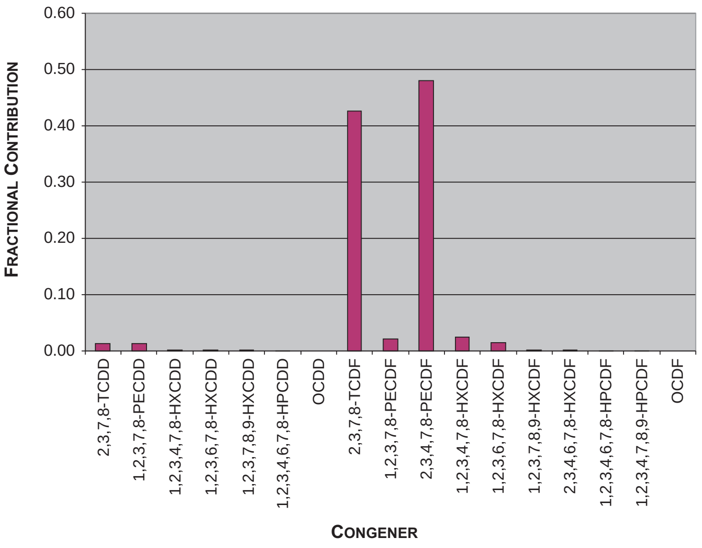
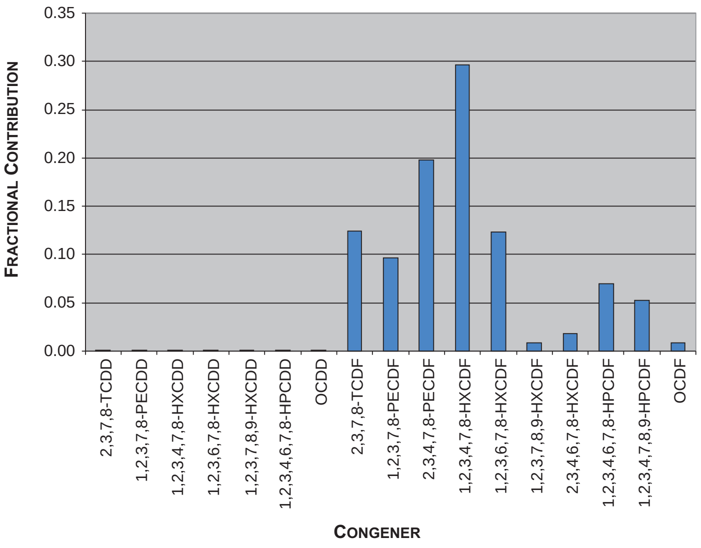
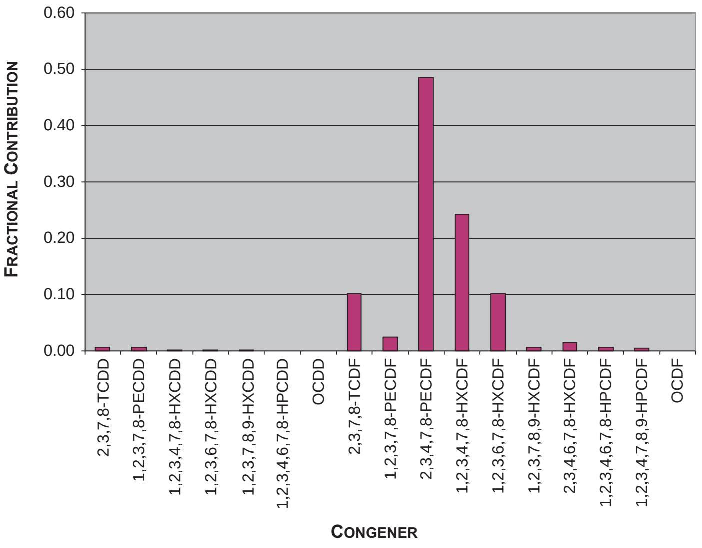




PCB 1254

Reference No. 3





PCB 1260

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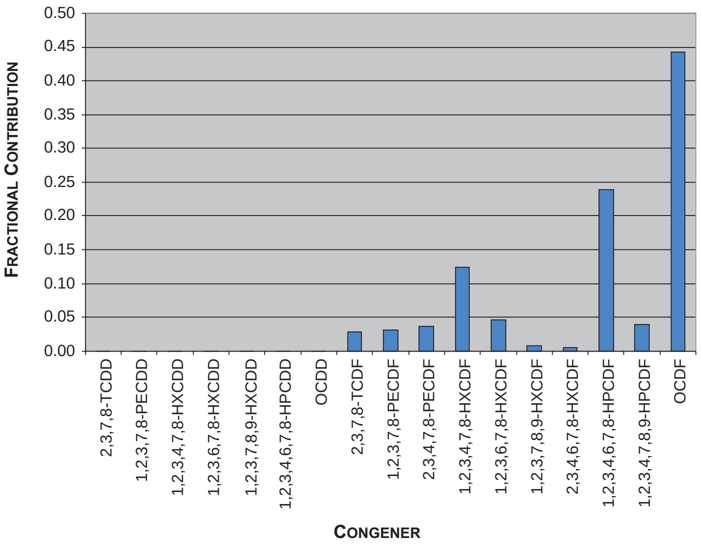
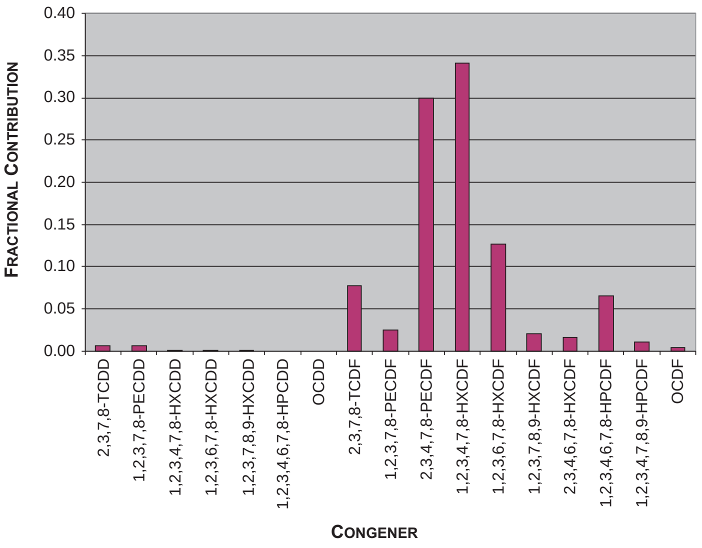
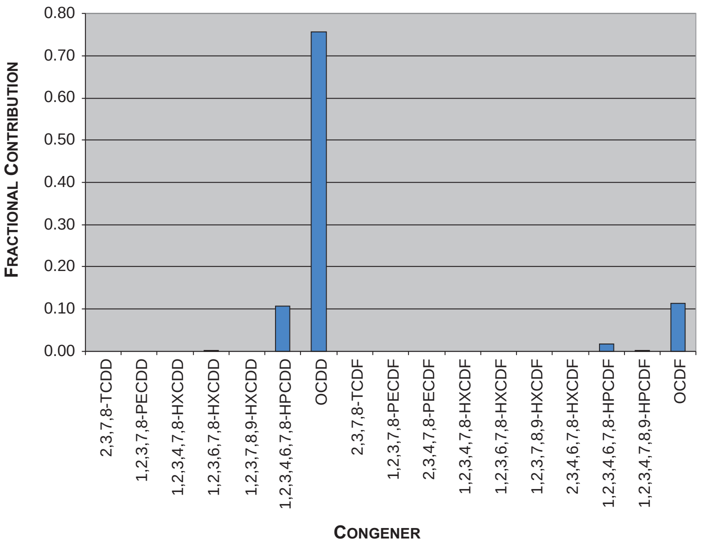
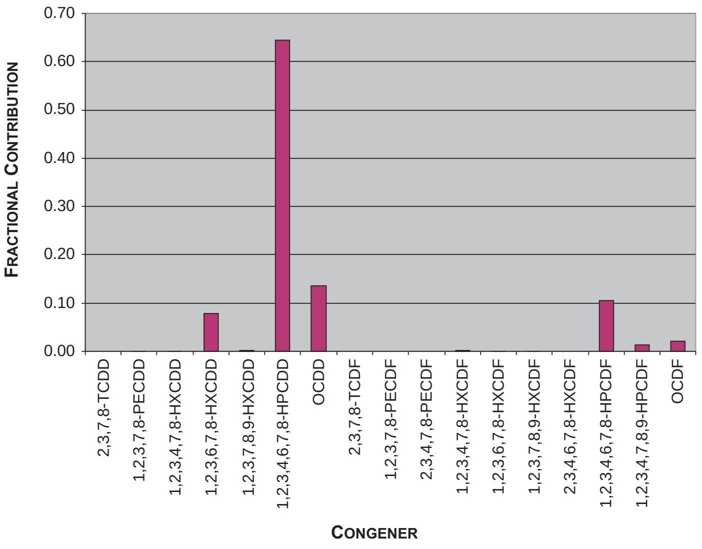




Pentachlorophenol

Reference No. 6

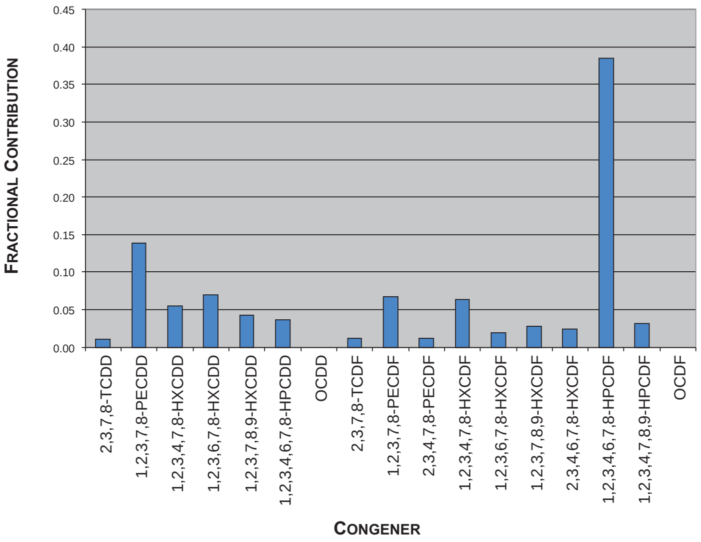




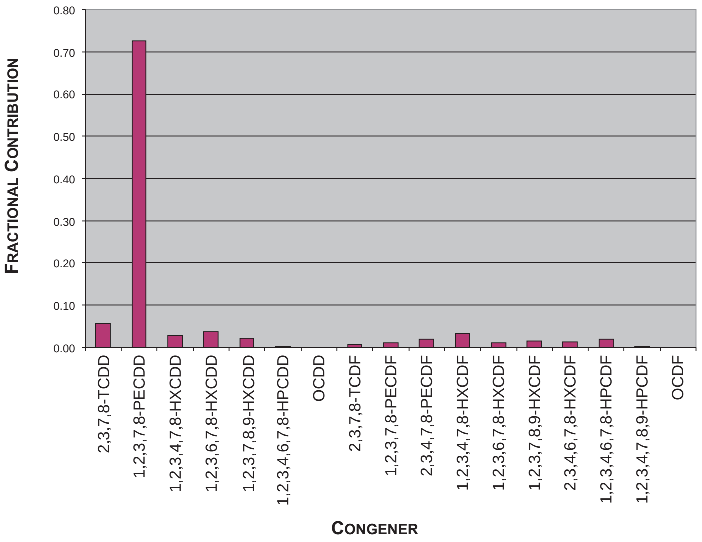
2,4-D

Reference No. 6

BULK PROFILE



TEQ PROFILE



Reference Number

1 AmTest Air Quality, Inc., 1995. Source Emission Evaluation for Rayonier, Inc. Port Angeles Mill #6 Boiler EFB Scrubber System, #4 and #5 Package Boiler Stacks, and Recovery Boiler Stack, April 25-28, Volumes 1 and 2. August 3.

2 AmTest Air Quality, 2009. Nippon Paper Industries USA Co., LTD. Port Angeles, Washington. #8 Hogged Fuel Boiler (EU2), Boiler Information Collection Request, July 29-30, 2009. ATAQ Project #2601-001. (A Division of Hoefler Consulting Group). Final Report, December 4.

3 Burkhard, Lawrence P. and Marta T. Lukasewycz, 2008. Toxicity Equivalency Values for Polychlorinated Biphenyl Mixtures. Environmental Toxicology and Chemistry 27, 529-534.

4 DeAbreu, Michael, 2009. Environment Canada, Pollution Data Division, Vancouver, BC. Personal communication with Gregory L. Glass providing data from the Canadian NPRI database. March 5.

5 Foster Wheeler Environmental Corporation, 1997. Current Situation/Site Conceptual Model Report for Rayonier Port Angeles Mill Site, Mt. Pleasant Road Landfill, and 13th and M Street Landfill. October.

6 U.S. Environmental Protection Agency, 2000. Exposure Assessment and Risk Characterization Group, National Center for Environmental Assessment, Office of Research and Development. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Part I: Estimating Exposure to Dioxin-Like Compounds. Volume 2: Sources of Dioxin-Like Compounds in the United States. EPA/600/P-00/001Bb. Volume 3: Properties, Environmental Levels, and Background Exposures. EPA/600/P-00/001Bc. September. Draft Final Report.

7 U.S. Environmental Protection Agency, 2006. National Center for Environmental Assessment, Office of Research and Development. An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the United States for the Years 1987, 1995, and 2000. EPA/600/P-03/002F. November.

8 Yake, Bill, Stacie Singleton, and Karol Erickson, 1998. Washington State Department of Ecology. Washington State Dioxin Source Assessment. Publication No. 98-320. Including Appendix D, Data Appendix, Publication No. 98-321. July.

ATTACHMENT 2
U.S. ENVIRONMENTAL PROTECTION AGENCY 2006 CONGENER PROFILES

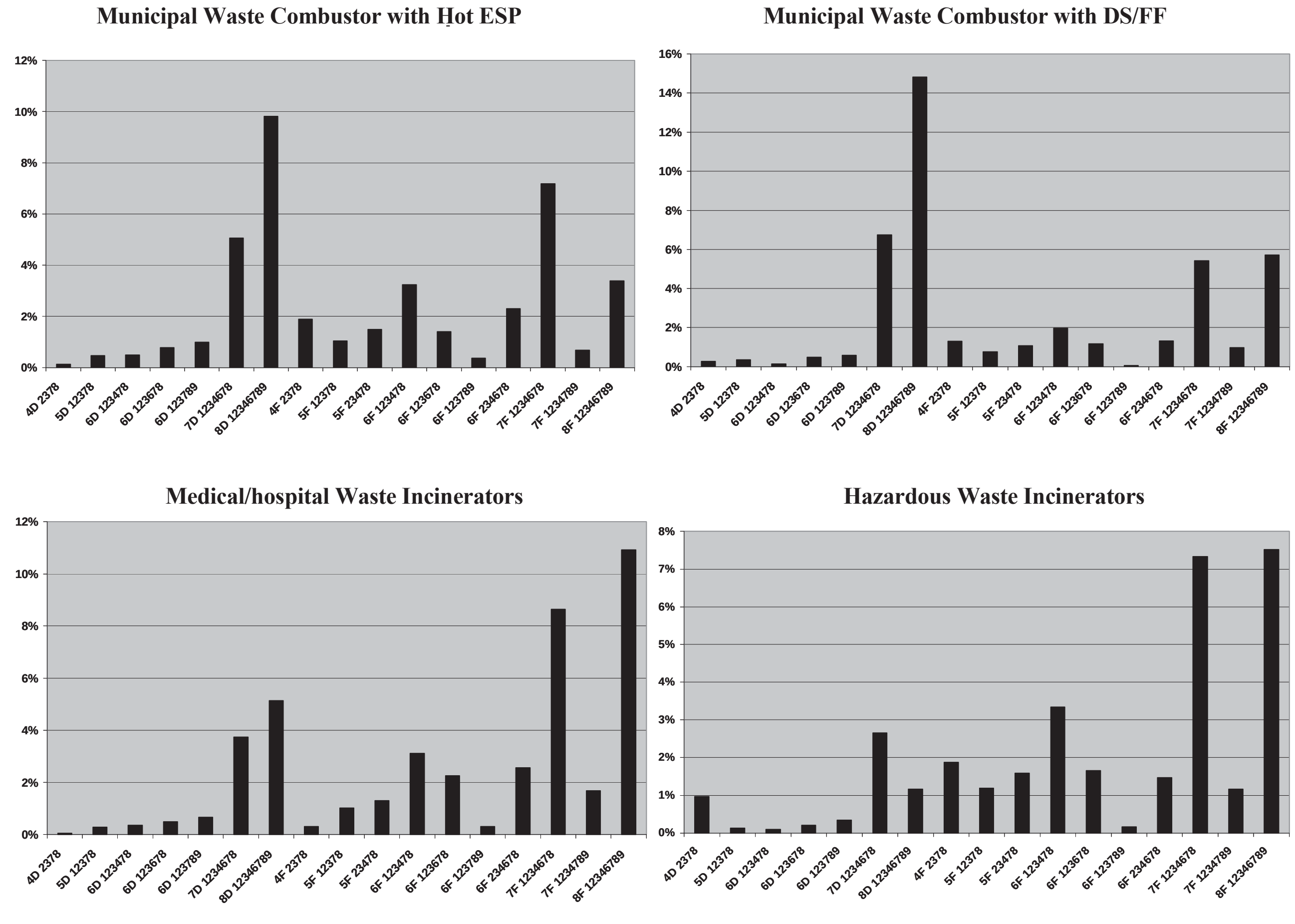
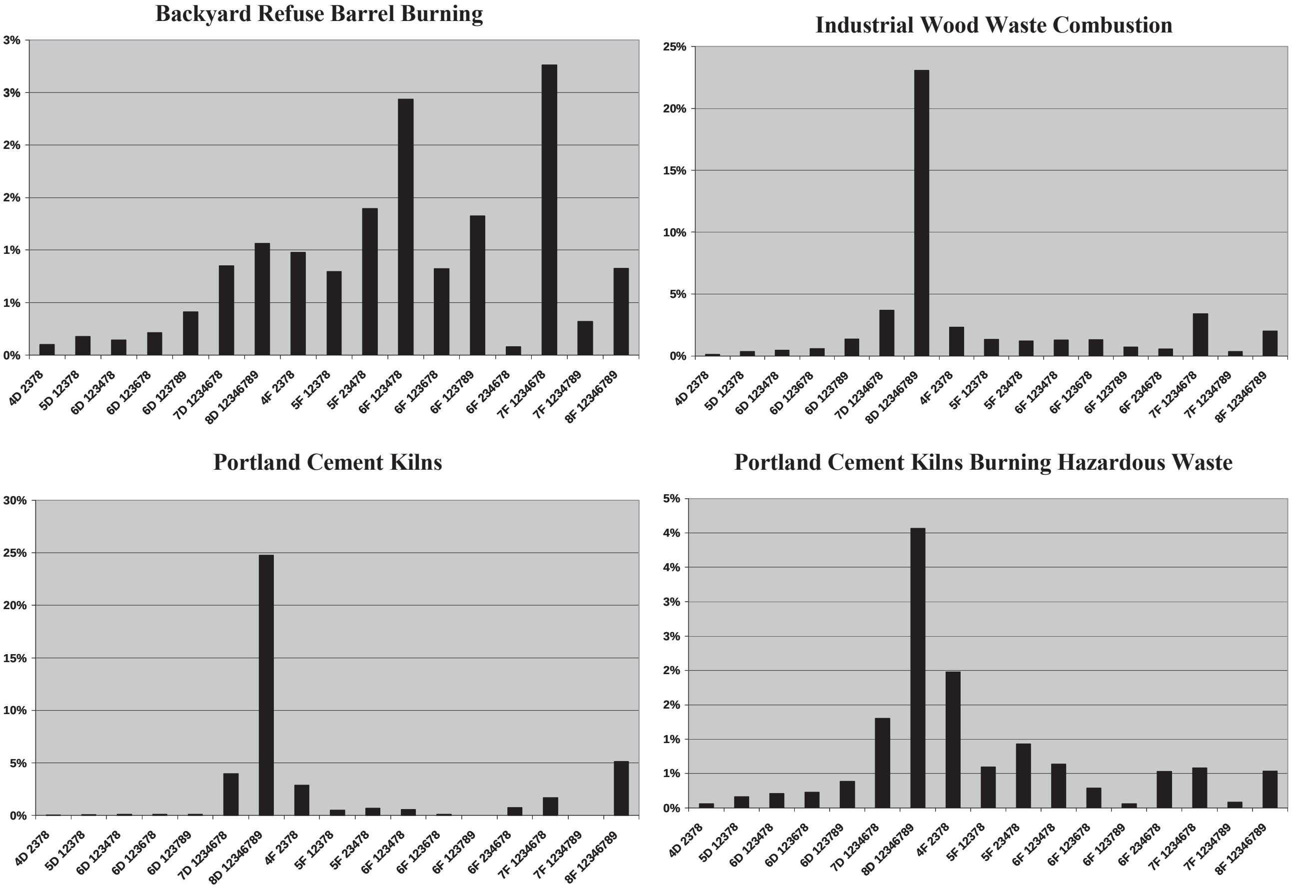


Figure 1-10. Congener profiles (as percent distributions to the sum of CDDs and CDFs) of anthropogenic sources of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the United States.

On the basis of inspection and comparisons of the average CDD/CDF congener profiles across combustion and noncombustion sources, the following observations were made (Cleverly et al., 1997) (these generalizations are derived from this data set, and their application beyond these data is uncertain):

- It appears that combustion sources emit all 2,3,7,8-substituted CDDs/CDFs, although in varying percentages of total CDDs/CDFs.

- In combustion source emissions, 2,3,7,8-TCDD is usually 0.1 to 1% of total CDDs/CDFs. The exception is stack emissions from industrial oil-fired boilers, where the available but limited data indicate that 2,3,7,8-TCDD constitutes an average of 7% of total CDD/CDF emissions.


Backyard Refuse Barrel Burning

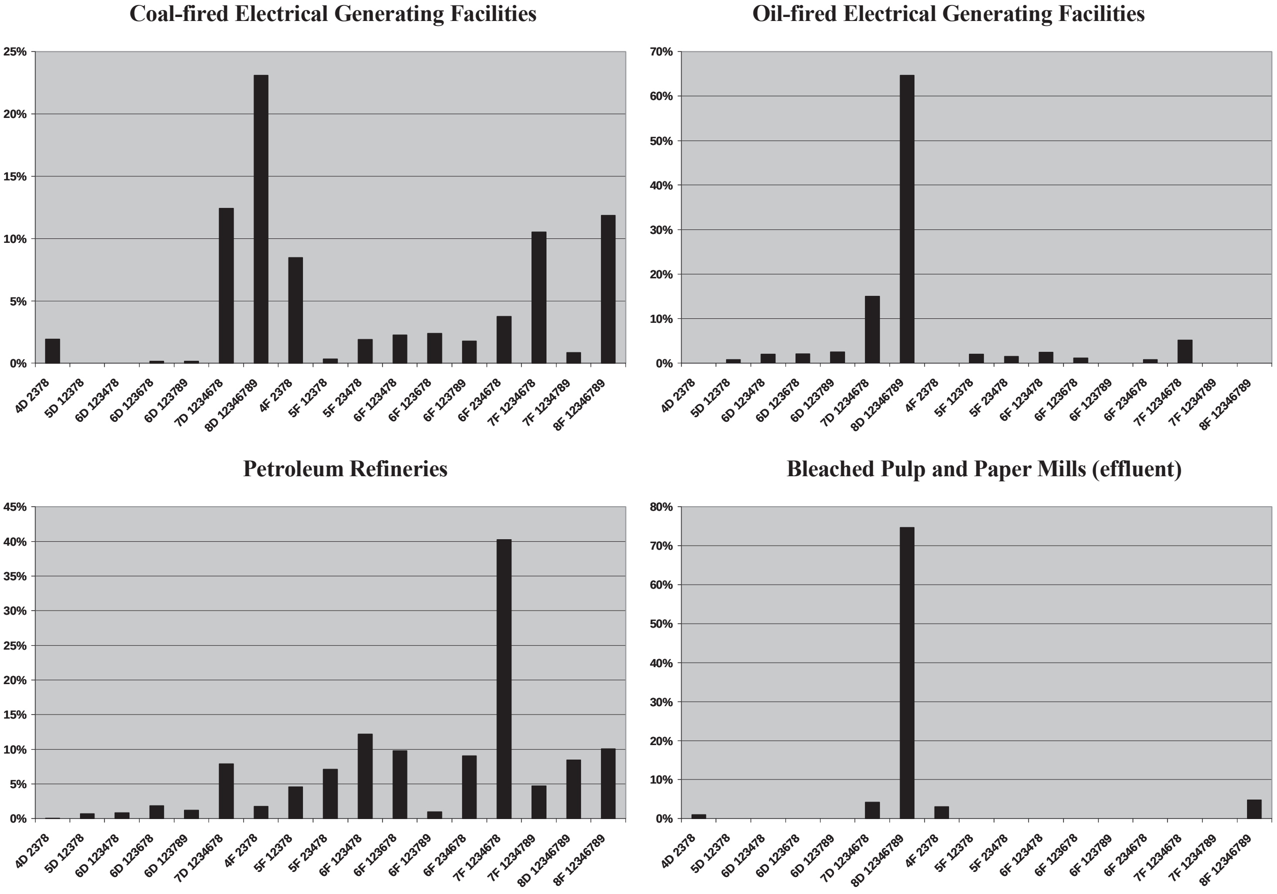
Industrial Wood Waste Combustion

Portland Cement Kilns

Portland Cement Kilns Burning Hazardous Waste

Figure 1-10. Congener profiles (as percent distributions to the sum of CDDs and CDFs) of anthropogenic sources of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the United States (continued).

- It cannot be concluded that OCDD is the dominant congener for all combustion-generated emissions of CDDs/CDFs. OCDD dominates total emissions from mass-burn MWCs that have DSs and FFs for dioxin control, industrial oil-fired boilers, industrial wood-fired boilers, unleaded gasoline combustion, diesel fuel combustion in trucks, and sewage sludge incinerators. The dominant congeners for other combustion sources are 1,2,3,4,6,7,8-HpCDF in emissions from mass-burn MWCs equipped with hot-sided electrostatic precipitators (ESPs), hazardous waste incineration, and secondary aluminum smelters and 2,4-D salts and esters; OCDF in emissions from medical waste incineration and industrial/utility coal-fired boilers; 2,3,4,7,8-PeCDF in cement kilns burning hazardous waste; and 2,3,7,8-TCDF in cement kilns not burning hazardous waste.



Coal-fired Electrical Generating Facilities

Oil-fired Electrical Generating Facilities

Petroleum Refineries

Bleached Pulp and Paper Mills (effluent)

Figure 1-10. Congener profiles (as percent distributions to the sum of CDDs and CDFs) of anthropogenic sources of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the United States (continued).

Evidence for a shift in the congener patterns potentially caused by the application of different air pollution control systems within a combustion source type can be seen in the case of mass-burn MWCs. For mass-burn MWCs equipped with hot-sided ESPs, the most prevalent CDD/CDF congeners are 1,2,3,4,6,7,8-HxCDF; OCDD; 1,2,3,4,6,7,8-HpCDD/1,2,3,4,7,8-HxCDF; 2,3,4,6,7,8-HxCDF/OCDF; 1,2,3,6,7,8-HxCDF. The most prevalent congeners emitted from MWCs equipped with DS/FF are OCDD; 1,2,3,4,6,7,8-HpCDD; 1,2,3,4,6,7,8-HpCDF; OCDF; and 2,3,7,8-TCDF/1,2,3,4,7,8-HxCDD; 2,3,4,6,7,8-HxCDF.

- There is evidence of marked differences in the distribution of CDD/CDF congeners between cement kilns that burn hazardous waste and those that do not. When not burning hazardous waste as supplemental fuel, the dominant congeners appear to be 2,3,7,8-TCDF; OCDD; 1,2,3,4,6,7,8-HpCDD, and OCDF. When burning hazardous waste, the dominant congeners are 2,3,7,8-PeCDF; 2,3,7,8-TCDF; 1,2,3,4,7,8-

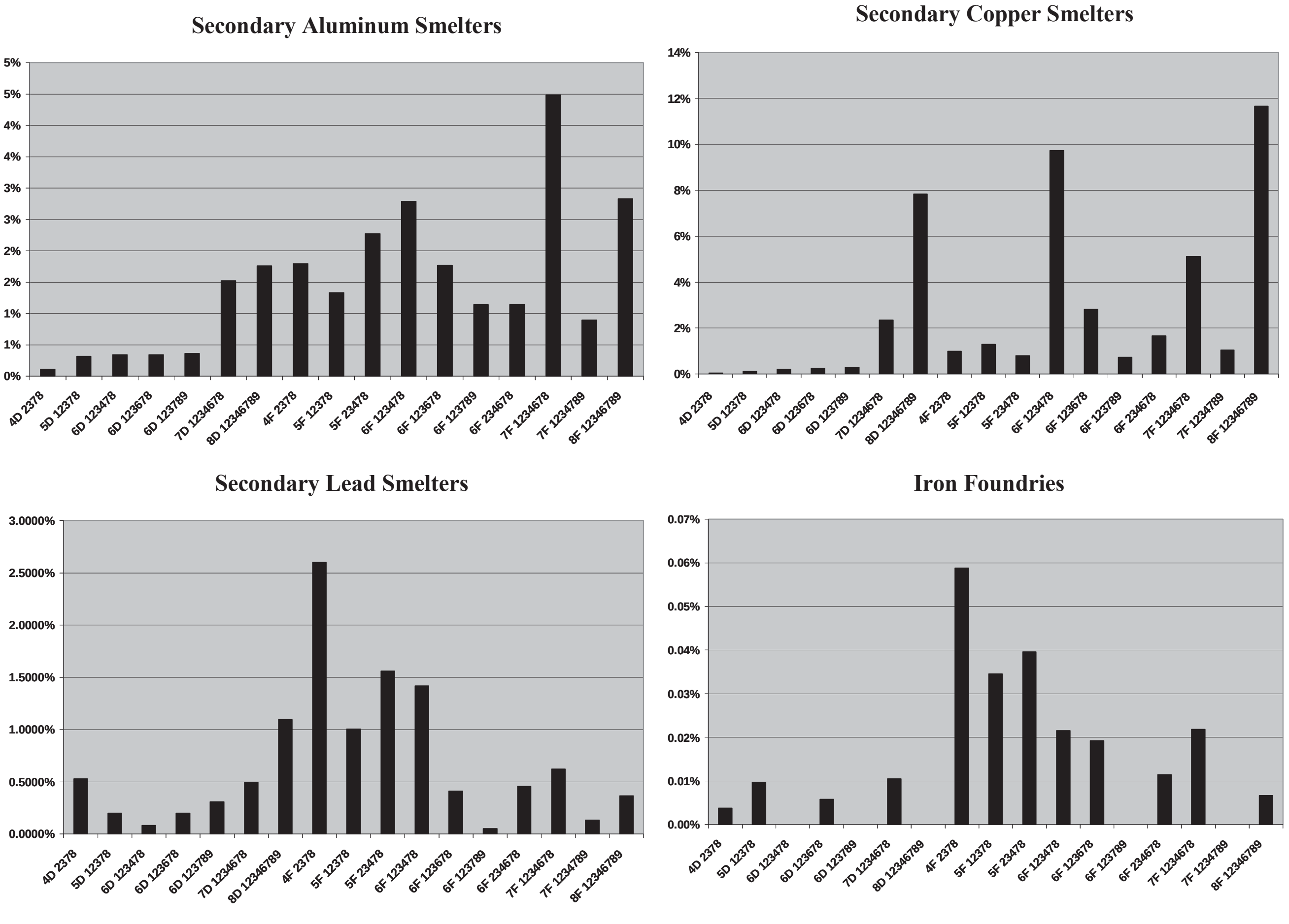


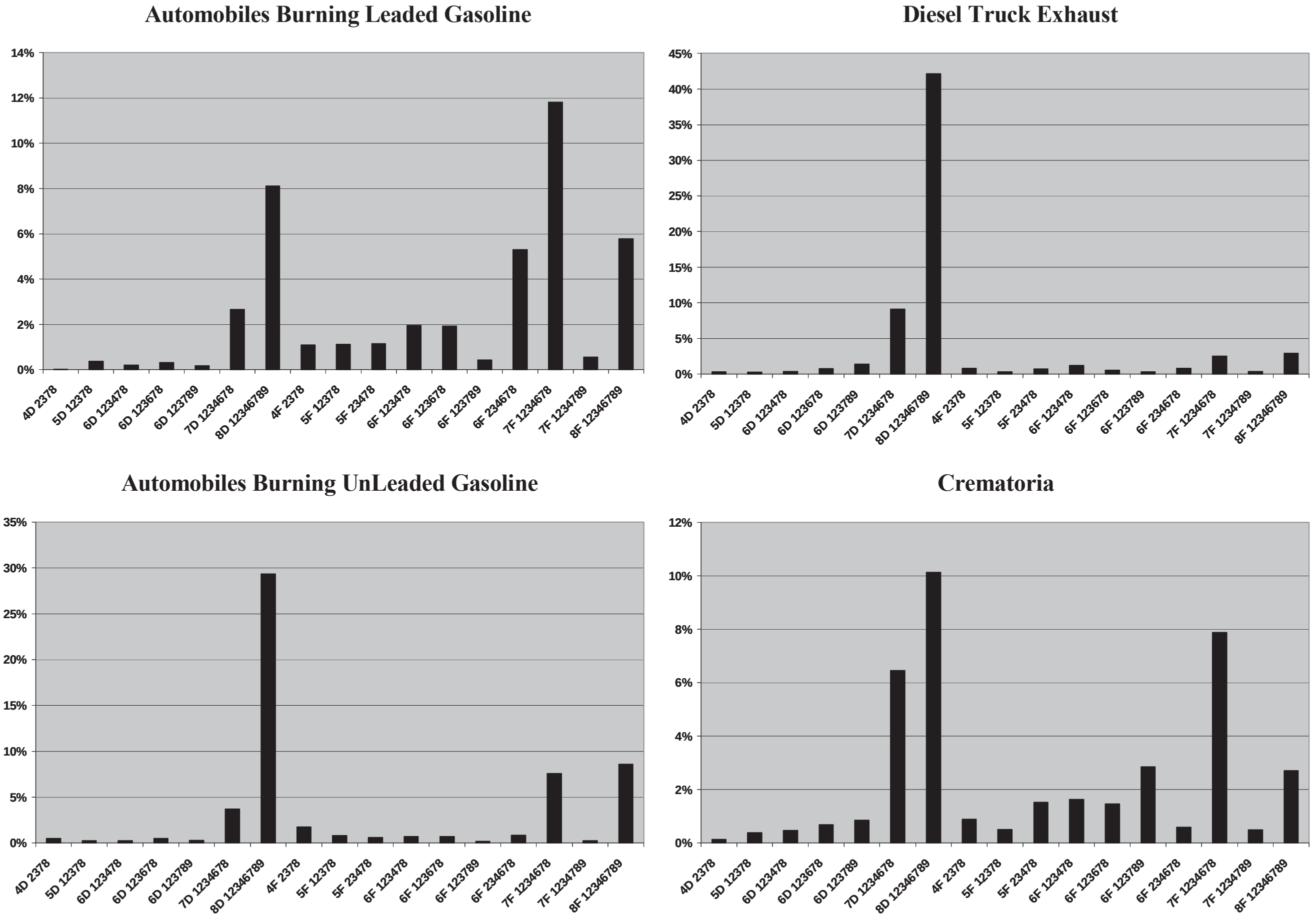
Figure 1-10. Congener profiles (as percent distributions to the sum of CDDs and CDFs) of anthropogenic sources of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the United States (continued).

xCDF; and 1,2,3,4,6,7,8-HpCDD. When burning hazardous waste, OCDD and OCDF are minor constituents of stack emissions.

- The congener profile of 2,4-D salts and esters seems to mimic a combustion source profile in the number of congeners represented and in the minimal amount of 2,3,7,8-TCDD relative to all 2,3,7,8-substituted congeners. A major difference is the prevalence of 1,2,3,7,8-PeCDD in 2,4-D (14%), which is not seen in any other combustion or noncombustion source presented here.

- There are similarities in the congener profiles of PCP, diesel truck emissions, unleaded gasoline vehicle emissions, and emissions from industrial wood combustors. In these sources, OCDD dominates total emissions, but the relative ratio of 1,2,3,4,6,7,8-HpCDD to OCDD is also quite similar.

- The congener profiles for diesel truck exhaust and those for air measurements from a tunnel study of diesel traffic are quite similar.



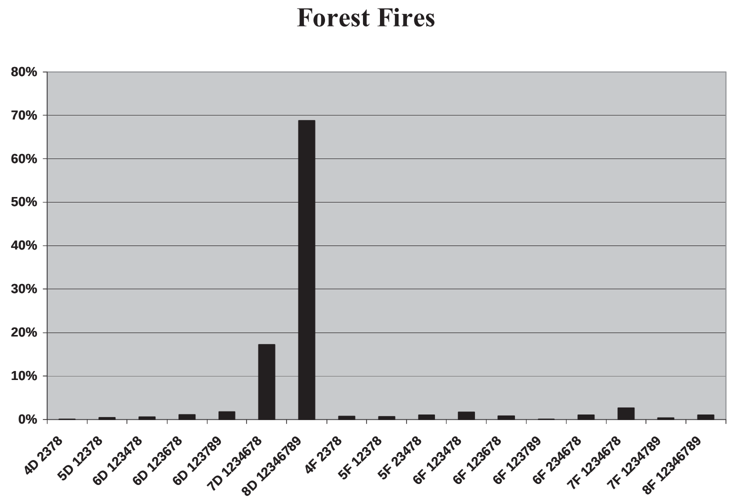
Automobiles Burning Leaded Gasoline

Diesel Truck Exhaust

Automobiles Burning UnLeaded Gasoline

Crematoria

Figure 1-10. Congener profiles (as percent distributions to the sum of CDDs and CDFs) of anthropogenic sources of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the United States (continued).



Forest Fires

Figure 1-10. Congener profiles (as percent distributions to the sum of CDDs and CDFs) of anthropogenic sources of chlorinated dibenzo-*p*-dioxins and chlorinated dibenzofurans in the United States (continued).

APPENDIX F
COST ESTIMATES

1 INTRODUCTION

This appendix presents the cost estimates for the remedial alternatives for the I&J Waterway FS. This appendix documents the common assumptions for all FS remedial alternatives, including sediment removal, dredged material transloading and disposal, material placement, remedial design, permitting, institutional controls, monitoring, and adaptive management. Remedial approach, unit costs, and construction timeframes presented in this appendix are based on recent project experience at other sediment remediation sites in the Puget Sound region. The cost assumptions for remediation of the Bornstein dock area were supported by an additional study of the dock structure and consultation with structural engineers to assess the structural considerations on remediation of contaminated sediment under and near the dock (see Attachments 1 and 2). All cost assumptions presented in this appendix were developed only for the purpose of estimating FS-level costs; the final details associated with remediation will be revisited in remedial design.

The unit cost assumptions, unit quantities for each alternative, and the costs for each alternative are presented in Table 1. This appendix reviews the major cost and construction assumptions for the remedial alternatives, organized parallel to Table 1. Table 2 presents the construction timeframe assumptions for various construction components, also discussed below. Table 3 presents the removal volume calculation for site units. Reference to the site units can be found through this appendix; these are depicted in Figure 9-1 of the FS.

2 MOBILIZATION, DEMOBILIZATION, AND PRE-CONSTRUCTION ACTIVITIES

The contractor must perform a number of activities prior to and after construction of the remedial alternatives, referred to as mobilization, demobilization, and pre-construction activities, such as moving removal and placement equipment, barges, upland equipment, and ancillary equipment to the site. This line item in Table 1 also includes costs for equipment preparation, procedural costs, special insurance, bonding, preparation of staging areas, transloading areas, stockpile areas, implementation of site controls, land lease, project management labor, office, and preparation of pre-construction submittals.

The mobilization, demobilization and pre-construction costs are likely to be different for each alternative. For example, the scope of Alternative 1 is significantly less than Alternative 5 and therefore would require the mobilization of less equipment, fewer barges, less insurance, etc. For this reason, this cost estimate assumes that costs for mobilization, demobilization, and pre-construction would be 12% of the total construction costs for each alternative, consistent with project experience.

3 REMOVAL

Removal is an aspect of all remedial alternatives. Open-water dredging is assumed to proceed relatively rapidly, with minimal delays for maneuvering equipment, debris removal, and scheduling with existing navigational needs. This FS assumes that removal in open-water areas would occur by dredging or excavation at a cost of approximately $20 per cubic yard, which is equivalent to approximately 750 cubic yards per day at $15,000 per day for equipment and labor, consistent with project experience in Puget Sound. Dredging of the Dock Unit is assumed to occur following the removal of the dock and supporting piles, and therefore would also occur in the "open water" with similar dredging production rates since pilings are expected to be removed during dock demolition.

As described in Section 10.4 of the FS, dredged sediment would likely be placed on a barge and dewatered by gravity. Water from wet sediment would be allowed to drain from the barge through appropriate turbidity barriers such as hay bales and filter fabric. Dewatered effluent is assumed to be discharged back to the waterway in the vicinity of dredging operations. Once dredged material is dewatered, the barge would be moved to the transloading facility either on site or off site, depending on the available infrastructure and the final destination of dredged sediment. At the transloading facility, dredged sediment could be transloaded either to trucks or directly to rail, depending on the facility. Trucks could either drive directly to a landfill facility or to a separate rail loading facility and sent by rail to the disposal facility. For the purpose of cost estimating, this appendix assumes that dredged sediment would be loaded to trucks, which would drive directly a Subtitle D landfill or a landfill permitted to accept contaminated sediment. The total cost for transloading, transportation, and tipping is estimated to be $120 per cubic yard, based on recent project experience.

As discussed in Section 10.4, resuspension of contaminated sediment and release of contaminants are a well-documented outcome of environmental dredging. These residuals are typically managed by placing a thin layer of sand similar to enhanced natural recovery ([ENR]; called residuals management cover [RMC]). This FS assumes that an average 1-foot layer of sand (e.g., to achieve a minimum of 6 inches) would be placed across all dredged areas, using the placement assumptions described below. However, during construction, chemical testing could be used to assess the need for RMC (e.g., if sediment concentrations are less than action levels, then RMC may not be necessary).

3.1 Estimation of Removal Volumes

The depth of contaminated sediment was estimated in one of two methods, depending on location, as presented in Table 3. For site units that do not border the shoreline (Navigation Channel West, Navigation Channel East, Berthing Area and Coast Guard units), the depth of contaminated sediment was estimated based on the average depth to the native clay layer shown in Figure 3-4 of the FS. A computer aided drafting program was used to calculate the average thickness of sediment between the elevations of the top of the clay layer and mudline across these areas. The native clay layer represents clean native material, and the depth to the native clay layer represents the maximum depth of contaminated sediment.

For site units that border the shoreline (Dock, Floating Dock, South Bank, Head of the Waterway, and Coast Guard Bank units), multiple considerations were weighed to best estimate the average depth of contaminated sediment. These considerations included the depth of contaminated sediment in cores, the depth of contaminated sediment in adjacent areas, and constructability of slopes (e.g., 3:1 maximum slope angle for dredging prisms).

For all site units, 1 foot was added to the average depth of contaminated sediment to account for potential overdredging. The total average dredging depths were multiplied by the area of each unit to estimate total dredging volumes for the remedial alternatives.

Capping the Head of the Waterway is anticipated to require sediment removal during implementation at the toe of the cap and at the upland to of the cap. The toe of the cap is at approximately 0 feet MLLW and at the top of a slope which grades down to the navigation channel at steeper than 3:1 slope. For geotechnical considerations, the toe of the cap may need to be thicker than 3 feet. For cost estimating purposes, a toe trench 3 feet deep and 10 feet wide is assumed to be necessary across the toe of the cap, for a total cap thickness of 6 feet in that location. In the upland area of the cap, partial removal is expected to be necessary to avoid loss of aquatic land associated with placement of a 3-foot thick cap.

Removal volume at the top of the cap is also assumed to be 3 feet deep and 10 feet wide across the top of the cap.

4 MATERIAL PLACEMENT

Material placement activities include the placement of capping material, ENR material, and RMC. This FS presents several preliminary placement layer designs based on the needs of each area. These preliminary material specifications are based on scour modeling documented in Appendix G and will be revisited in remedial design.

- **Under-dock cap:** The under-dock cap (Alternatives 1 through 3 and 5) is assumed to be 4 feet thick and consist of a 1-foot isolation layer (sand), a 1-foot filter layer (gravel), and a 2-foot armor layer (6-inch stone). The cap would be designed for slope stability and vessel scour.
- **Head-of-the-waterway cap:** The head of the waterway intertidal cap (Alternatives 1 through 5) is assumed to be 3 feet thick and consist of an isolation layer and an appropriate gravel layer on the surface for habitat. The cap would be designed to be protective to a depth of 45 cm to comply with the point of compliance for cleanup levels based on direct contact (see FS Section 8.2).
- **ENR** (Navigation Channel – East, Coast Guard, Coast Guard Bank, and South Bank site units): The ENR thickness is assumed to average 1 foot (minimum 9-inches). ENR is assumed to be a sand/gravel mixture for stability in the bank areas.
- **RMC in all areas except the Dock Unit:** Similar to ENR, RMC thickness is assumed to average 1 foot (minimum 9-inches) but consist of sand instead of gravel.
- **Slope armor in the Dock Unit:** Rather than placement of RMC in the Dock Unit following dredging in Alternatives 4 and 6, armor material will be placed to stabilize the slope from propwash forces. This is assumed to consist of filter and armor material. Similarly, Alternatives 1 through 3 and 5 will have armor placed in a portion of the Berthing Area Unit to support the sheetpile toe wall.

For the purpose of cost estimating, the cost of material is broken into two groups: sand and gravel, and cap armor. Sand and gravel are anticipated to cost approximately $20 per cubic yard delivered to the site, and 6-inch cap armor is anticipated to cost approximately $35 per cubic yard. Sand and gravel are assumed to be the constituents of all placement layers except the armor layer under the dock, which is assumed to be 6-inch armor stone.

As described in Sections 10.2 and 10.3, open-water material placement would occur using standard dredging or excavation buckets. The cost for placement for sand and gravel materials (capping, ENR, and RMC) is assumed to be $20 per cubic yard for all open-water areas (i.e., all placement activities except capping the Dock Unit). This is equivalent to approximately 750 cubic yards per day at $15,000 per day for materials and labor. Cost to place rip-rap is assumed to be double this cost, at $40 per cubic yard.

Placement of capping material in the Dock Unit is assumed to occur by casting material under the dock with a Telebelt® or an alternative method. Casting material is significantly slower than by bucket, and the cost is assumed to be $60 per cubic yard, based on approximately 250 cubic yards per day at $15,000 per day for materials and labor. Placement of slope armor in the Dock Unit is assumed to have the same unit cost of open-water placement because the dock would be removed at the time of filter/armor placement.

5 STRUCTURAL COST COMPONENTS

All alternatives include at least one structural cost component that will be necessary to perform remediation. The structural cost components identified for one or more remedial alternatives include sheetpile toe wall, Bornstein dock replacement, moving and restoring the Bornstein floating dock, moving and restoring the Coast Guard dock, and bulkhead replacement.

The sheetpile toe wall is an aspect of Alternatives 1, 2, 3, and 5, aligned between the Dock Unit and the Berthing Area Unit to support under-dock capping on one side, and dredging of the Berthing Area on the other. The sheetpile is also designed to reduce the potential structural impact to the adjacent dock due to dredging the Berthing Area. The wall is expected to be approximately 10 feet high and cost approximately $3,800 per linear foot. Preliminary structural costs are provided in Attachment 1. Costs are included for replacement of a similar fender pile system, but the details of this system would be refined during design as the fender piles would be installed several feet from the pierface beyond the sheetpile toe wall. Costs are not included for business interruptions to Bornstein Seafoods operations during construction.

Geotechnical and structural evaluation indicates that removal of contaminated sediment from under the dock would destabilize the existing dock. Therefore, for Alternatives 4 and 6, sediment removal under the dock would be accomplished following dock demolition. The cost for dock removal and replacement of a dock with the same overwater coverage as the existing dock is estimated to be approximately $320 per square foot. Preliminary structural costs are provided in Attachment 1. Costs are not included for business interruption to Bornstein Seafoods operations during construction, including temporary relocation of the existing ice house or other equipment located on the dock or use of an alternate nearby dock structure to serve fishing vessels.

Similar to the Bornstein dock, geotechnical and structural analysis indicates that sediment removal adjacent to the Bornstein bulkhead would undermine and compromise the existing bulkhead, which would require bulkhead replacement. These are estimated to cost

$5,900 per linear foot (applicable to Alternatives 4 and 6). Preliminary structural costs are provided in Attachment 1.

Dredging in the area of the Bornstein floating dock and/or the Coast Guard floating dock is assumed to temporarily relocate the dock structures, pull and dispose of support piles, dredge sediment (place RMC as necessary), reinstall piles, and reinstall the previous floating dock structures. The costs for temporarily relocating and reinstalling the Bornstein floating dock and Coast Guard floating dock are estimated to be approximately $94,000 and $195,000, respectively.

The construction timeframe assumptions for these construction activities are shown in Table 2 and are based on best professional judgment.

6 OTHER COSTS

Table 1 provides a number of other project costs, as described below:

- It is typical for remediation projects to have interim progress surveys throughout the project. These surveys are assumed to occur weekly (every 5 construction days) and cost $3,000 per event.
- Sales tax is assumed to be 8.7% of total base construction costs.
- Project contingency is assumed to be 30% of total base construction costs (including tax), consistent with other sediment remediation projects of this magnitude. This contingency includes uncertainty in unit cost assumptions as well as uncertainty in overall project scope (e.g., total dredging volume).
- Design and permitting and construction management support vary from $500,000 to $750,000 depending on the alternative, consistent with other sediment remediation projects of this magnitude.
- Water quality monitoring is assumed to be $3,000 per day, consistent with project experience.
- Post-construction monitoring is assumed to be approximately $104,000 per monitoring event, which is assumed to include a sampling and analysis plan, mobilization/ demobilization, collection of approximately 20 samples over a 2-day period, analysis, validation, and reporting. This cost estimate assumes that post-construction performance monitoring would occur following construction, and long-term monitoring of a similar intensity would occur for all alternatives in years 5, 10, and 15 following construction.
- Agency review and oversight are assumed to be $30,000 per year during construction and during years 5, 10, and 15 post construction.

7 SUMMARY

The total construction costs are estimated to range from $5,400,000 for Alternative 1 to $20,600,000 for Alternative 5. These costs are based on the best estimate of costs for the remedial alternative for FS-level costing, and are accurate to a range of approximately +50% to -30%.

TABLES

Table 1
Remedial Alternative Costs

Item No.	Item Description	Unit Cost	Unit	Unit Cost Notes	Alternative 1 Total Quantity	Alternative 2 Total Quantity	Alternative 3 Total Quantity	Alternative 4 Total Quantity	Alternative 5 Total Quantity	Alternative 6 Total Quantity	Alternative 1 Cost	Alternative 2 Cost	Alternative 3 Cost	Alternative 4 Cost	Alternative 5 Cost	Alternative 6 Cost
Pre-construction																
1	**Mobilization/Demobilization and Pre-construction Activities**	12%	-	Percent of construction costs (pre-tax, pre-contingency). Assumed to include mobilization and demobilization of removal and placement operations, barges, equipment preparation, upland equipment, ancillary equipment, procedural costs, special insurance, bonding, preparation of staging areas, transloading areas, stockpile areas, implementation of site controls, land lease, project management labor, office, preparation of pre-construction submittals.	1	1	1	1	1	1	$ 284,241	$ 286,884	$ 451,415	$ 826,363	$ 879,854	$ 1,413,031
	Subtotal Pre-construction										**$ 284,241**	**$ 286,884**	**$ 451,415**	**$ 826,363**	**$ 879,854**	**$ 1,413,031**
Construction																
3	**Removal, Dewatering, Offloading, and Disposal**															
3a	Open-water Dredging	$ 20	cy	Consistent with recent project experience. Equivalent to approximately 750 cy per day and $15,000 per day for equipment and labor.	5,563	5,563	14,964	18,144	30,093	39,101	$ 111,254	$ 111,254	$ 299,285	$ 362,875	$ 601,862	$ 782,023
3b	Transload, Transportation and Disposal	$ 120	cy	Cost includes material transfer from barge onto offloading area, water management at transloading facility, load dewatered sediment onto truck with containers, truck transport to rail facility, offloading of sediments from barges at Subtitle D landfill. Assume 1.5 ton/cy.	5,563	5,563	14,964	18,144	30,093	39,101	$ 667,526	$ 667,526	$ 1,795,712	$ 2,177,250	$ 3,611,172	$ 4,692,136
4	**Material Placement (Capping, ENR and Residuals Management Cover)**															
4a	Furnish Sand/ Gravel	$ 20	cy	Based on recent project experience and cost estimates. Applies to Engineered Cap Isolation Layer, Backfill, RMC, and ENR in open-water areas.	4,832	5,371	6,532	6,031	7,879	4,991	$ 96,635	$ 107,429	$ 130,643	$ 120,614	$ 157,579	$ 99,820
4b	Furnish Armor	$ 35	cy	Based on recent project experience and cost estimates.	1,003	1,003	1,003	0	1,003	0	$ 35,103	$ 35,103	$ 35,103	$ -	$ 35,103	$ -
4c	Furnish Rip-rap	$ 40	cy	Based on recent project experience and cost estimates.	0	0	0	1,003	0	1,003	$ -	$ -	$ -	$ 40,118	$ -	$ 40,118
4d	Place Sand/Gravel-Open Water	$ 20	cy	Based on recent project experience and cost estimates.	3,829	4,369	5,529	6,031	6,876	4,991	$ 76,576	$ 87,370	$ 110,584	$ 120,614	$ 137,520	$ 99,820
4e	Place Sand/Gravel-Under Dock	$ 60	cy	Based on recent project experience and cost estimates.	1,003	1,003	1,003	0	1,003	0	$ 60,177	$ 60,177	$ 60,177	$ -	$ 60,177	$ -
4f	Place Armor-Under Dock	$ 60	cy	Based on recent project experience and cost estimates.	1,003	1,003	1,003	0	1,003	0	$ 60,177	$ 60,177	$ 60,177	$ -	$ 60,177	$ -
4g	Place Rip Rap	$ 40	cy	Based on recent project experience and cost estimates.	0	0	0	1,003	0	1,003	$ -	$ -	$ -	$ 40,118	$ -	$ 40,118
5	**Structural Cost Components**															
5a	Sheetpile Toe Wall (Dock)	$ 3,755	lf	Rough order of magnitude from KPFF analysis assuming 50 year design life.	330	330	330	0	330	0	$ 1,239,000	$ 1,239,000	$ 1,239,000	$ -	$ 1,239,000	$ -
5c	Dock replacement	$ 324	sqft	Rough order of magnitude from KPFF analysis assuming replacement in kind on existing footprint.	0	0	0	5,600	0	5,600	$ -	$ -	$ -	$ 1,817,000	$ -	$ 1,817,000
5d	Move and restore floating dock with pile replacement	$ 93,727	ls	Rough order of magnitude from KPFF analysis.	0	0	0	1	0	1	$ -	$ -	$ -	$ 93,727	$ -	$ 93,727
5e	Move and restore Coast Guard dock and structure with pile replacement	$ 194,665	ls	Rough order of magnitude from KPFF analysis.	0	0	0	0	1	1	$ -	$ -	$ -	$ -	$ 194,665	$ 194,665
5f	Bulkhead replacement	$ 5,923	lf	Rough order of magnitude from KPFF analysis assuming replacement in kind along existing delineation.	0	0	0	350	200	650	$ -	$ -	$ -	$ 2,073,000	$ 1,184,571	$ 3,849,857
6	**Surveys and Monitoring**															
6a	Contractor weekly progress surveys	$ 3,000	wk	Based on recent project experience and cost estimates. Assume 5 day weeks.	7.4	7.6	10	14	17	22	$ 22,227	$ 22,659	$ 31,109	$ 41,040	$ 50,289	$ 65,974
	Subtotal Construction Base Costs (including mob/demob)										*$ 2,652,918*	*$ 2,677,581*	*$ 4,213,207*	*$ 7,712,718*	*$ 8,211,971*	*$ 13,188,289*
7	**Sales Tax**															
7a	Sales Tax	8.7%	--	Percent of subtotal of pre-construction costs and construction base costs.	1	1	1	1	1	1	$ 230,804	$ 232,950	$ 366,549	$ 671,006	$ 714,441	$ 1,147,381
	Subtotal Pre-construction and Construction Costs										**$ 2,883,722**	**$ 2,910,531**	**$ 4,579,756**	**$ 8,383,724**	**$ 8,926,413**	**$ 14,335,670**

Table 1
Remedial Alternative Costs

Item No.	Item Description	Unit Cost	Unit	Unit Cost Notes	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
					Total Quantity	Total Quantity	Total Quantity	Total Quantity	Total Quantity	Total Quantity	Cost	Cost	Cost	Cost	Cost	Cost
Non-construction Costs																
8	**Pre-construction**															
8a	Design and Permitting	varies by alternative	ls	Based on experience with similar projects.	1	1	1	1	1	1	$ 500,000	$ 500,000	$ 500,000	$ 500,000	$ 550,000	$ 750,000
9	**During Construction**															
9a	Construction Management Support	$ 25,000	mo	Percent of construction costs. Typical Conceptual-level Contingency; mid-range of EPA FS Cost Guidance for contingency. Percent of pre-construction, construction, and tax.	1.9	1.9	2.6	3.4	4.2	5.5	$ 46,307	$ 47,207	$ 64,810	$ 85,499	$ 104,770	$ 137,445
9b	**Environmental Compliance**															
9bi	Water Quality Monitoring	$ 20,000	mo	Includes labor, equipment, materials, and analytical testing.	1.9	1.9	2.6	3.4	4.2	5.5	$ 37,046	$ 37,765	$ 51,848	$ 68,399	$ 83,816	$ 109,956
9bii	Post-construction Performance Monitoring	$ 104,000	ls	Includes SAP, mob/demob, ~20 surface sediment samples, analysis, validation, reporting.	1	1	1	1	1	1	$ 104,000	$ 104,000	$ 104,000	$ 104,000	$ 104,000	$ 104,000
9c	Agency Review and Oversight	$ 30,000	ls	Annually during construction.	1	1	1	1	1	1	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
10	**Post-construction Costs**															
10a	Long-term Monitoring (years 5, 10, 15)	$ 104,000	event	Includes SAP, mob/demob, ~20 surface sediment samples, analysis, validation, reporting.	3	3	3	3	3	3	$ 312,000	$ 312,000	$ 312,000	$ 312,000	$ 312,000	$ 312,000
10b	Agency Review and Oversight	$ 10,000	Annual	Assume 3 events in years 5, 10, and 15 post construction for reviews.	3	3	3	3	3	3	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
10c	Cap Lease	$ 8,000	ac*yr	30 years. Costs could range up to $20,000/ac/yr.	29	29	29	20	29	0	$ 232,800	$ 232,800	$ 232,800	$ 158,400	$ 232,800	$ -
Subtotal Non-construction Costs											**$ 1,292,153**	**$ 1,293,772**	**$ 1,325,459**	**$ 1,288,298**	**$ 1,447,386**	**$ 1,473,401**
11	**Contingency**															
11a	Contingency	30%	--	Percent of construction costs. Typical conceptual-level contingency. Percent of pre-construction, construction, non-construction, and tax.	1	1	1	1	1	1	$ 1,252,762	$ 1,261,291	$ 1,771,564	$ 2,901,607	$ 3,112,139	$ 4,742,722
Total Cost											**$ 5,428,637**	**$ 5,465,594**	**$ 7,676,779**	**$ 12,573,629**	**$ 13,485,938**	**$ 20,551,793**
Total Cost (rounded)											**$ 5,400,000**	**$ 5,500,000**	**$ 7,700,000**	**$ 12,600,000**	**$ 13,500,000**	**$ 20,600,000**

Notes:

Feasibility Study cost estimates are considered accurate to +50% and -30%.

Costs are contingent on regulatory acceptability and may change during remedial design and permitting.

All unit and estimated costs are probable costs based on best professional judgment, local contractor input, and experience with similar projects in the region.

Construction-related and non-construction costs do not include costs for bid tendering, agency oversight, legal, or cultural resources oversight costs.

Costs do not include long term operations and maintenance costs for sediment caps and sheetpile walls.

Lease rates for sediment caps are subject to discussion with Washington Department of Natural Resources.

Costs are based on 2014 rates and costs; no cost escalation has been applied.

EPA = Environmental Protection Agency

RMC = Residuals Management Cover

ENR = Enhanced Natural Recovery

SAP = Sampling and Analysis Plan

Table 2
Estimated Construction Duration for Alternatives

Construction Description	Unit Assumption	Unit	Notes	Alternative					
				Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Dredging				**Days**					
Open-water Dredging	750	cy/day	Based on dredge production calculations	7	7	20	24	40	52
Placement - Capping, ENR, and RMC				**Days**					
Placement - Open Water Sand or Gravel	750	cy/day	Based on recent Puget Sound project experience	5	6	7	8	9	7
Placement - Under Dock Sand or Gravel	250	cy/day	Based on recent Puget Sound project experience	4	4	4	0	4	0
Placement - Under Dock Armor	250	cy/day	Based on recent Puget Sound project experience	4	4	4	0	4	0
Improvements				**Days**					
Sheetpile and Bulkhead	20	lf/day	Best Professional Judgement	17	17	17	18	27	33
Dock Replacement	300	sq ft/day	Best Professional Judgement	0	0	0	19	0	19
Total Construction Time				**Days**					
Total construction time			**Total of all operations**	**37**	**38**	**52**	**68**	**84**	**110**

Notes:
cy = cubic yards
ENR = enhanced natural recovery
lf = linear feet
RMC = Residuals Management Cover
sq ft = square feet

Table 3
Removal Volumes

Site Unit	Average Depth of Contamination (ft)	Basis	Assumed Overdredge Depth (ft)	Average Dredging Depth (ft)	Area (acre)	Dredge Volume for Full Removal (cy)
Full Removal						
Navigation Channel West	7.1	Calculated in CAD based on the depth to the clay layer	1.0	8.1	0.72	9,402
Navigation Channel East	8.3	Calculated in CAD based on the depth to the clay layer	1.0	9.3	0.41	6,095
Coast Guard	9.9	Calculated in CAD based on the depth to the clay layer	1.0	10.9	0.28	4,984
Coast Guard Bank	4.0	Estimated considering sediment cores, adjacent areas, and slopes	1.0	5.0	0.15	1,170
Berthing Area	8.0	Calculated in CAD based on the depth to the clay layer	1.0	9.0	0.24	3,443
Dock	5.6	Estimated considering sediment cores, adjacent areas, and slopes	1.0	6.6	0.17	1,831
Floating Dock	5.0	Estimated considering sediment cores, adjacent areas, and slopes	1.0	6.0	0.14	1,335
South Bank	4.3	Estimated considering sediment cores, adjacent areas, and slopes	1.0	5.3	0.33	2,879
Head of Waterway	6.5	Estimated considering sediment cores, adjacent areas, and slopes	1.0	7.5	0.66	7,948
Site-wide Totals	6.8	n/a	1.0	7.8	3.1	39,087
Partial Removal for Capping the Head of the Waterway (toe trench for geotechnical considerations and upland removals for habitat mitigation)						
Head of Waterway	n/a	Assume 3ft of removal in 2/3 of the area	n/a	3.0	0.44	2,119

Notes:
cy = cubic yards
ft = feet
n/a = not applicable

ATTACHMENT 1
PORT OF BELLINGHAM I&J WATERWAY PRELIMINARY STRUCTURAL EVALUATION

kpff Consulting Engineers

March 26, 2014

Mr. Dan Berlin, Anchor QEA
720 Olive Way #1900
Seattle, WA, 98101

Re: **DRAFT** Port of Bellingham I&J Waterway Structural Dredging Options

Dear Mr. Berlin,

KPFF has been supporting Anchor QEA in evaluating the structures that may be affected due to dredging operations in the I&J Waterway, located in Bellingham, Washington. The structures that are affected include the Bornstein Seafood timber dock, and the adjacent timber bulkhead on the south shoreline. KPFF has evaluated several options to allow for dredging to occur adjacent to the existing structures.

The existing timber dock deck elevation is approximately +16.5' MLLW, with a top of pile elevation of approximately +14.0' MLLW. Based on the Pile Integrity Testing (PIT) that was completed, the piles have an average length of approximately 37 feet. Therefore, the pile tip elevation is approximately -23.0' MLLW. Dredging to a depth of -20' MLLW is expected to occur at the dock face, and the dock piles may have as little as 3 feet of embedment. Due to the potential dock instability, it was determined that the piles would need to be replaced or a sheet pile toe wall would need to be installed.

Option 1: Complete Dock and Bulkhead Replacement

The first option evaluated includes dredging all contaminated sediment in front of, and under the existing timber dock. The dredging required for this option would most likely compromise the structural integrity of the existing timber dock, and undermine the upland timber bulkhead due to their existing condition.

The existing timber bulkhead is approximately 350 feet long, and constructed with timber piles and timber lagging. A replacement bulkhead designed to today's standards would consist of new steel sheet pile bulkhead with drilled tiebacks that would be installed directly in front of the existing bulkhead. The area between the walls would be backfilled.

The existing timber dock is approximately 160 feet long, 35 feet wide and supported on timber piling. A replacement dock designed to today's standards would consist of concrete piles, a concrete deck, and would occupy the same footprint as the existing timber dock. Option 1 will cause disruptions to ongoing site operations.

Option 2: Sheet Pile Toe Wall

The second option evaluated involves dredging in front of the existing dock, with a cap placed on the slope underneath the dock. KPFF determined that an underwater toe wall would be required at the face of the dock to retain the capped soil and prevent dock instability due to the limited pile embedment. The steel sheet pile toe wall would be driven in front of the existing dock structure, and would be approximately 250 feet long. This wall would stabilize the soil under the dock, and allow for dredging of the waterway.

The risks for this option include potential instability of the dock piling due to the vibrations caused by the toe wall installation which may require modifications to the dock to ensure its stability (these costs have not been estimated). In addition, the dock fender system would likely need to be replaced and extended farther into the waterway to allow for the toe wall installation. Option 2 will cause fewer disruptions to ongoing site operations than Option 1.

We appreciate the opportunity to complete this work for Anchor QEA and the Port of Bellingham. Please contact us at (206) 382-0600 if you have any questions or require any additional information.

Sincerely,

Trevor Lighty, PE
Structural Engineer
KPFF Consulting Engineers

Bob Riley, PE, SE
Principal
KPFF Consulting Engineers

DRAFT Rough Order of Magnitude Probable Cost of Construction
I and J Waterway
Summary of Structural Items
4/3/2014
EDE

Preliminary Structural Cost Summary

Structural Item	Total Cost
Dock Replacement with Concrete Dock (Option 1)	$ 2,600,000
Bulkhead Replacement (Option 1)	$ 3,000,000
New Sheet Pile Toe Wall (Option 2)	$ 1,800,000

Assumptions

Costs include 8.7% Tax and 30% Contingency

Dock Replacement with Concrete Dock

Assumes 5600 sq ft of timber dock removal and disposal and replacement with a concrete deck and piles. Cost includes fender replacement.

Bulkhead Replacement

Costs assume steel sheet pile wall with 16 ft exposed height, 350 feet long with one row of tiebacks.

Toe Wall

Costs assume wall that has 13 ft retained height and is 330 LF long and that the fender system is replaced.

DRAFT Rough Order of Magnitude Probable Cost of Construction

I and J Waterway

4/3/2014

DRAFT

Dock Replacement with Concrete Dock (Option 1)

	Item	Quantity	Unit	Unit Cost		Cost (2014$)
1.00	**Mobilization/Demobilization**	**1**	**LS**			
2.00	**Demo Dock**	**5,600**	**SQFT**	**$36**		**$200,000**
2.01	Demolish and remove timber dock	5,600	SQFT	$15	$84,000	
2.02	Pull piles	100	EA	$600	$60,000	
2.03	Timber Haul and Disposal	280	TON	$200	$56,000	
3.00	**Build New Pier**	**5,600**	**SQFT**	**$232**		**$1,297,000**
3.01	Concrete deck 5600 sqft 2 ft thick	415	CY	$1,500	$622,222	
3.02	Furnish Concrete Piles 54 piles 100 LF	5,400	LF	$75	$405,000	
3.03	Drive Piles Concrete Piles	54	EA	$5,000	$270,000	
4.00	**New Fender System**	**160**	**LF**	**$2,000**		**$320,000**
4.01	New Fender System	160	LF	$2,000	$320,000	
	Replacement Dock Subtotal Construction Cost					$ 1,817,000
	Contingency (30%)					$ 545,000
	Sales Tax (8.7%)					$ 205,000
	Replacement Dock Estimate					**$ 2,567,000**

$ 458 $/SQFT

Notes

1.00 Mobilization to be added by Anchor
2.01 From Whatcom waterway Chevron pier
2.02 From Whatcom waterway
2.03 From Whatcom waterway, from Anchor QEA

3.01 Unit Cost from Gulfport
3.02 Unit Cost from Gulfport, also confirmed with EBOW
3.03 Unit Cost from Gulfport, also confirmed with EBOW

4.01 $2,000 per LF from BST fender replacement

PORT OF BELLINGHAM
Washington State

ANCHOR QEA

kpff

DRAFT Rough Order of Magnitude Probable Cost of Construction

I and J Waterway

4/3/2014 **Length** 350 ft

DRAFT

Bulkhead Replacement (Option 1)

	Item	Quantity	Unit	Unit Cost		Cost (2014$)
1.00	**Mobilization/Demobilization**	**1**	**LS**			
2.00	**Excavation/Demolition/Earthwork**	**84**	**CY**	**$150**		**$13,000**
2.01	Dispose of contaminated soil for drilling spoils (8" dia x 100' long)	84	CY	$150	$12,601	
3.00	**New Concrete**	**136**	**CY**	**$1,200**		**$163,000**
3.01	New 3'x3.5' cap beam	136	CY	$1,200	$163,333	
4.00	**New Steel**	**467**	**TONS**	**$2,287**		**$1,069,000**
4.01	C15x50 Waler (2 members) plus +15% for connections	20	TONS	$4,500	$90,563	
4.02	Bearing plates at tieback (250lb per connection)	6	TONS	$5,000	$31,875	
4.03	Strands ((5).6" 7 wire strands x 100' long) plus hardware	51	EA	$2,500	$127,500	
4.04	AZ 38-700N Sheet Pile (60' tall)	390	TONS	$2,100	$818,737	
5.00	**Drive Piles**	**77**	**EA**	**$1,800**		**$138,000**
5.01	Drive AZ 38-700N pairs	77	EA	$1,800	$137,700	
6.00	**Drill Anchors**	**51**	**EA**	**$12,000**		**$612,000**
6.01	Drill, grout, and test 100' tie back	51	EA	$12,000	$612,000	
7.00	**CDF Fill**	**778**	**CY**	**$100**		**$78,000**
7.01	Between walls	778	CY	$100	$77,778	
	Subtotal Bulkhead Construction Cost					$ 2,073,000
	Contingency (30%)					$ 622,000
	Sales Tax (8.7%)					$ 234,000
	Bulkhead Estimate					**$ 2,930,000**

$ 8,371 $/LF

Notes

1.00 Mobilization to be added by Anchor
2.01 Quantity assumes 30% for bulking of drilled material
6.01 Based on discussion with DBM drilling contractors
7.01 Distance between walls is assumed to be 3' to 4'

DRAFT Rough Order of Magnitude Probable Cost of Construction

I and J Waterway

4/3/2014 **Length** 330 ft

DRAFT

New Sheet Pile Toe Wall (Option 2)

	Item	Quantity	Unit	Unit Cost		Cost (2014$)
1.00	**Mobilization/Demobilization**	**1**	**LS**			
2.00	**New Steel**	**258**	**TONS**	**$2,100**		**$542,000**
2.01	AZ 36-700N Sheet Pile (45' tall)	258	TONS	$2,100	$542,279	
3.00	**Drive Piles**	**72**	**EA**	**$5,000**		**$360,000**
3.01	Drive Sheet Piles	72	EA	$5,000	$360,000	
4.00	**New Fender System**	**160**	**LF**	**$2,104**		**$337,000**
4.01	Remove piles	21	EA	$600	$12,600	
4.02	Timber Haul and Disposal	20	TON	$200	$4,000	
4.03	New Fender System	160	LF	$2,000	$320,000	
	Subtotal Toe Wall Construction Cost					$ 1,239,000
	Contingency (30%)					$ 372,000
	Sales Tax (8.7%)					$ 140,000
	Toe Wall Estimate					**$ 1,751,000**

$ 5,306 $/LF

Notes

1.00 Mobilization to be added by Anchor

3.01 From Gulfport bid tabs of $2200 a pair for 60 ft tall wall, $1750 from BST

4.03 $2,000 per LF from BST fender replacement

ATTACHMENT 2
SUMMARY OF PILE TESTING SERVICES

PO Box 44840
Tacoma, WA 98448
253-537-9400
253-537-9401 Fax

E^{3}RA

March 14, 2014
T13124

Anchor QEA, LLC
720 Olive Way, Suite 1900
Seattle, Washington 98101

Attention: Dan Berlin

Subject: **Summary of Pile Testing Services**
Bornstein Building
1001 Hilton Avenue
Bellingham, WA

Dear Mr. Berlin:

E3RA, Inc. (E3RA) is pleased to submit this report which summarizes the results of low strain impact testing of the timber pile foundations located at 1001 Hilton Avenue in Bellingham, WA. Project records indicate that the average timber pile length is 40 feet; however, it is not clear if all piles are about 40 feet long or if the shore side timber piles are 30 feet long and the waterside timber piles are about 50 feet long. The purpose of our testing is to better define the pile length and clarify the meaning of project records.

This effort was completed in general accordance with the scope of services included in our proposal for this project and our contract with E3RA's client, Anchor QEA, LLC (Anchor). Mr. Jon Boyce, acting on behalf of Anchor, authorized the testing and professional test interpretation services. This report has been prepared for the exclusive use of Anchor, and their consultants, for specific application to this project in accordance with generally accepted engineering practice, no other expressed or implied warranty exists.

For the reasons summarized below, determination of unknown pile lengths using the low strain impact testing selected by Anchor, and executed by E3RA, is very close to the limit of what can be tested using available technologies. Interpretation of test results is very complex and highly subjective. Therefore, our conclusions should be considered an indicator of likely pile length, but not as conclusive proof of pile length or pile quality. Any conclusions based on this testing and the anticipated construction documents should reflect this uncertainty. If a more accurate assessment of pile length is necessary, E3RA recommends two or three of the tested piles be extracted and tested. This additional testing would allow calibration of the test results, would result in a more accurate input parameters and less uncertainty in estimated pile length.

Based on the limited information available at the beginning of the project, it was assumed that it would be impossible to perform testing during high tide (due to limited clearance below the bottom of the dock and the water surface) and two partial days of testing were anticipated. During testing, it was discovered that testing could occur during high tide and significantly more test data was collected than anticipated at the start of the project. During a conference call which occurred on December 19, 2013, all parties agreed the project's interests were best served if testing and interpretation were performed in a manner generally consistent with ASTM 5882, but the detailed reporting requirements of ASTM 5882 be waived. This approach was intended to provide the project team the data they require for the originally agreed to fee; therefore, this report is not intended to comply with the reporting requirements of ASTM 5882.

Description of Testing Apparatus and Summary of Test Method

Pile length testing was performed using a Pile Integrity Tester (PIT) manufactured by Pile Dynamics, Inc. The PIT system satisfies the requirements of ASTM 5882. Pile length testing was performed in general accordance with the test procedure described in ASTM 5882. Attachment A provides information regarding the PIT system and the testing method. A copy of ASTM 5882, which was purchased by the undersigned specifically for this project, is available for review in the E3RA office (as required by ASTM's copyright statement).

Background Information

The pile naming convention used for this project and other information considered by E3RA is provided in Attachment B.

Summary of Data Collected

All of the data collected by E3RA is summarized Attachment C. In an effort to simplify review of the data collected, data from which reliable estimates of pile length that were obtained are provided in Attachment D.

Summary of Results

On November 26 and 27, 2013, E3RA tested 38 of the 70 piles at the site. The 32 piles not tested were not accessible using the vessel provided by Anchor. In our opinion, use of a smaller vessel would provide access to more piles, but would be less safe and is not recommended. Of the 38 piles tested, meaningful results were obtained from 19 piles (59% of tested piles). E3RA's opinion regarding the minimum likely pile length for each pile is summarized in Table 1 at the end of this report.

Discussion of Results

The results of low strain impact testing methods are influenced by many factors, including but not limited to:

- The actual length of the tested pile,
- The nature of the pile-to-pile cap connection,
- The nature and quantity of cross bracing connections,
- The diameter of the pile,
- Changes in pile diameter including the taper of the timber pile and the growth of barnacles on the pile,
- The length of the pile above the mud line,
- The number of soil layers the pile penetrates,
- The stiffness of each soil layer the pile penetrates,
- The condition of the pile (e.g. rot or decay, damage during installation, damage during its service life), and
- The wave speed of the compression wave. The speed of the compression wave might vary along the length of the pile and is likely to vary from pile to pile.

Each of these items is likely to cause the original compression wave to reflect and create multiple second and third order compression waves which will combine with each other and the original wave to create a very complex test record and prevent reliable interpretation of pile length.

Closure

We appreciate the opportunity to be of service to you on this project. If you have any questions regarding this report or any aspects of the project, please feel free to contact our office.

Respectfully submitted,

E3RA, Inc.

Mark Rohrbach, PE. GE, P.Eng.
Associate Engineer

MAR:jb
TACO\\Tacnew\f\2013 JOB FILES\T13124 Anchor QEA - Bornstein Bldg Bellingham\Bellingham Pile Embedment Report.doc

Attachments: *Table 1 – Summary of Results from Timber Pile Length Testing*
Attachment A – PIT System and Testing Method Information
Attachment B – Pile Naming Convention and Relevant Information
Attachment C – All Data Collected
Attachment D – Reliable Data Collected

Summary of results from timper pile length testing:
Bornstein Building located in Bellingham, WA

Pile Name	Estimated Length Below Impact Block	Distance From Top of Pile to Impact Block	Estimated Pile Length	Length from Impact Block to Mud Line
1A	36	6-in.	36.5-ft.	24.1-ft.
1B	No Result	7-in.	No Result	21.2-ft.
1C	No Result	7-in.	No Result	19.2-ft.
1D	No Result	4-in.	No Result	16.2-ft.
3A	36	11-in.	36.9-ft.	24.5-ft.
3B	No Result	13-in.	No Result	19.8-ft.
3C	No Result	8-in.	No Result	18.2-ft.
3D	38	17-in.	39.4-ft.	18.0-ft.
4A	35	17-in.	36.4-ft.	24.2-ft.
4B	No Result	8-in.	No Result	20.0-ft.
4C	No Result	9-in.	No Result	18.1-ft.
4D	No Result	12-in.	No Result	15.9-ft.
8A	No Result	11-in.	No Result	23.7-ft.
8B	32	9-in.	32.7-ft.	20.2-ft.
8C	No Result	9-in.	No Result	17.4-ft.
8D	No Result	8-in.	No Result	15.4-ft.
9A	No Result	8-in.	No Result	23.7-ft.
9B	36	8-in.	36.7-ft.	20.7-ft.
9C	37.5	8-in.	38.2-ft.	16.7-ft.
9D	No Result	8-in.	No Result	15.0-ft.
11A	38	8-in.	38.7-ft.	23.2-ft.
11B	No Result	10-in.	No Result	20.6-ft.
11C	35	8-in.	35.7-ft.	17.2-ft.
11D	40	8-in.	40.7-ft.	14.4-ft.
12A	38	10-in.	38.8-ft.	23.3-ft.
12B	37	9-in.	37.7-ft.	20.2-ft.
12C	36	8-in.	36.7-ft.	16.6-ft.
12D	35.5	8-in.	36.1-ft.	14.8-ft.
13A	35	8-in.	35.7-ft.	23.2-ft.
13B	36	6-in.	36.5-ft.	19.8-ft.
13C	No Result	8-in.	No Result	18.7-ft.
13D	No Result	7-in.	No Result	15.0-ft.
14A	No Result	9-in.	No Result	23.0-ft.
14B	No Result	5-in.	No Result	19.3-ft.
14C	No Result	7-in.	No Result	16.2-ft.
14D	37	8-in.	37.7-ft.	15.3-ft.
16A	38.4	10-in.	39.2-ft.	21.3-ft.
16B	39	9-in.	39.7-ft.	18.5-ft.
	Average Length		**37.4-ft.**	

Attachment A

PIT System and Testing Method Information

Pile Dynamics, Inc.

Quality Assurance for Deep Foundations

Pile Integrity Tester Model Comparison: PIT-X, PIT-X2, PIT-V and PIT-FV

January 2011

The Pile Integrity Tester is available in 4 models, with one (PIT-X and PIT-V) or two (PIT-X2 and PIT-FV) channels of data acquisition. All models come with a Fast Fourier Transform (FFT) feature, a license of PIT-W Standard and a demonstration license of PIT-S.

This discussion is intended to help you select which model to purchase, as well as to decide if you should acquire a license of PIT-W Professional Software (PIT-W Pro) and / or a permanent license of PIT-S.

PIT-X (wireless) and PIT-V (traditional)

PIT-X and PIT-V have identical functionality, except PIT-X is much smaller and reads data from a wireless accelerometer, while PIT-V uses a traditional (cabled) accelerometer. It is possible to upgrade a PIT-V to a PIT-FV. Upgrades involve hardware modifications and are performed at Pile Dynamics Inc.

PIT-X and PIT-V both have **one** data input channel, used to record the **acceleration** measured on the pile. This is sufficient for many, and perhaps most, applications. The analysis of acceleration data is usually performed in the **time domain**.

The PIT-W Standard software is sufficient for most time domain analyses.

The PIT-W Professional software makes it possible to assess the severity of a defect (β-Analysis) from acceleration measurements. PIT-W Pro also estimates the profile (shape) of the foundation from acceleration measurements.

Profile estimates may also be obtained by performing simplified signal matching with the PIT-S software.

It is possible to perform a simple **frequency domain analysis** with PIT-X or PIT-V in the field, by employing the FFT feature which is standard in all PIT models. This analysis may aid in determining foundation depth or distance to a major defect.

PIT-X2 and PIT-FV

PIT-FV and PIT-X2 both have **two** data input channels. The first input is always the **acceleration** measured on the foundation, and is required for all testing. The second input is either from an **instrumented hammer (PIT-FV)** or from a **second accelerometer (PIT-FV or PIT-X2)**. The second input becomes necessary when additional analyses are required, either by project specification or for technical reasons. These analyses usually require PIT-W Pro. **Only PIT-FV has a channel that allows an instrumented hammer as the second input.**

PIT-FV with Instrumented Hammer, PIT V has a similar look

Applications suitable for PIT-X2 or PIT-FV

1) PIT-X2 or PIT-FV with a **second accelerometer** must be used to measure two velocities separated along the shaft by some known distance. This is useful in the case of **piles under existing structures**, where it is necessary to separate downwards from upwards reflections (Figure 1). The two velocity measurements are further analyzed by PIT-W Pro.

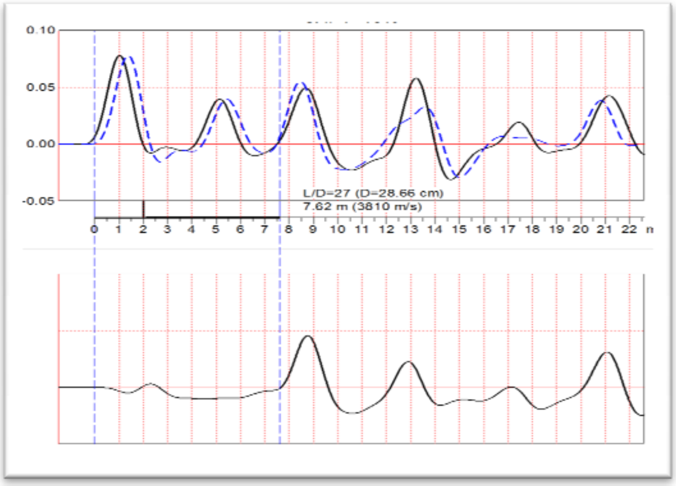


Figure 1 top: Two velocity measurements taken with two accelerometers at two vertically separated locations on a pile.
Figure 1 bottom: wave up velocity component (solid) calculated for the upper accelerometer location from both accelerometer measurements.

2) Either PIT-X2 or PIT-FV **with a second accelerometer** are necessary to determine to determine the **length of existing foundations** with accuracy better than plus or minus **12.5%.** This is accomplished by accurately determining wave speed from the analysis, with PIT-W Pro, of two velocity measurements.

3) PIT-X2 or PIT-FV **with a second accelerometer** permit the elimination of Rayleigh wave components from the PIT records of **relatively large piles**. To accomplish this record enhancement, both vertical and horizontal accelerations have to be measured at the pile top surface at the same location. Subtracting the scaled horizontal motion component from the vertical one reduces the vertical top motion to that corresponding to the compressive axial wave. Figure 2 shows that a remarkable improvement of data quality can be achieved in this manner.

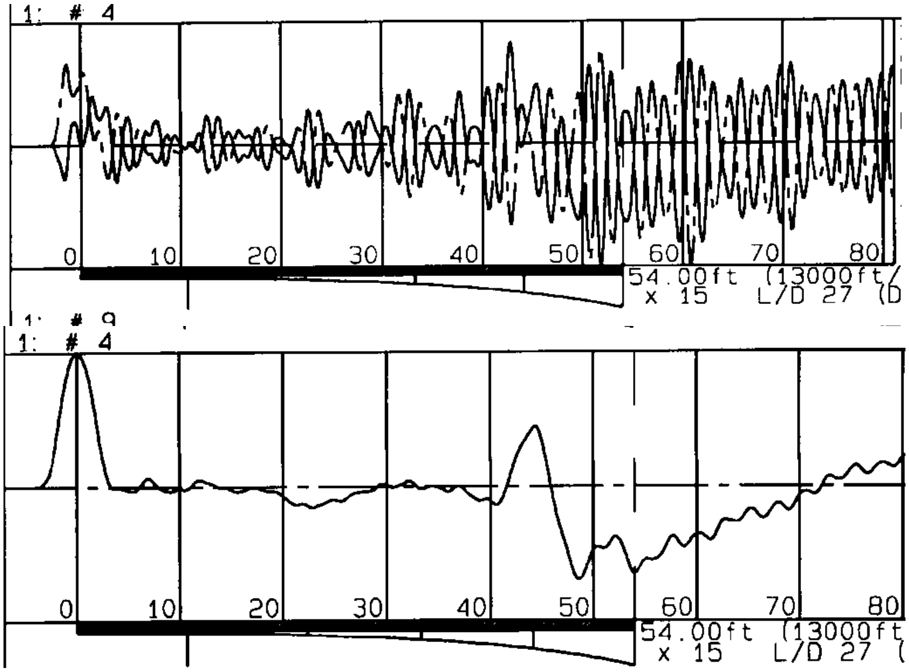


Figure 2: Vertical (Dash-dot) and horizontal (solid) pile top velocity measurements reduced to axial motion signal by Raleigh wave analysis.

Applications that require PIT-FV

1) PIT-FV must be used if specifications require that the **Mobility** of the foundation be determined according to the **Transient Response Method.** Mobility may also help the detection and location of defects in some situations where velocity alone does not, such as floor slabs or other short thickness members like tunnel liners (although there are minimum thickness restrictions).

Mobility is defined as

$\boldsymbol{M(f)} = \frac{\boldsymbol{V(f)}}{\boldsymbol{F(f)}}$ where $\boldsymbol{V(f)}$ is the velocity at a frequency f and $\boldsymbol{F(f)}$ is the force at a frequency $\boldsymbol{f}$.

The calculation of mobility requires an **instrumented hammer** to measure the force signal in addition to the velocity signal. The Transient Response Analysis is performed with PIT-W Pro. Figure 3 shows the Mobility plot from PIT-W Pro. The pile length may be determined from the frequency intervals of the peak mobility values as in Figure 3, and the characteristic mobility of the shaft (SQRT(PQ)) is calculated by the program; PDI suggests, however, checking the frequency based results with the standard time domain approach.

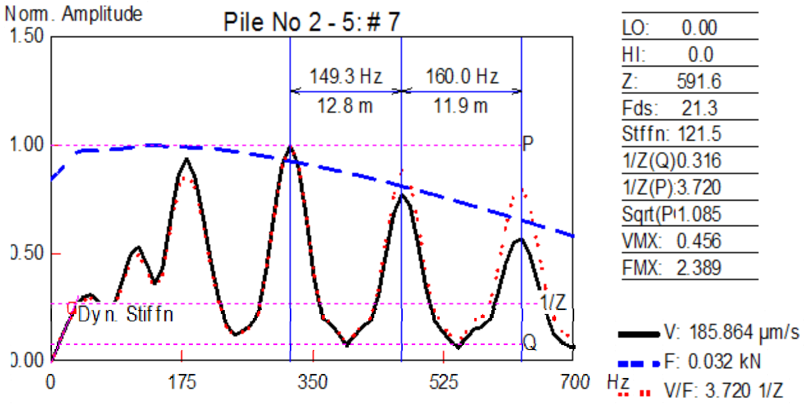


Figure 3: Mobility plot with dynamic stiffness

2) PIT-FV with an **instrumented hammer** must be used if it is necessary to calculate the **Dynamic Stiffness**, Z(fo).

Dynamic Stiffness is defined as

$$Z(fo) = \frac{\frac{F(fo)}{V(fo)}}{2\pi fo} = \frac{2\pi fo}{M(fo)}$$

where

$$\frac{V(fo)}{2\pi fo}$$

is the displacement (velocity divided by frequency) at a low frequency fo; Z(fo) is a pseudostatic stiffness. By comparing the stiffness of various shafts, it is possible to single out the one with the lowest stiffness. This is the weakest shaft, and therefore might have a defect.

3) PIT-FV with an **instrumented hammer** helps to check the **integrity of a foundation near the top.** This application does not require PIT-W Pro. In this application one compares the velocity pulse width with the force pulse width. In sound foundations the force – time pulse typically has the same width or is wider than the velocity - time pulse. If the velocity pulse is wider (as in Figure 4) then this may indicate an impedance reduction close to the pile top which is not easily detected when only the

velocity pulse is measured (since the reflection superimposes on the input, making the apparent velocity longer). This procedure may help detect defects at depths smaller than the pulse width. Upper portion defect detection may also be achieved by comparing the velocity pulse widths on all tested shafts. Because a given hammer has a nominal pulse width, shafts with unusually wide velocity pulse widths are likely to have defects near the top.

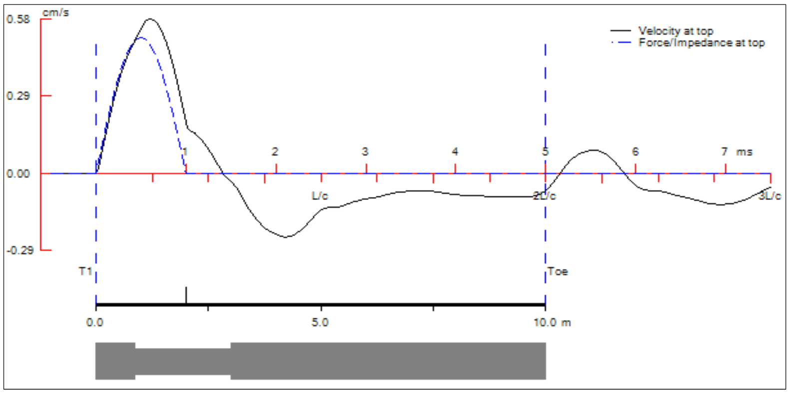


Figure 4: Velocity pulse (solid) wider than force pulse (dashed); pile with reduced impedance near top

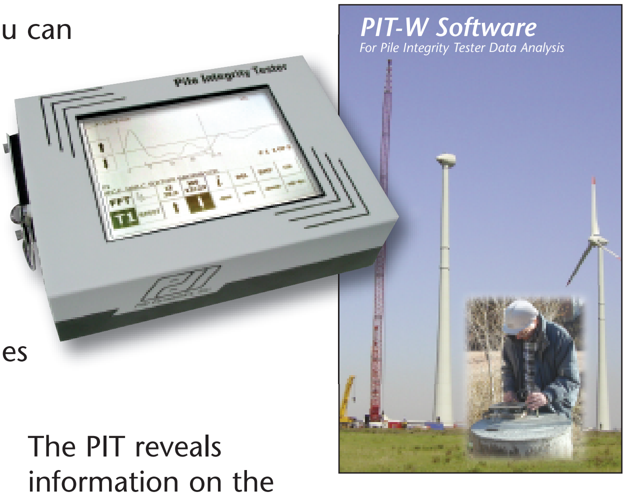
4) PIT-FV with an **instrumented hammer** is recommended to evaluate the integrity of **floor slabs, bridge decks**, **columns** or other structural components. In this case the hammer impact generates a stress wave that arrives at a second accelerometer, allowing for the calculation of the wave speed. The value of the wave speed is typically affected if the structural element is deficient. Dynamic Stiffness and Mobility determination would be as useful in this case as in the case of tests on piles by the Transient Response Method. The shortest pile length or slab thickness that can be tested for a given structure is a function of the wave speed of the material of the structure and varies with the weight of the hammer.

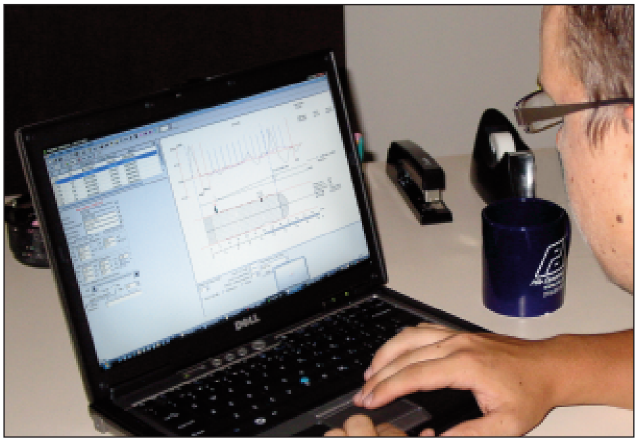
PIT-W Professional

Software for In-Depth Analysis of Data Collected with the Pile Integrity Tester

PIT-W Professional maximizes the information you can extract from data collected with the Pile Integrity Tester (PIT). PIT-W Pro is particularly useful for

- Comparing records from several piles on the same site
- Analyzing data from foundations of existing structures
- Assessing unknown foundation length
- Evaluating the severity and location of anomalies along the shaft

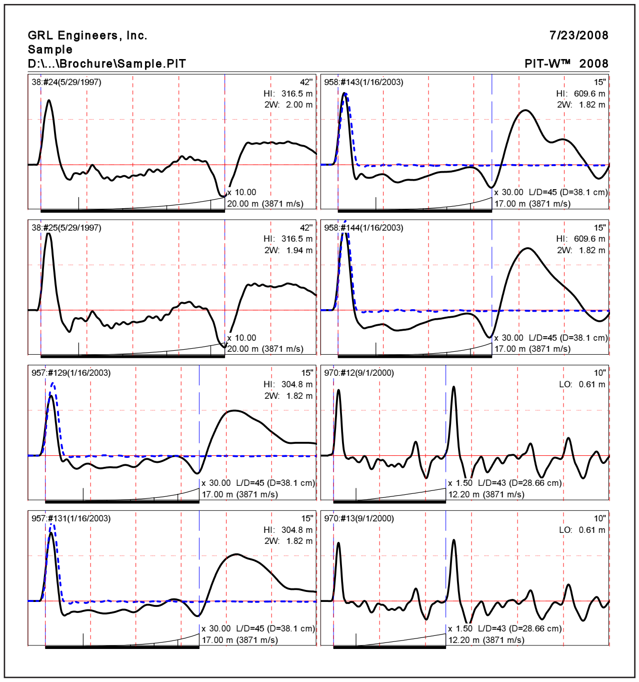




The PIT reveals information on the integrity of a shaft. In either model PIT-V or PIT-FV, it is furnished with the Standard version of the PIT-W software, that permits data uploading and adjustment, analysis in the time domain, record organizing and report preparation.

PIT-W Pro enhances PIT-W Standard with Advanced Features:

- **Profile Analysis** - generates a pile impedance versus depth plot to help estimate the shape of the foundation
- **ß-Analysis** - quantifies impedance changes to help assess the severity of defects
- **Frequency Domain Analysis** - calculates and displays velocity spectra and peaks to assist in defect detection and location. If force data is available from PIT-FV, also calculates Mobility and Dynamic Stiffness. Mobility may help the detection and location of defects in special situations where velocity spectra alone does not. Dynamic stiffness is useful to single out potentially weak piles (when several similar adjacent piles are tested).
- **Two-Velocity Analysis** - calculates wave speed using two velocity measurements (from PIT-FV) and separates upward from downward traveling velocities, aiding in the interpretation of data from foundations of existing structures and/or foundations of unknown length.
- **Multiple Column Plot** - generates user customized summary sheets for easy record comparison.



Multiple Column Plot

Quality Assurance for Deep Foundations

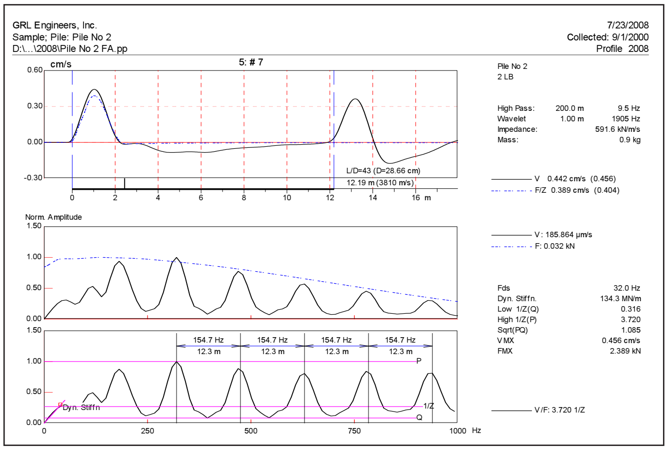
Cleveland Ohio USA *info@pile.com*
tel: +1-216-831-6131 ***www.pile.com***

Pile Dynamics, Inc.

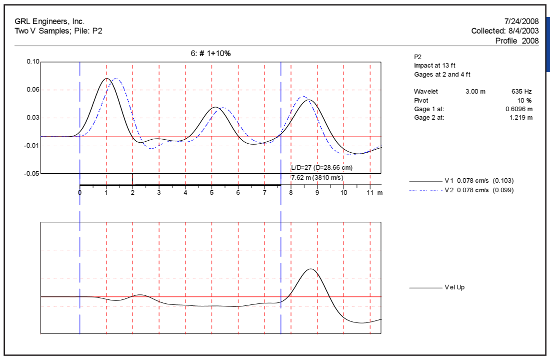
PIT-W Professional

Software for In-Depth Analysis of Data Collected with the Pile Integrity Tester

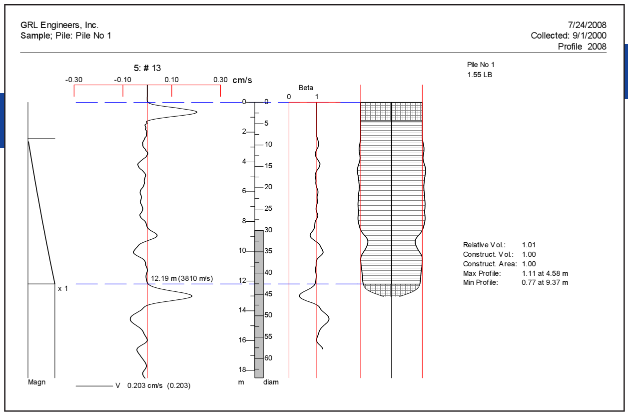
	Features	PIT-W STANDARD	PIT-W PROFESSIONAL
PIT-V or PIT-FV data	PIT data import	•	•
	Record filtering and averaging	•	•
	Exponential amplification	•	•
	Re-analysis of saved data files	•	•
	Customized tabular output	•	•
	Customized report	•	•
	Data transfer to other applications	•	•
	SI, Metric and English units	•	•
	On screen help	•	•
	Velocity plot display	•	•
	Time Domain Analysis	•	•
	Frequency Domain Analysis (velocity)		•
	Profile Analysis		•
	ß-Analysis		•
	Multiple Column Plot		•
PIT-FV DATA REQUIRED	Force-Velocity Plot	•	•
	Surface (Raleyigh) Wave Analysis	•	•
	Frequency Domain Analysis (complete)		•
	Two-Velocity Analysis		•



Frequency Domain Analysis



Two-Velocity Analysis



Profile Analysis

Minimum System Requirements

- Windows Vista, XP or 2000
- 16 MB RAM
- 10 MB of free hard disk space
- CD-ROM drive
- VGA Monitor
- Mouse or compatible pointing device
- Compatible with PIT models 3-27-98 or later

Pile Dynamics, Inc.

Quality Assurance for Deep Foundations

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Printed on recycled paper.

TWO VELOCITY MEASUREMENTS

This document focuses on the two velocity measurement. The analysis, interpretation, and background can be found in **PIT-W Users Manuals for 2003 or 2008**. Two velocity measurements can help calculate wave speed and separate upward traveling velocity from downward traveling velocity, the latter is useful for piles under existing structures.

The **Sonic Pulse Echo** Test can be applied to piles under existing structures where the pile top is incorporated in the superstructure and the pile length is unknown. However, two complications need to be addressed for proper evaluation of the velocity records: 1) The concrete stress wave speed is generally unknown, which is an important variable to affect pile length determination; 2) For piles tested below their head (when they are tied to a structure) or piles with non-uniformities, stress waves not only travel downward but also upward where they are reflected by the structure or pile top. These secondary reflections have to be identified so as not to be confused with reflections from pile impedance changes and the pile toe. For this reason, two acceleration signals are taken simultaneously along the pile shaft providing a means of determining the stress wave speed as well as the necessary information for separating downward from upward traveling waves as shown in Figure 1.

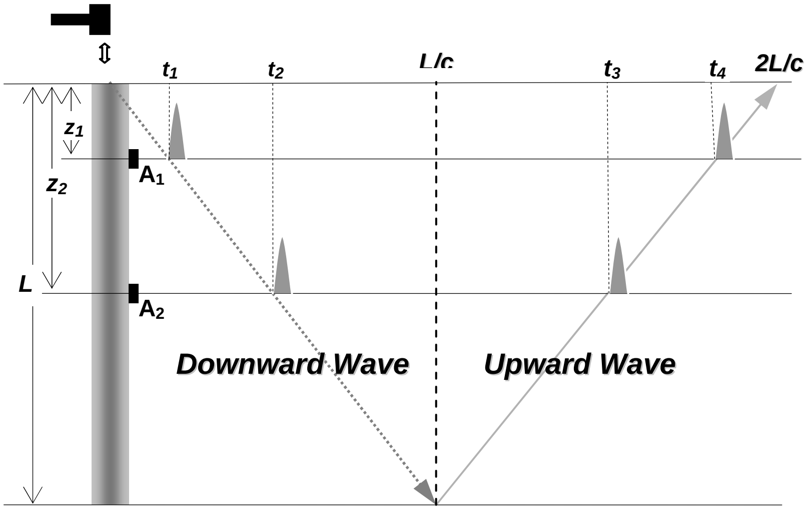


Figure 1. Illustration of the two accelerometer locations and wave propagation

Accelerometer Mounting

Two accelerometers A_1 and A_2 are installed along the pile at depths z_1 and z_2 measured from pile top or other reference point which should same for z_1 and z_2. It is important to get accurate distance between A_1 and A_2. Velocities resulting from an impact applied somewhere above A_1 are measured by both A_1 and A_2. A_1 should be connected to 1st channel on PIT Collector and A_2 should be connected to 2_{nd} channel on PIT Collector as shown in Figure 2. Side mount accelerometers are recommended and can be glued to the side of concrete piles. Under wet condition or unclear surface, anchors can be used to screw the gage to side of concrete piles. For timber pile, the side mount gages can be directly screwed to the side of piles. Please make sure:

1. The cables connected to the accelerometers should point to opposite direction of impact. In case of vertical pile and hammer hitting downward, the cables should point vertically up;
2. A_1 should be closer to impact location.

If no side mount gages are available, top mount gages can be used. Figure 3 demonstrates examples of gage mounting.

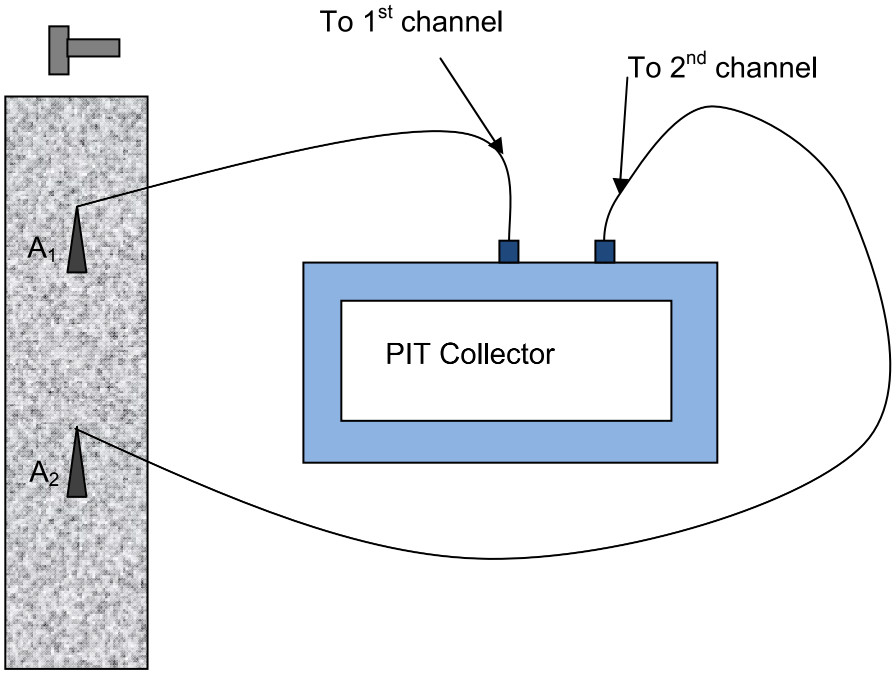
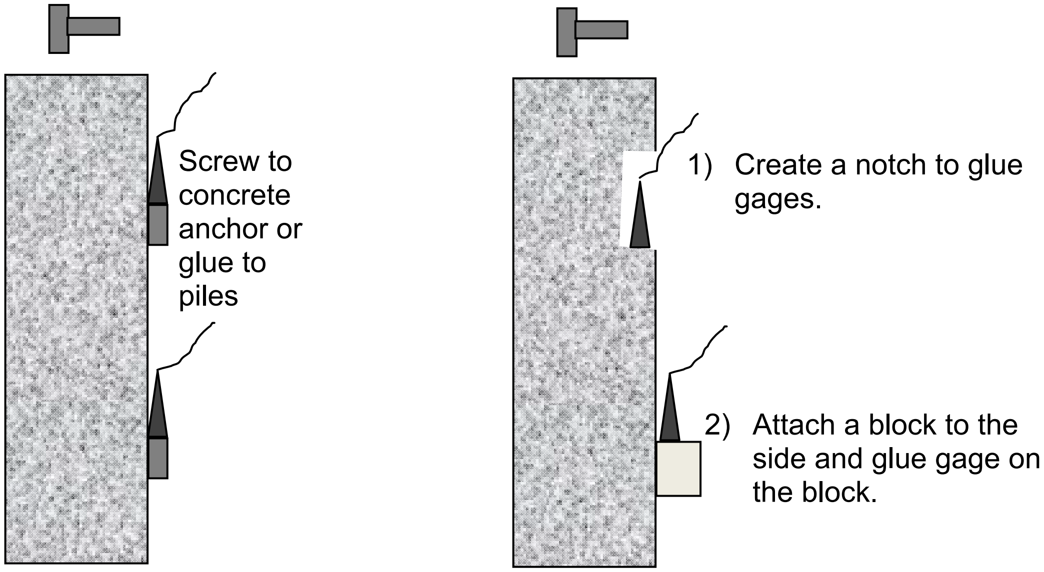


Figure 2. Connection



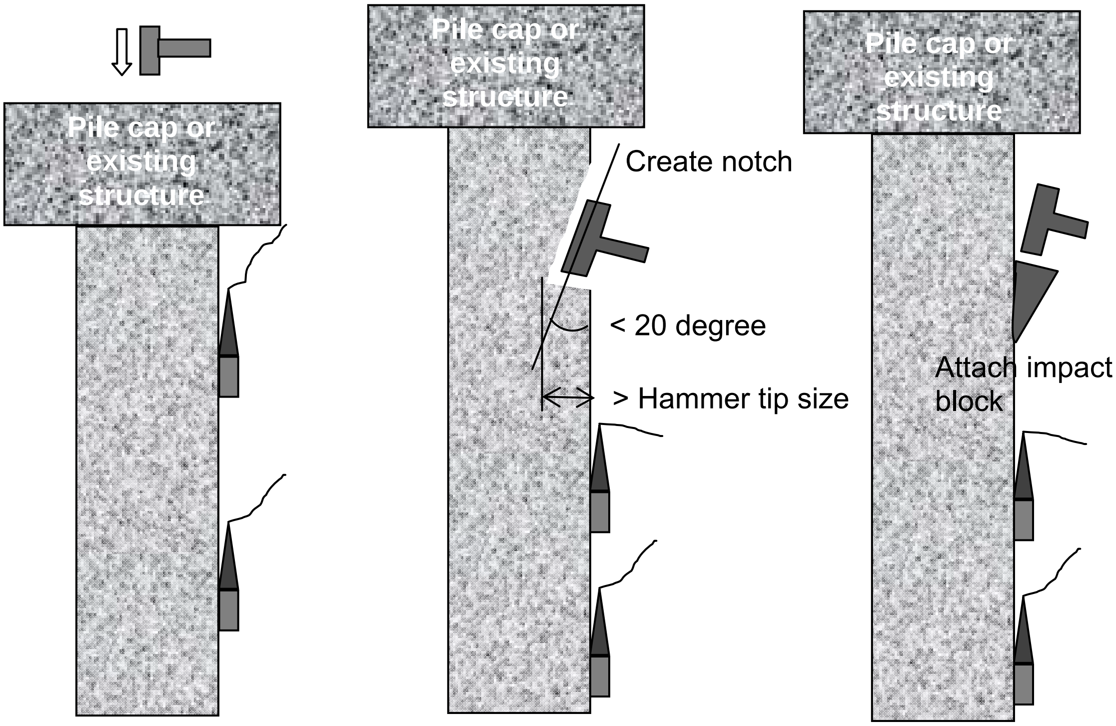
Use of side mounting gages

Use of top mounting gages: 1) is preferred if top mounting is the only choice.

Figure 3. Gage mounting

Impact Technique

Figure 4 demonstrates several choices of impact spots. Due to the complexity of existing structure, it is recommended that testers try both top hit and side hit. The way to attach impact block and the material of impact block will definitely affect the signal quality. If an impact block is the only choice, same material of pile is preferred for the impact block.



Directly impacting above pile generally gives better signal if the connection between pile top and structure is good.

Side impact: Notch is preferred; If pile diameter is small (e.g. < 3 ft or 0.9 m), impact may be applied 90 degree away from gage.

Figure 4. Impact spot choices

To Determine Wave Speed

The accuracy of wave speed determination depends on accuracy of the measurements of the distance between two gage and the Δt (time for wave travel from A_1 to A_2). Following is a list of factors that affect the accuracy of Δt:

1. The data quality will affect all types of PIT analyses and, in particular, the wave speed determination. In **Two Velocity Analysis** low quality data might cause a difficulty in assessing the arrival times of downward and/or upward traveling waves;

2. Increasing the distance between two accelerometers and/or the sampling frequency generally improves the accuracy of Δt determination. (Note: For pre-2003 model of **PIT Collectors**, the sampling frequency varies depending on the pile length entered by the user. The shorter the pile, the higher the sampling frequency that the **PIT Collector** employs. For

2003 and later model of **PIT Collectors**, the user can select the maximum sampling frequency. For details, please read the PIT Collector Users Manual by **Pile Dynamics, Inc.**) Assuming material wave speed is 4000 m/s (13100 ft/s), if sample frequency of 150,000 hz and gages are 5 ft (1.5 m) apart, the accuracy could be within 2%.

Tips:

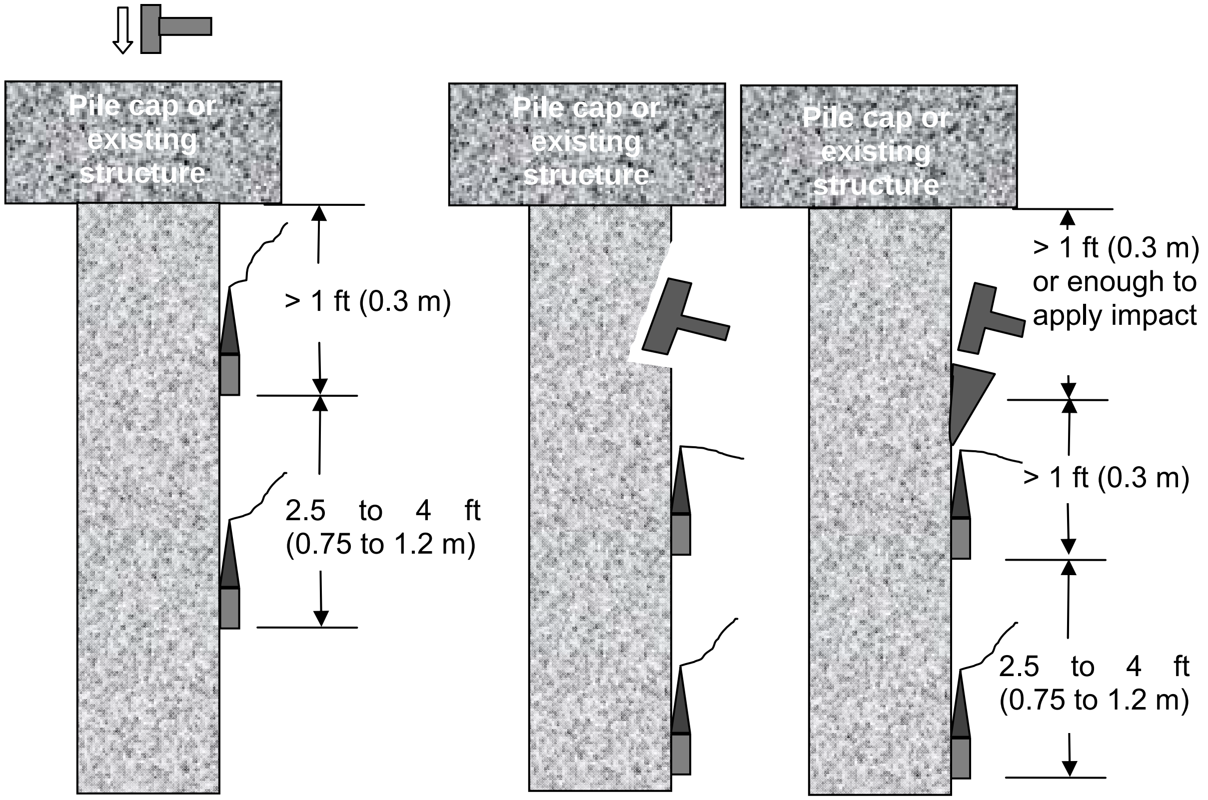
- Attach gage as far as possible: > 5 ft (1.5 m) is recommended;
- Measure the distance between gage accurately;
- Select highest sampling frequency: 150,000 hz for current PIT collector;
- Enter distance between gages as pile length to make sure the collector use the highest sampling frequency.

To Separate Downward and Upward Traveling Velocities

Since the mathematical manipulation is performed between two velocity records acquired from two accelerometers at different locations, it is very important to make sure that correct calibrations are used for both accelerometers. Unlike one velocity measurements, where the velocity magnitude is immaterial, the absolute velocity is used in **Two Velocity Analysis**. Calibration values are therefore important and should be checked, for example, by repeating the measurements with reversed accelerometer locations. However, for final wave up calculation it is important to make sure that the 1st sensor (A_1 or 1st channel) is the one closest to the impact location.

Figure 5 shows possible layouts for the type of test. Please note:

1) The distances recommended in Figure 5 are based on rule of thumb;
2) The cross section of pile between A_1 and A_2 should be uniform;
3) Too small a distance between A_1 and A_2 makes it difficult to separate velocity curves recorded by two gages;
4) Too large a distance between A_1 and A_2 is not necessary for this purpose and may not be feasible in many cases.



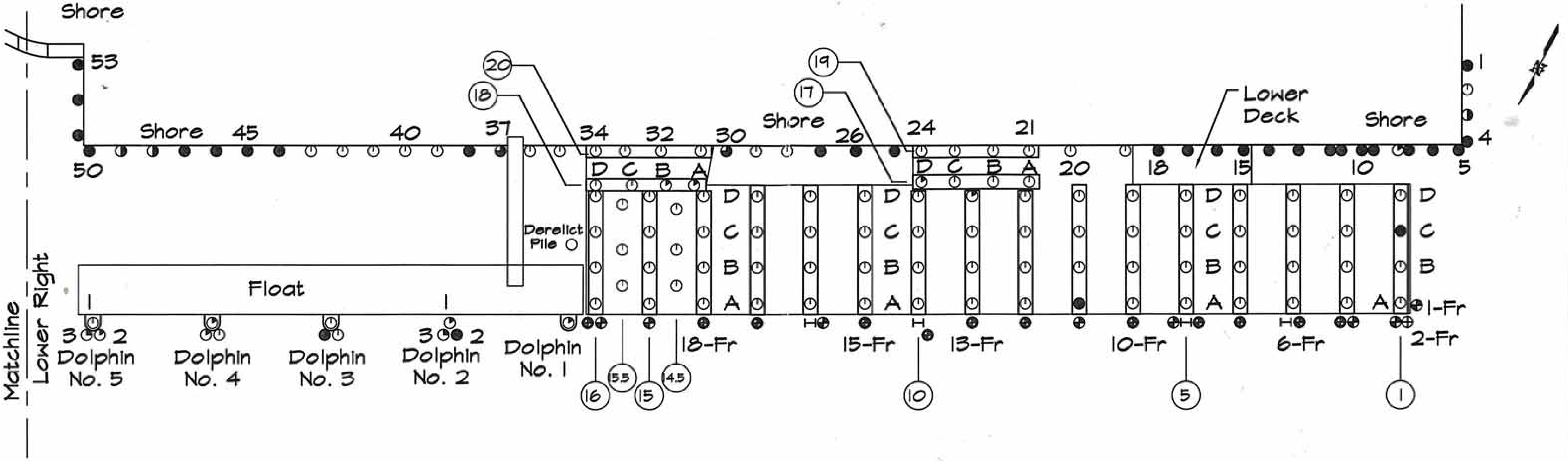
Directly impacting above pile

Side impact.

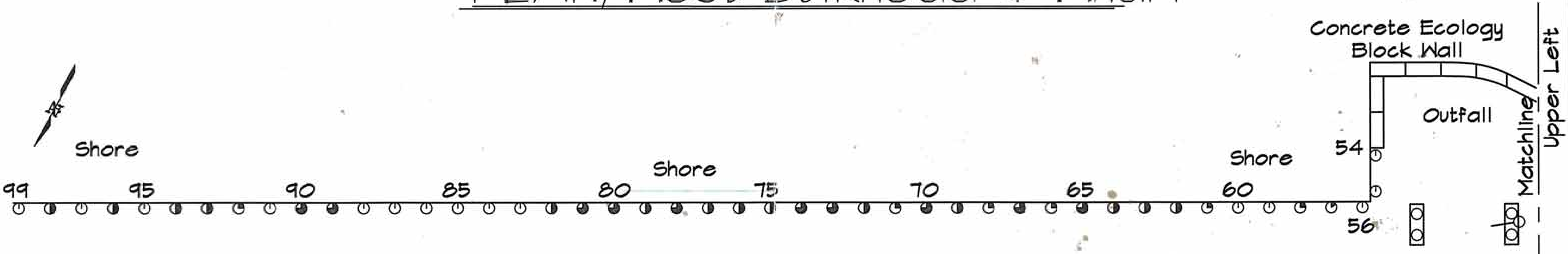
Figure 5. Examples of V+V Test Layouts to Separate Downward and Upward Travelling Velocities

Attachment B

Pile Naming Convention and Relevant Information



PLAN: West Bulkhead & Wharf



PLAN: East Bulkhead

LEGEND

- ○ 100% Rating Category
- ◔ 90% Rating Category
- ◔ 75% Rating Category
- ◑ 50% Rating Category
- ◕ 25% Rating Category
- ● 0% Rating Category
- ⊕ Fender Pile - Undamaged
- ⊕ Fender Pile - Functional
- ● Fender Pile - Damaged
- ○ Timber Pile - Not In Contract
- ▭ Pile Cap

Not To Scale

ANCHOR QEA

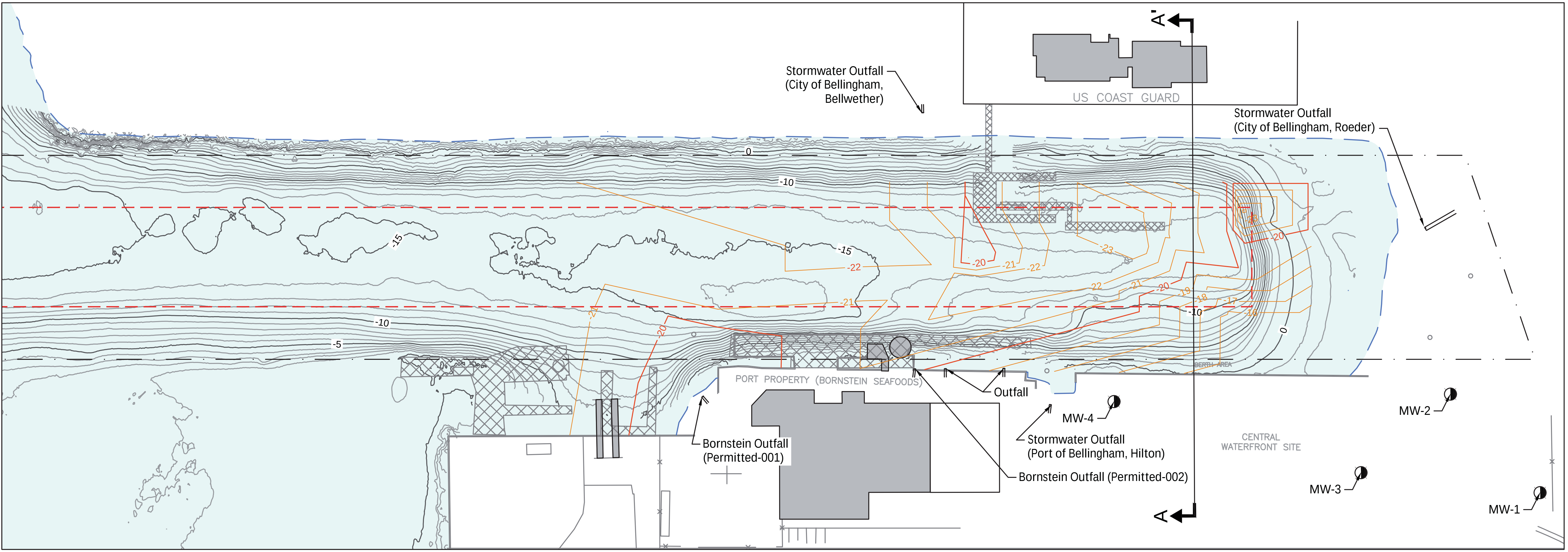
Inspection Results

Bornstein Seafood Wharf
Pile Plan

DATE: July 2012
PROJECT: 12-2412
SHEET: 1 of 1
DRAWN: SDS/JDS

ECHELON ENGINEERING INC.
Civil/Marine Consulting Engineers
Lynnwood, Washington 425/672.8424

SDS, Echelon Engineering, Inc. 5/30/2012 11:05 AM 2341-Sht-1.dwg



LEGEND:

- ▨ Docks or Piers
- ▬ Existing Structures
- Federal Channel Boundary
- Existing Shoreline
- Central Waterfront Site Boundary
- I & J Waterway Boundary
- -10 Bathymetric Contour (1 foot interval)
- -20 Clay Surface Contour (1 foot interval)
- ◑ Central Waterfront Monitoring Well Location

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTES:

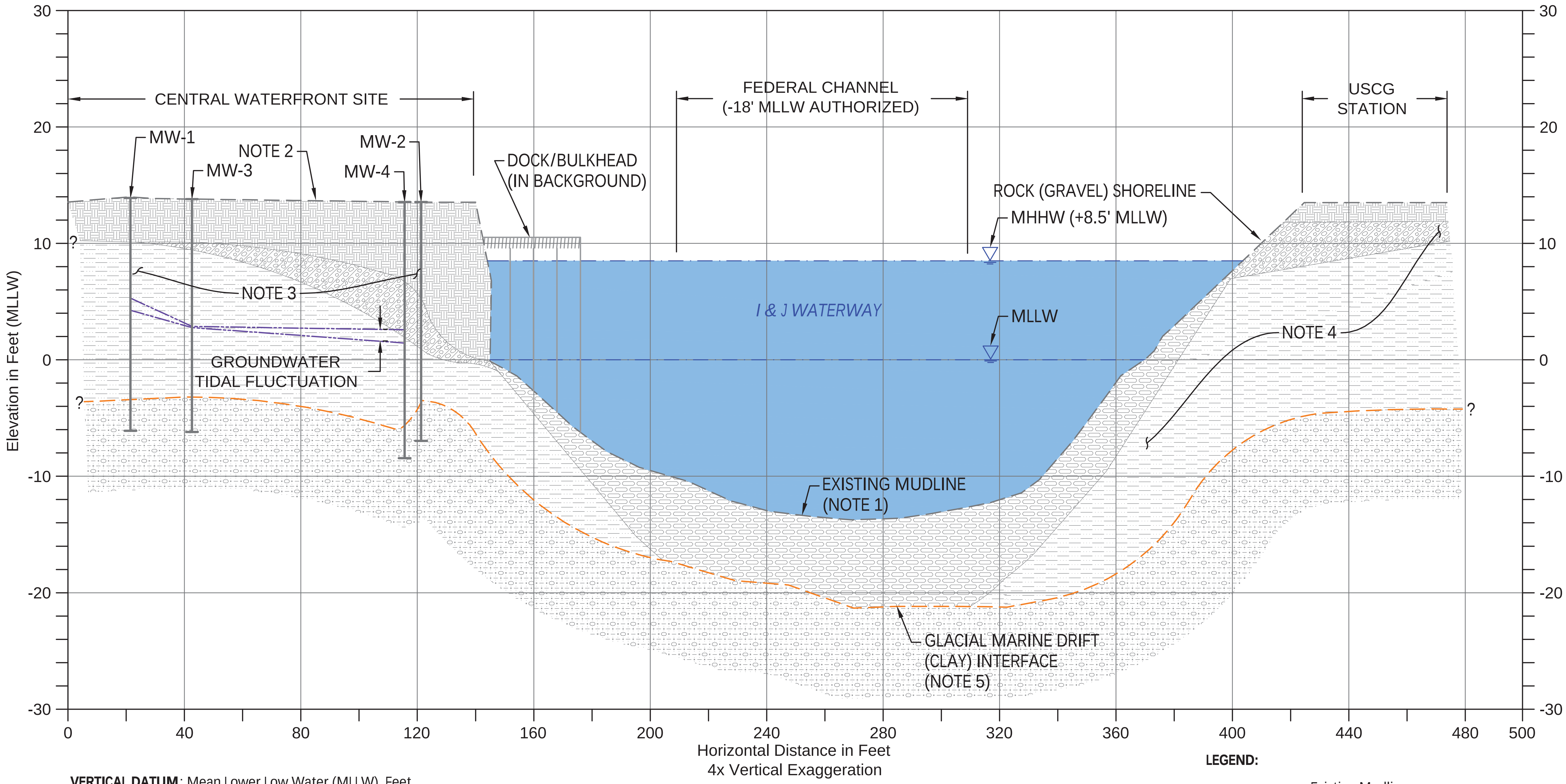
1. Bathymetric survey from eTrac dated April 5, 2012.
2. Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.

R:\Jobs\090007-01_I&J_Waterway\Maps\2013_04\Geologic Section.dwg 3-4

Nov 12, 2013 2:46pm epipkin

Figure 3-4
Elevation of Native Clay Layer
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham, WA

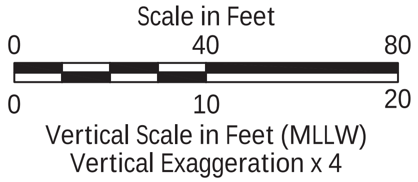
ANCHOR QEA



VERTICAL DATUM: Mean Lower Low Water (MLLW), Feet.

NOTE:

1. Bathymetric survey from eTrac dated April 5, 2012.
2. Upland survey conducted by Walker Associates (2004).
3. Upland boring data from Harding Lawson Associates. Soil, Sediment, and Groundwater Investigation prepared for U.S. Coast Guard (1995).
4. North upland geologic conditions inferred based on vicinity geology and known historical land use.
5. Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.



LEGEND:

— — —	Existing Mudline
— — —	Glacial Marine Drift (Clay) Interface
▨	Fill (Various Grain Size)
▨	Fill (Sand/Silty Sand)
▨	Recent Deposits (Soft Silt)
▨	Post Glacial Fluvial Deposits (Sand/Silty Sand)
▨	Glacial Marine Drift (Stiff Clay)

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May 29, 2013 11:54am epipkin

ANCHOR QEA

Figure 3-5

Conceptual Geologic Cross Section
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham, WA

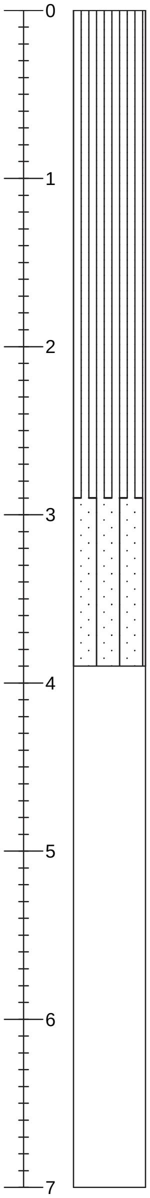
Sediment Core Log

Sheet 1 of 1

IJ13-VC-101

Project: **I&J Waterway RI/FS**	Location: **Bornstein Seafoods, Bellingham, WA**	Tube Length (ft): **8**
Project #: **090007-01.02**	Water Elevation (ft): **5.6**	Penetration Depth (ft): **8**
Client: **Port of Bellingham**	Water Depth (ft): **10.8**	Sample Quality: **Good**
Collection Date: **20 August 2013**	Calculated Mudline Elevation (ft): **-5.2**	Field Recovery (%): **58 %**
Contractor: **RSS**	Northing/LAT: **644336.26** Easting/LONG: **1239977.68**	Process Date: **20 August 2013**
Vessel: **R/V Carolyn Dow**	Horiz. Datum: **WA SP N, NAD 83, ft** Vert. Datum: **MLLW**	Process Method: **Cut Tube**
Operator: **Eric Parker**	Method/Tube ID: **Vibracore/3.75" round**	Logged By: **AC**

Recoverd Depth (ft)	Recovered Interval	Sample	**Sediment Description** Samples and descriptions are in Recovered Depths. Classification Scheme: USCS



IJ13-VC-101-0-2

IJ13-VC-101-2-3.9

Soft, wet, black, f-m-sandy, SILT. Moderate shell fragments and substantial organic matter (fish scales and sticks). Slight H2S-like odor.

@ 0.2': Grades to moist.

@ 1.0': Grades to medium stiff.

@ 2.6': 3 cm subangular c-gravel

@ 2.9': Grades to medium dense, moist, dark gray, slightly silty, f-m SAND, trace c-gravel, trace cobbles (subrounded up to 6 cm). Sand grains are multicolored. Occassional wood fragments. Moderate pockets of stiff, moist, gray, CLAY.

End of core @ 3.9'

ANCHOR QEA

1605 Cornwall Avenue
Bellingham, WA
360-733-4311

Footnote (1): Attempt 1 of 2; 0-4' easy coring, 4-5' some resistance, 5-8' easy

Footnote (2): Estimated coordinates, sampling location 11 ft from pier face.

Footnote (3): Moist, gray, stiff CLAY present in shoe.

Calculated Recovery

Recovery Length/Penetration Depth:

4.6 ft/8 ft = 58%

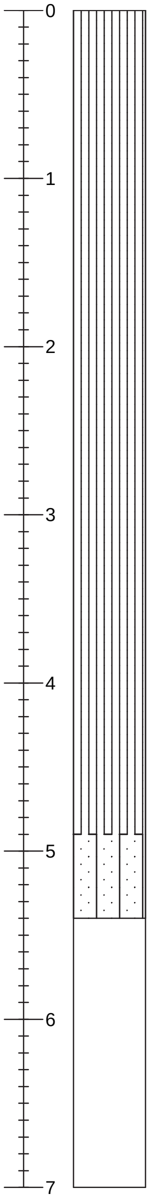
Sediment Core Log

Sheet 1 of 1

IJ13-VC-102

Project: **I&J Waterway RI/FS**	Location: **Bornstein Seafoods, Bellingham, WA**	Tube Length (ft): **8**
Project #: **090007-01.02**	Water Elevation (ft): **4.4**	Penetration Depth (ft): **8**
Client: **Port of Bellingham**	Water Depth (ft): **11.2**	Sample Quality: **Good**
Collection Date: **20 August 2013**	Calculated Mudline Elevation (ft): **-6.8**	Field Recovery (%): **80 %**
Contractor: **RSS**	Northing/LAT: **644244.9** Easting/LONG: **1239881.59**	Process Date: **20 August 2013**
Vessel: **R/V Carolyn Dow**	Horiz. Datum: **WA SP N, NAD 83, ft** Vert. Datum: **MLLW**	Process Method: **Cut Tube**
Operator: **Eric Parker**	Method/Tube ID: **Vibracore/3.75" round**	Logged By: **AC**

Recoverd Depth (ft)	Recovered Interval	Sample	**Sediment Description** Samples and descriptions are in Recovered Depths. Classification Scheme: USCS



Sample	Sediment Description
IJ13-VC-102-0-2	Soft, wet, black, f-m-sandy, SILT. Moderate shell fragments, occasional wood fragments. Slight H2S-like odor. @ 0.6': 3" wood fragment @ 0.8': Grades to stiff, moist, dark gray, slightly f-sandy, SILT, trace shell fragments.
IJ13-VC-102-2-4	@ 2.6': Grades to moderate organic fibers (brown, decomposed).
IJ13-VC-102-4-5.4	@ 4.9': Grades to medium dense, moist, dark gray, slightly silty, f-m SAND. Sand grains are multicolored and are white, black, red and beige. Moderate shell fragments (bivalve).
	End of core @ 5.4'

ANCHOR QEA
1605 Cornwall Avenue
Bellingham, WA
360-733-4311

Footnote (1): Attempt 1 of 1; 0-8' easy drive

Footnote (2): Estimated coordinates, sampling location 12 ft from pier face.

Footnote (3): Moist, gray, stiff CLAY present in shoe.

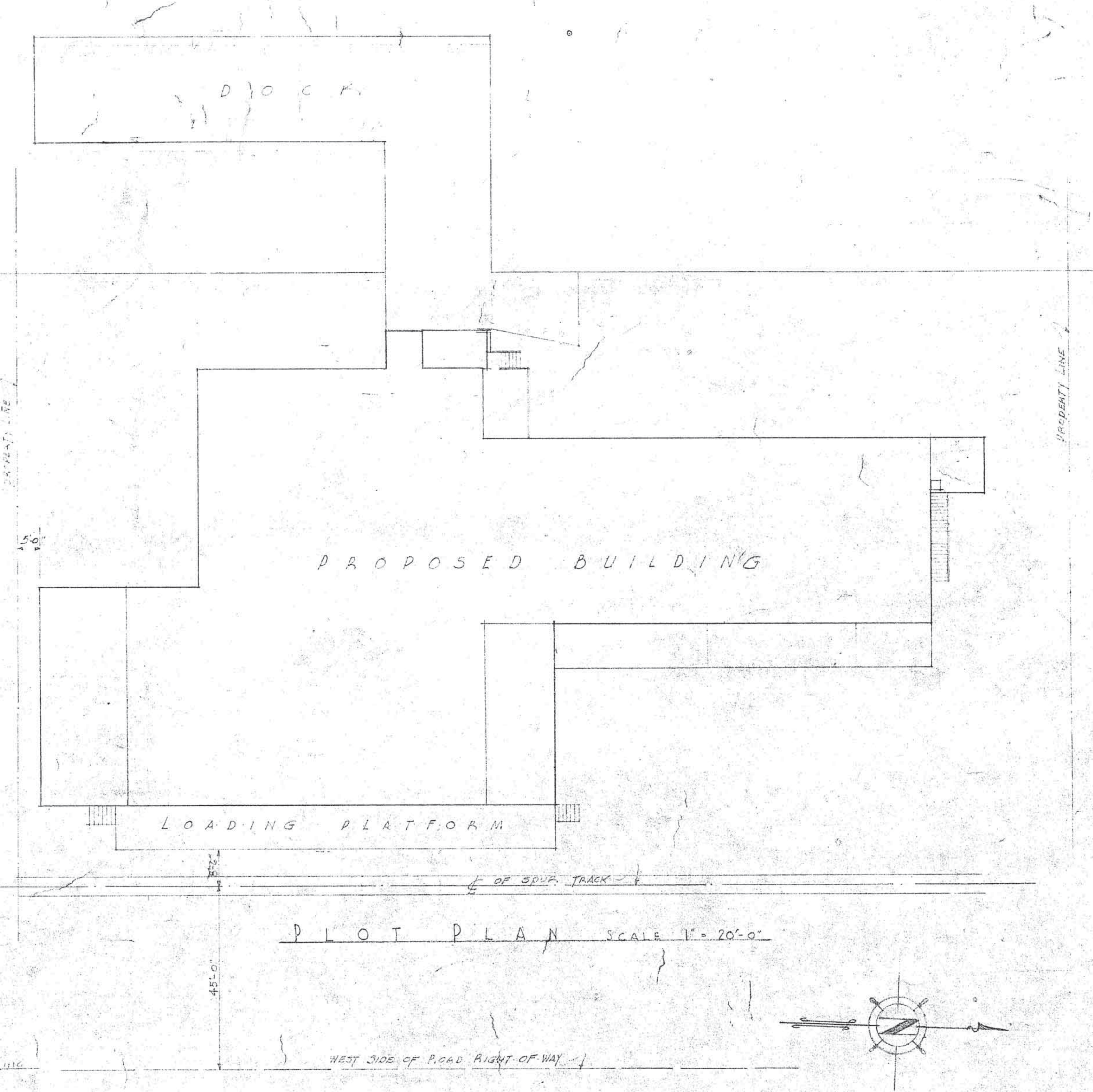
Calculated Recovery
Recovery Length/Penetration Depth:
6.4 ft/8 ft = 80%


BRUTE

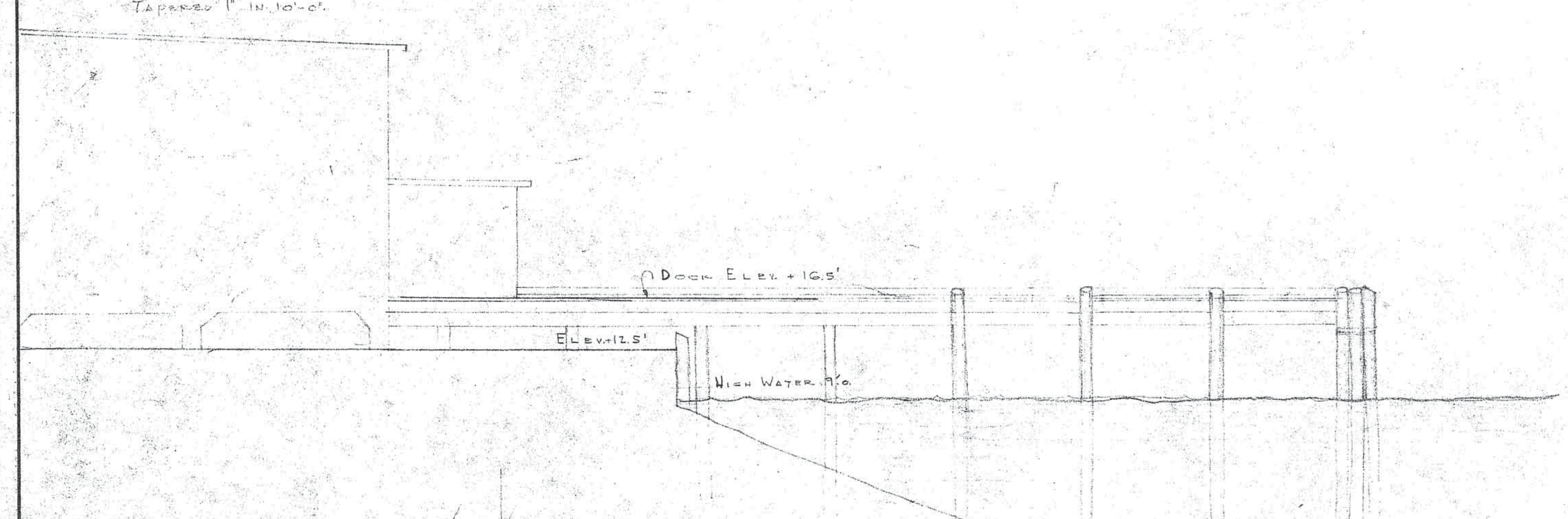
GENERAL NOTES—.
- TIMBER TO BE 1200 #/☐" GRADE.
- CAPS TO BE FASTENED TO PILES WITH 1-¾" ϕ DRIFT EXTENDING 10" INTO PILE.
- DECK TO BE FASTENED TO STRINGERS WITH 1-60D SPIKE EACH STRINGER - STAGGERED - AND 2 AT ENDS.
- DECK TO BE LAID WITH HEART SIDE DOWN.
- ALL BOLTS TO HAVE 1 M.I. WASHER EACH END
- ALL SAW CUTS AND CONTACT SURFACES TO HAVE ONE HEAVY BRUSH COAT OF HOT CREOSOTE.
- ALL HOLES FOR DRIFT BOLTS TO BE FILLED WITH CREOSOTE BEFORE DRIFT IS DRIVEN. TOP OF DRIFTS TO BE PROTECTED WITH MASTIC.
- HEADS OF ALL BOLTS AND NUTS TO BE BEDDED IN MASTIC.
- DECK PLANKS WITH JOINTS AS DIRECTED.
- ALL PILES IN APRON TO BE PROTECTED WITH CAP OF 45# ASBESTOS FELT FASTENED ALL AROUND.
- ALL DOLPHIN PILES TO BE 44'-0" LONG

ALL DOCK PILING TO BE AN AVERAGE OF 40'-0" LONG - 8" @ TIP - TAPERED 1" IN 10'-0".

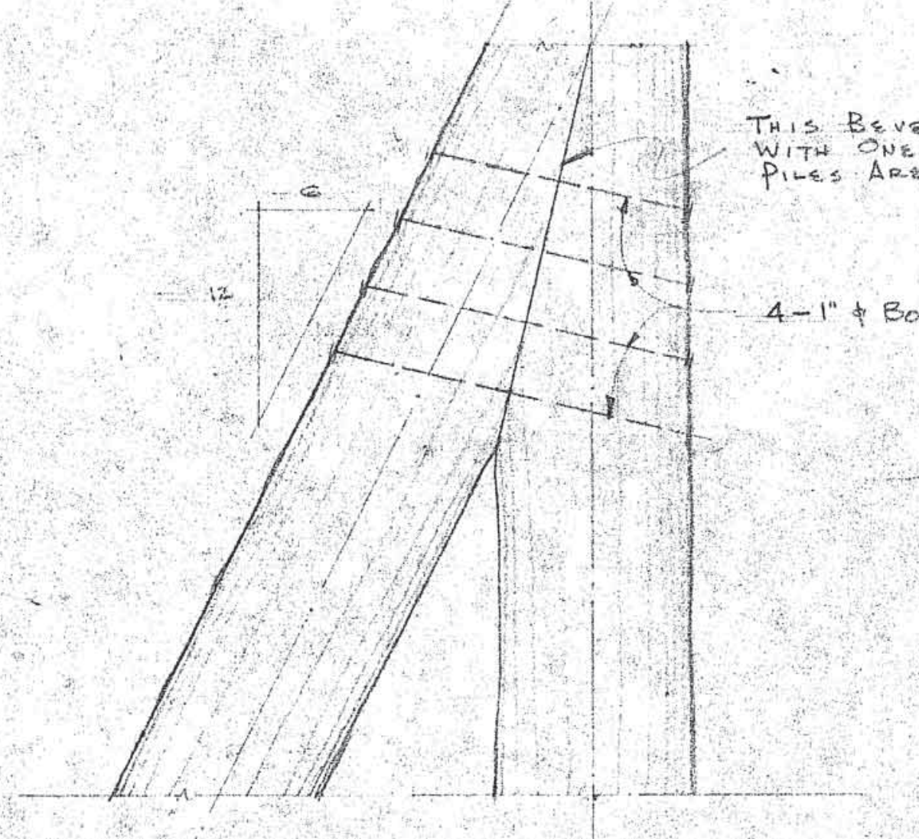
APPROACH PILING TO BE AN AVERAGE OF 20'-0" LONG - 8" @ TIP - TAPERED 1" IN 10'-0".



PLOT PLAN SCALE 1" = 20'-0"

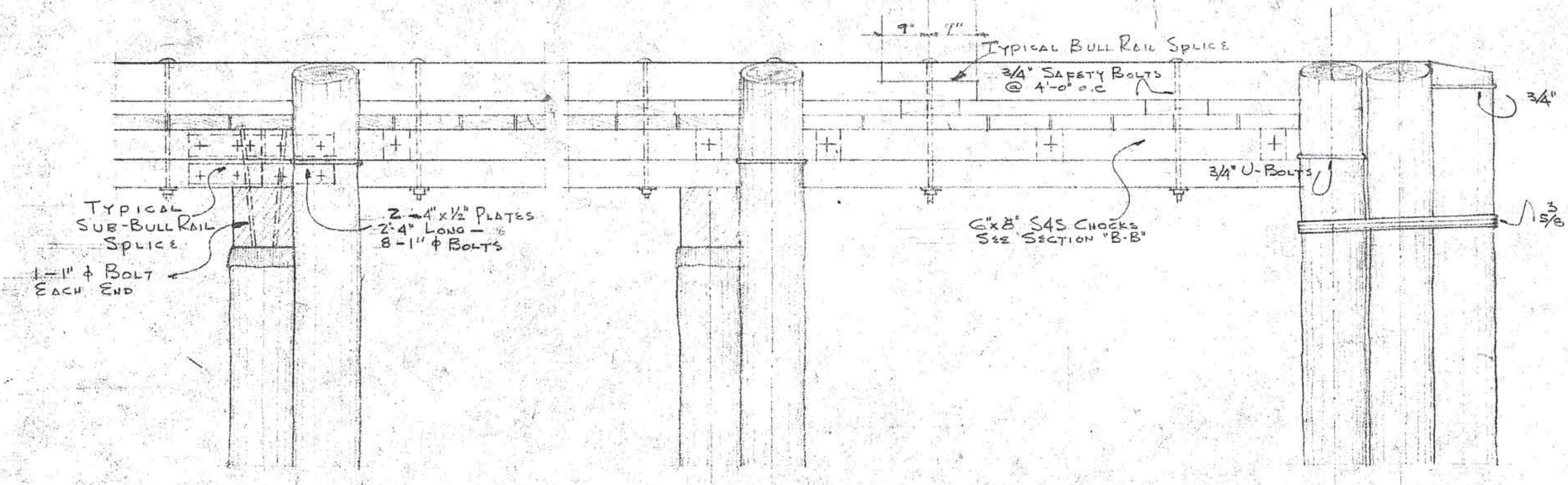


SECTION "C-C"
SCALE - ⅛" = 1'-0".

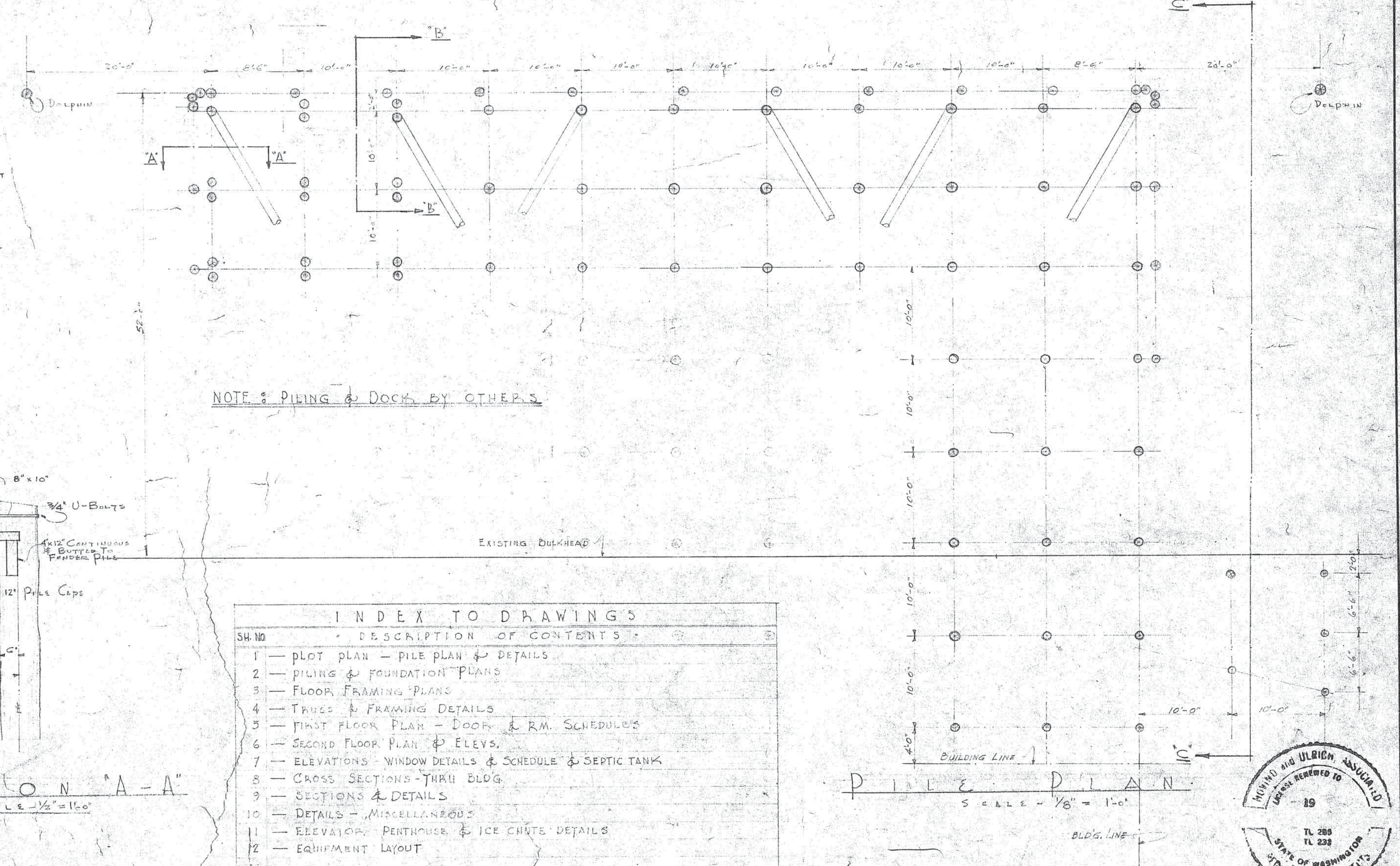


DETAIL OF BRACE PILE CONNECTION
SCALE - 1" = 1'-0".

NOTE!
PILES TO BE DRIVEN TO 20 TONS REFUSAL ACCORDING TO "ENGINEERING NEWS" FORMULA.

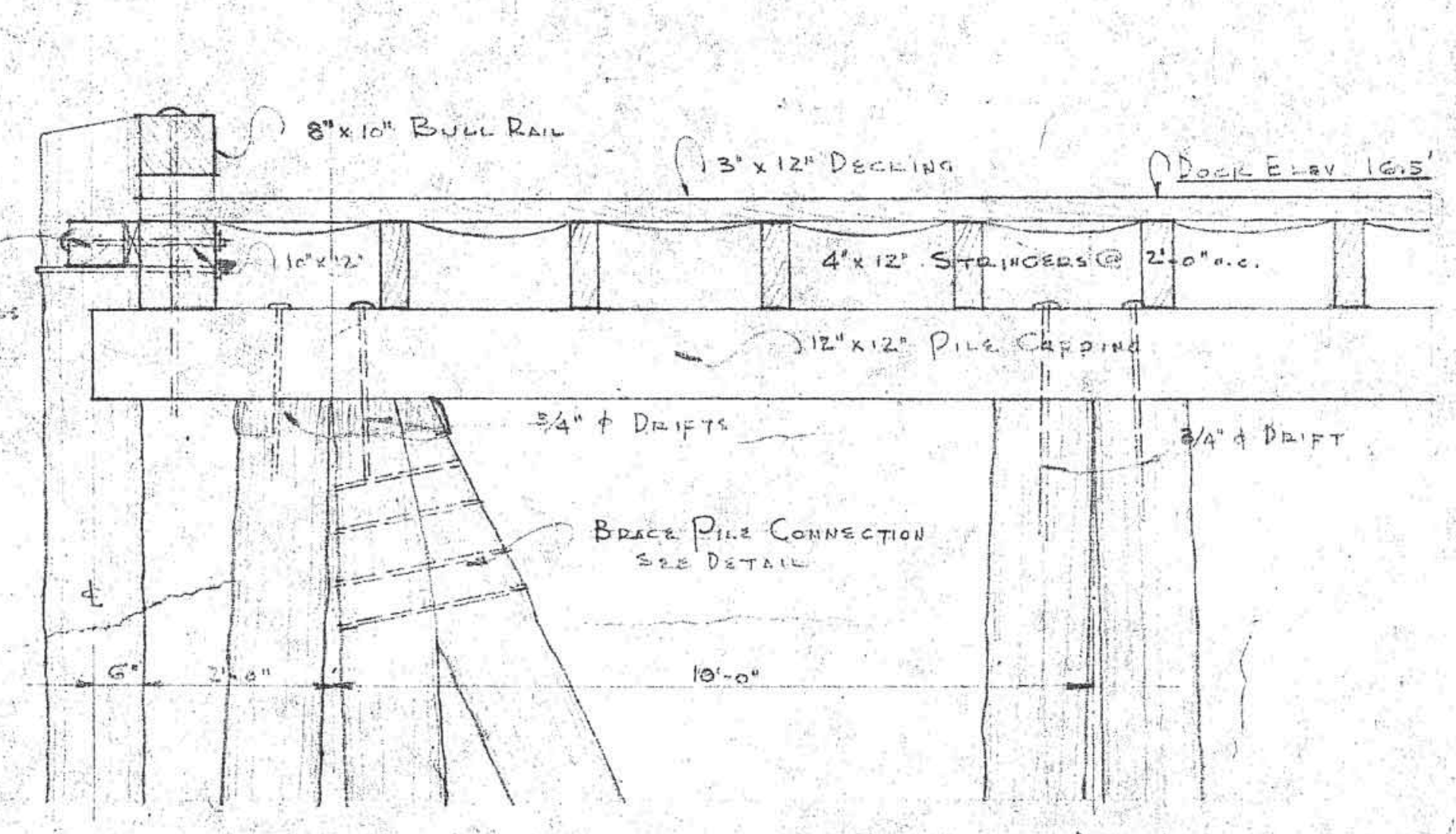


ELEVATION
SCALE — ½" = 1'-0"

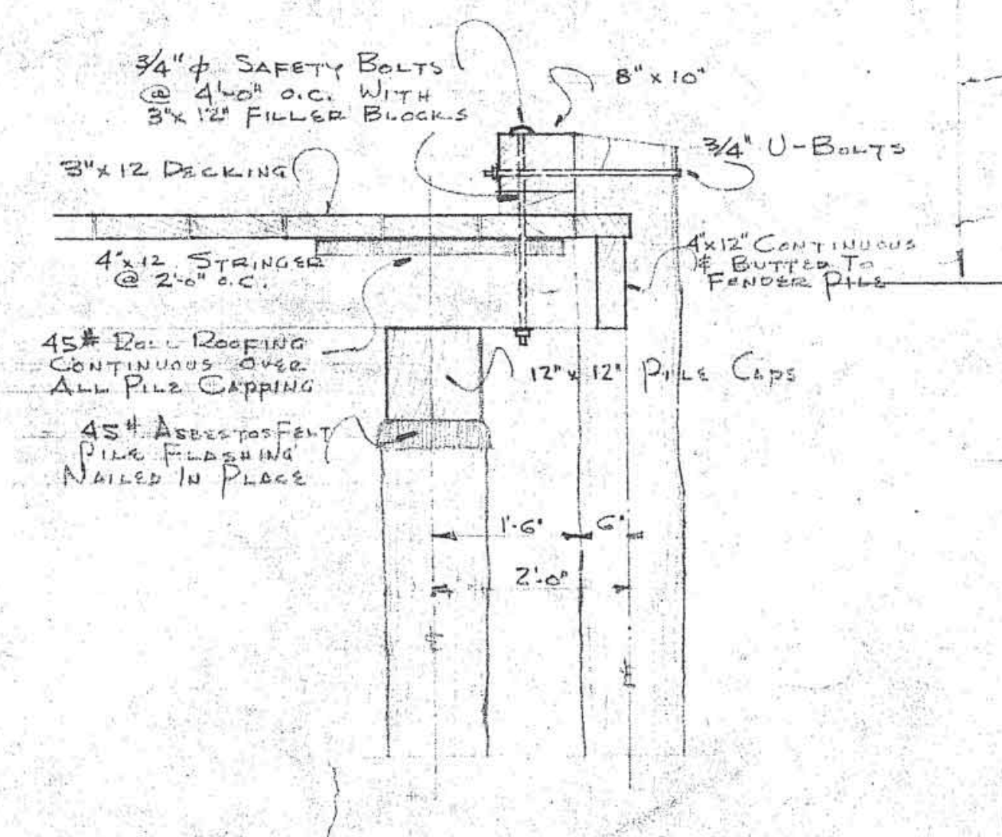


NOTE: PILING & DOCK BY OTHERS.

PILE PLAN
SCALE - ⅛" = 1'-0"



SECTION "B-B"
SCALE — ½" = 1'-0"



SECTION "A-A"
SCALE - ½" = 1'-0"

INDEX TO DRAWINGS

HOVIND AND ULRICH ASSOCIATED
LICENSE RENEWED TO
19
TL 289
TL 232

DATE	REVISIONS	BY	DATE	REVISIONS	BY
[redacted]		●	[redacted]		●
[redacted]		●	[redacted]		●
[redacted]		●	[redacted]		●
[redacted]		●	[redacted]		●

HOVIND AND ULRICH
ASSOCIATE ARCHITECTS
GENERAL INSURANCE BUILDING • SEATTLE, WASHINGTON

PROCESSING & FREEZER PLANT FOR
NORTH PACIFIC FROZEN PRODUCTS CO.
BELLINGHAM, WASHINGTON

PILE PLAN & DETAILS

JOB
2/46
DATE
SET

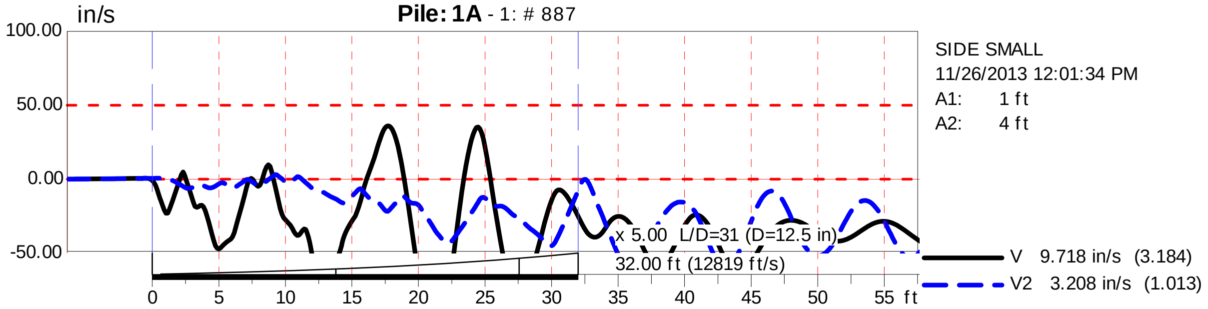
SHEET
1
OF 11 SHEETS

BORNSTEIN BUILDING

PORT OF BELLINGHAM
Dwg. No. B05-46-01
Sht. 1

Attachment C

All Data Collected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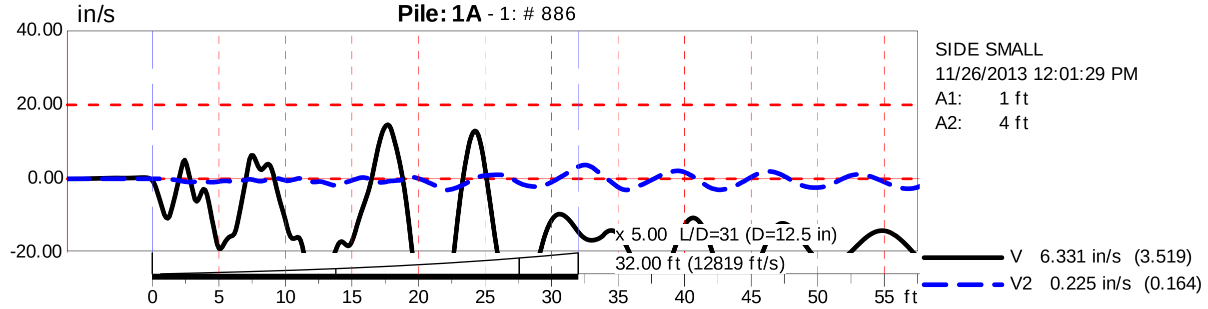
A2: 4 ft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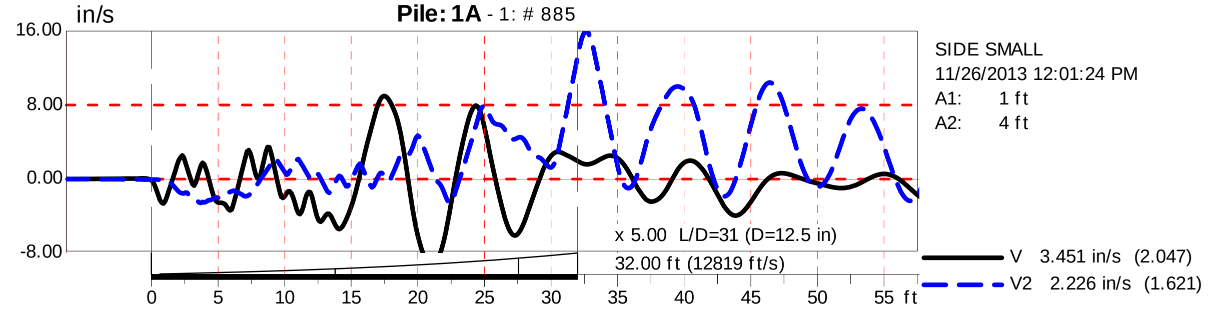
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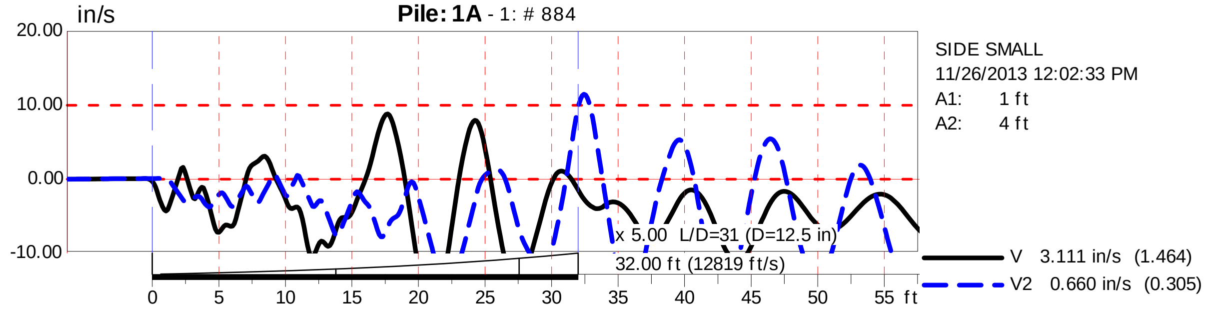
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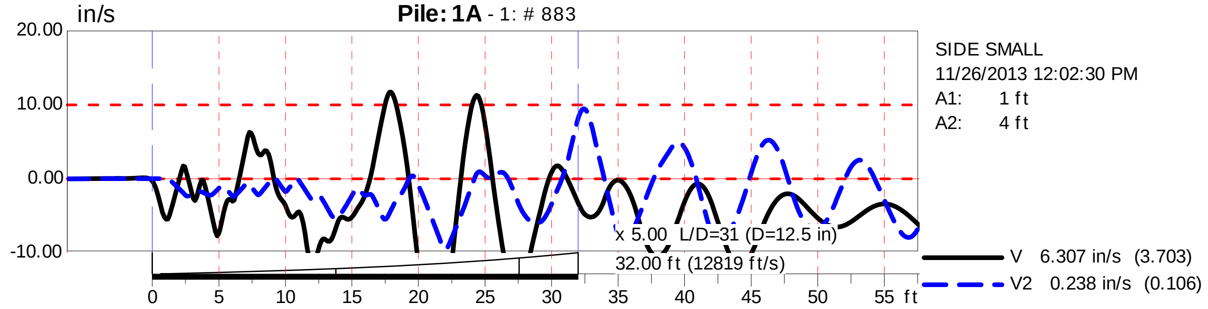
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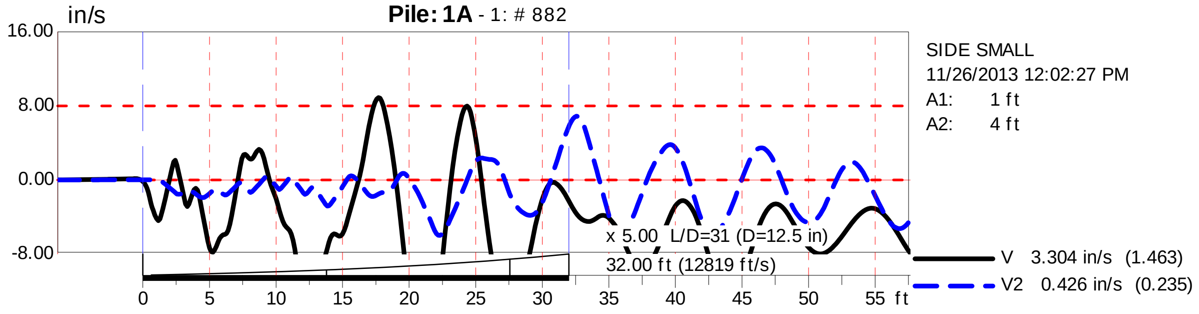
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16.00
8.00
0.00
-8.00
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
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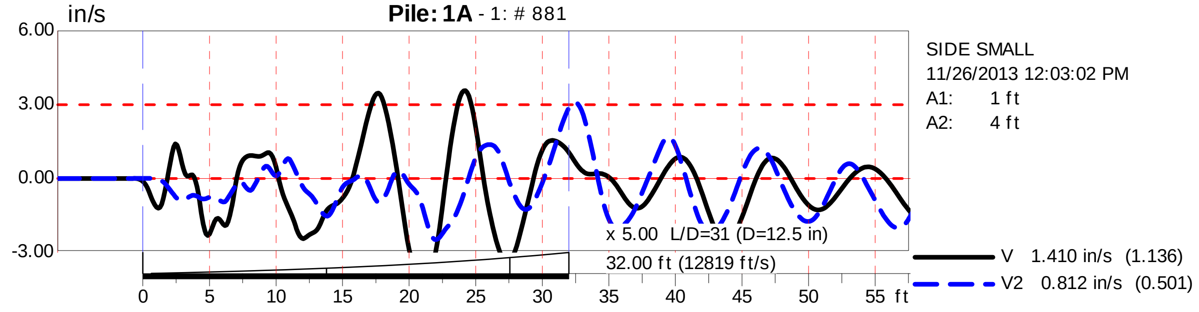
A1: 1 ft
A2: 4 ft
V 3.304 in/s (1.463)
V2 0.426 in/s (0.235)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3.00
0.00
-3.00
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
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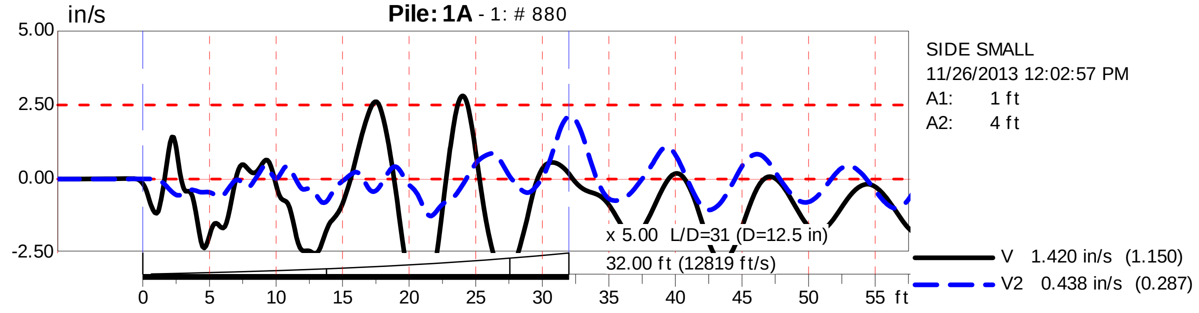
A1: 1 ft
A2: 4 ft
V 1.410 in/s (1.136)
V2 0.812 in/s (0.501)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2.50
0.00
-2.50
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
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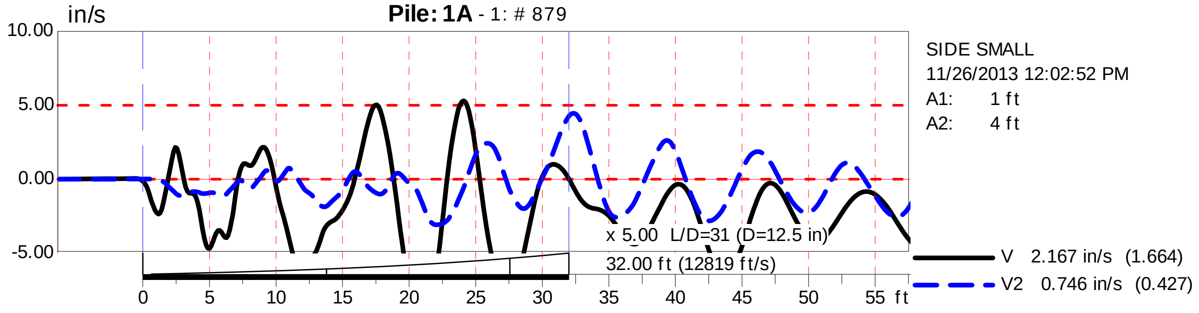
A1: 1 ft
A2: 4 ft
V 1.420 in/s (1.150)
V2 0.438 in/s (0.287)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10.00
5.00
0.00
-5.00
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
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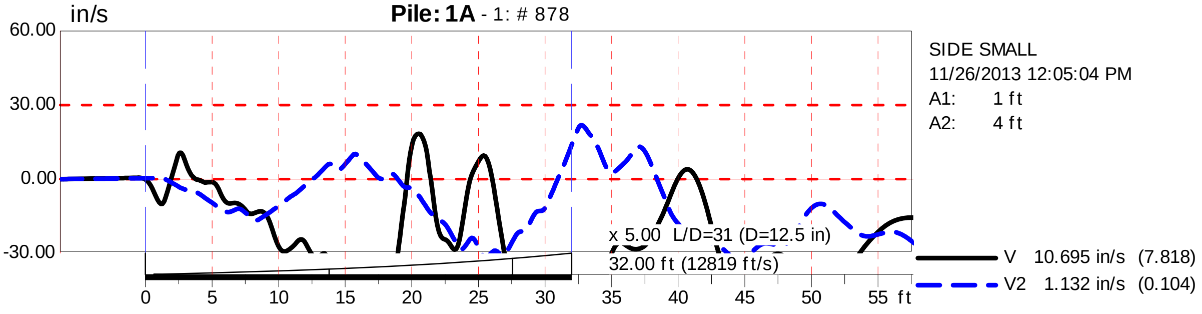
A1: 1 ft
A2: 4 ft
V 2.167 in/s (1.664)
V2 0.746 in/s (0.427)


in/s
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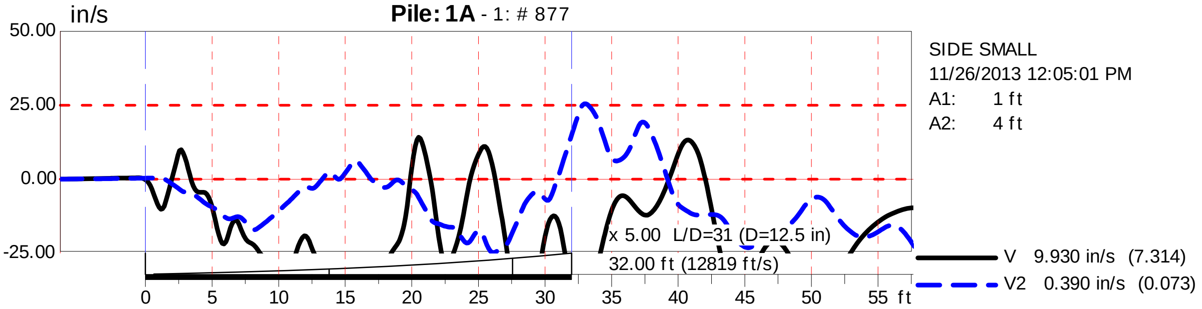
60.00
30.00
0.00
-30.00
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:05:04 PM
A1: 1 ft
A2: 4 ft
V 10.695 in/s (7.818)
V2 1.132 in/s (0.104)

Pile: 1A - 1: # 877



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A2: 4 ft

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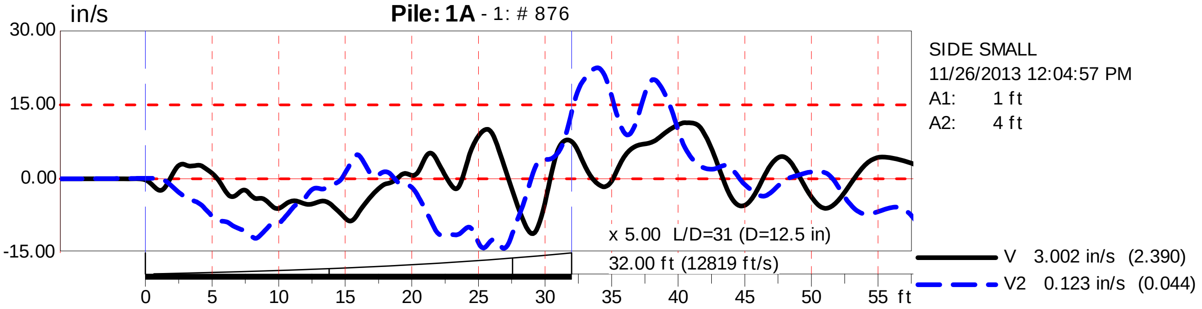

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A1: 1 ft
A2: 4 ft

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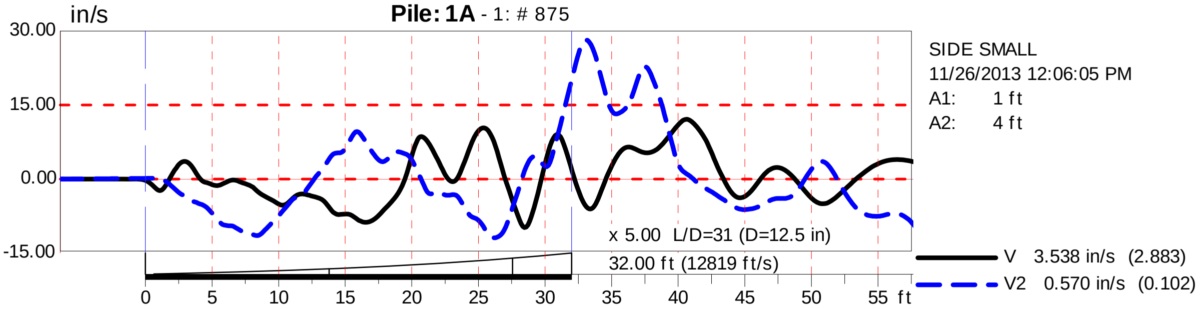

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A1: 1 ft
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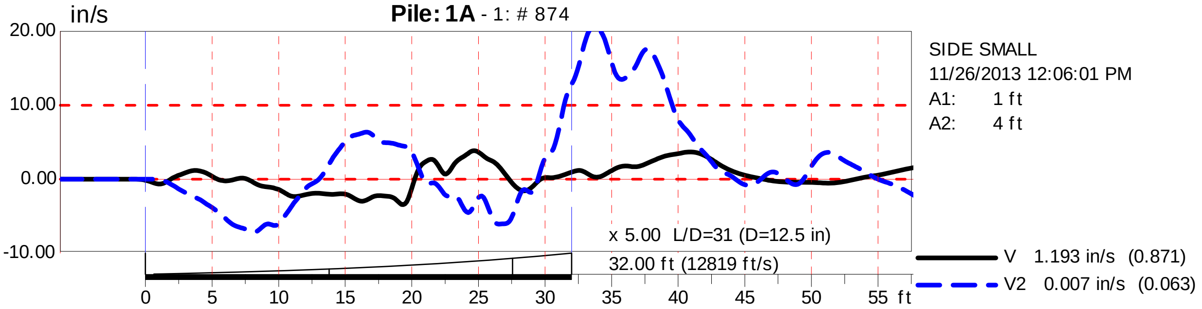

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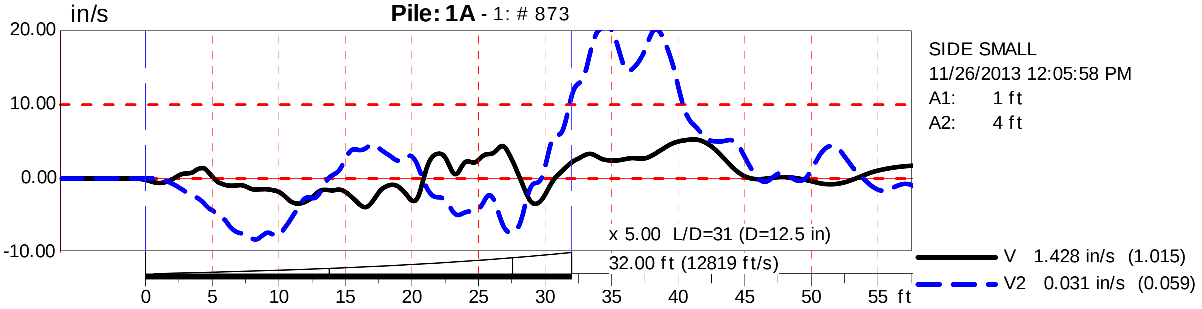
A1: 1 ft
A2: 4 ft

Pile: 1A - 1: # 873



SIDE SMALL
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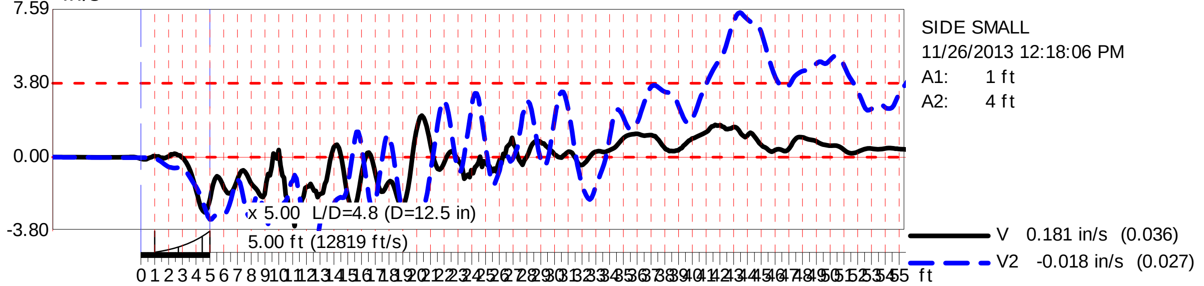
A1: 1 ft
A2: 4 ft

Pile: 1B - 1: # 45



SIDE SMALL
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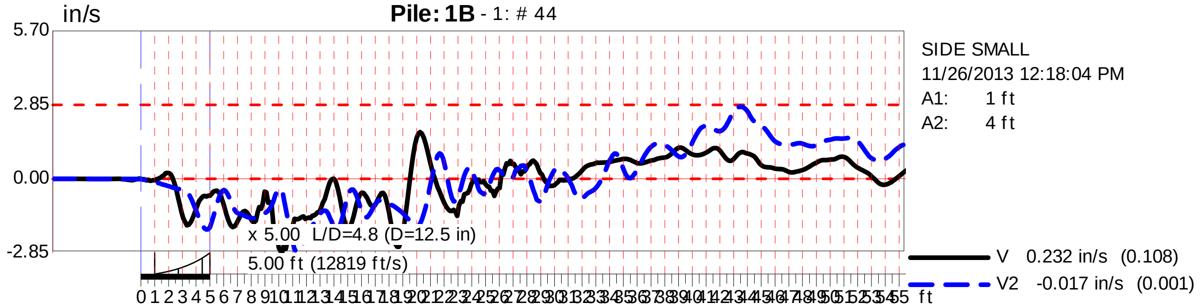
A1: 1 ft
A2: 4 ft

Pile: 1B - 1: # 44



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A1: 1 ft
A2: 4 ft

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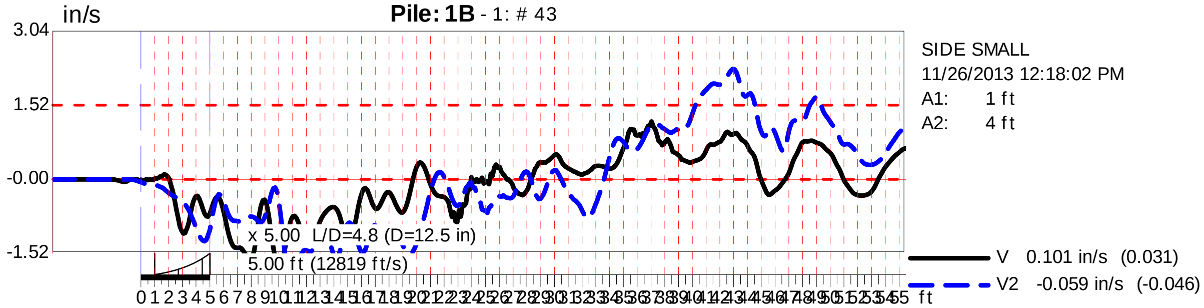

SIDE SMALL
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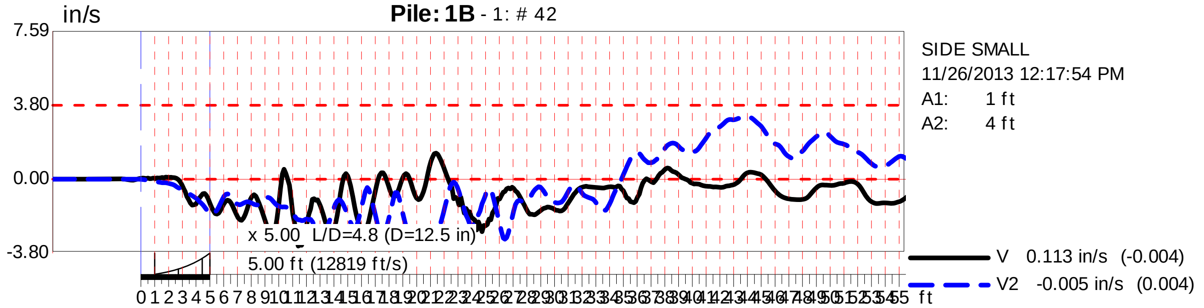
A1: 1 ft
A2: 4 ft

Pile: 1B - 1: # 42



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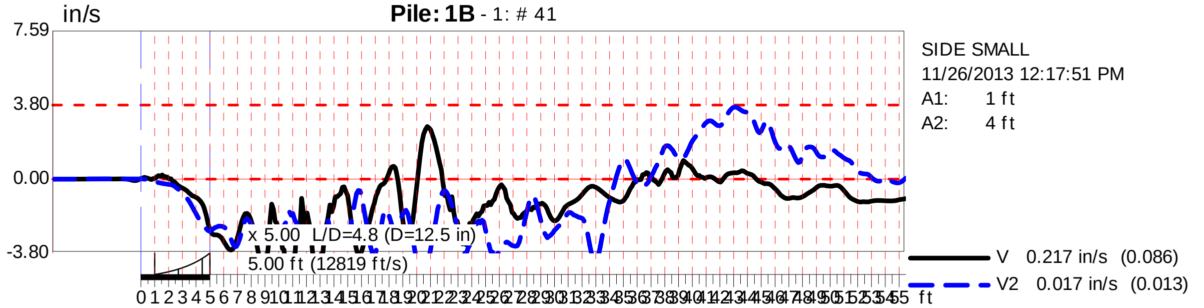
A1: 1 ft
A2: 4 ft

Pile: 1B - 1: # 41



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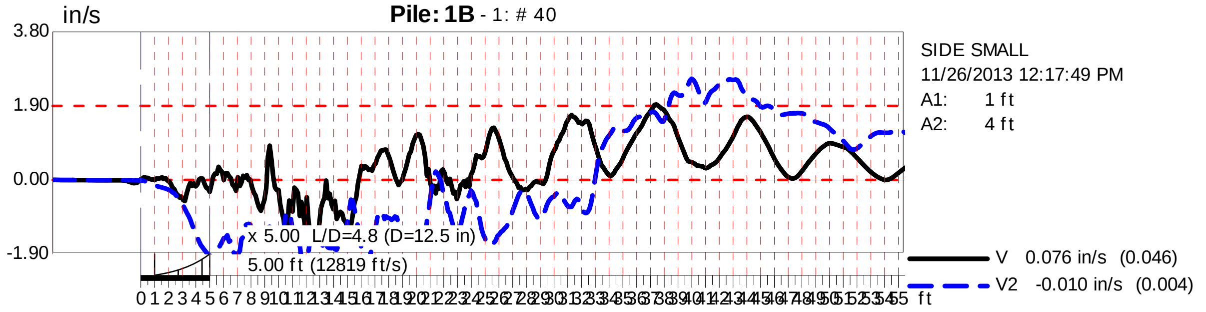
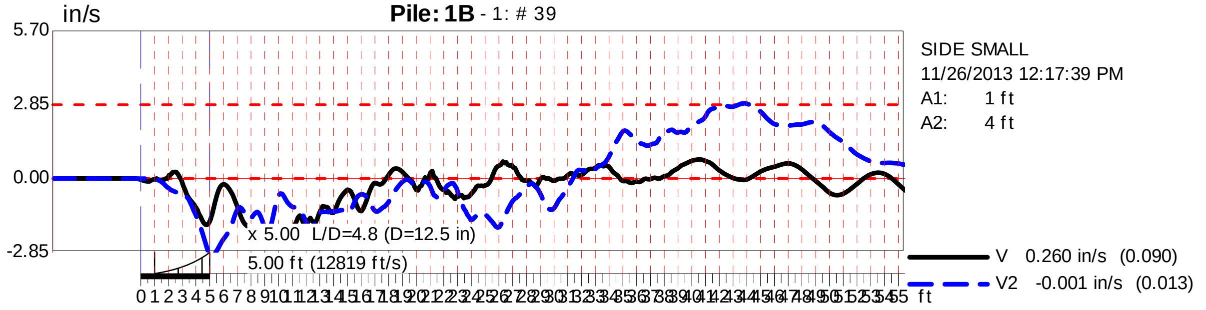
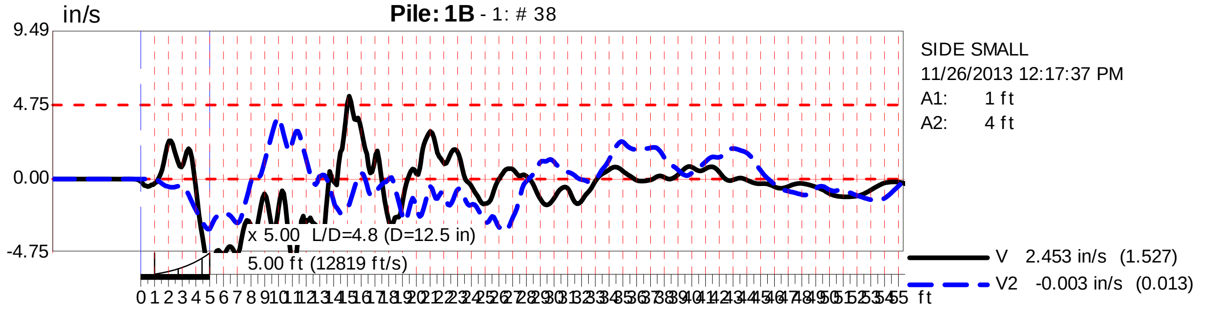
A1: 1 ft
A2: 4 ft


in/s
Pile: 1B - 1: # 40
3.80
1.90
0.00
-1.90
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:49 PM
A1: 1 ft
A2: 4 ft
V 0.076 in/s (0.046)
V2 -0.010 in/s (0.004)


in/s
Pile: 1B - 1: # 39
5.70
2.85
0.00
-2.85
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:39 PM
A1: 1 ft
A2: 4 ft
V 0.260 in/s (0.090)
V2 -0.001 in/s (0.013)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9.49
4.75
0.00
-4.75
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5.00 ft (12819 ft/s)
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SIDE SMALL
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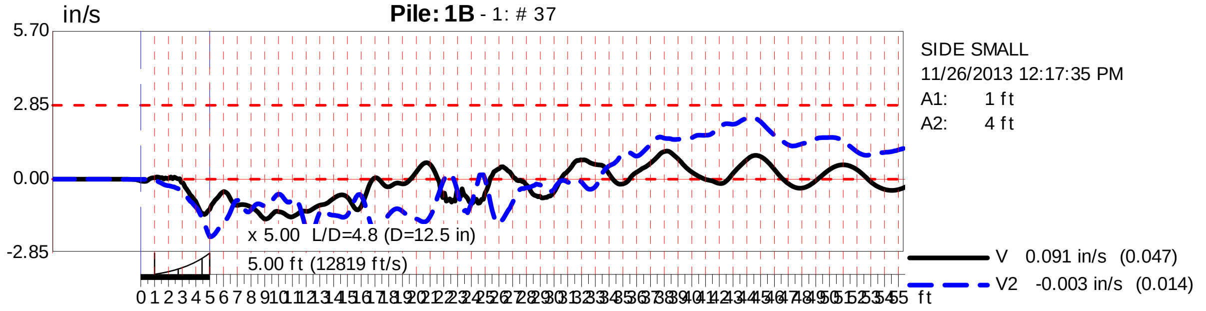
A1: 1 ft
A2: 4 ft
V 2.453 in/s (1.527)
V2 -0.003 in/s (0.013)


in/s
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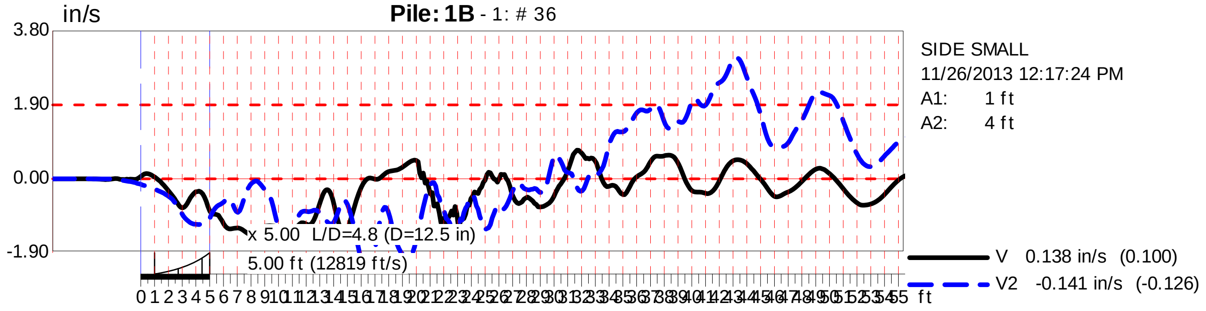
5.70
2.85
0.00
-2.85
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:35 PM
A1: 1 ft
A2: 4 ft
V 0.091 in/s (0.047)
V2 -0.003 in/s (0.014)


in/s
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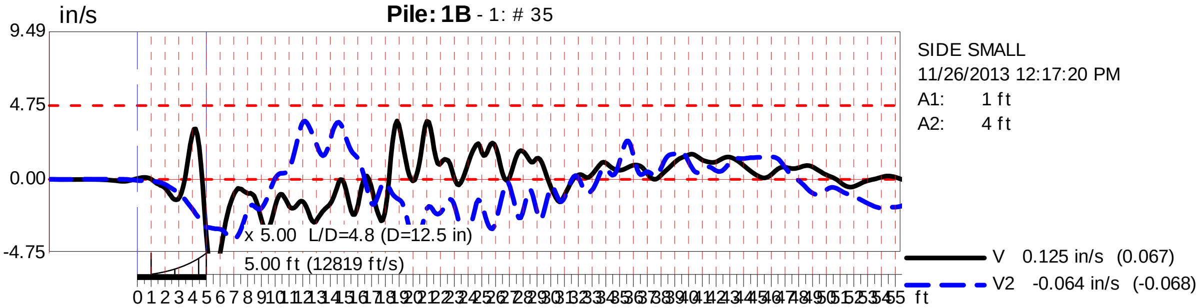
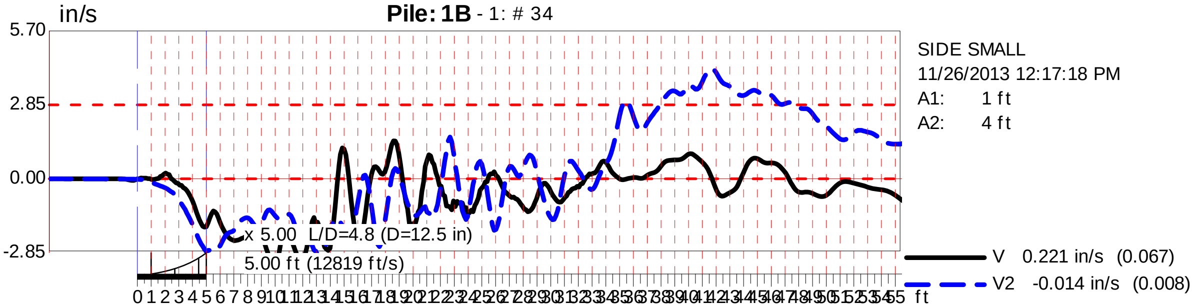
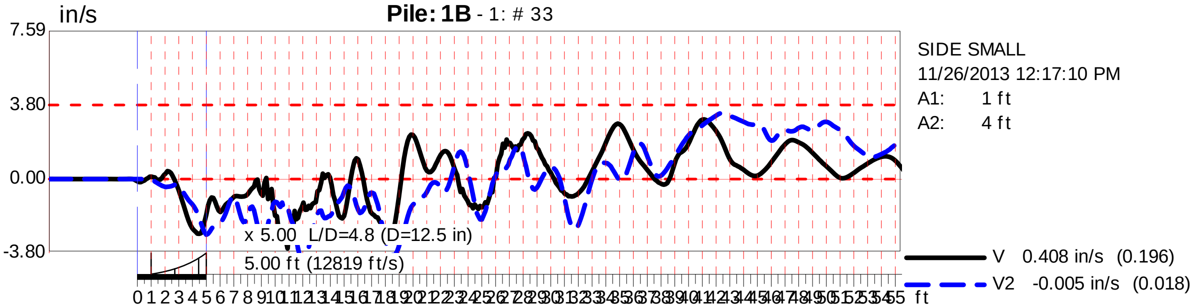
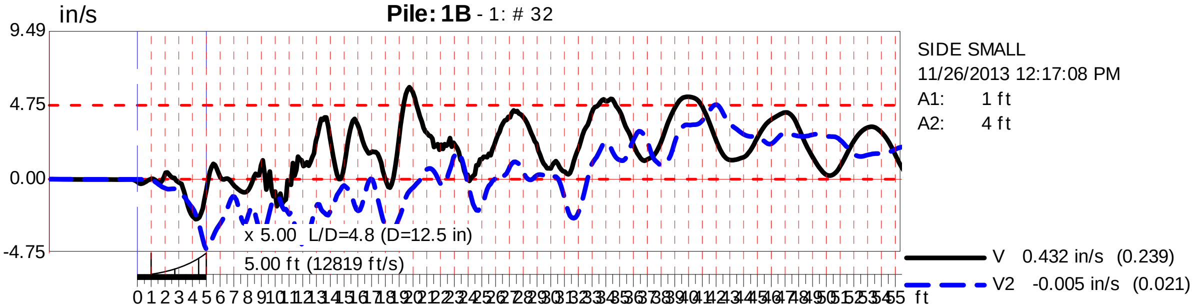
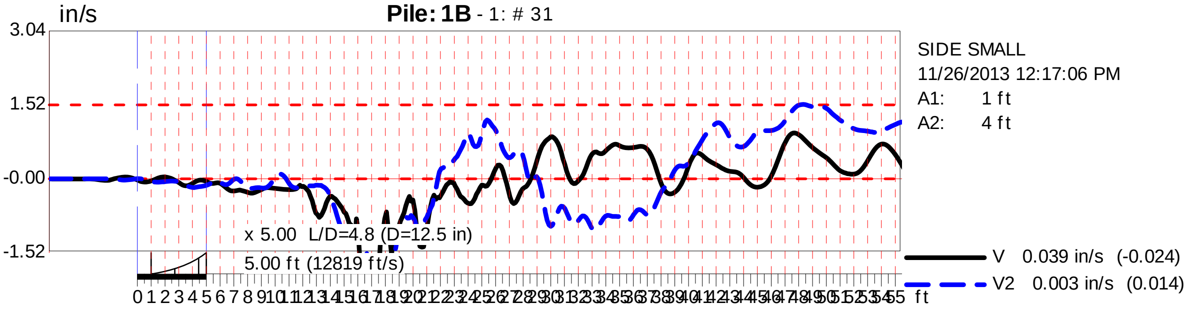
3.80
1.90
0.00
-1.90
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:24 PM
A1: 1 ft
A2: 4 ft
V 0.138 in/s (0.100)
V2 -0.141 in/s (-0.126)

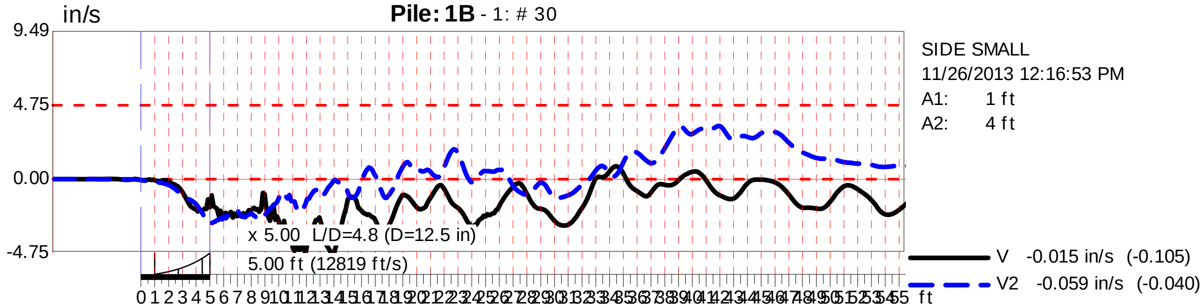

in/s
Pile: 1B - 1: # 35
9.49
4.75
0.00
-4.75
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:20 PM
A1: 1 ft
A2: 4 ft
V 0.125 in/s (0.067)
V2 -0.064 in/s (-0.068)


in/s
Pile: 1B - 1: # 34
5.70
2.85
0.00
-2.85
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:18 PM
A1: 1 ft
A2: 4 ft
V 0.221 in/s (0.067)
V2 -0.014 in/s (0.008)


in/s
Pile: 1B - 1: # 33
7.59
3.80
0.00
-3.80
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:10 PM
A1: 1 ft
A2: 4 ft
V 0.408 in/s (0.196)
V2 -0.005 in/s (0.018)

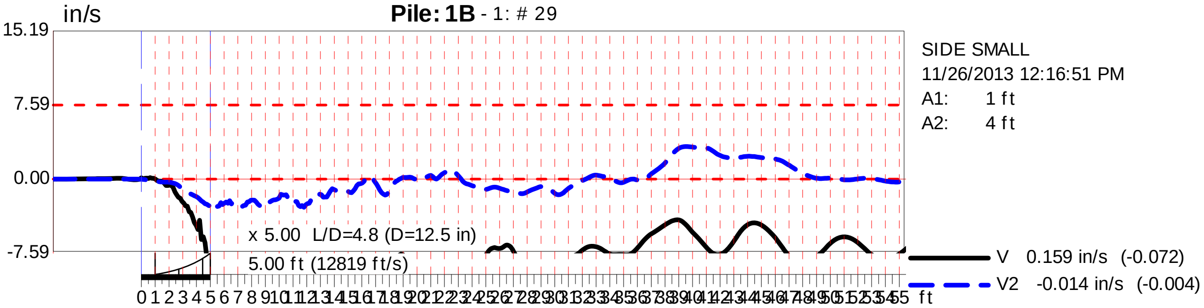

in/s
Pile: 1B - 1: # 32
9.49
4.75
0.00
-4.75
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:08 PM
A1: 1 ft
A2: 4 ft
V 0.432 in/s (0.239)
V2 -0.005 in/s (0.021)


in/s
Pile: 1B - 1: # 31
3.04
1.52
-0.00
-1.52
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:17:06 PM
A1: 1 ft
A2: 4 ft
V 0.039 in/s (-0.024)
V2 0.003 in/s (0.014)



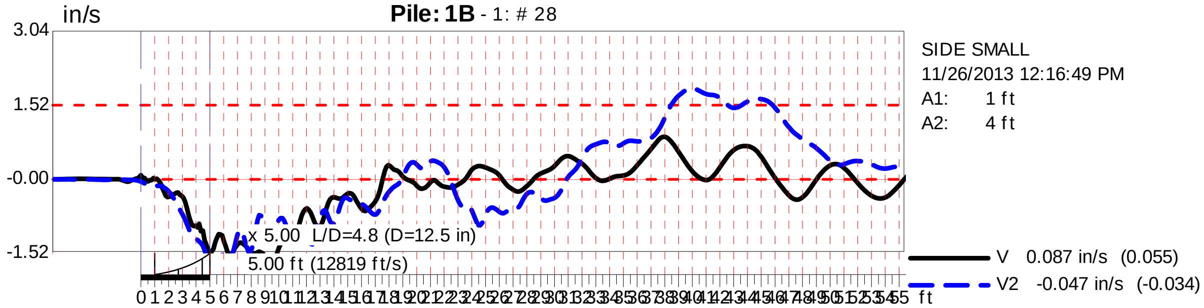
Pile: 1B - 1: # 30

SIDE SMALL
11/26/2013 12:16:53 PM
A1: 1 ft
A2: 4 ft



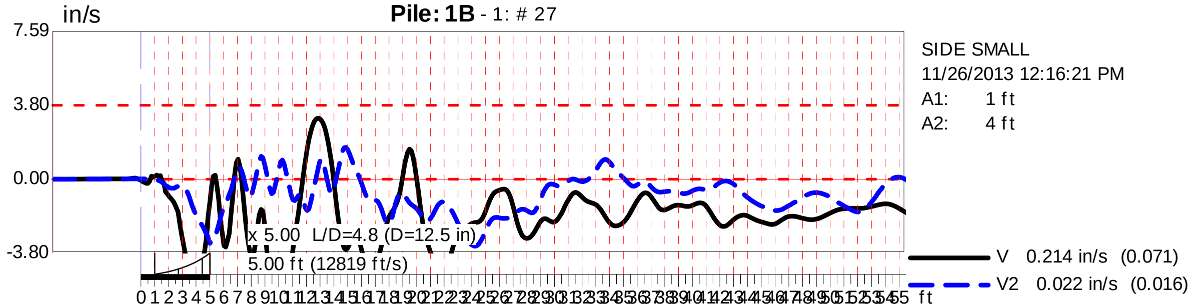
Pile: 1B - 1: # 29

SIDE SMALL
11/26/2013 12:16:51 PM
A1: 1 ft
A2: 4 ft



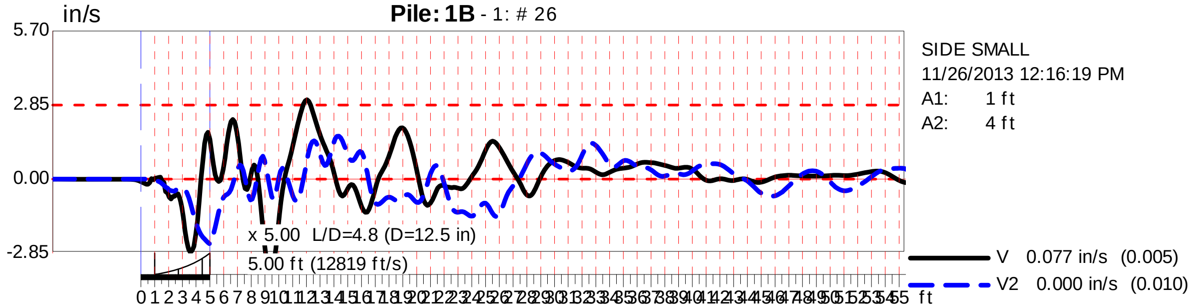
Pile: 1B - 1: # 28

SIDE SMALL
11/26/2013 12:16:49 PM
A1: 1 ft
A2: 4 ft



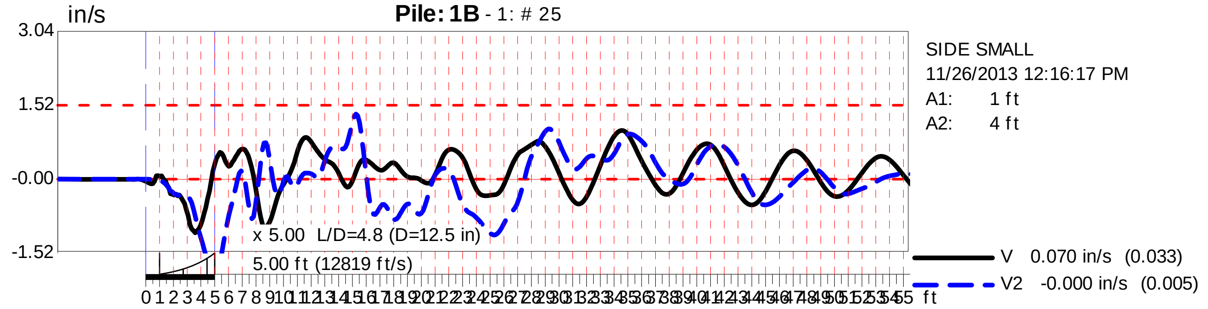
Pile: 1B - 1: # 27

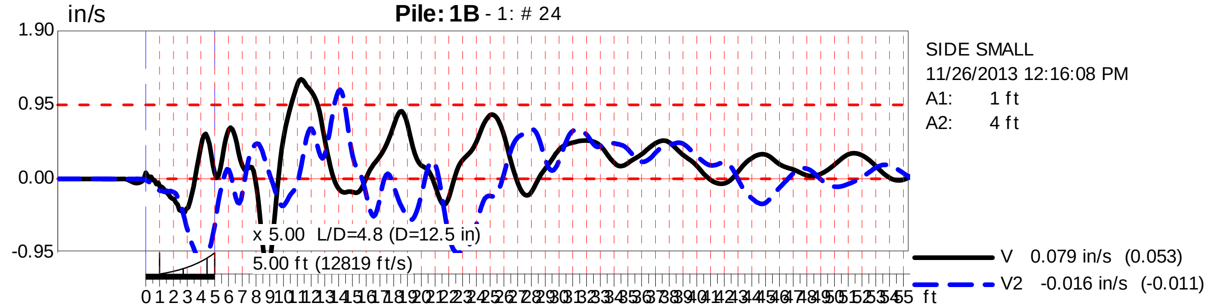
SIDE SMALL
11/26/2013 12:16:21 PM
A1: 1 ft
A2: 4 ft

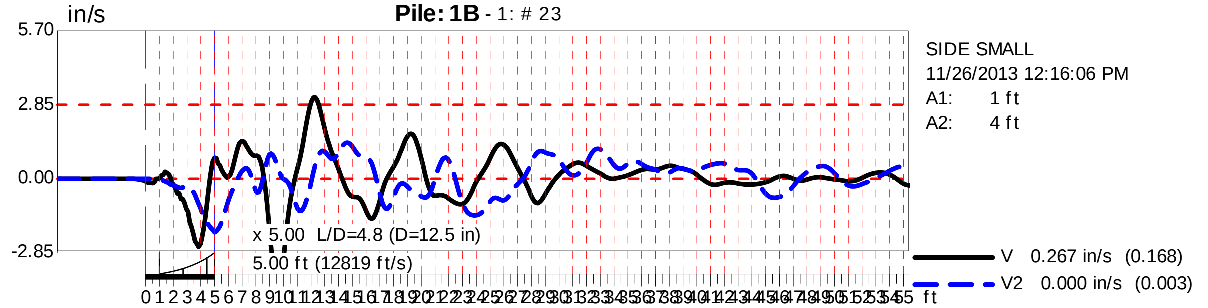


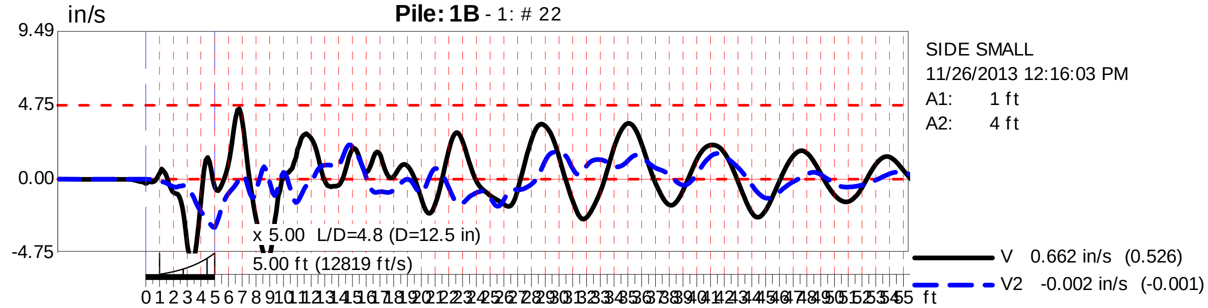
Pile: 1B - 1: # 26

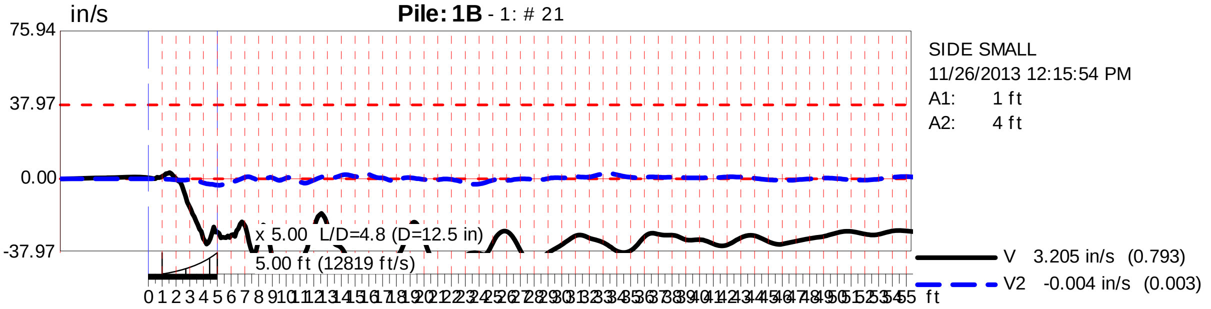
SIDE SMALL
11/26/2013 12:16:19 PM
A1: 1 ft
A2: 4 ft

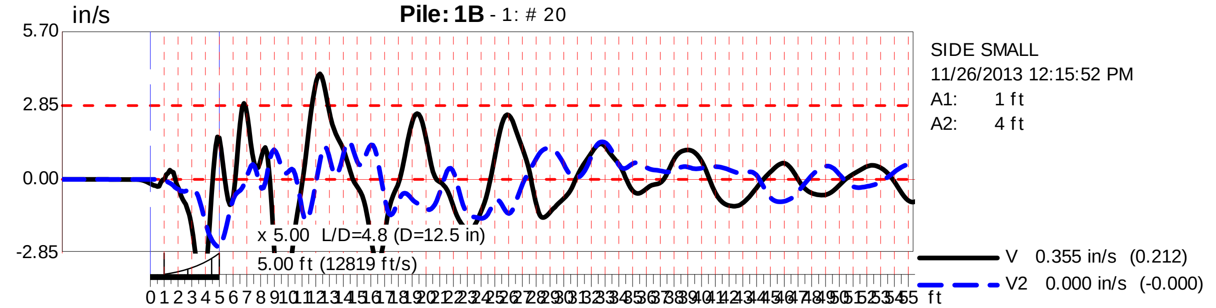

in/s
Pile: 1B - 1: # 25
3.04
1.52
-0.00
-1.52
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:16:17 PM
A1: 1 ft
A2: 4 ft
V 0.070 in/s (0.033)
V2 -0.000 in/s (0.005)

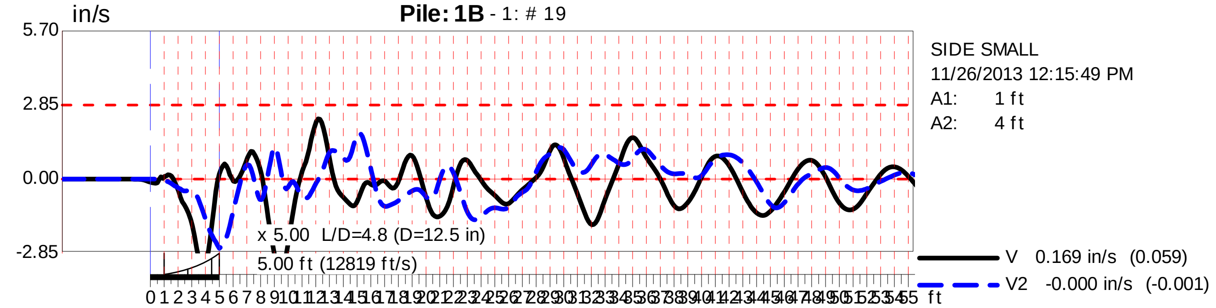

in/s
Pile: 1B - 1: # 24
1.90
0.95
0.00
-0.95
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:16:08 PM
A1: 1 ft
A2: 4 ft
V 0.079 in/s (0.053)
V2 -0.016 in/s (-0.011)

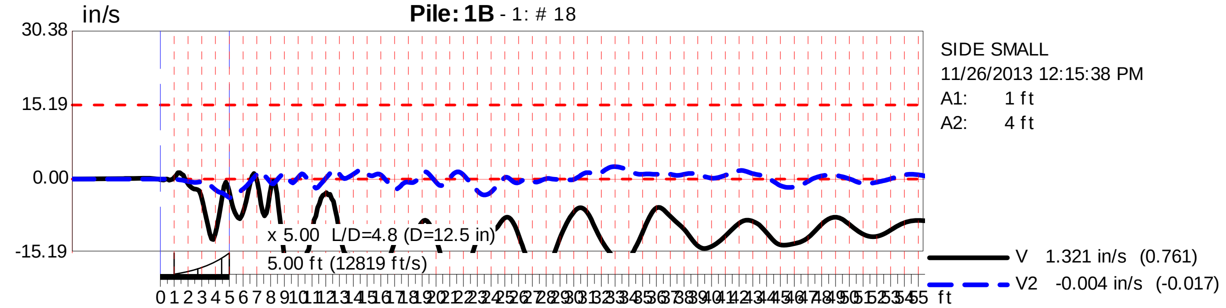

in/s
Pile: 1B - 1: # 23
5.70
2.85
0.00
-2.85
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:16:06 PM
A1: 1 ft
A2: 4 ft
V 0.267 in/s (0.168)
V2 0.000 in/s (0.003)

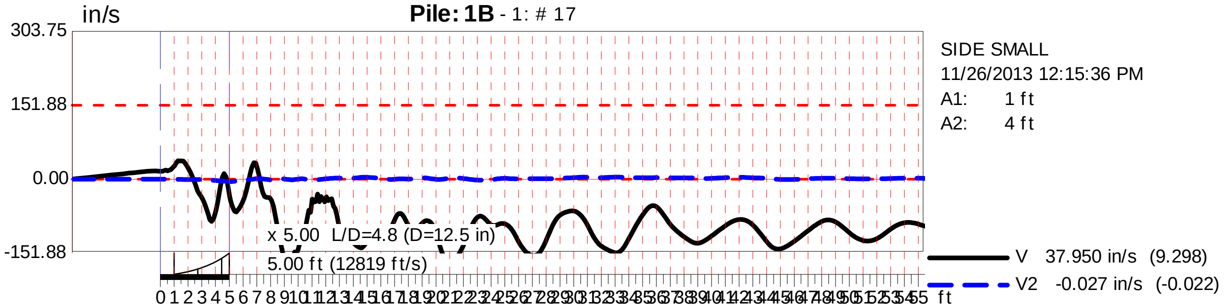

in/s
Pile: 1B - 1: # 22
9.49
4.75
0.00
-4.75
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:16:03 PM
A1: 1 ft
A2: 4 ft
V 0.662 in/s (0.526)
V2 -0.002 in/s (-0.001)

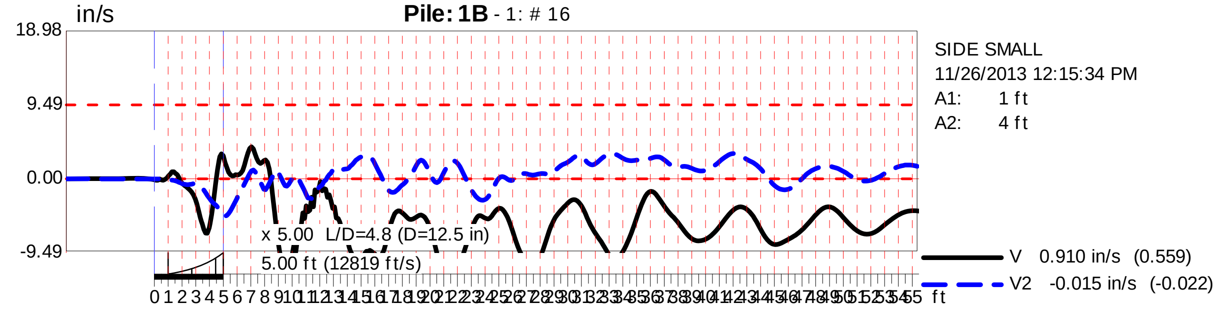

in/s
Pile: 1B - 1: # 21
75.94
37.97
0.00
-37.97
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:15:54 PM
A1: 1 ft
A2: 4 ft
V 3.205 in/s (0.793)
V2 -0.004 in/s (0.003)


in/s
Pile: 1B - 1: # 20
5.70
2.85
0.00
-2.85
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:15:52 PM
A1: 1 ft
A2: 4 ft
V 0.355 in/s (0.212)
V2 0.000 in/s (-0.000)

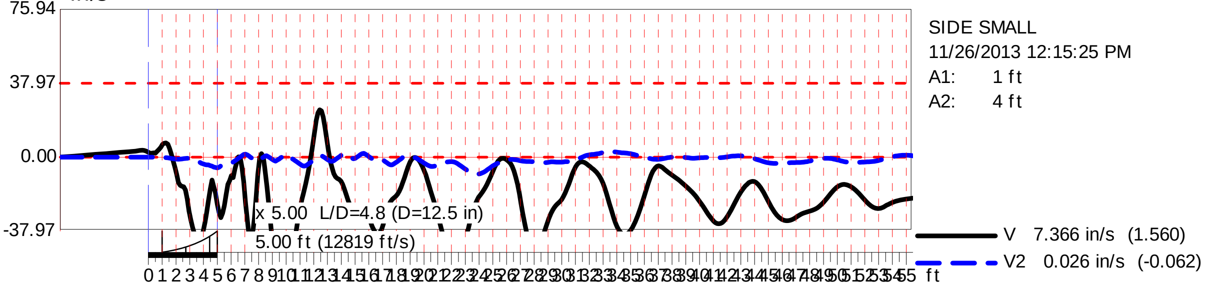

in/s
Pile: 1B - 1: # 19
5.70
2.85
0.00
-2.85
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:15:49 PM
A1: 1 ft
A2: 4 ft
V 0.169 in/s (0.059)
V2 -0.000 in/s (-0.001)


in/s
Pile: 1B - 1: # 18
30.38
15.19
0.00
-15.19
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:15:38 PM
A1: 1 ft
A2: 4 ft
V 1.321 in/s (0.761)
V2 -0.004 in/s (-0.017)


in/s
Pile: 1B - 1: # 17
303.75
151.88
0.00
-151.88
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:15:36 PM
A1: 1 ft
A2: 4 ft
V 37.950 in/s (9.298)
V2 -0.027 in/s (-0.022)

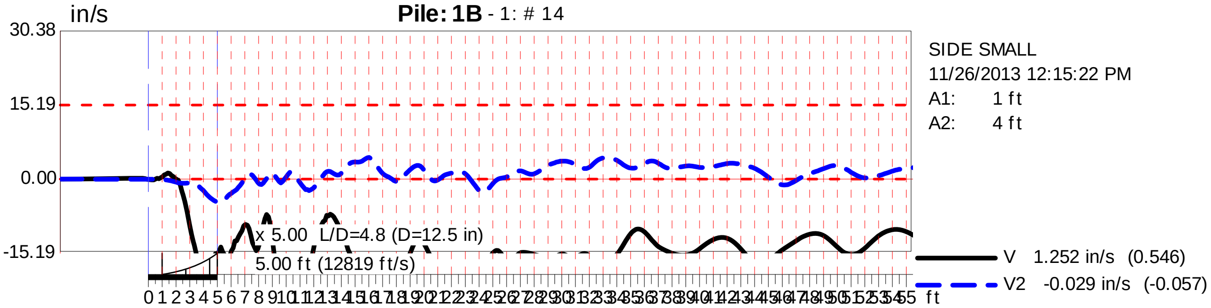

in/s
Pile: 1B - 1: # 16
18.98
9.49
0.00
-9.49
x 5.00 L/D=4.8 (D=12.5 in)
5.00 ft (12819 ft/s)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 ft
SIDE SMALL
11/26/2013 12:15:34 PM
A1: 1 ft
A2: 4 ft
V 0.910 in/s (0.559)
V2 -0.015 in/s (-0.022)

Pile: 1B - 1: # 15



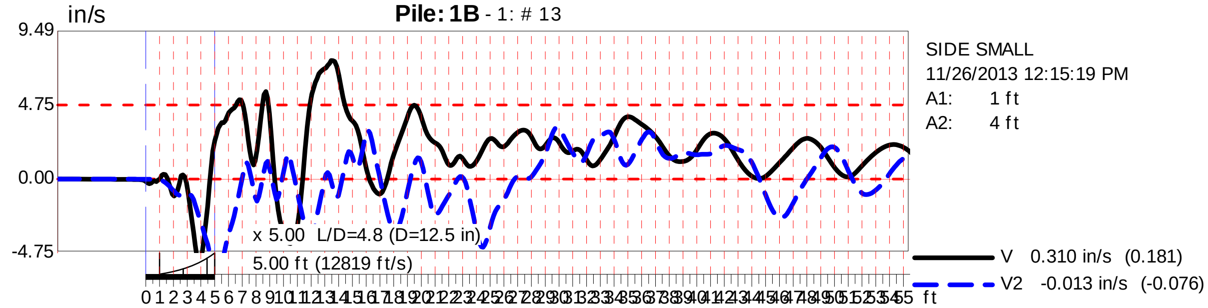
SIDE SMALL
11/26/2013 12:15:25 PM
A1: 1 ft
A2: 4 ft

Pile: 1B - 1: # 14



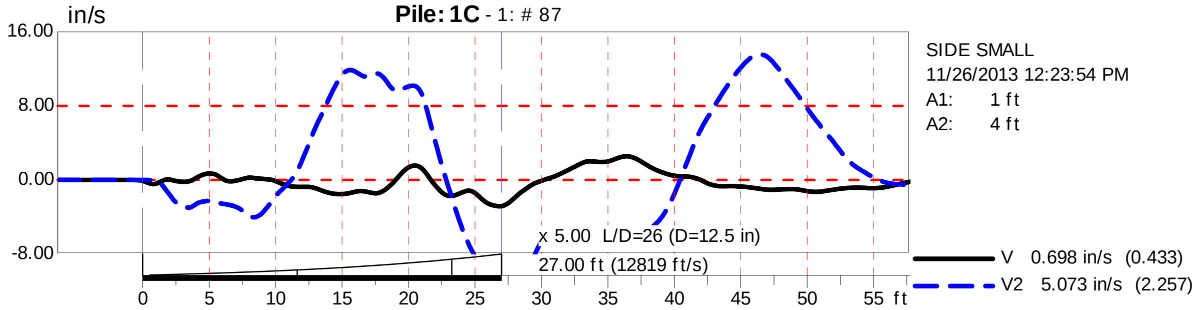
SIDE SMALL
11/26/2013 12:15:22 PM
A1: 1 ft
A2: 4 ft

Pile: 1B - 1: # 13



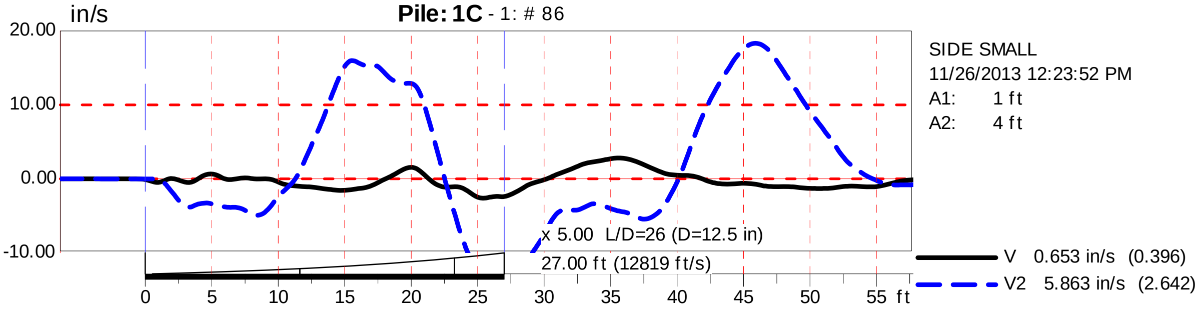
SIDE SMALL
11/26/2013 12:15:19 PM
A1: 1 ft
A2: 4 ft

Pile: 1C - 1: # 87



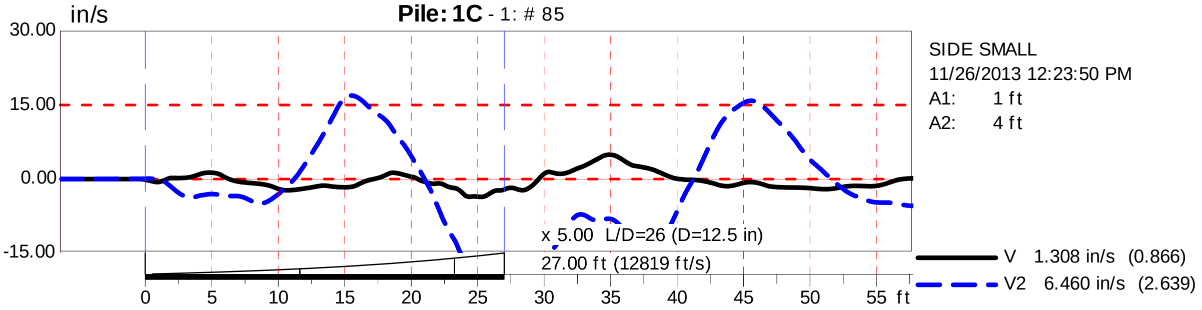
SIDE SMALL
11/26/2013 12:23:54 PM
A1: 1 ft
A2: 4 ft

Pile: 1C - 1: # 86



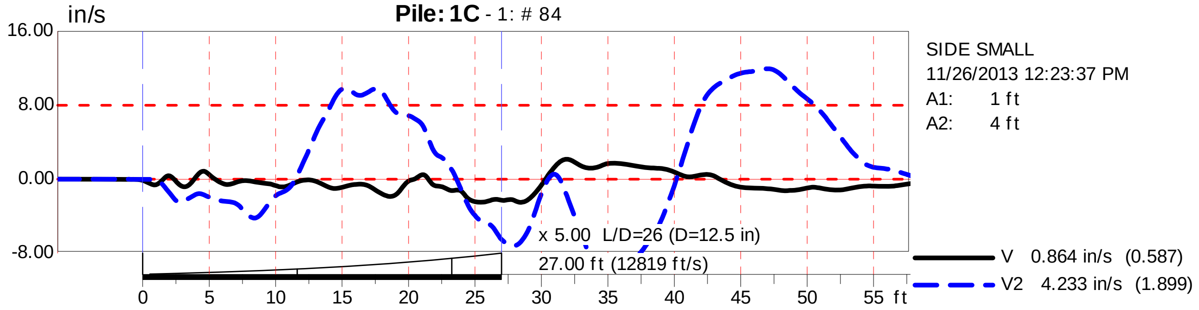
SIDE SMALL
11/26/2013 12:23:52 PM
A1: 1 ft
A2: 4 ft

Pile: 1C - 1: # 85



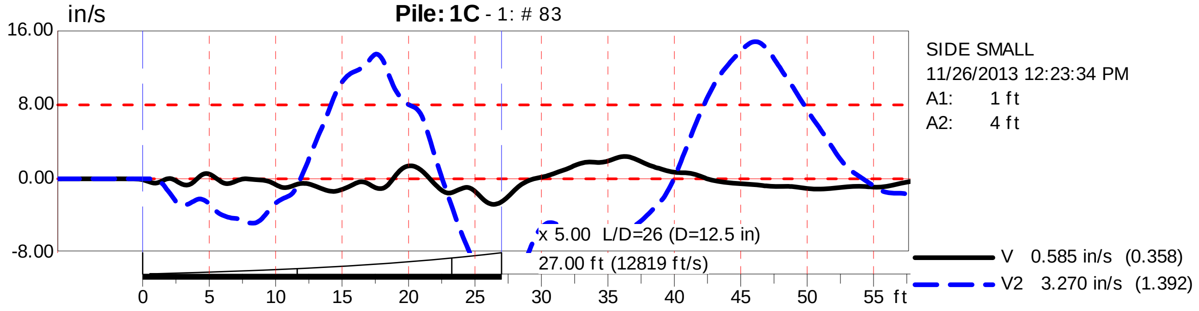
SIDE SMALL
11/26/2013 12:23:50 PM
A1: 1 ft
A2: 4 ft

Pile: 1C - 1: # 84



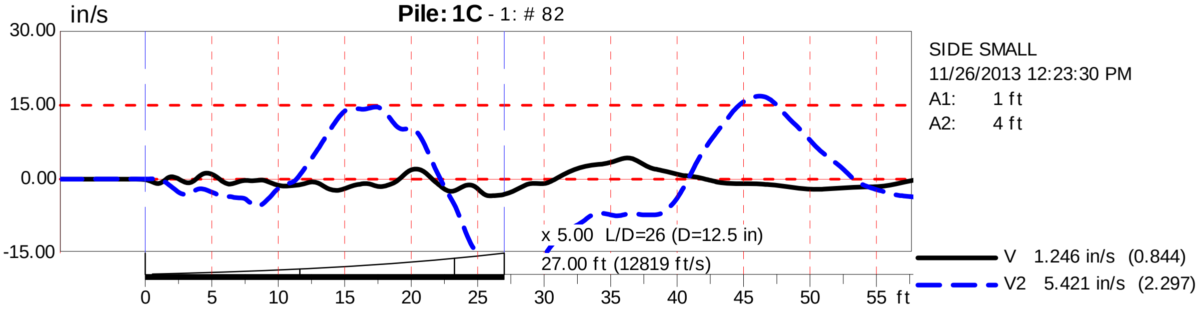
SIDE SMALL
11/26/2013 12:23:37 PM
A1: 1 ft
A2: 4 ft

Pile: 1C - 1: # 83

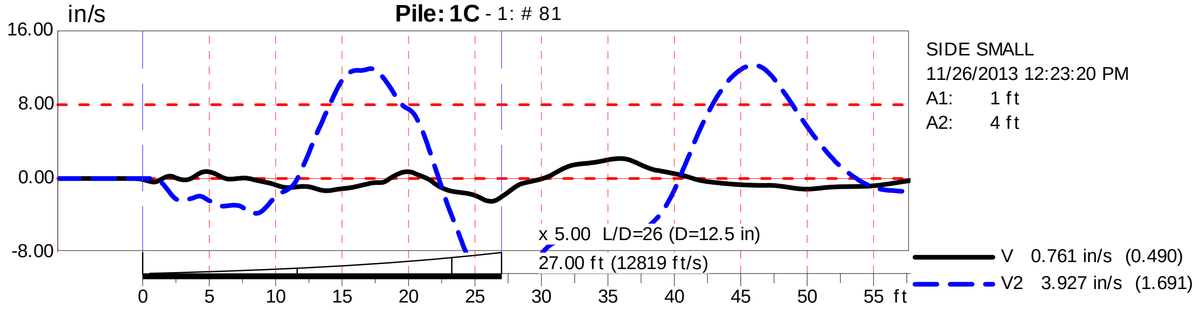


SIDE SMALL
11/26/2013 12:23:34 PM
A1: 1 ft
A2: 4 ft

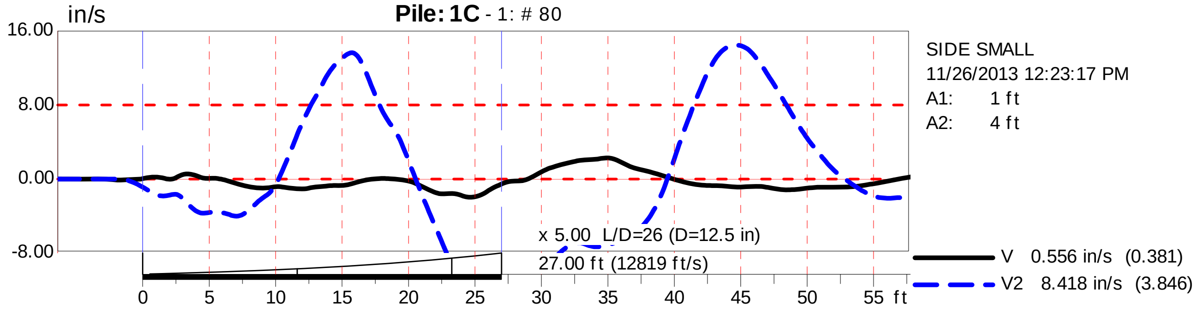
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 1C - 1: # 82

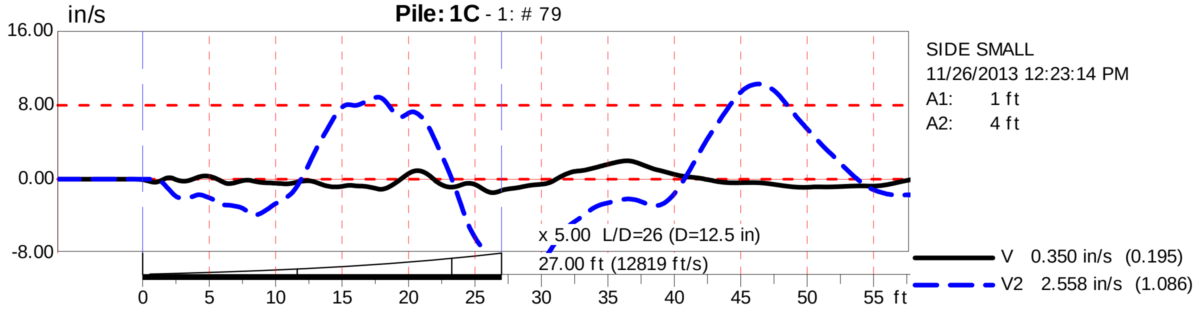
SIDE SMALL
11/26/2013 12:23:30 PM
A1: 1 ft
A2: 4 ft


Pile: 1C - 1: # 81

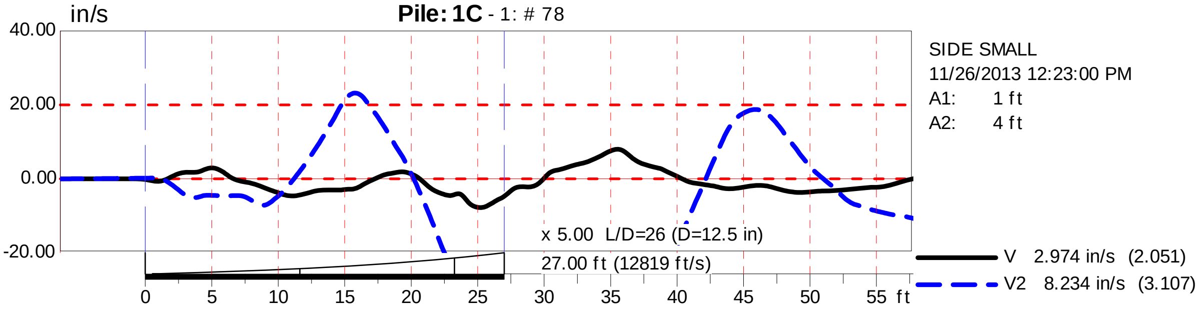
SIDE SMALL
11/26/2013 12:23:20 PM
A1: 1 ft
A2: 4 ft


Pile: 1C - 1: # 80

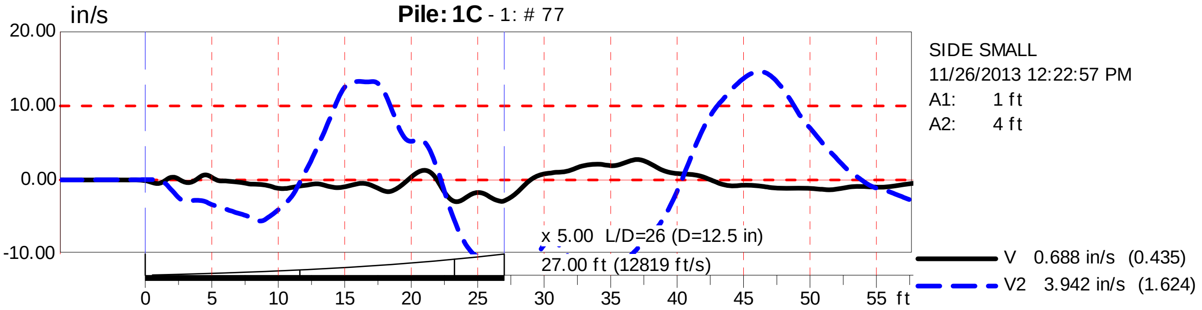
SIDE SMALL
11/26/2013 12:23:17 PM
A1: 1 ft
A2: 4 ft


Pile: 1C - 1: # 79

SIDE SMALL
11/26/2013 12:23:14 PM
A1: 1 ft
A2: 4 ft

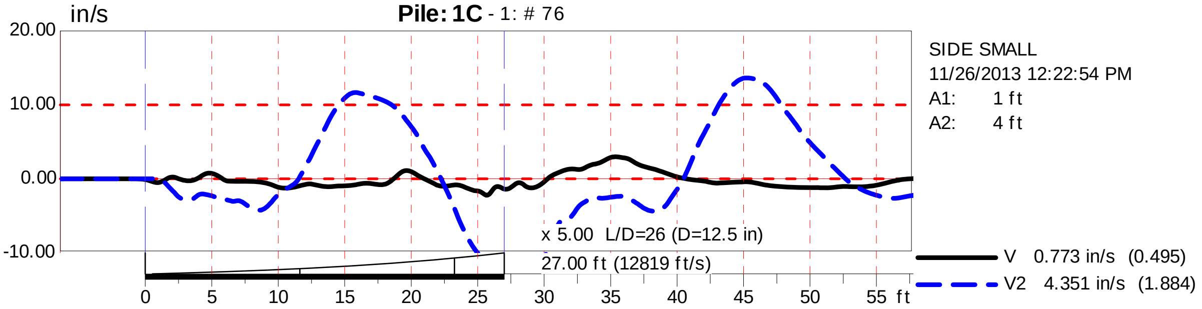

Pile: 1C - 1: # 78

SIDE SMALL
11/26/2013 12:23:00 PM
A1: 1 ft
A2: 4 ft



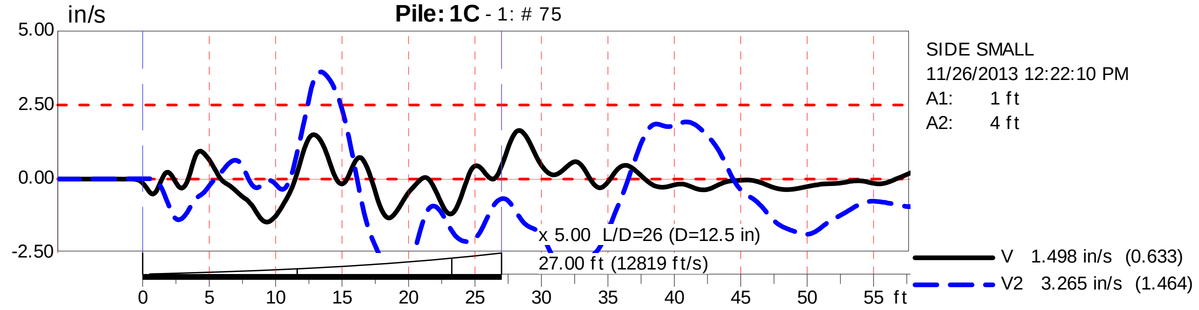
SIDE SMALL
11/26/2013 12:22:57 PM
A1: 1 ft
A2: 4 ft

V 0.688 in/s (0.435)
V2 3.942 in/s (1.624)



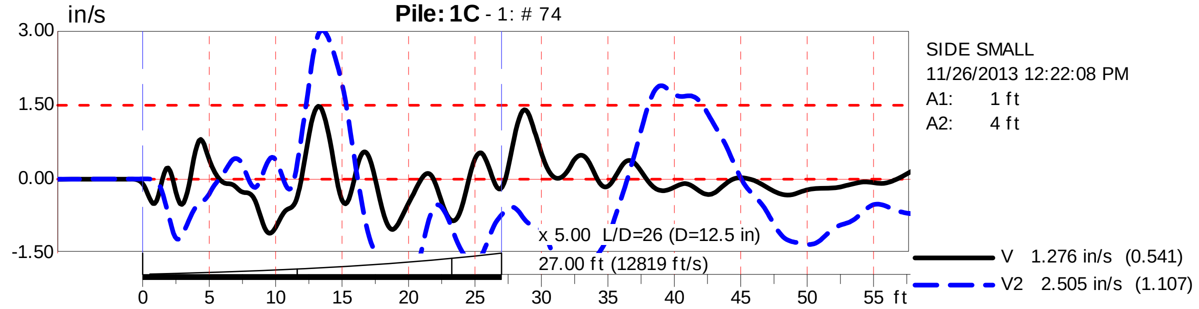
SIDE SMALL
11/26/2013 12:22:54 PM
A1: 1 ft
A2: 4 ft

V 0.773 in/s (0.495)
V2 4.351 in/s (1.884)



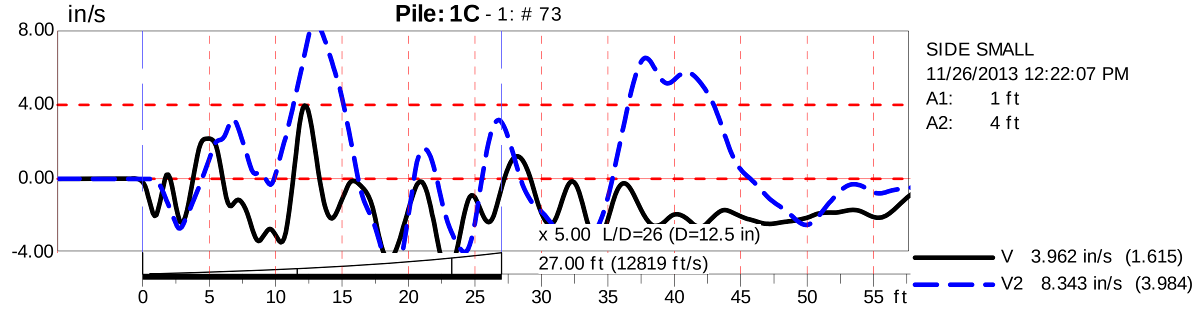
SIDE SMALL
11/26/2013 12:22:10 PM
A1: 1 ft
A2: 4 ft

V 1.498 in/s (0.633)
V2 3.265 in/s (1.464)



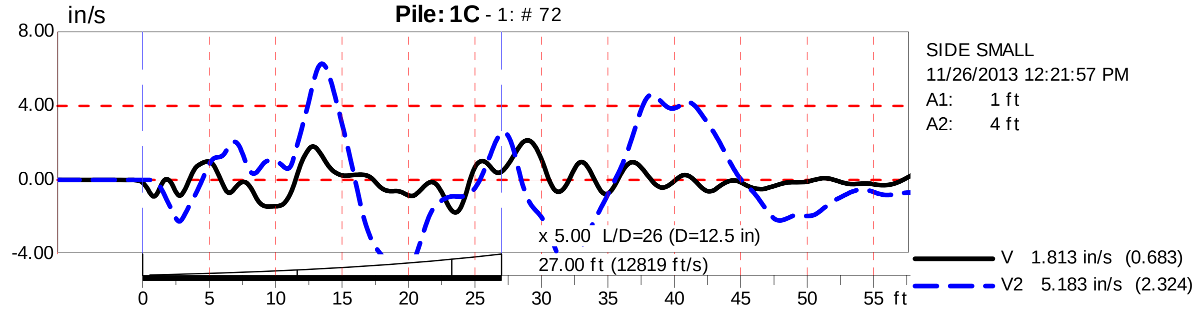
SIDE SMALL
11/26/2013 12:22:08 PM
A1: 1 ft
A2: 4 ft

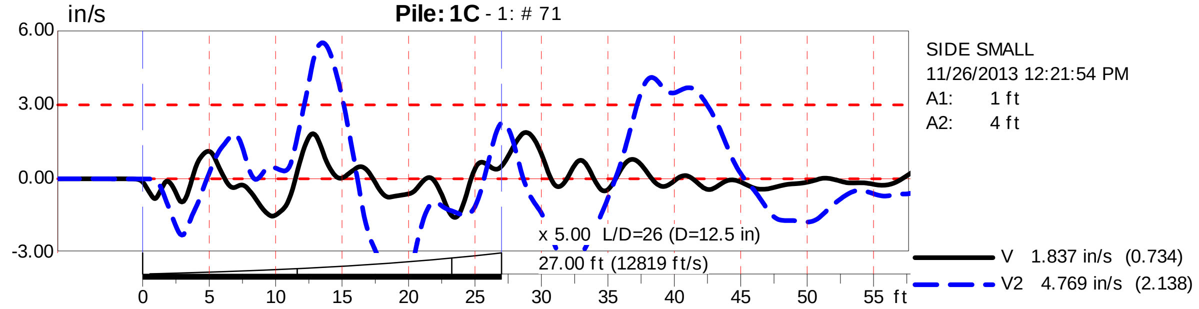
V 1.276 in/s (0.541)
V2 2.505 in/s (1.107)

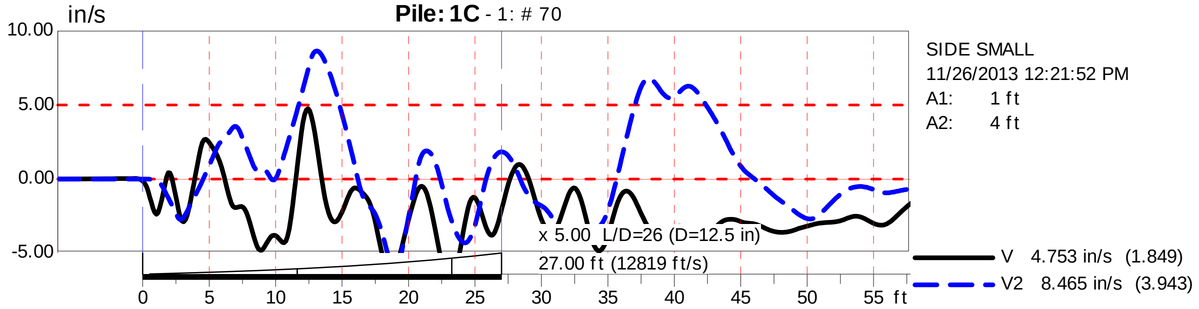


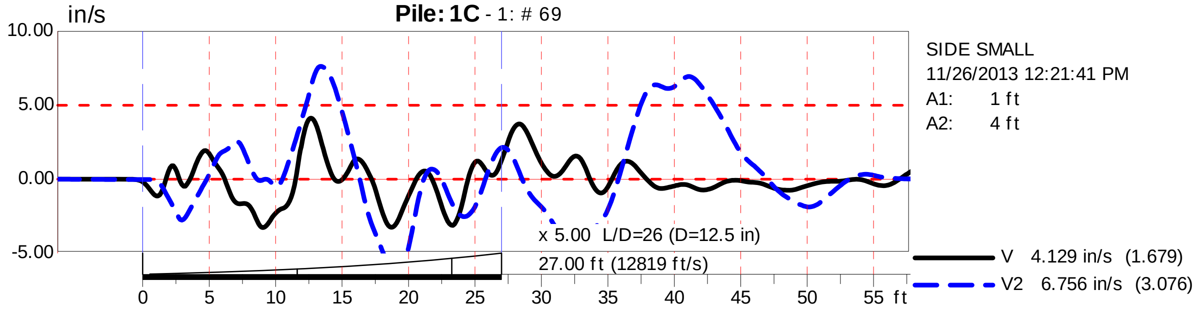
SIDE SMALL
11/26/2013 12:22:07 PM
A1: 1 ft
A2: 4 ft

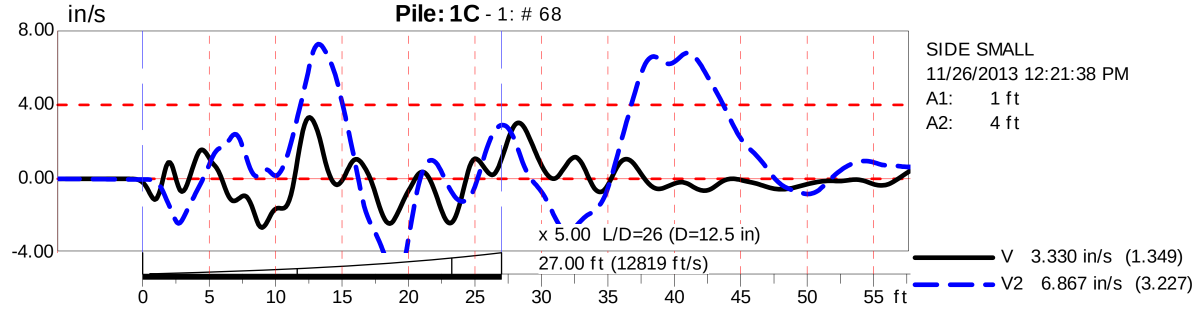
V 3.962 in/s (1.615)
V2 8.343 in/s (3.984)


in/s
Pile: 1C - 1: # 72
8.00
4.00
0.00
-4.00
x 5.00 L/D=26 (D=12.5 in)
27.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:21:57 PM
A1: 1 ft
A2: 4 ft
V 1.813 in/s (0.683)
V2 5.183 in/s (2.324)

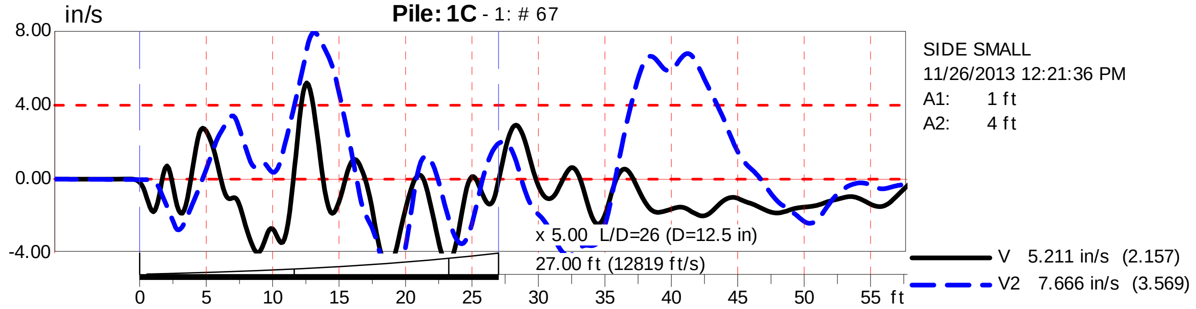

in/s
Pile: 1C - 1: # 71
6.00
3.00
0.00
-3.00
x 5.00 L/D=26 (D=12.5 in)
27.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:21:54 PM
A1: 1 ft
A2: 4 ft
V 1.837 in/s (0.734)
V2 4.769 in/s (2.138)

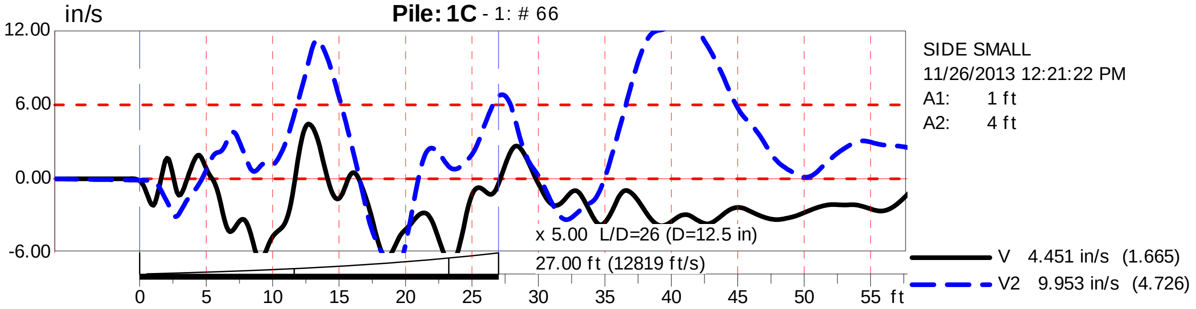

in/s
Pile: 1C - 1: # 70
10.00
5.00
0.00
-5.00
x 5.00 L/D=26 (D=12.5 in)
27.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:21:52 PM
A1: 1 ft
A2: 4 ft
V 4.753 in/s (1.849)
V2 8.465 in/s (3.943)

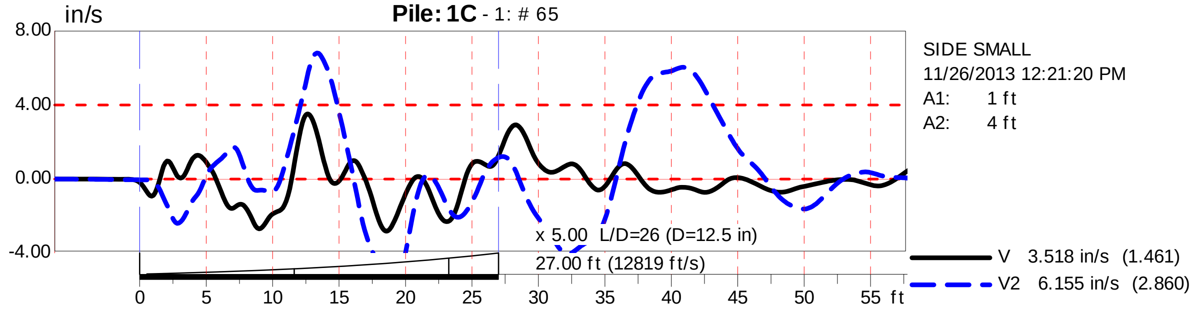

in/s
Pile: 1C - 1: # 69
10.00
5.00
0.00
-5.00
x 5.00 L/D=26 (D=12.5 in)
27.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:21:41 PM
A1: 1 ft
A2: 4 ft
V 4.129 in/s (1.679)
V2 6.756 in/s (3.076)

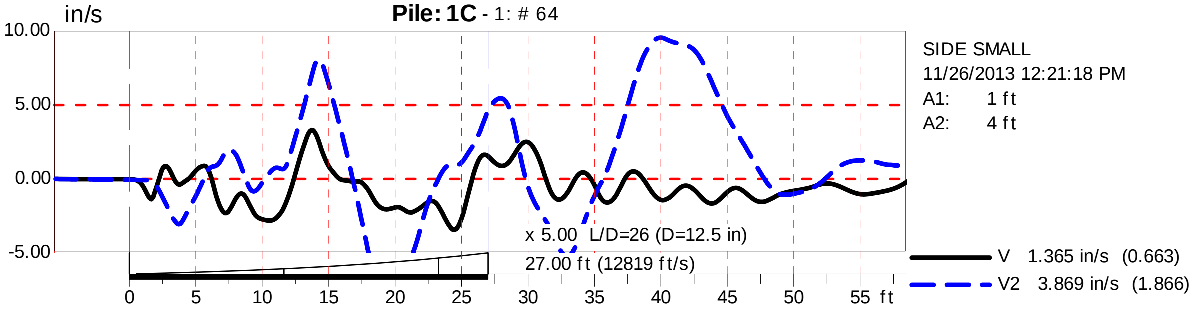

in/s
Pile: 1C - 1: # 68
8.00
4.00
0.00
-4.00
x 5.00 L/D=26 (D=12.5 in)
27.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:21:38 PM
A1: 1 ft
A2: 4 ft
V 3.330 in/s (1.349)
V2 6.867 in/s (3.227)

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 1C - 1: # 67


Pile: 1C - 1: # 66


Pile: 1C - 1: # 65


Pile: 1C - 1: # 64

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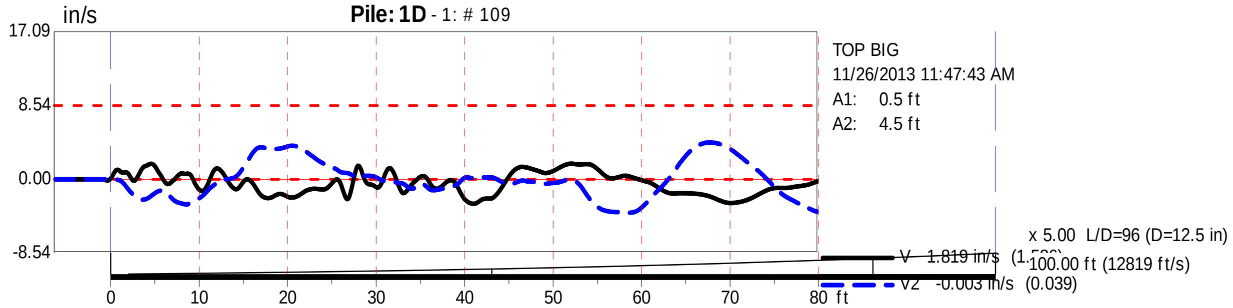
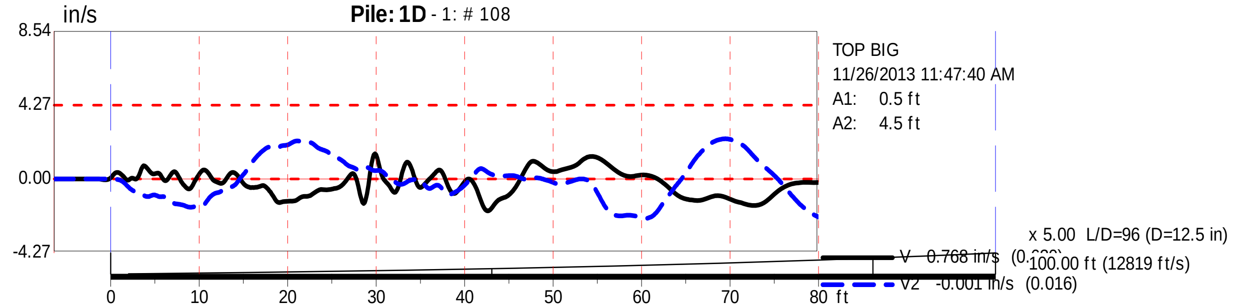
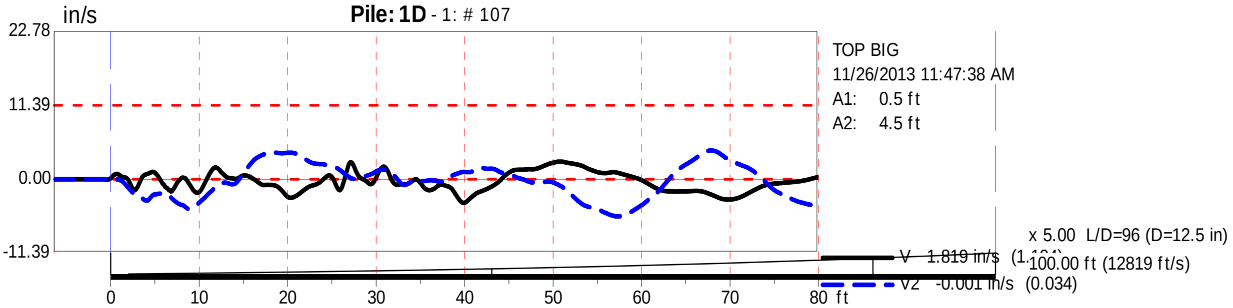
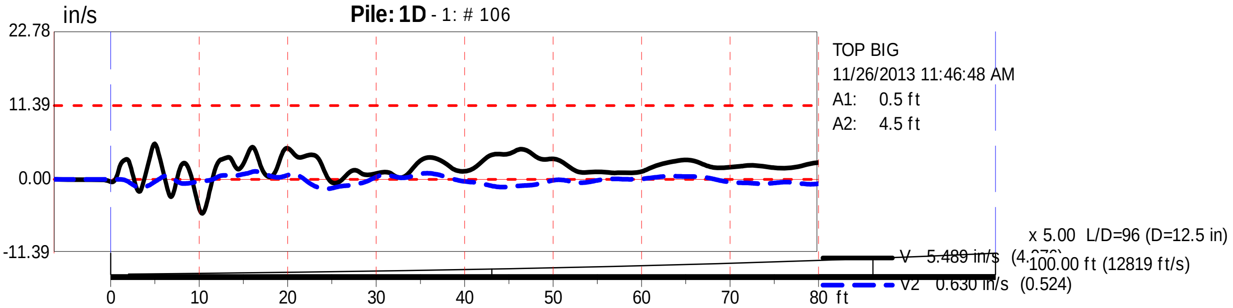
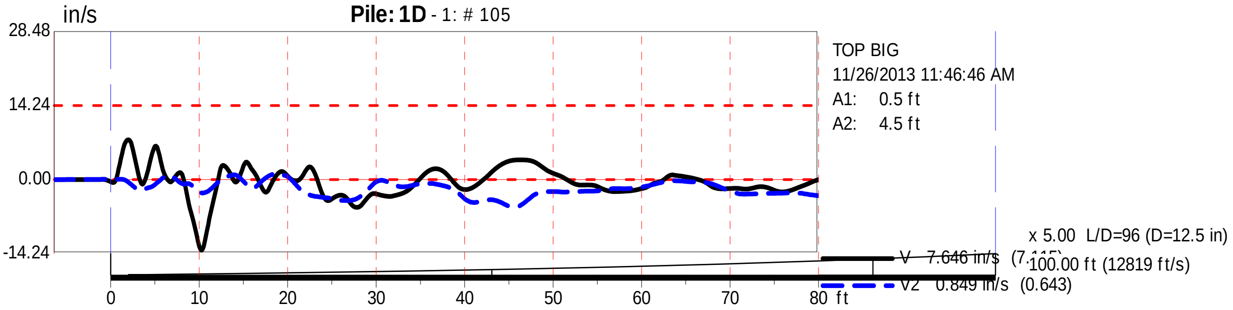
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

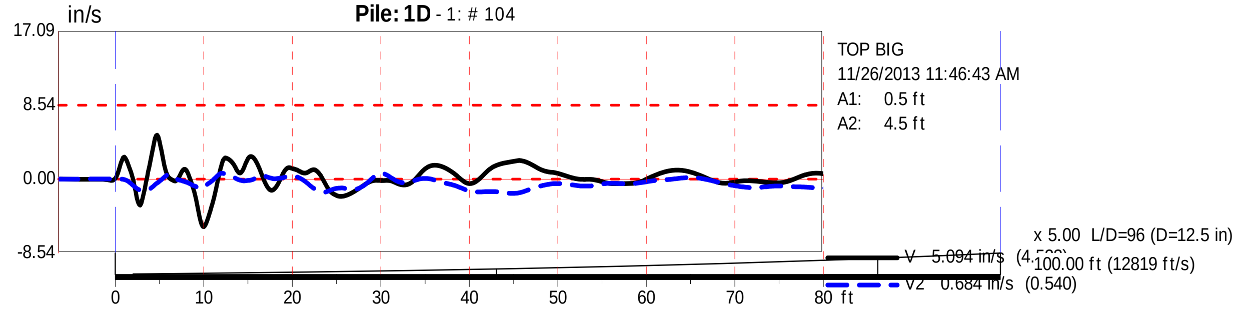


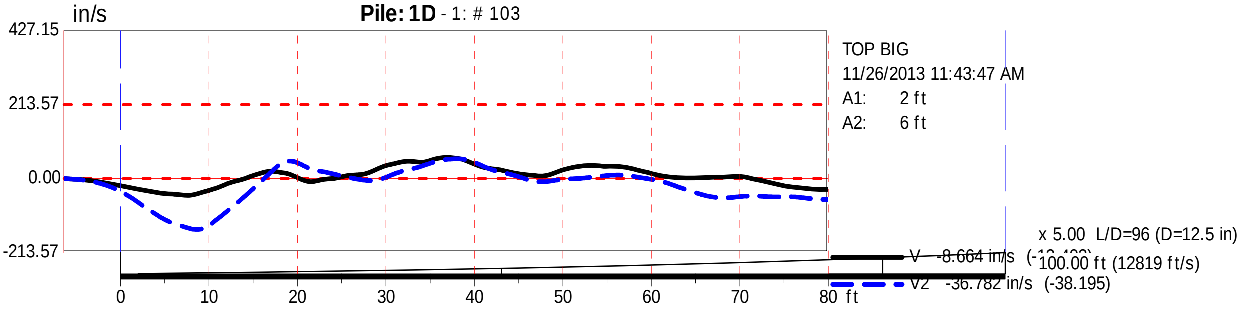


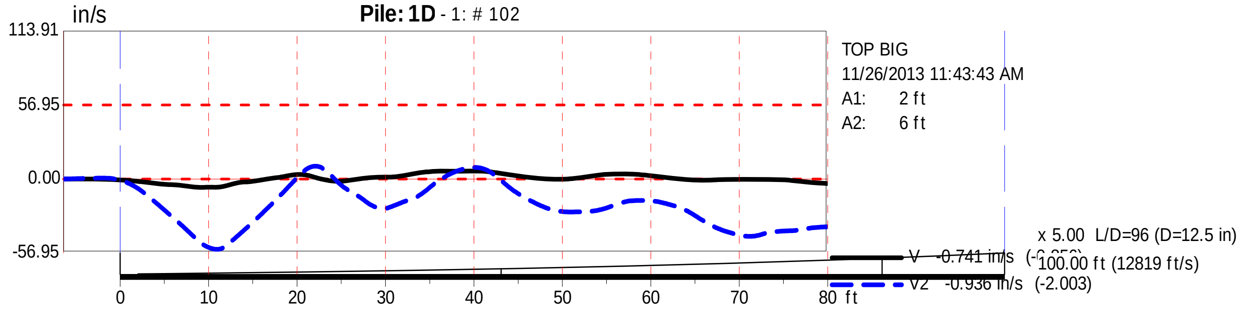


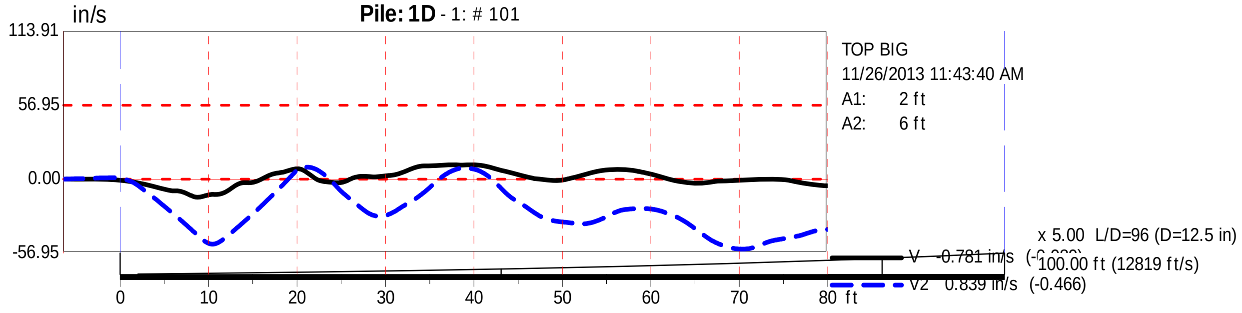


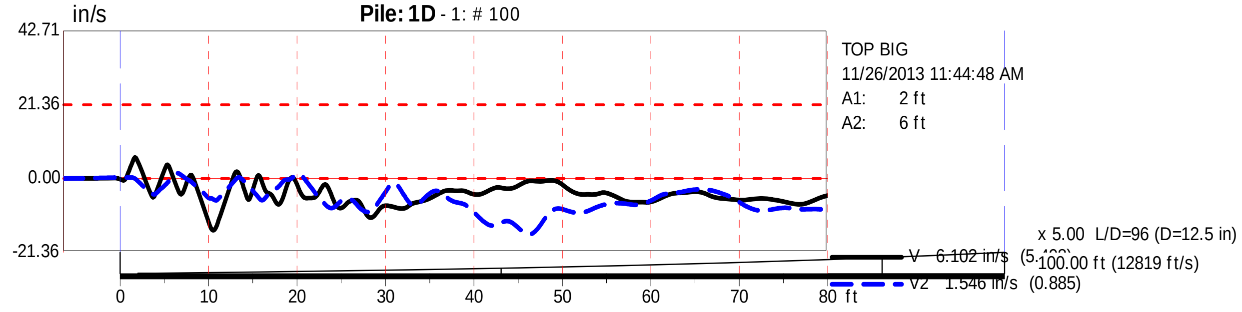


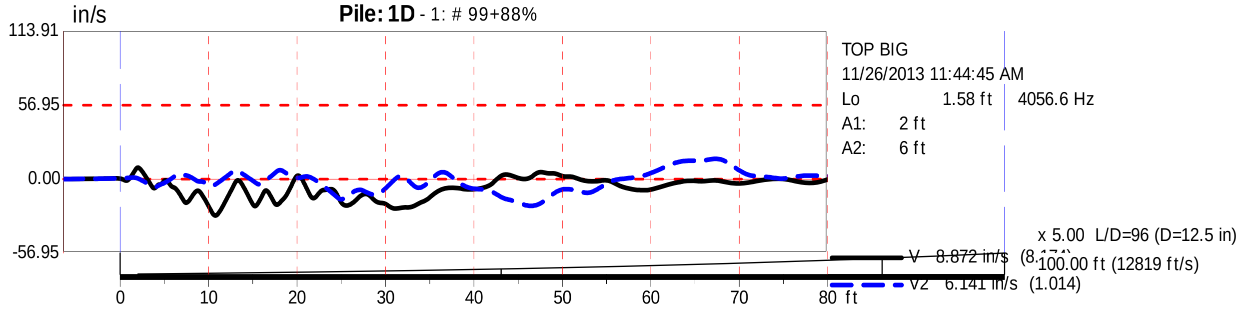

in/s
Pile: 1D - 1: # 104
17.09
8.54
0.00
-8.54
0
10
20
30
40
50
60
70
80 ft
TOP BIG
11/26/2013 11:46:43 AM
A1: 0.5 ft
A2: 4.5 ft
x 5.00 L/D=96 (D=12.5 in)
V 5.094 in/s
100.00 ft (12819 ft/s)
V2 0.684 in/s (0.540)

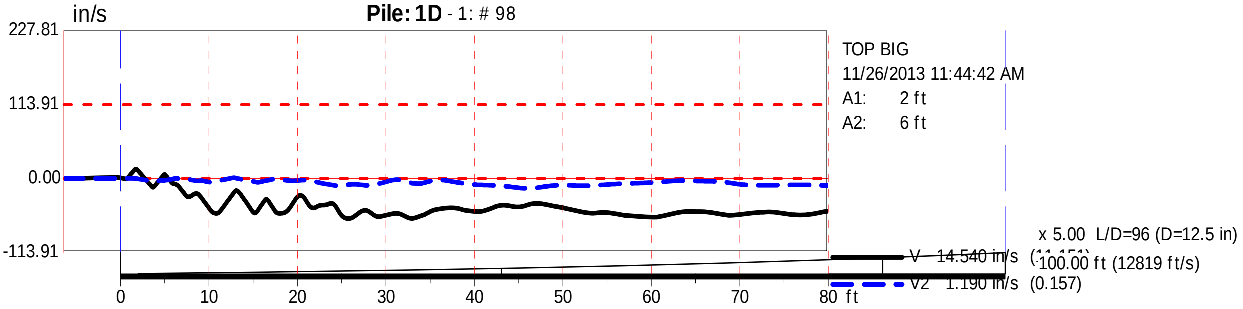

in/s
Pile: 1D - 1: # 103
427.15
213.57
0.00
-213.57
0
10
20
30
40
50
60
70
80 ft
TOP BIG
11/26/2013 11:43:47 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
V -8.664 in/s
100.00 ft (12819 ft/s)
V2 -36.782 in/s (-38.195)

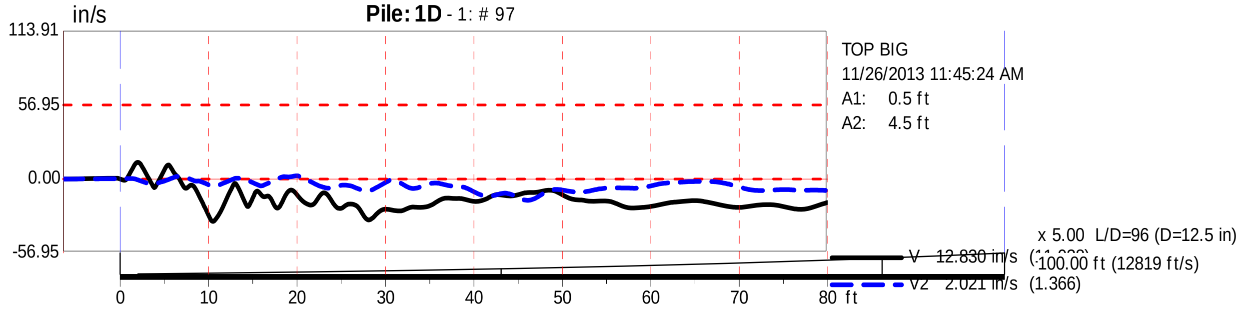

in/s
Pile: 1D - 1: # 102
113.91
56.95
0.00
-56.95
0
10
20
30
40
50
60
70
80 ft
TOP BIG
11/26/2013 11:43:43 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
V -0.741 in/s
100.00 ft (12819 ft/s)
V2 -0.936 in/s (-2.003)

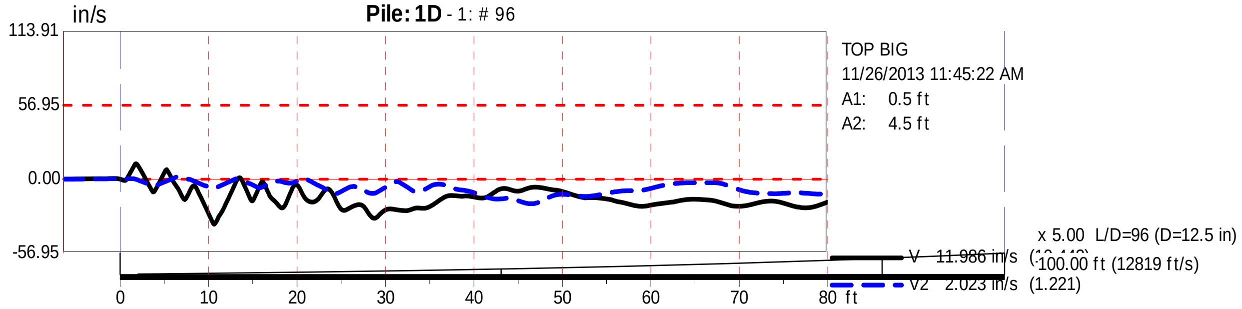

in/s
Pile: 1D - 1: # 101
113.91
56.95
0.00
-56.95
0
10
20
30
40
50
60
70
80 ft
TOP BIG
11/26/2013 11:43:40 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
V -0.781 in/s
100.00 ft (12819 ft/s)
V2 0.839 in/s (-0.466)

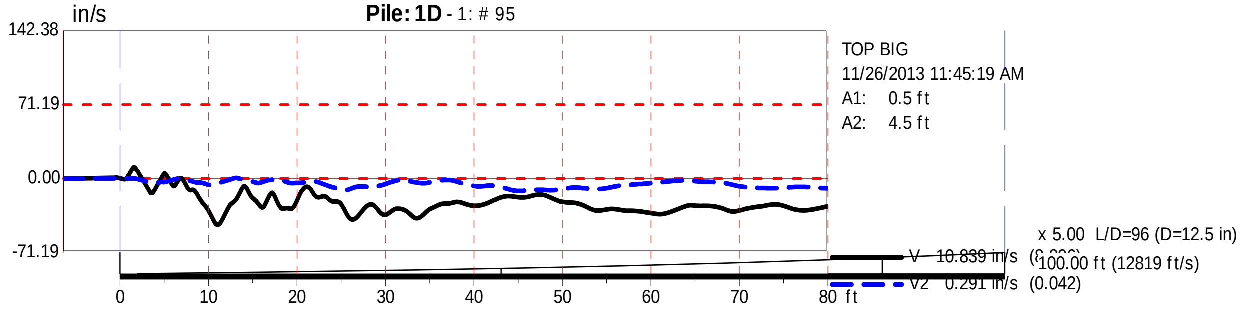

in/s
Pile: 1D - 1: # 100
42.71
21.36
0.00
-21.36
0
10
20
30
40
50
60
70
80 ft
TOP BIG
11/26/2013 11:44:48 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
V 6.102 in/s
100.00 ft (12819 ft/s)
V2 1.546 in/s (0.885)


in/s
Pile: 1D - 1: # 99+88%
113.91
56.95
0.00
-56.95
0 10 20 30 40 50 60 70 80 ft
TOP BIG
11/26/2013 11:44:45 AM
Lo 1.58 ft 4056.6 Hz
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
V 8.872 in/s
100.00 ft (12819 ft/s)
V2 6.141 in/s (1.014)


in/s
Pile: 1D - 1: # 98
227.81
113.91
0.00
-113.91
0 10 20 30 40 50 60 70 80 ft
TOP BIG
11/26/2013 11:44:42 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
V 14.540 in/s
100.00 ft (12819 ft/s)
V2 1.190 in/s (0.157)


in/s
Pile: 1D - 1: # 97
113.91
56.95
0.00
-56.95
0 10 20 30 40 50 60 70 80 ft
TOP BIG
11/26/2013 11:45:24 AM
A1: 0.5 ft
A2: 4.5 ft
x 5.00 L/D=96 (D=12.5 in)
V 12.830 in/s
100.00 ft (12819 ft/s)
V2 2.021 in/s (1.366)


in/s
Pile: 1D - 1: # 96
113.91
56.95
0.00
-56.95
0 10 20 30 40 50 60 70 80 ft
TOP BIG
11/26/2013 11:45:22 AM
A1: 0.5 ft
A2: 4.5 ft
x 5.00 L/D=96 (D=12.5 in)
V 11.986 in/s
100.00 ft (12819 ft/s)
V2 2.023 in/s (1.221)


in/s
Pile: 1D - 1: # 95
142.38
71.19
0.00
-71.19
0 10 20 30 40 50 60 70 80 ft
TOP BIG
11/26/2013 11:45:19 AM
A1: 0.5 ft
A2: 4.5 ft
x 5.00 L/D=96 (D=12.5 in)
V 10.839 in/s
100.00 ft (12819 ft/s)
V2 0.291 in/s (0.042)

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PIT Raw data
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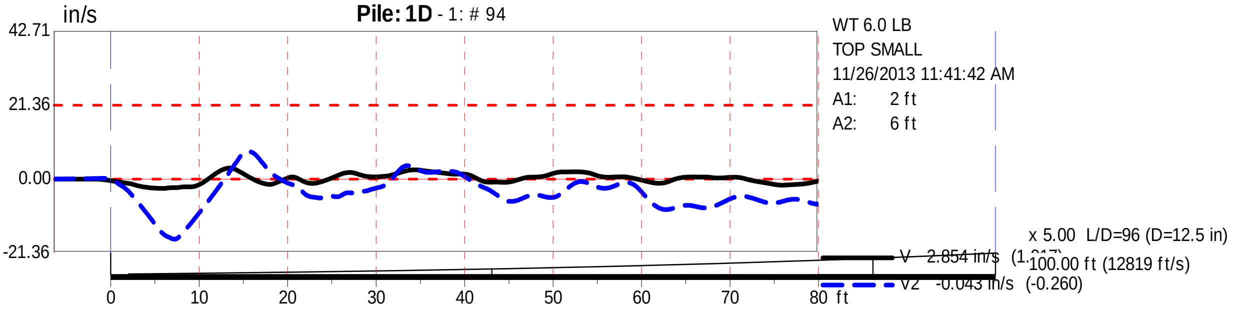
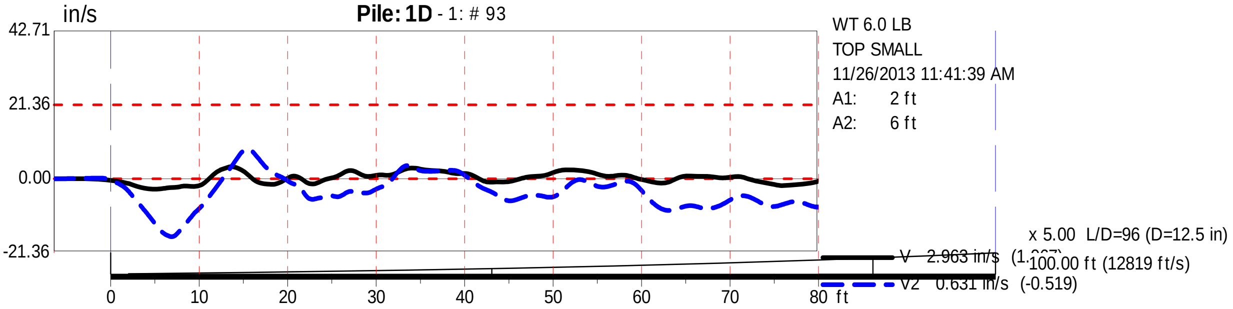
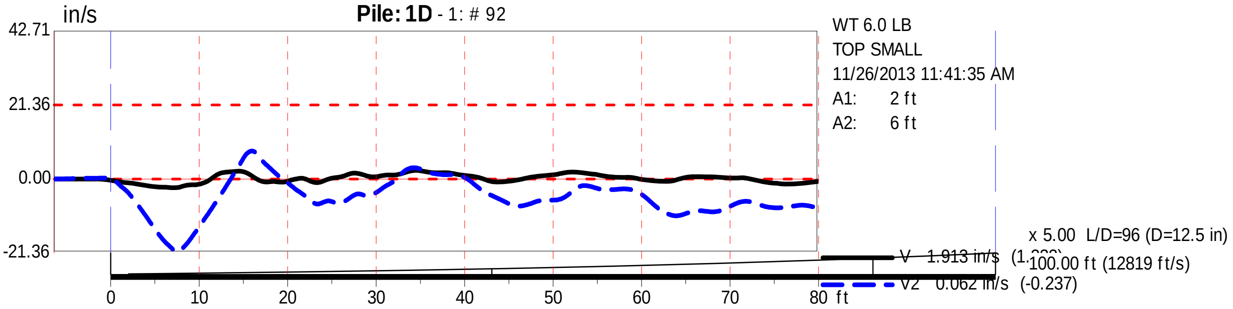


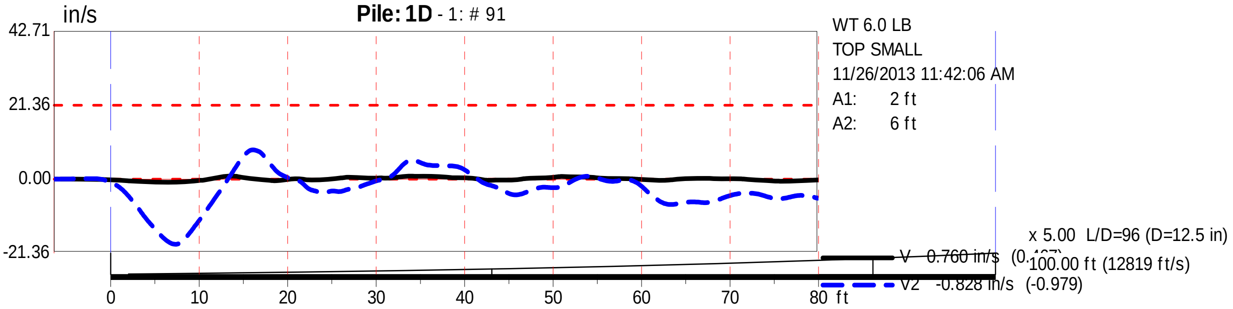
WT 6.0 LB
TOP SMALL
11/26/2013 11:41:42 AM
A1: 2 ft
A2: 6 ft



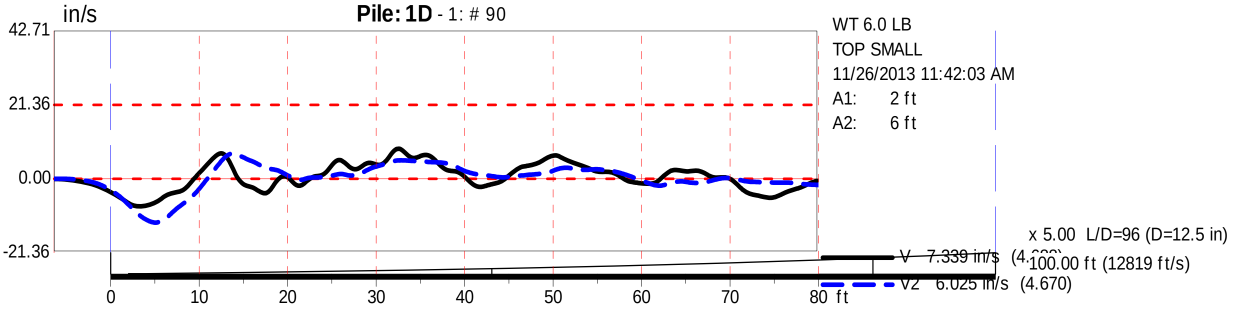
WT 6.0 LB
TOP SMALL
11/26/2013 11:41:39 AM
A1: 2 ft
A2: 6 ft



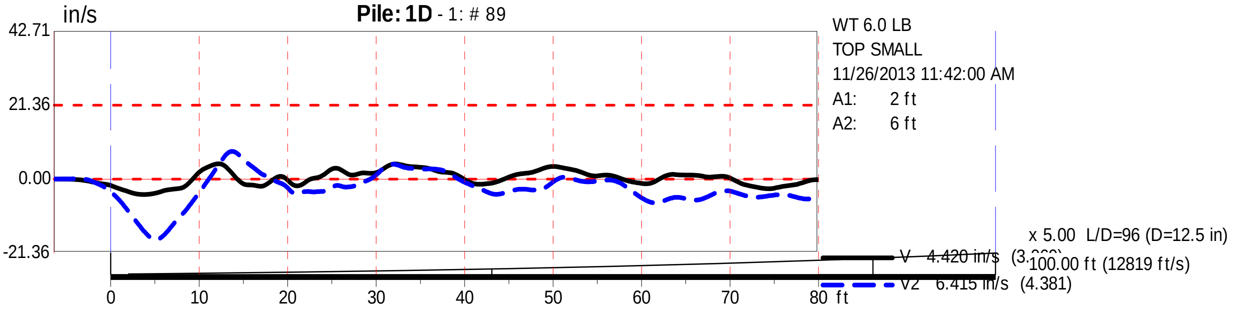
WT 6.0 LB
TOP SMALL
11/26/2013 11:41:35 AM
A1: 2 ft
A2: 6 ft

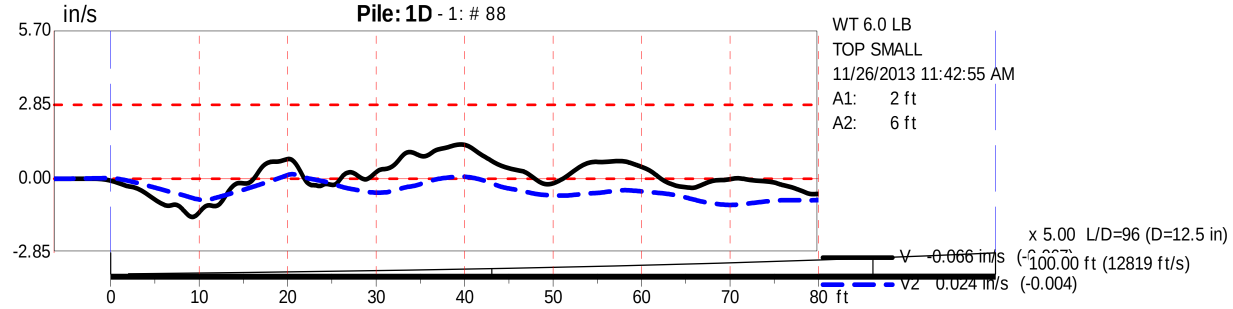


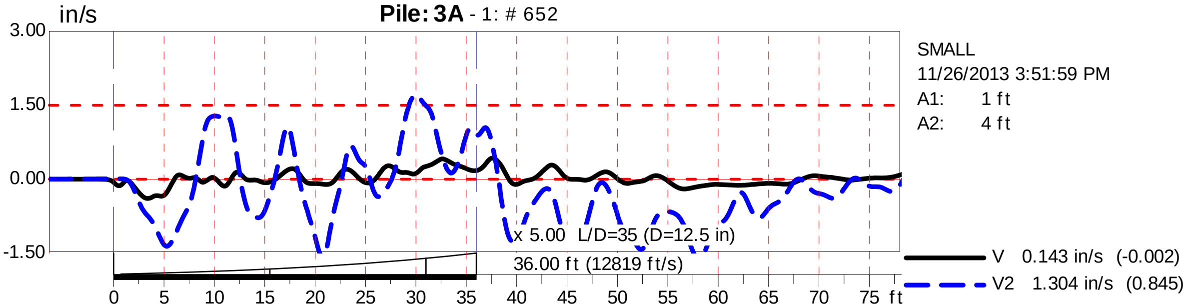
WT 6.0 LB
TOP SMALL
11/26/2013 11:42:06 AM
A1: 2 ft
A2: 6 ft



WT 6.0 LB
TOP SMALL
11/26/2013 11:42:03 AM
A1: 2 ft
A2: 6 ft

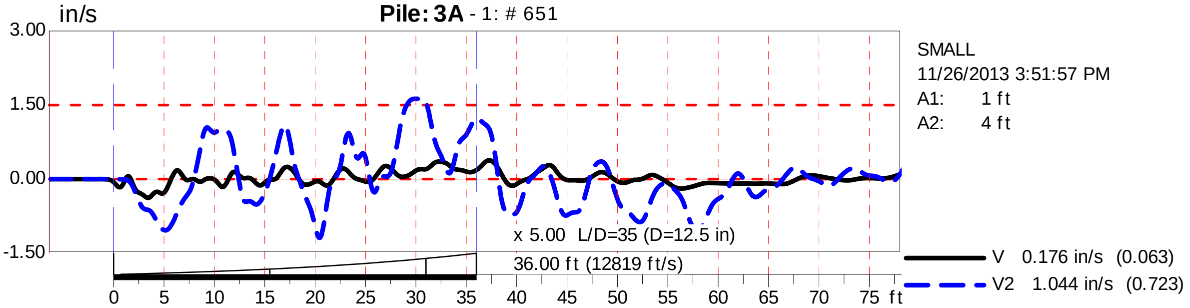

in/s
Pile: 1D - 1: # 89
42.71
21.36
0.00
-21.36
0
10
20
30
40
50
60
70
80 ft
WT 6.0 LB
TOP SMALL
11/26/2013 11:42:00 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V 4.420 in/s
V2 6.415 in/s (4.381)


in/s
Pile: 1D - 1: # 88
5.70
2.85
0.00
-2.85
0
10
20
30
40
50
60
70
80 ft
WT 6.0 LB
TOP SMALL
11/26/2013 11:42:55 AM
A1: 2 ft
A2: 6 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V -0.066 in/s
V2 0.024 in/s (-0.004)



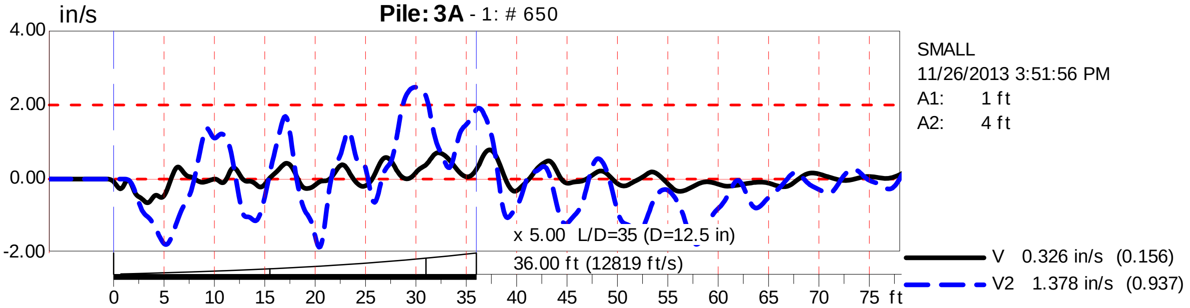
Pile: 3A - 1: # 652

SMALL
11/26/2013 3:51:59 PM
A1: 1 ft
A2: 4 ft



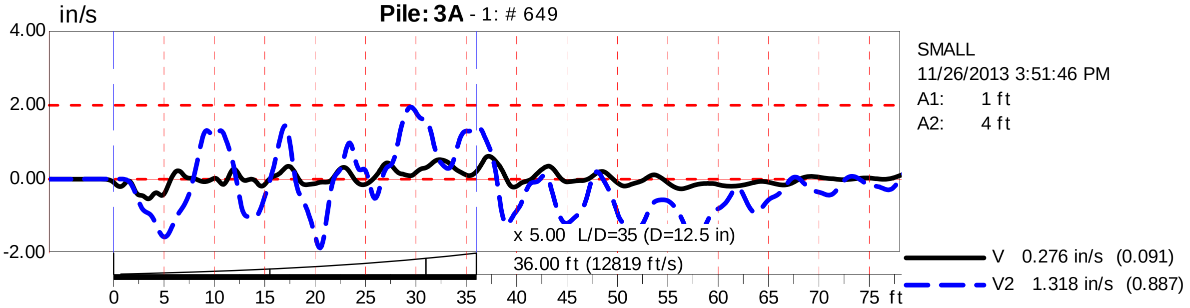
Pile: 3A - 1: # 651

SMALL
11/26/2013 3:51:57 PM
A1: 1 ft
A2: 4 ft



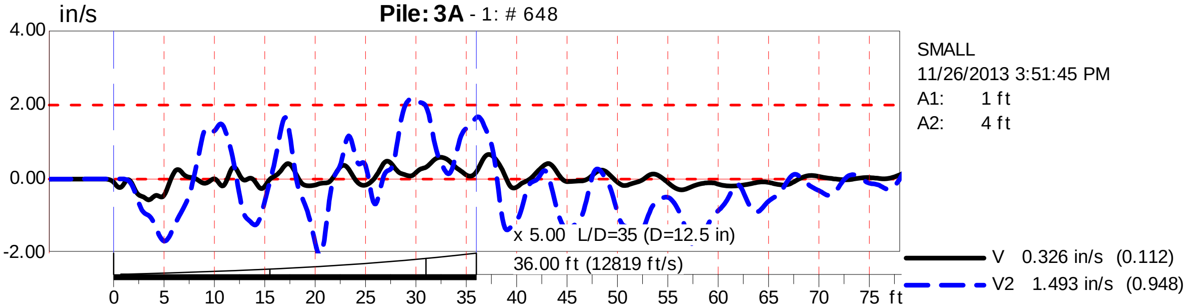
Pile: 3A - 1: # 650

SMALL
11/26/2013 3:51:56 PM
A1: 1 ft
A2: 4 ft



Pile: 3A - 1: # 649

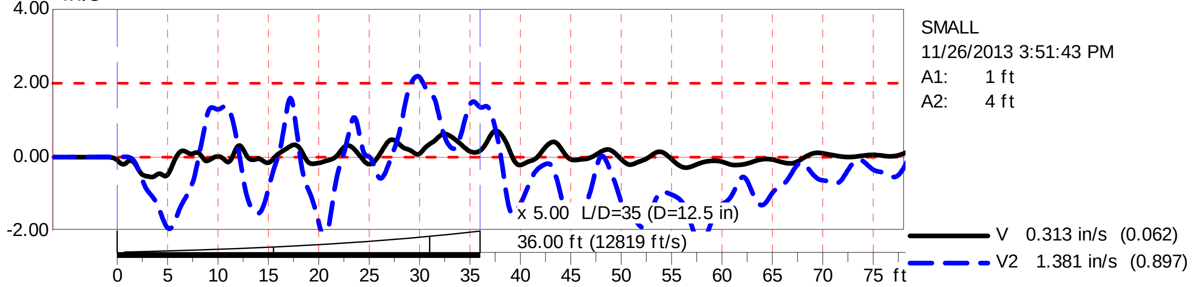
SMALL
11/26/2013 3:51:46 PM
A1: 1 ft
A2: 4 ft



Pile: 3A - 1: # 648

SMALL
11/26/2013 3:51:45 PM
A1: 1 ft
A2: 4 ft

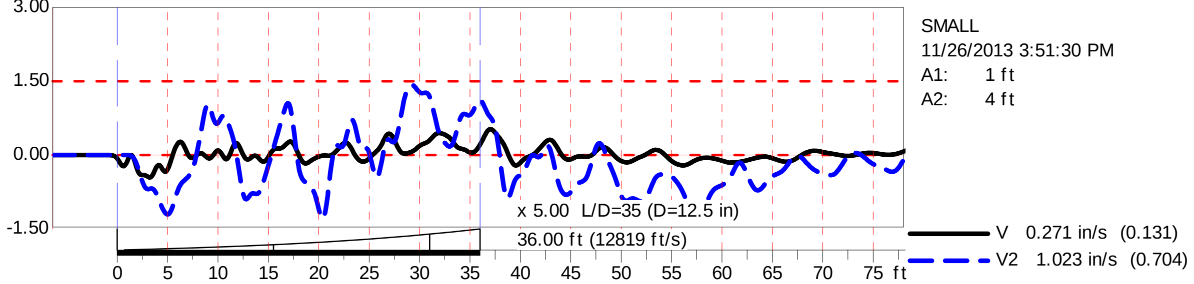
Pile: 3A - 1: # 647



SMALL
11/26/2013 3:51:43 PM
A1: 1 ft
A2: 4 ft

V 0.313 in/s (0.062)
V2 1.381 in/s (0.897)

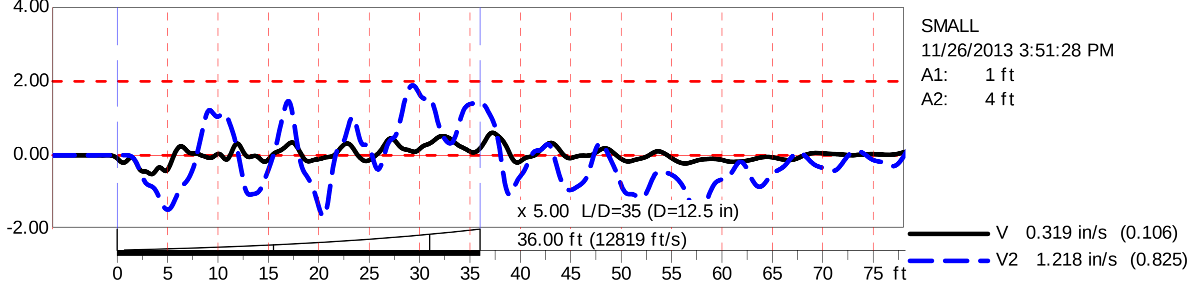
Pile: 3A - 1: # 646



SMALL
11/26/2013 3:51:30 PM
A1: 1 ft
A2: 4 ft

V 0.271 in/s (0.131)
V2 1.023 in/s (0.704)

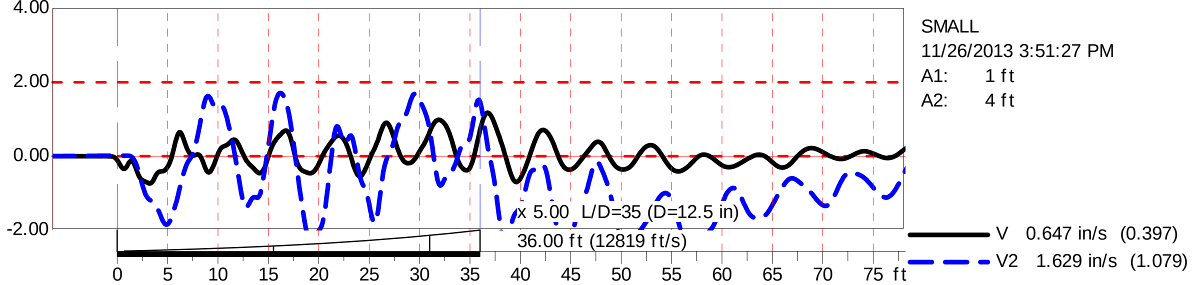
Pile: 3A - 1: # 645



SMALL
11/26/2013 3:51:28 PM
A1: 1 ft
A2: 4 ft

V 0.319 in/s (0.106)
V2 1.218 in/s (0.825)

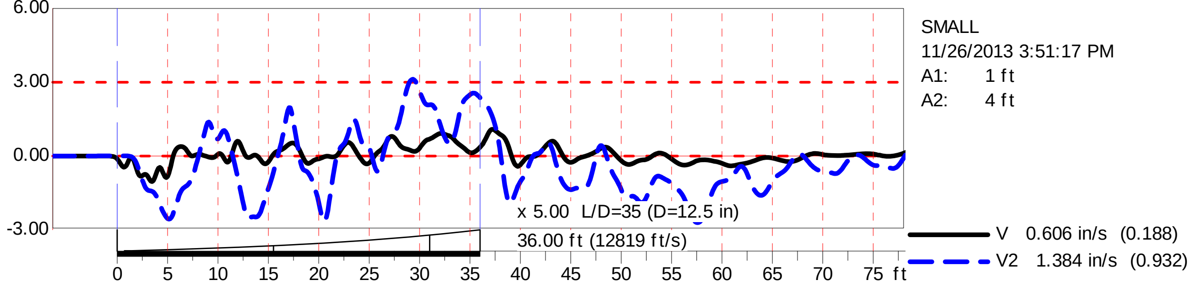
Pile: 3A - 1: # 644



SMALL
11/26/2013 3:51:27 PM
A1: 1 ft
A2: 4 ft

V 0.647 in/s (0.397)
V2 1.629 in/s (1.079)

Pile: 3A - 1: # 643



SMALL
11/26/2013 3:51:17 PM
A1: 1 ft
A2: 4 ft

V 0.606 in/s (0.188)
V2 1.384 in/s (0.932)

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PIT Raw data
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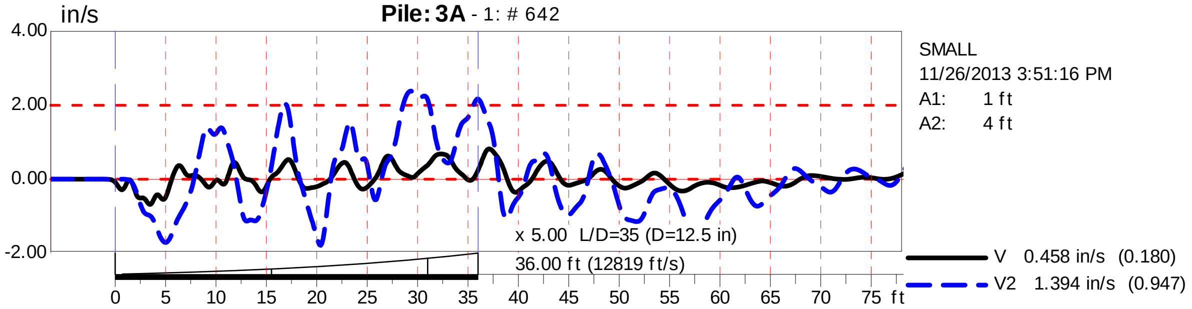
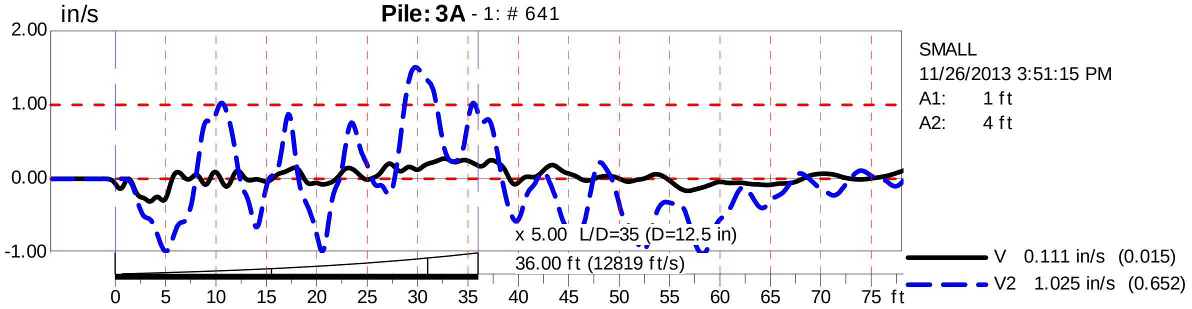
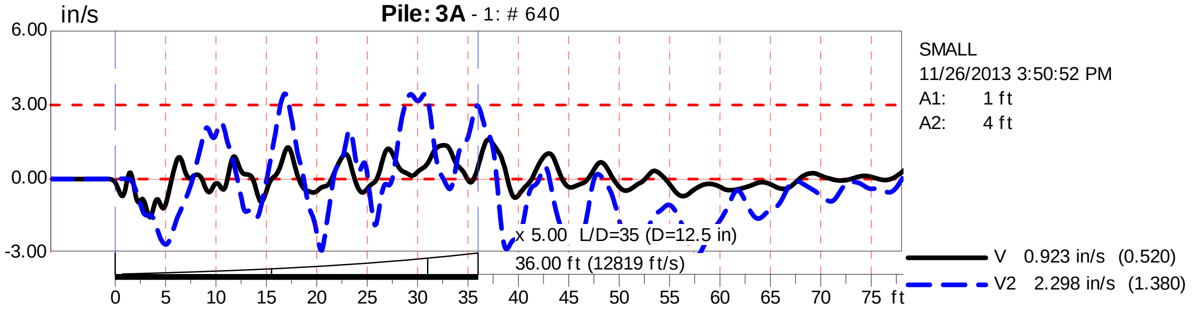
Pile: 3A - 1: # 642



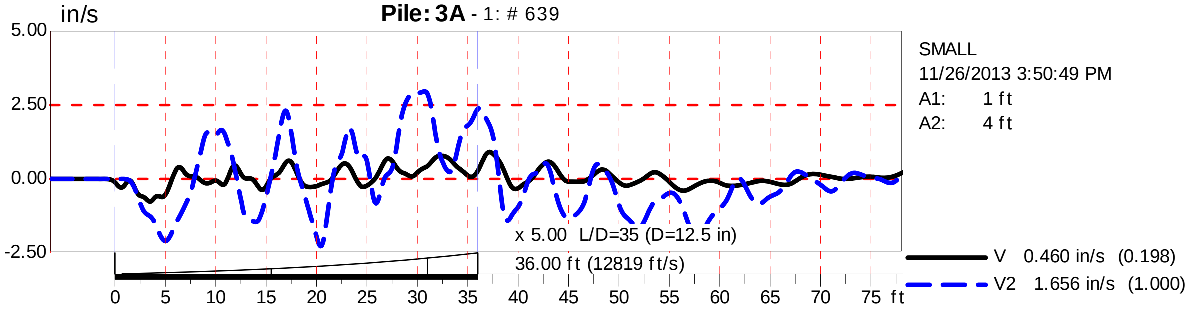
Pile: 3A - 1: # 641



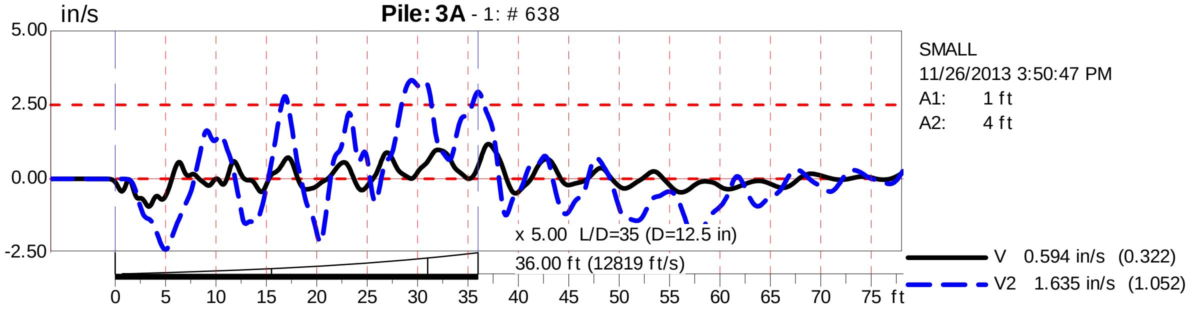
Pile: 3A - 1: # 640

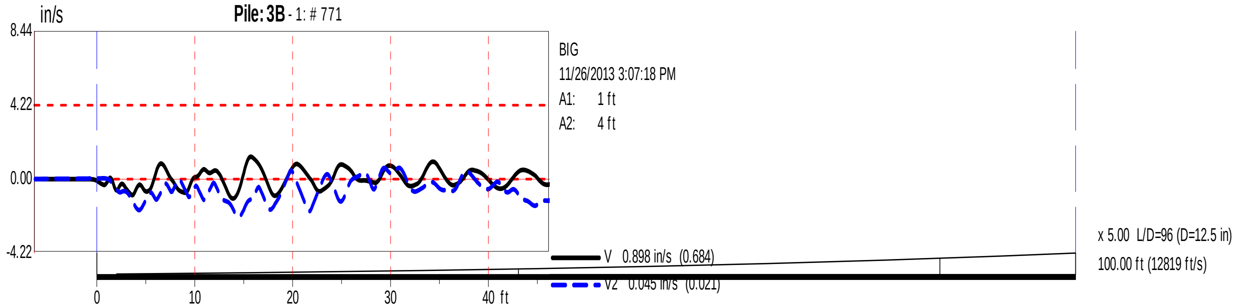


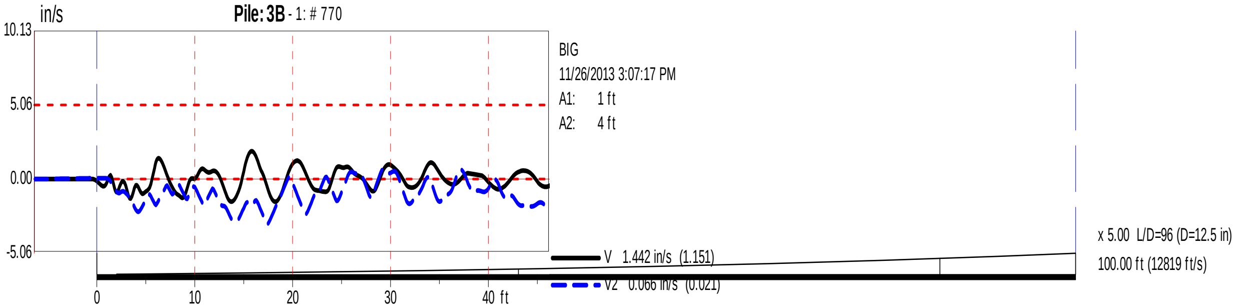
Pile: 3A - 1: # 639

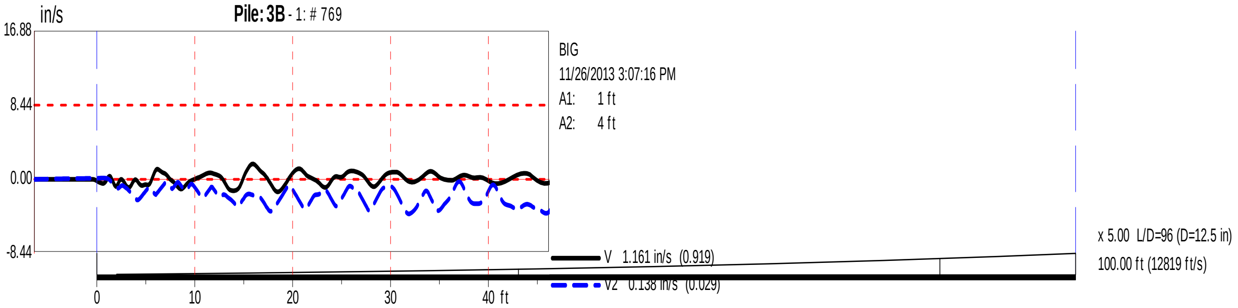


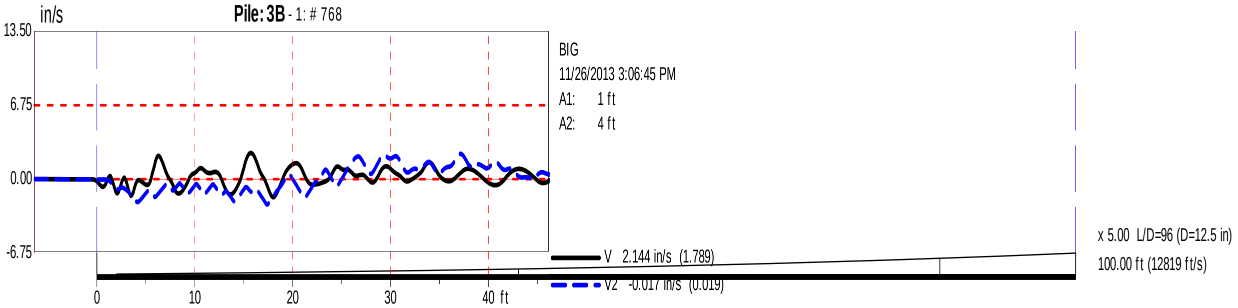
Pile: 3A - 1: # 638

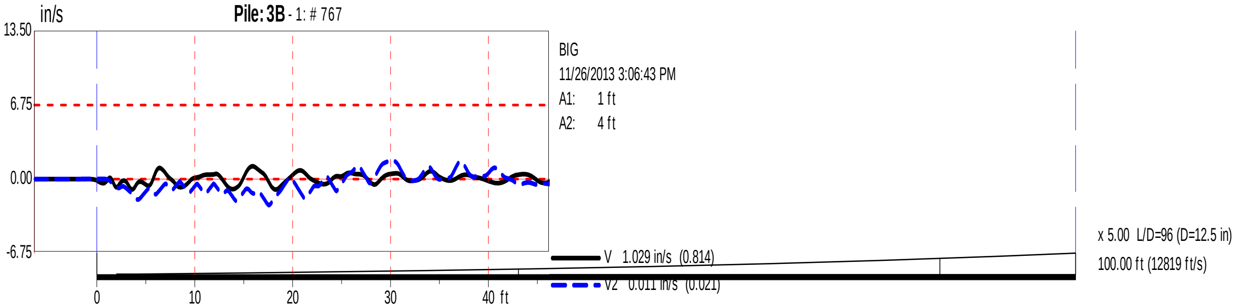



in/s
Pile: 3B - 1: # 771
8.44
4.22
0.00
-4.22
BIG
11/26/2013 3:07:18 PM
A1: 1 ft
A2: 4 ft
V 0.898 in/s (0.684)
V2 0.045 in/s (0.021)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40 ft


in/s
Pile: 3B - 1: # 770
10.13
5.06
0.00
-5.06
BIG
11/26/2013 3:07:17 PM
A1: 1 ft
A2: 4 ft
V 1.442 in/s (1.151)
V2 0.066 in/s (0.021)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40 ft


in/s
Pile: 3B - 1: # 769
16.88
8.44
0.00
-8.44
BIG
11/26/2013 3:07:16 PM
A1: 1 ft
A2: 4 ft
V 1.161 in/s (0.919)
V2 0.138 in/s (0.029)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40 ft


in/s
Pile: 3B - 1: # 768
13.50
6.75
0.00
-6.75
BIG
11/26/2013 3:06:45 PM
A1: 1 ft
A2: 4 ft
V 2.144 in/s (1.789)
V2 -0.017 in/s (0.019)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40 ft


in/s
Pile: 3B - 1: # 767
13.50
6.75
0.00
-6.75
BIG
11/26/2013 3:06:43 PM
A1: 1 ft
A2: 4 ft
V 1.029 in/s (0.814)
V2 0.011 in/s (0.021)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40 ft

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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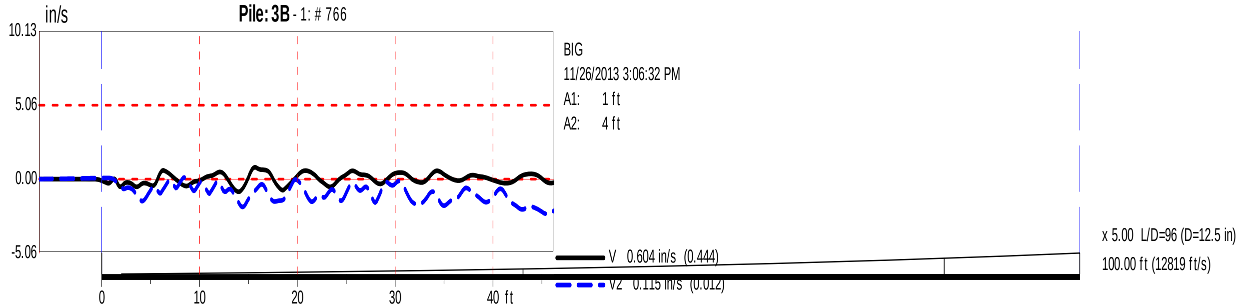
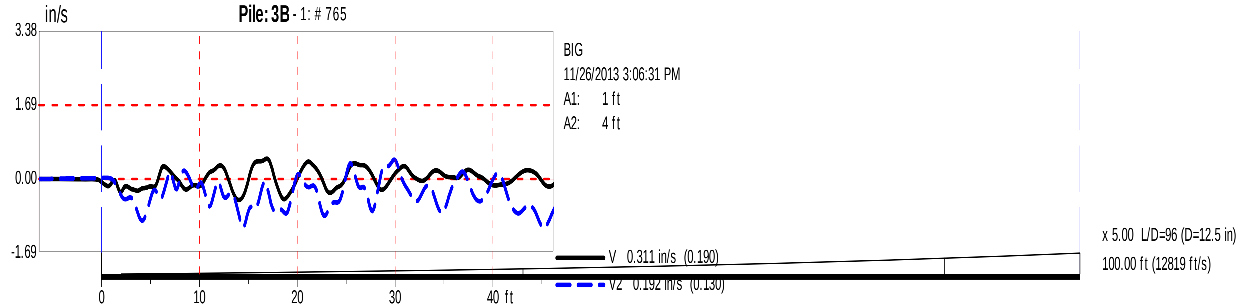
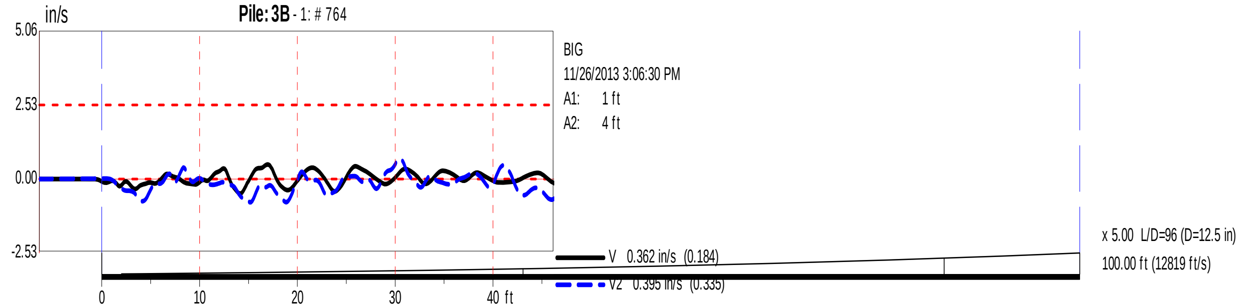
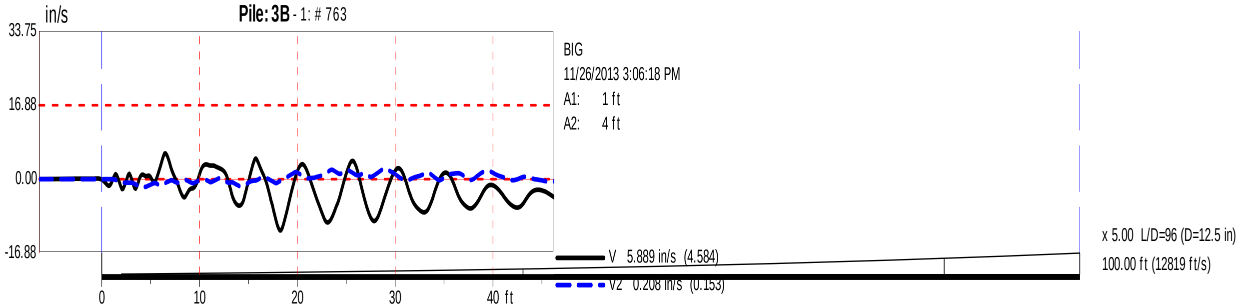
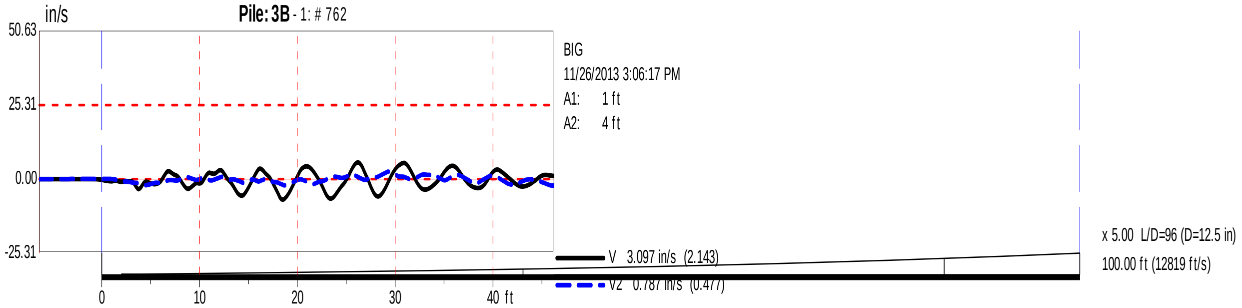
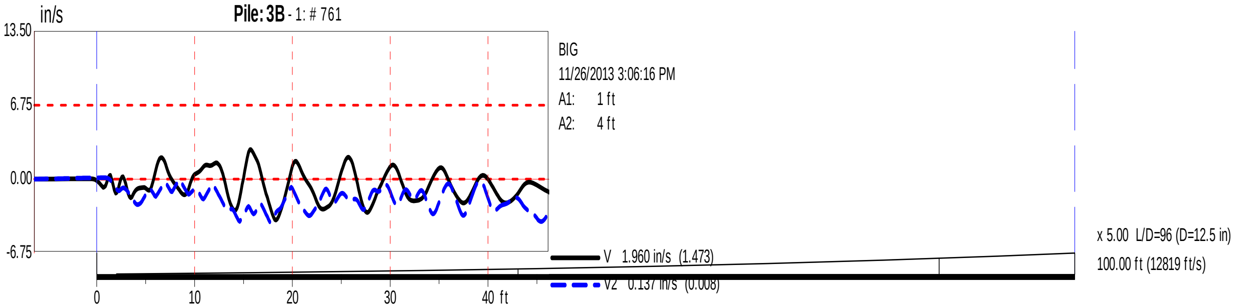


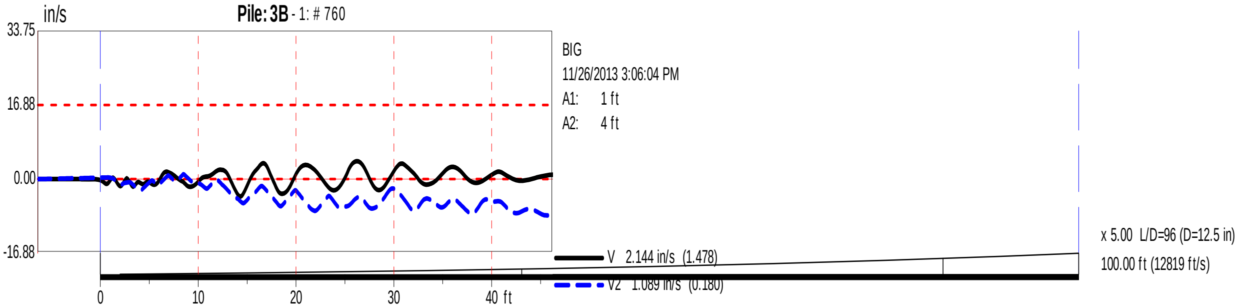


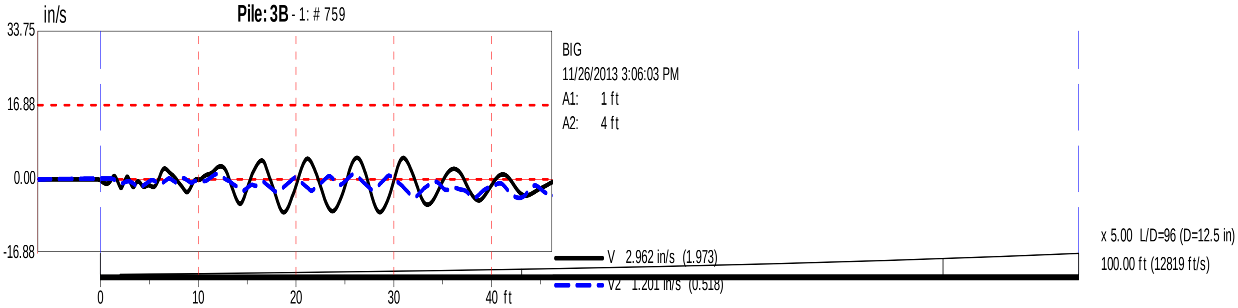


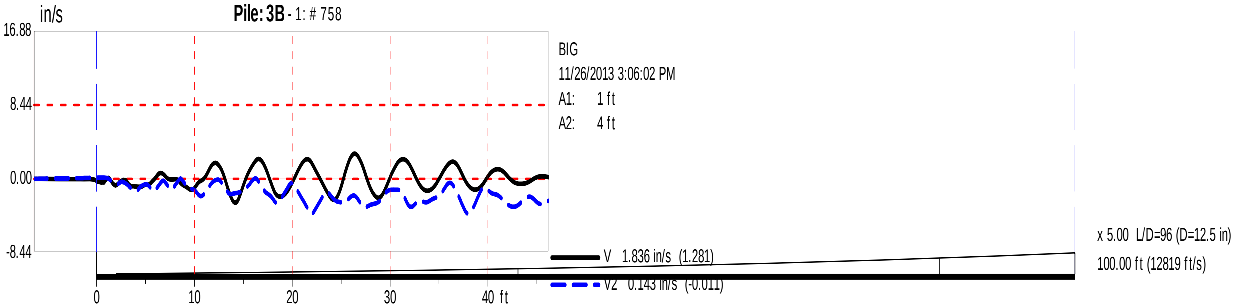





in/s
Pile: 3B - 1: # 761
13.50
6.75
0.00
-6.75
0
10
20
30
40 ft
BIG
11/26/2013 3:06:16 PM
A1: 1 ft
A2: 4 ft
V 1.960 in/s (1.473)
V2 0.137 in/s (0.008)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3B - 1: # 760
33.75
16.88
0.00
-16.88
0
10
20
30
40 ft
BIG
11/26/2013 3:06:04 PM
A1: 1 ft
A2: 4 ft
V 2.144 in/s (1.478)
V2 1.089 in/s (0.180)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3B - 1: # 759
33.75
16.88
0.00
-16.88
0
10
20
30
40 ft
BIG
11/26/2013 3:06:03 PM
A1: 1 ft
A2: 4 ft
V 2.962 in/s (1.973)
V2 1.201 in/s (0.518)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3B - 1: # 758
16.88
8.44
0.00
-8.44
0
10
20
30
40 ft
BIG
11/26/2013 3:06:02 PM
A1: 1 ft
A2: 4 ft
V 1.836 in/s (1.281)
V2 0.143 in/s (-0.011)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

Pile Dynamics, Inc. 12/29/2013
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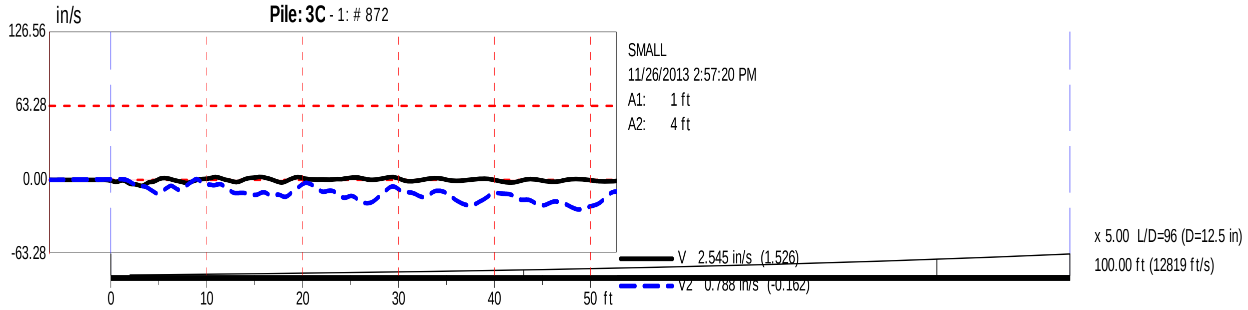
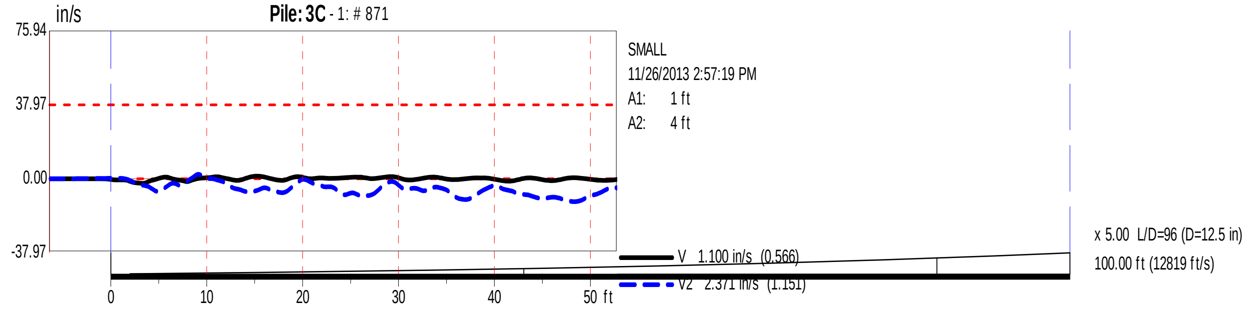
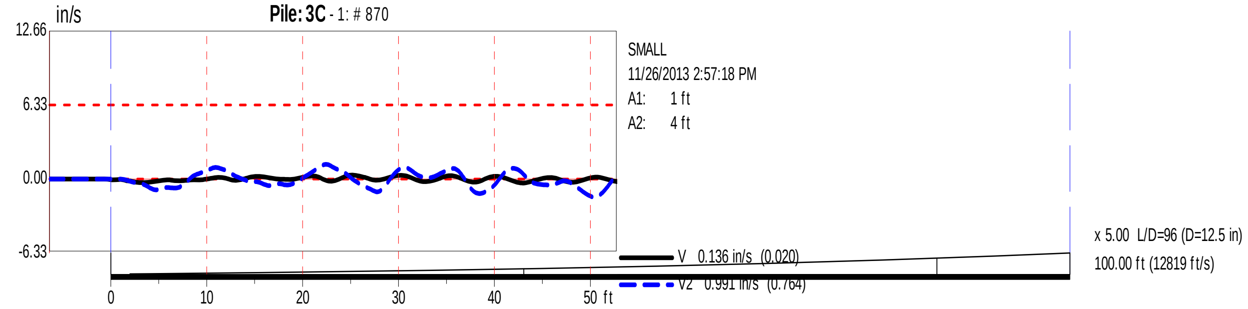
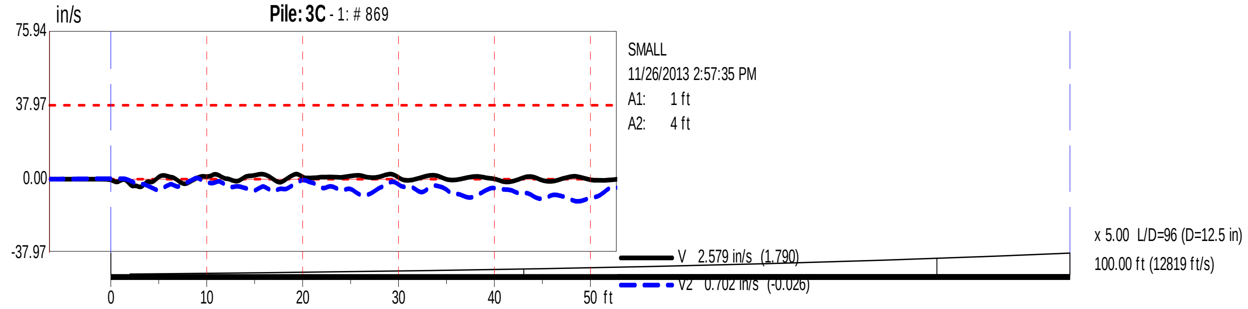
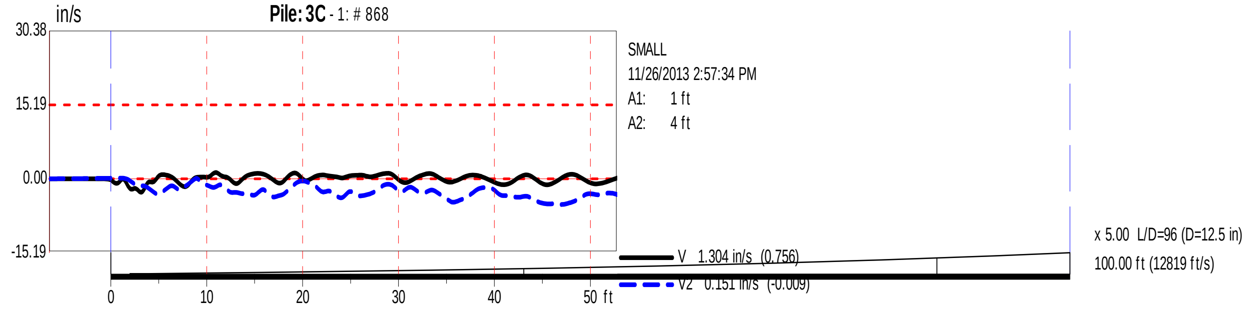
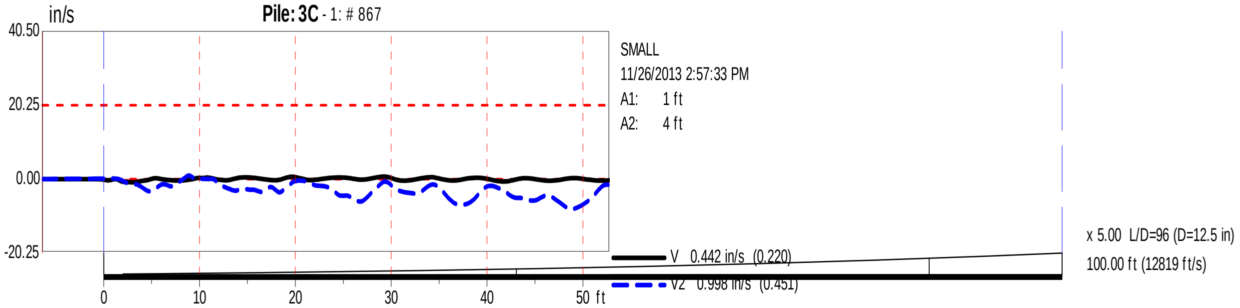


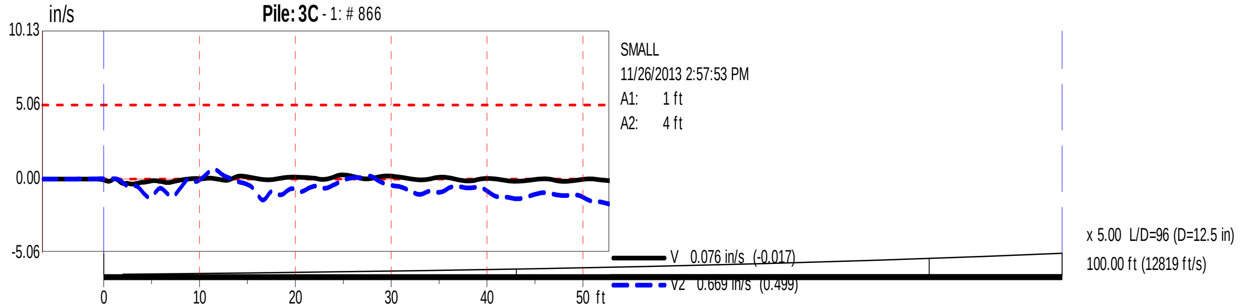


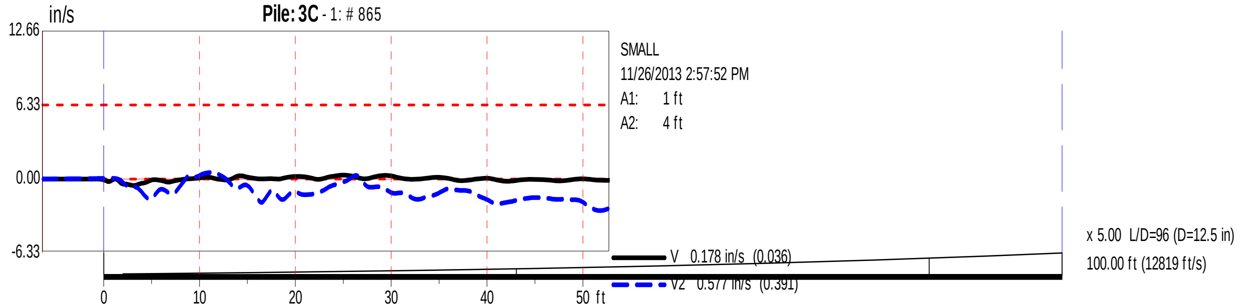


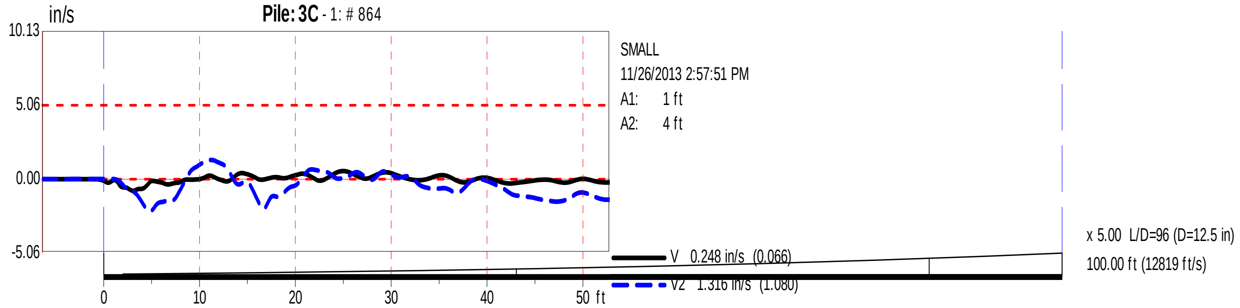


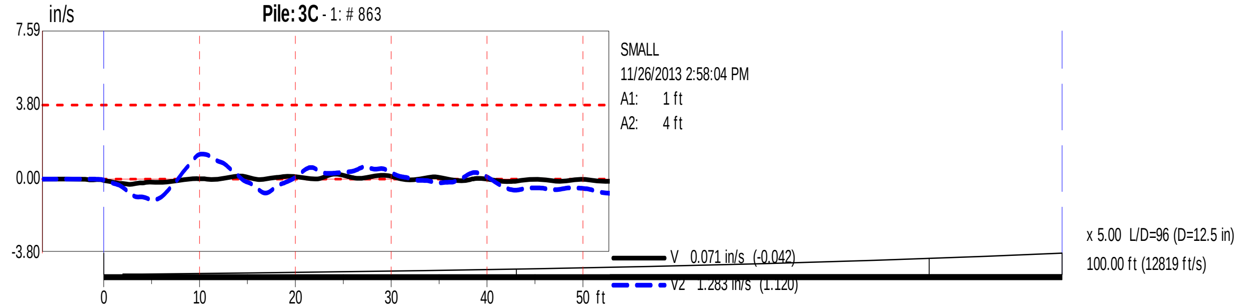



in/s
Pile: 3C - 1: # 867
40.50
20.25
0.00
-20.25
0
10
20
30
40
50 ft
SMALL
11/26/2013 2:57:33 PM
A1: 1 ft
A2: 4 ft
V 0.442 in/s (0.220)
V2 0.998 in/s (0.451)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3C - 1: # 866
10.13
5.06
0.00
-5.06
0
10
20
30
40
50 ft
SMALL
11/26/2013 2:57:53 PM
A1: 1 ft
A2: 4 ft
V 0.076 in/s (-0.017)
V2 0.669 in/s (0.499)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3C - 1: # 865
12.66
6.33
0.00
-6.33
0
10
20
30
40
50 ft
SMALL
11/26/2013 2:57:52 PM
A1: 1 ft
A2: 4 ft
V 0.178 in/s (0.036)
V2 0.577 in/s (0.391)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3C - 1: # 864
10.13
5.06
0.00
-5.06
0
10
20
30
40
50 ft
SMALL
11/26/2013 2:57:51 PM
A1: 1 ft
A2: 4 ft
V 0.248 in/s (0.066)
V2 1.316 in/s (1.080)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 3C - 1: # 863
7.59
3.80
0.00
-3.80
0
10
20
30
40
50 ft
SMALL
11/26/2013 2:58:04 PM
A1: 1 ft
A2: 4 ft
V 0.071 in/s (-0.042)
V2 1.283 in/s (1.120)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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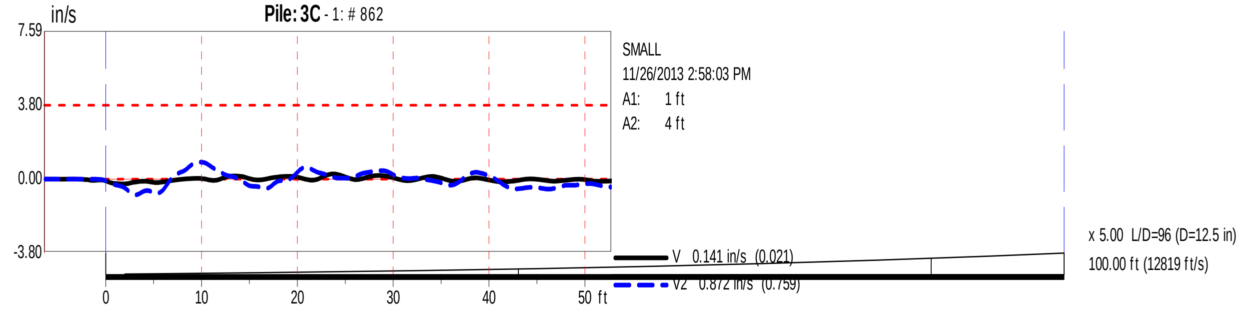
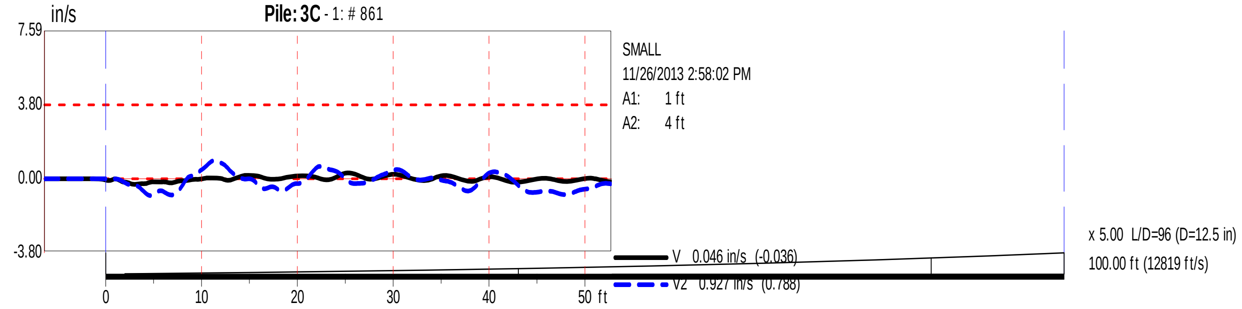
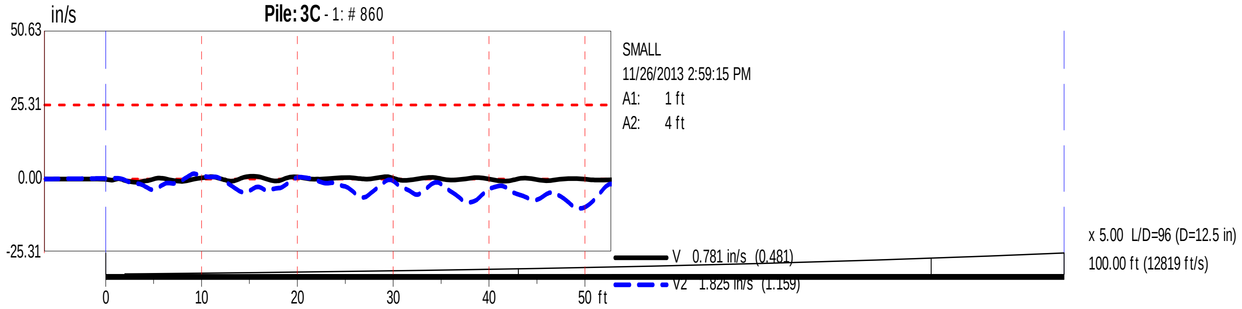
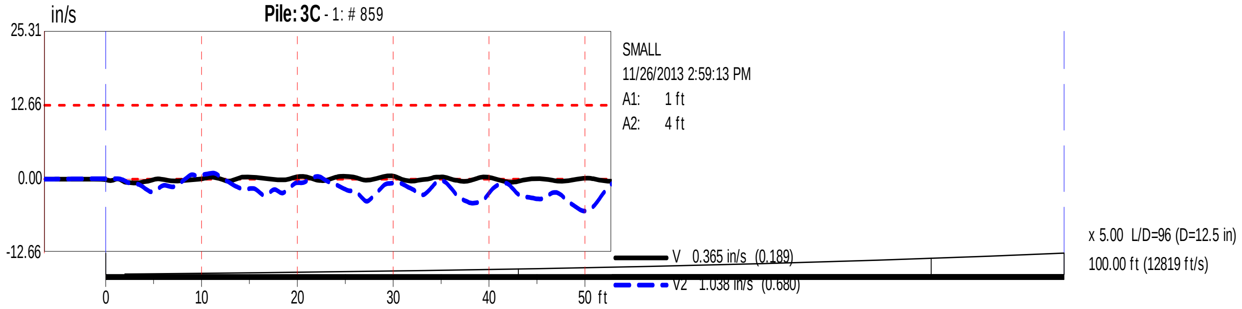
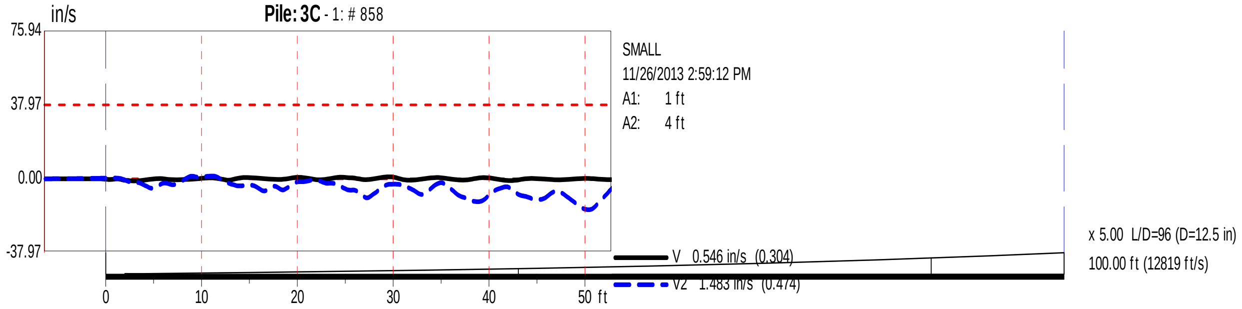
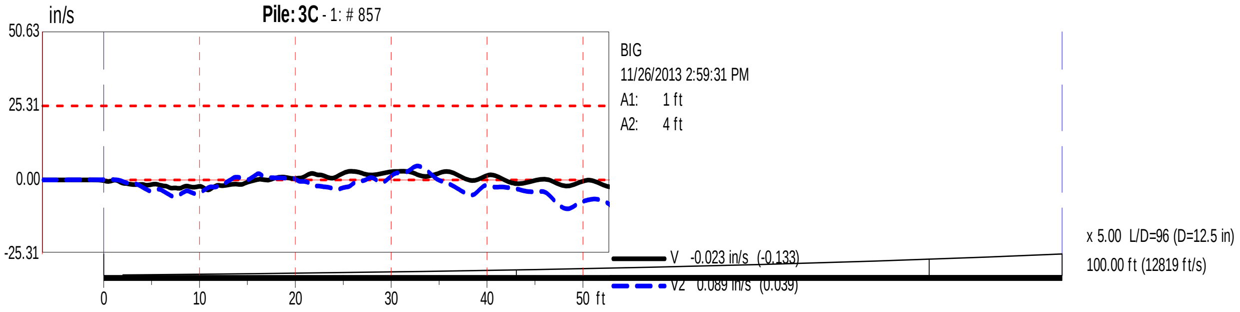


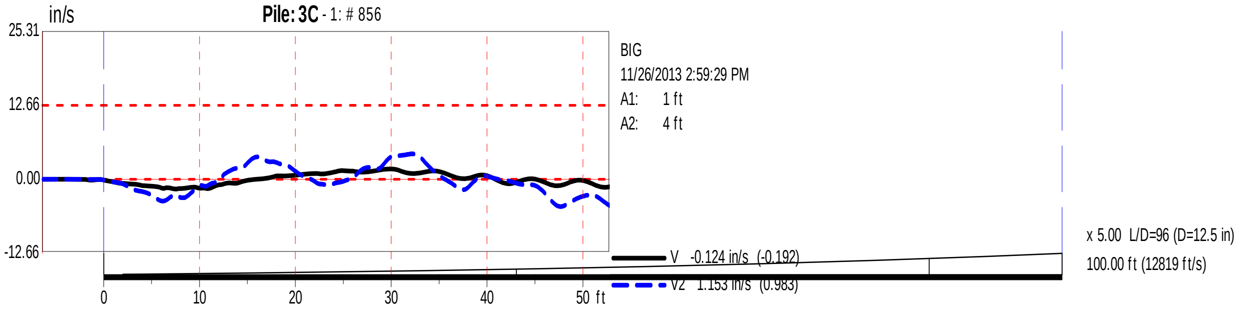


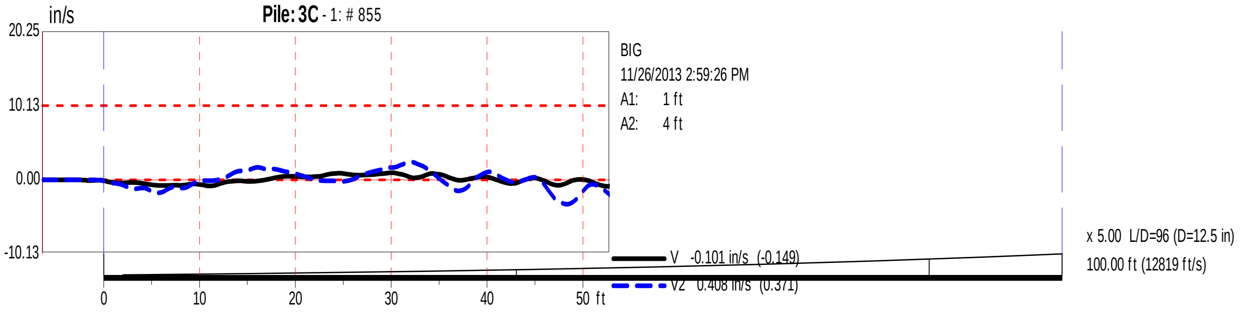


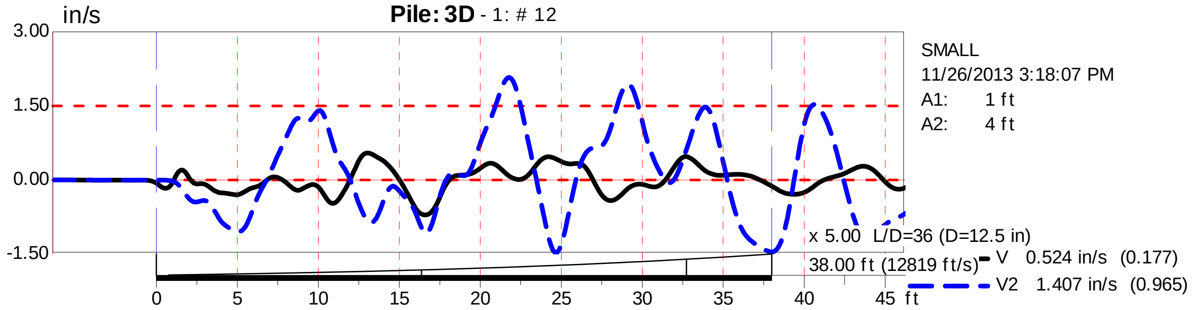


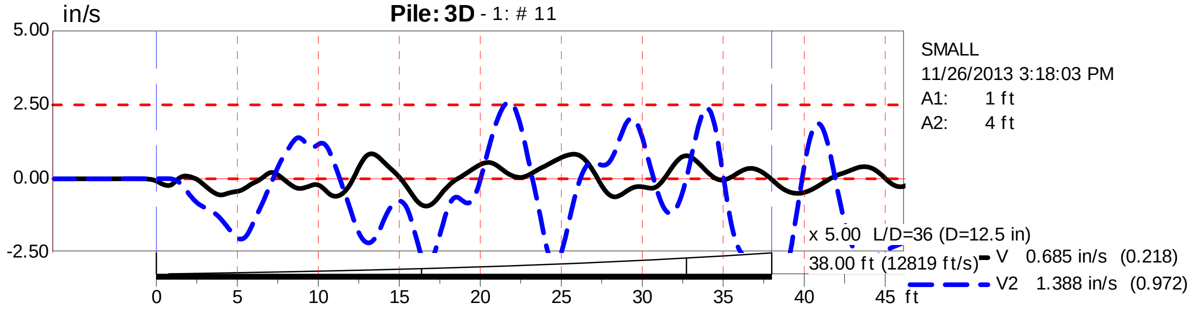


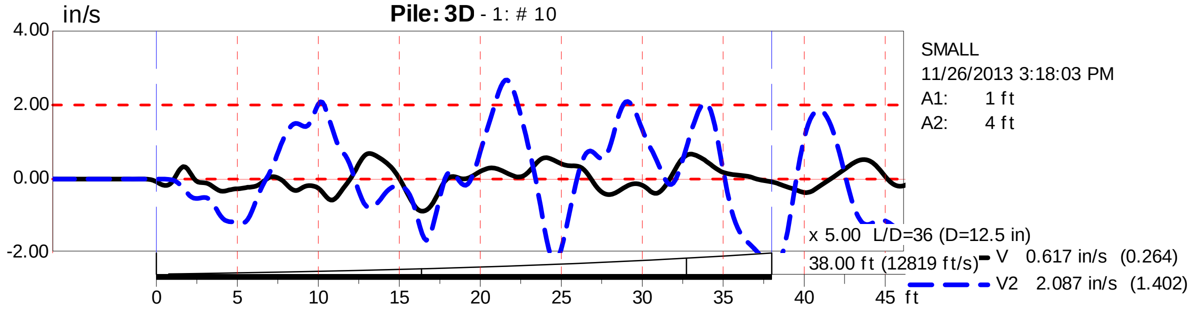

in/s
Pile: 3C - 1: # 857
50.63
25.31
0.00
-25.31
0
10
20
30
40
50 ft
BIG
11/26/2013 2:59:31 PM
A1: 1 ft
A2: 4 ft
V -0.023 in/s (-0.133)
V2 0.089 in/s (0.039)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

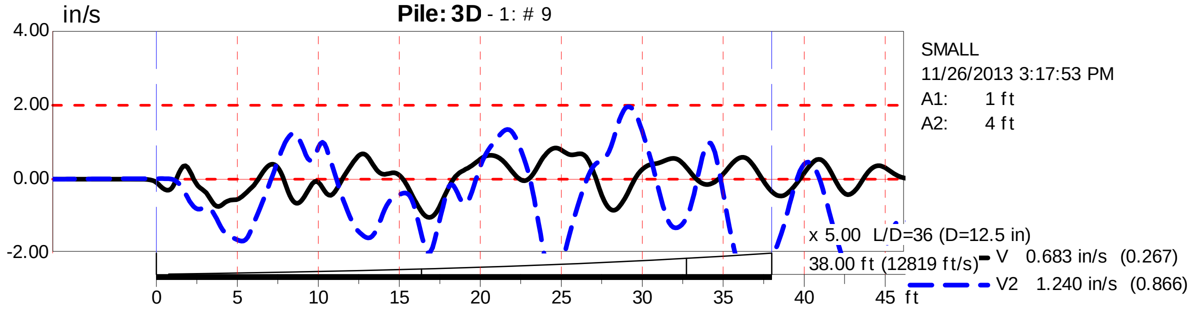

in/s
Pile: 3C - 1: # 856
25.31
12.66
0.00
-12.66
0
10
20
30
40
50 ft
BIG
11/26/2013 2:59:29 PM
A1: 1 ft
A2: 4 ft
V -0.124 in/s (-0.192)
V2 1.153 in/s (0.983)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

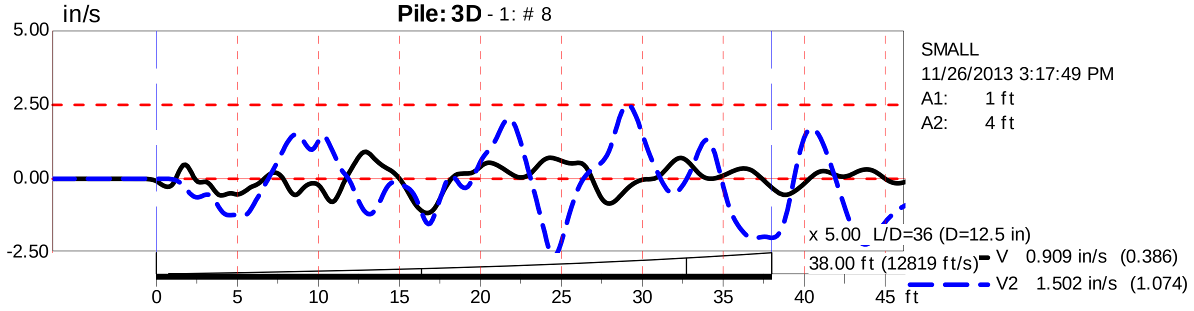

in/s
Pile: 3C - 1: # 855
20.25
10.13
0.00
-10.13
0
10
20
30
40
50 ft
BIG
11/26/2013 2:59:26 PM
A1: 1 ft
A2: 4 ft
V -0.101 in/s (-0.149)
V2 0.408 in/s (0.371)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

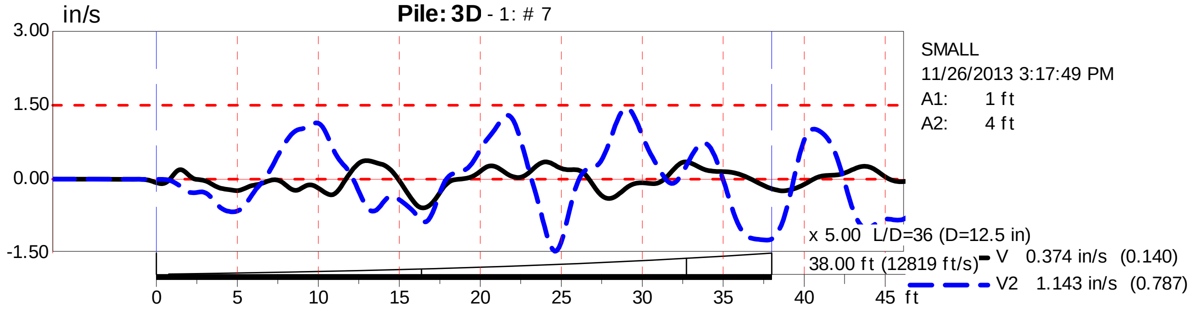

in/s
Pile: 3D - 1: # 12
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/26/2013 3:18:07 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.524 in/s (0.177)
V2 1.407 in/s (0.965)


in/s
Pile: 3D - 1: # 11
5.00
2.50
0.00
-2.50
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/26/2013 3:18:03 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.685 in/s (0.218)
V2 1.388 in/s (0.972)

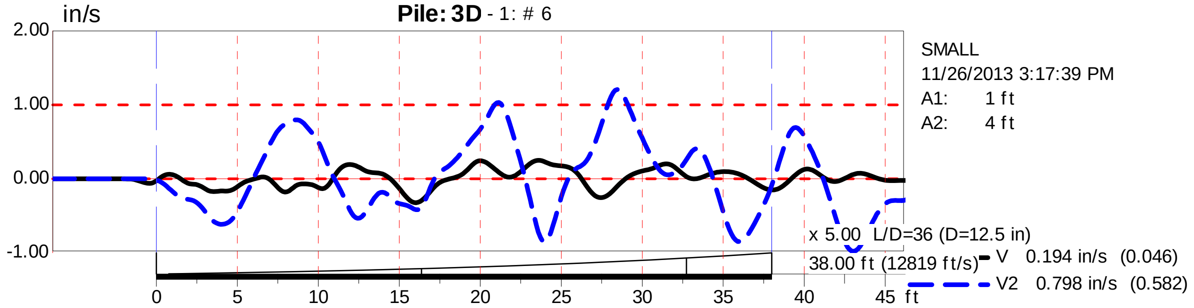

in/s
Pile: 3D - 1: # 10
4.00
2.00
0.00
-2.00
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/26/2013 3:18:03 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.617 in/s (0.264)
V2 2.087 in/s (1.402)


in/s
Pile: 3D - 1: # 9
4.00
2.00
0.00
-2.00
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/26/2013 3:17:53 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.683 in/s (0.267)
V2 1.240 in/s (0.866)

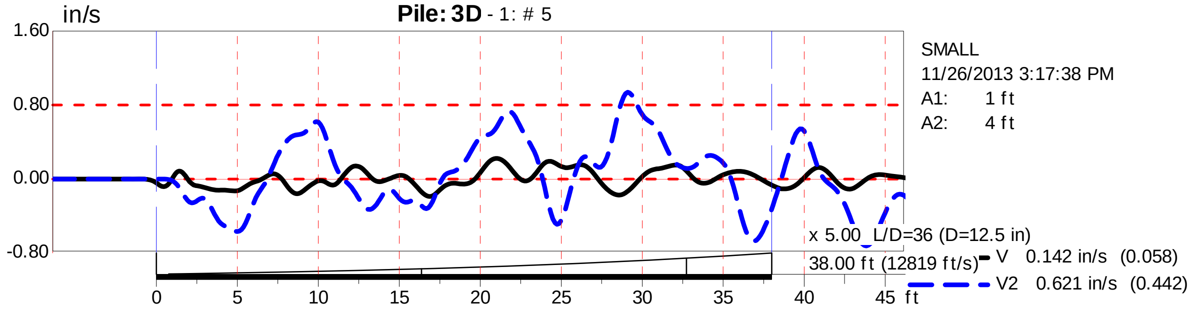

in/s
Pile: 3D - 1: # 8
5.00
2.50
0.00
-2.50
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/26/2013 3:17:49 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.909 in/s (0.386)
V2 1.502 in/s (1.074)


Pile: 3D - 1: # 7

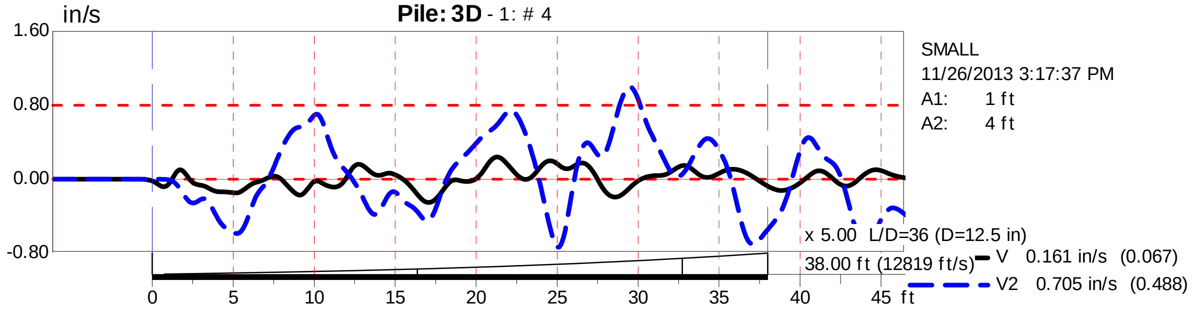
SMALL
11/26/2013 3:17:49 PM
A1: 1 ft
A2: 4 ft


Pile: 3D - 1: # 6

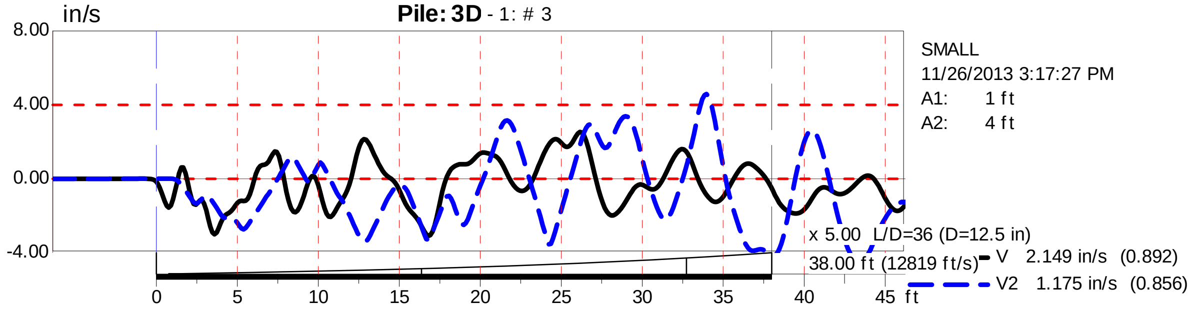
SMALL
11/26/2013 3:17:39 PM
A1: 1 ft
A2: 4 ft


Pile: 3D - 1: # 5

SMALL
11/26/2013 3:17:38 PM
A1: 1 ft
A2: 4 ft


Pile: 3D - 1: # 4

SMALL
11/26/2013 3:17:37 PM
A1: 1 ft
A2: 4 ft


Pile: 3D - 1: # 3

SMALL
11/26/2013 3:17:27 PM
A1: 1 ft
A2: 4 ft

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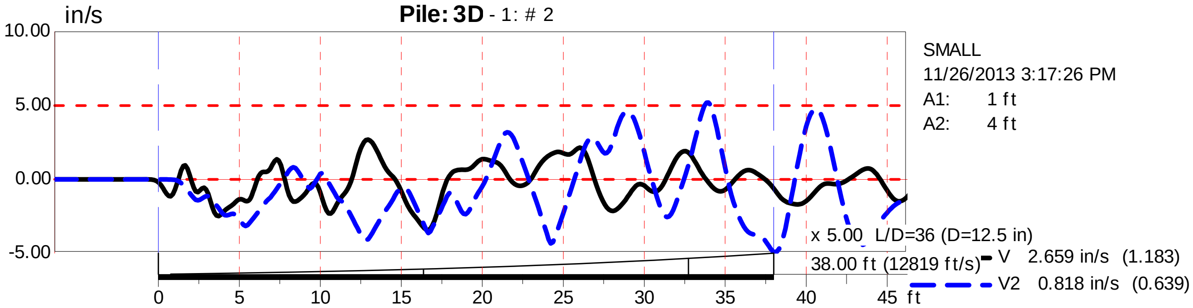
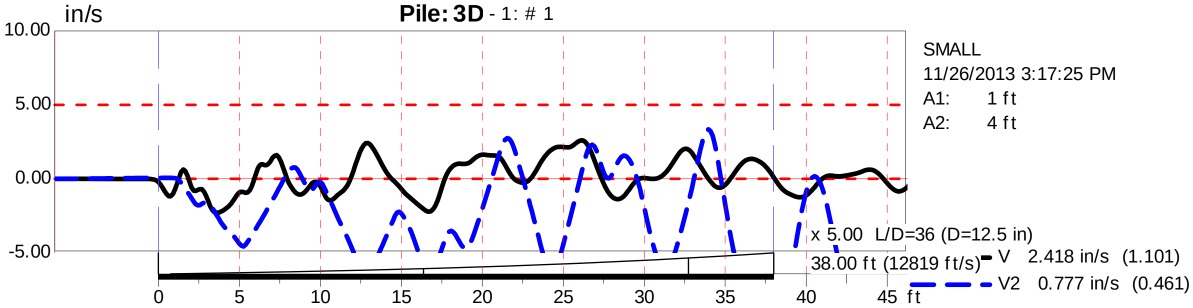
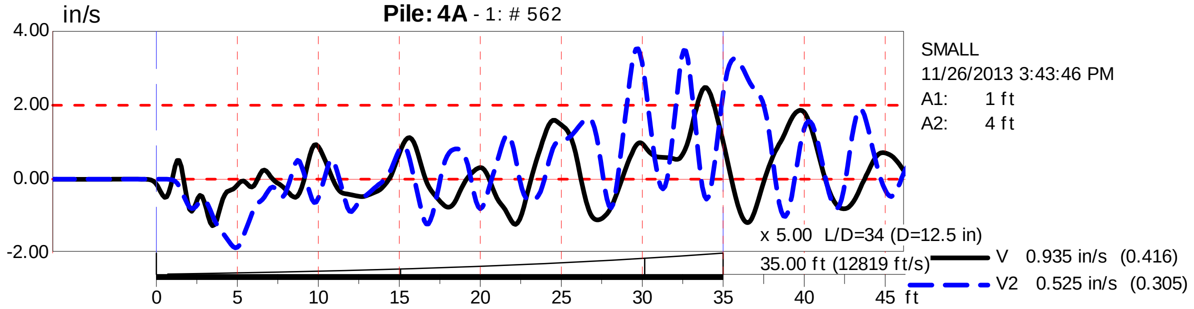
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



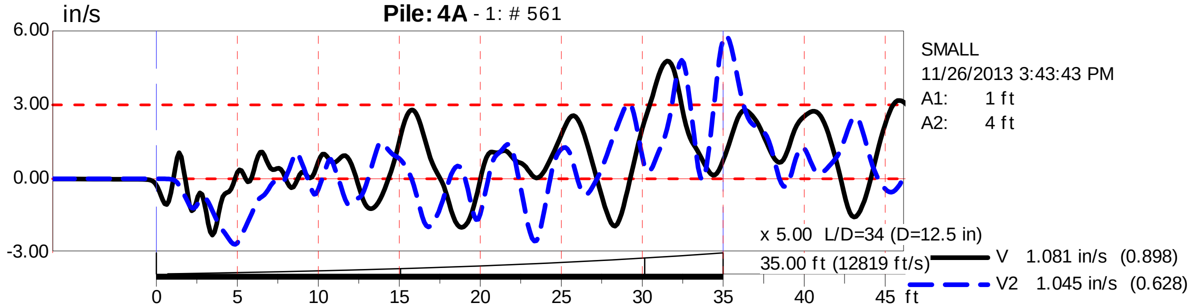




Pile: 4A - 1: # 562

SMALL
11/26/2013 3:43:46 PM
A1: 1 ft
A2: 4 ft

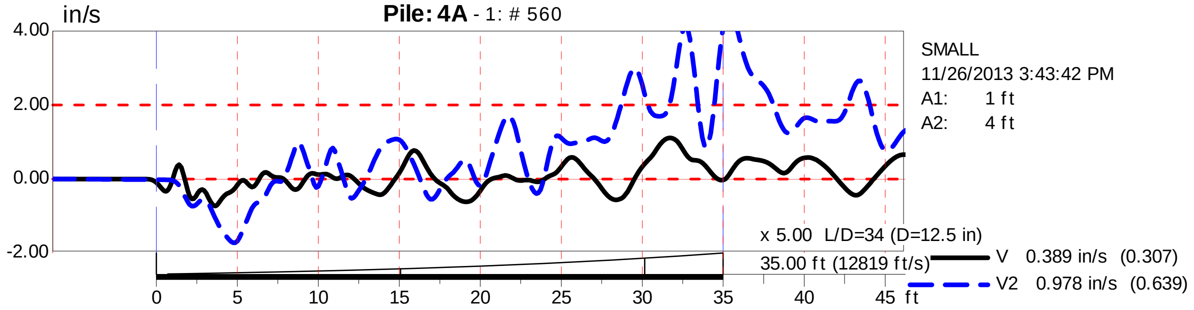
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.935 in/s (0.416)
V2 0.525 in/s (0.305)



Pile: 4A - 1: # 561

SMALL
11/26/2013 3:43:43 PM
A1: 1 ft
A2: 4 ft

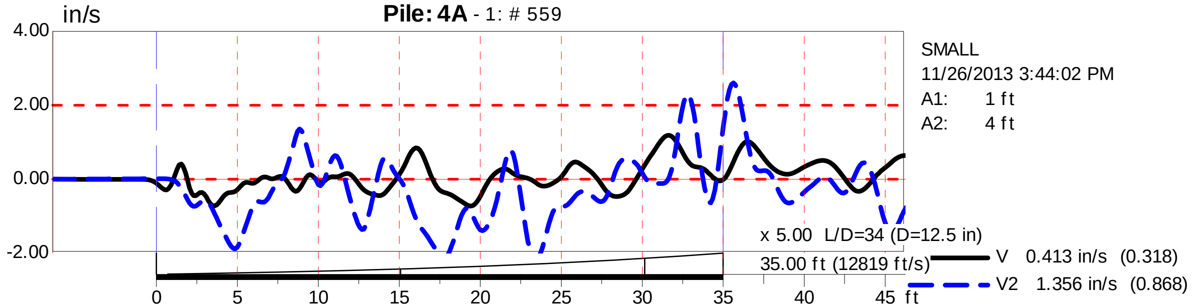
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.081 in/s (0.898)
V2 1.045 in/s (0.628)



Pile: 4A - 1: # 560

SMALL
11/26/2013 3:43:42 PM
A1: 1 ft
A2: 4 ft

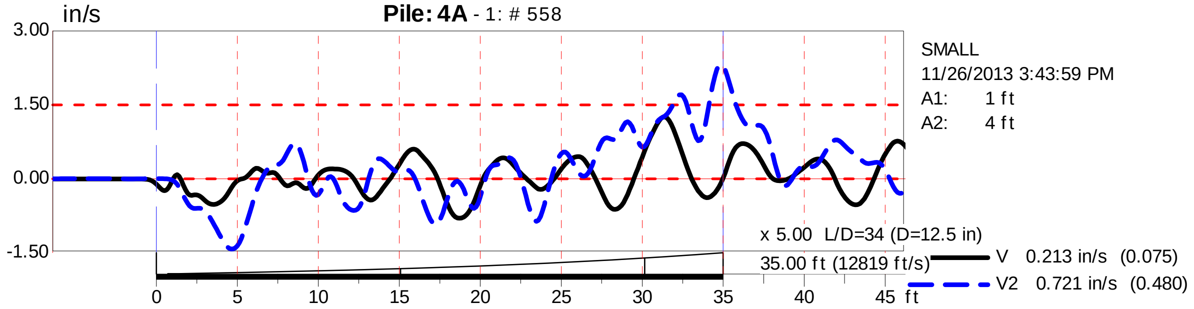
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.389 in/s (0.307)
V2 0.978 in/s (0.639)



Pile: 4A - 1: # 559

SMALL
11/26/2013 3:44:02 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.413 in/s (0.318)
V2 1.356 in/s (0.868)

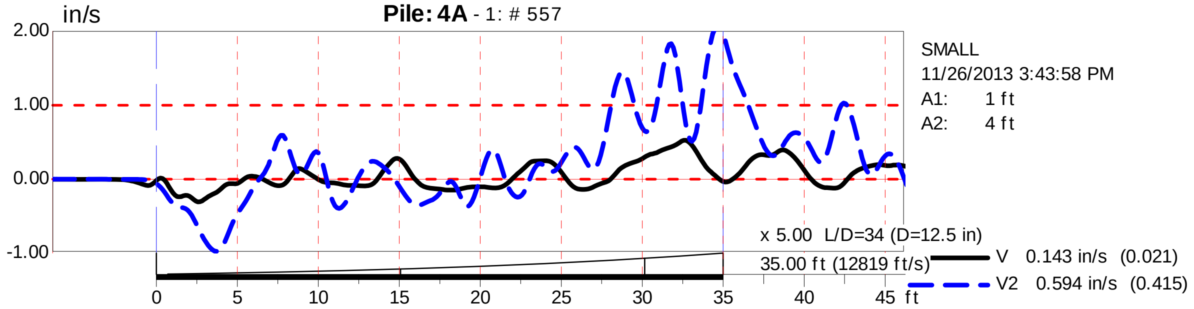


Pile: 4A - 1: # 558

SMALL
11/26/2013 3:43:59 PM
A1: 1 ft
A2: 4 ft

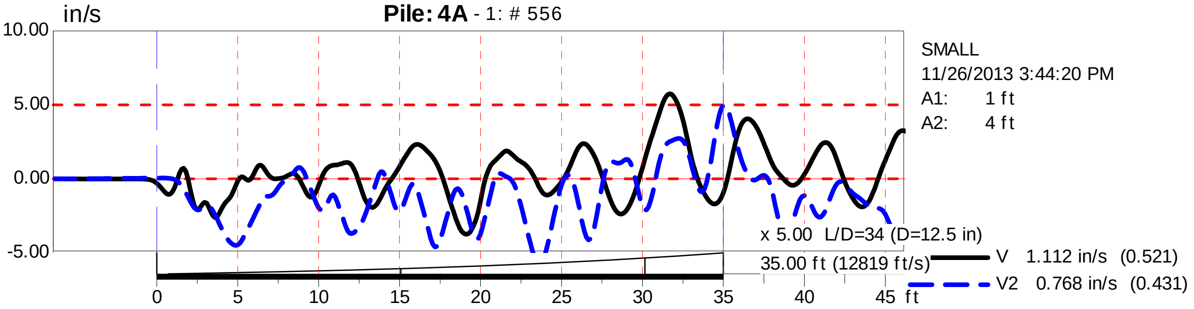
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.213 in/s (0.075)
V2 0.721 in/s (0.480)

Pile: 4A - 1: # 557



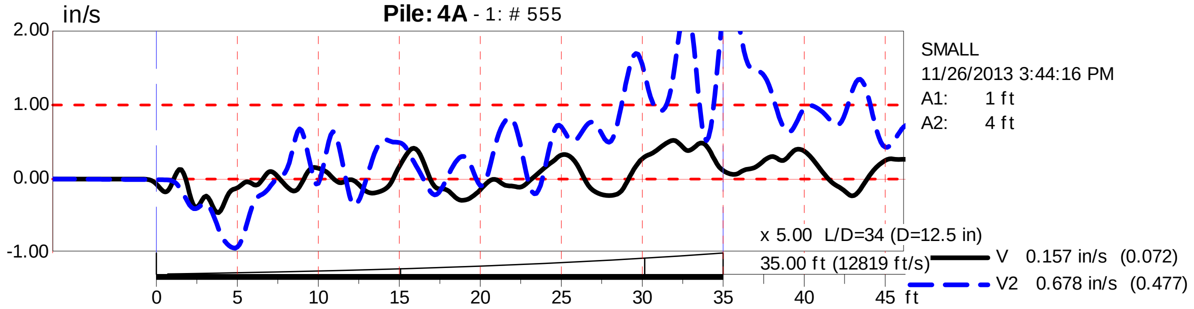
SMALL
11/26/2013 3:43:58 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.143 in/s (0.021)
V2 0.594 in/s (0.415)

Pile: 4A - 1: # 556



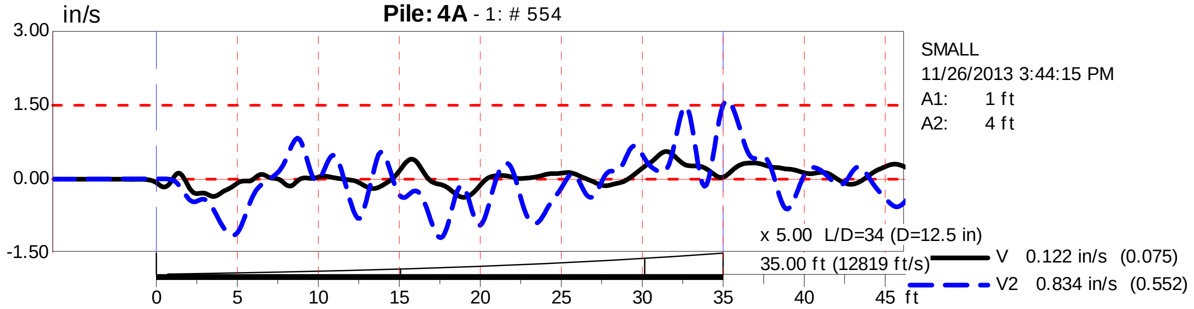
SMALL
11/26/2013 3:44:20 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.112 in/s (0.521)
V2 0.768 in/s (0.431)

Pile: 4A - 1: # 555



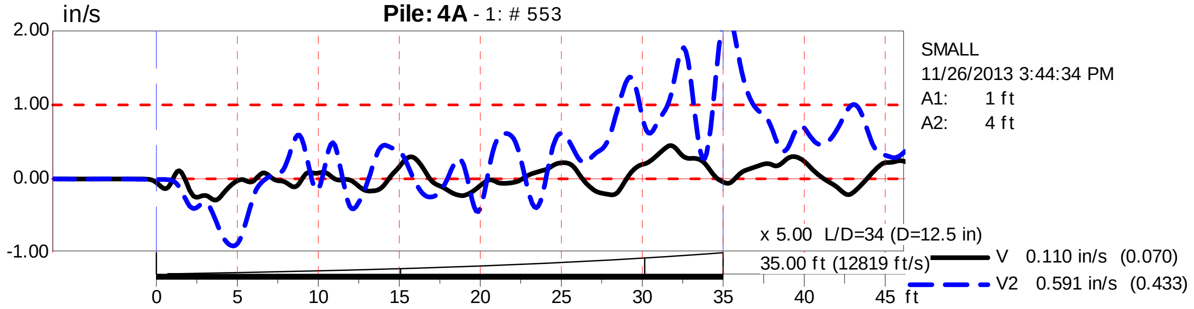
SMALL
11/26/2013 3:44:16 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.157 in/s (0.072)
V2 0.678 in/s (0.477)

Pile: 4A - 1: # 554



SMALL
11/26/2013 3:44:15 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.122 in/s (0.075)
V2 0.834 in/s (0.552)

Pile: 4A - 1: # 553



SMALL
11/26/2013 3:44:34 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.110 in/s (0.070)
V2 0.591 in/s (0.433)

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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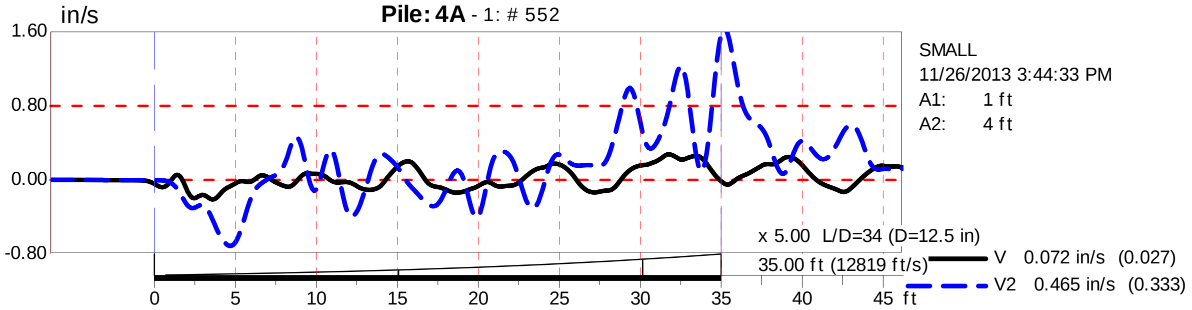
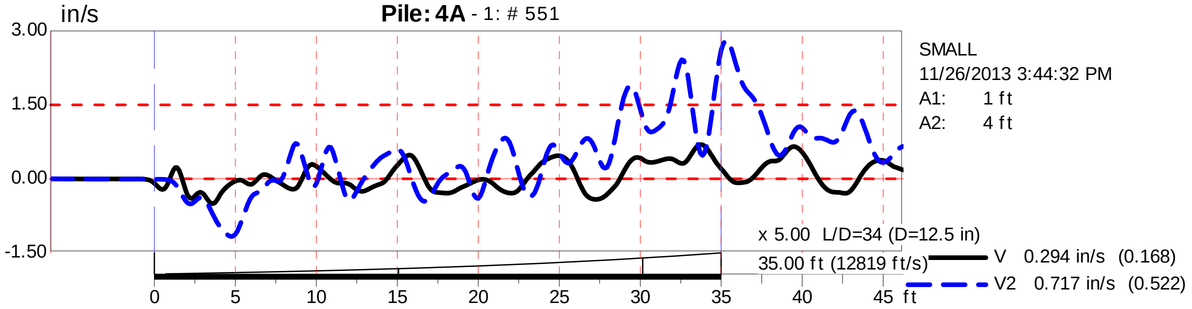
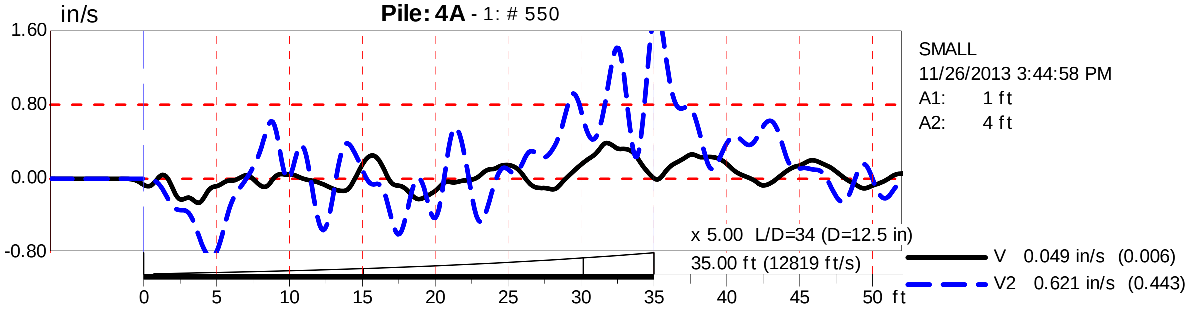
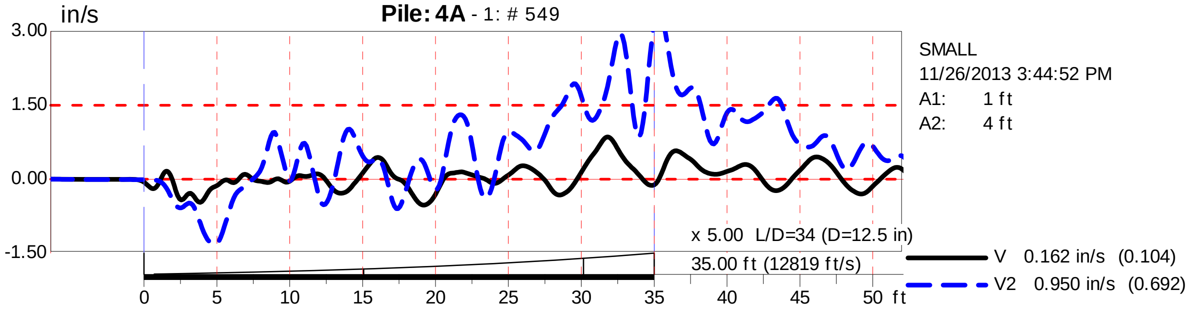
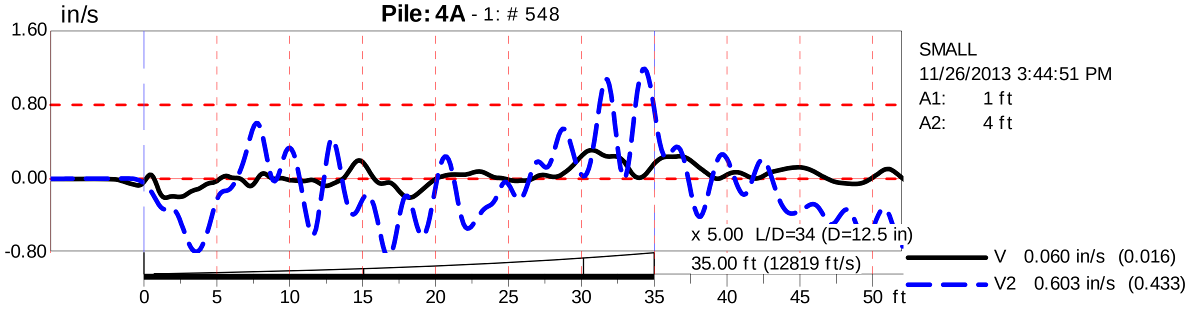
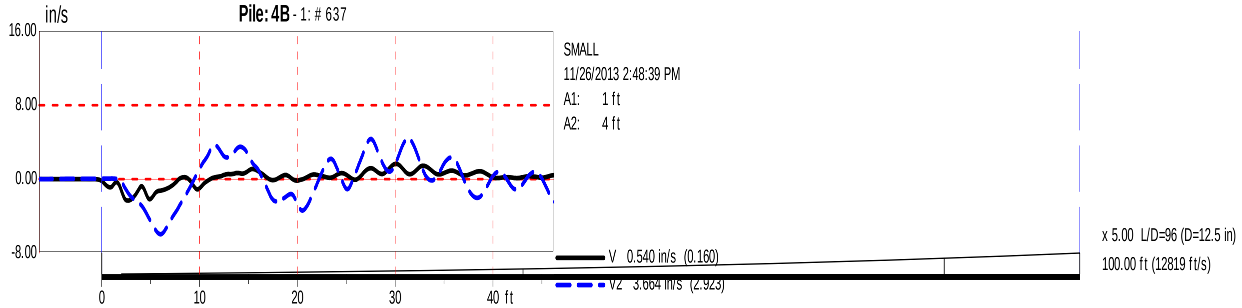


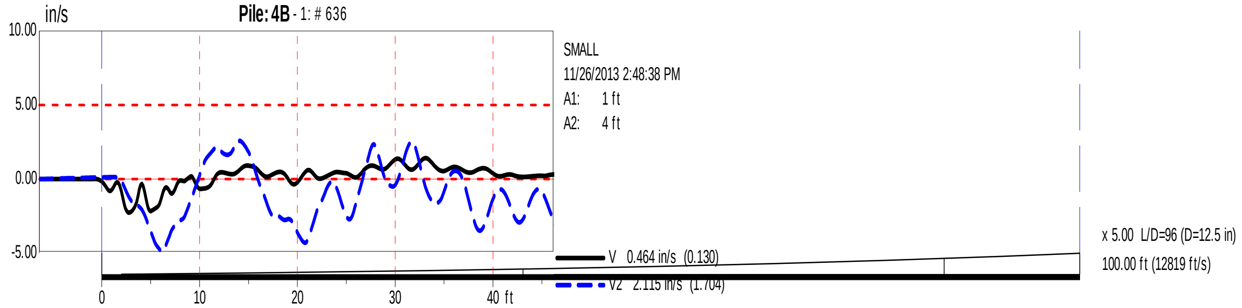


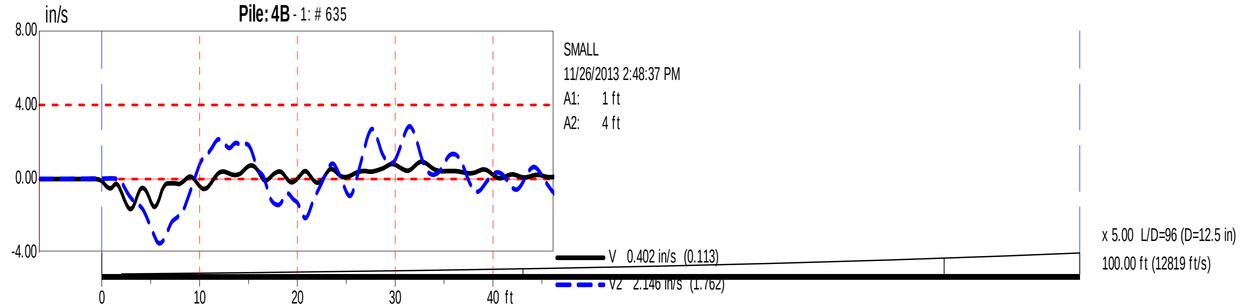


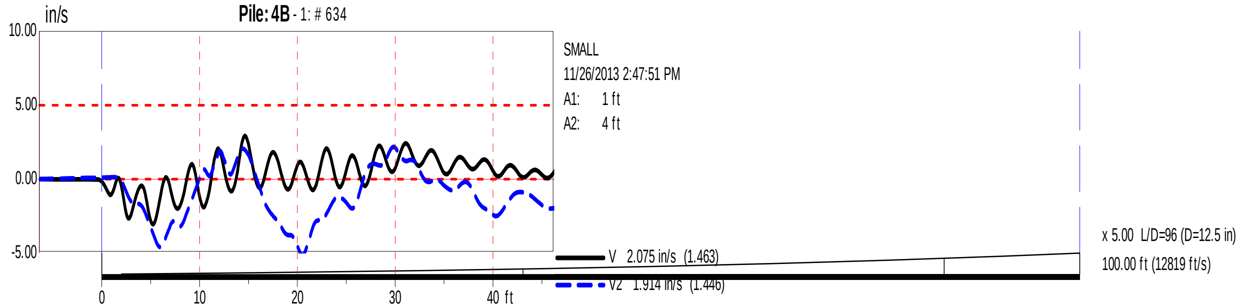


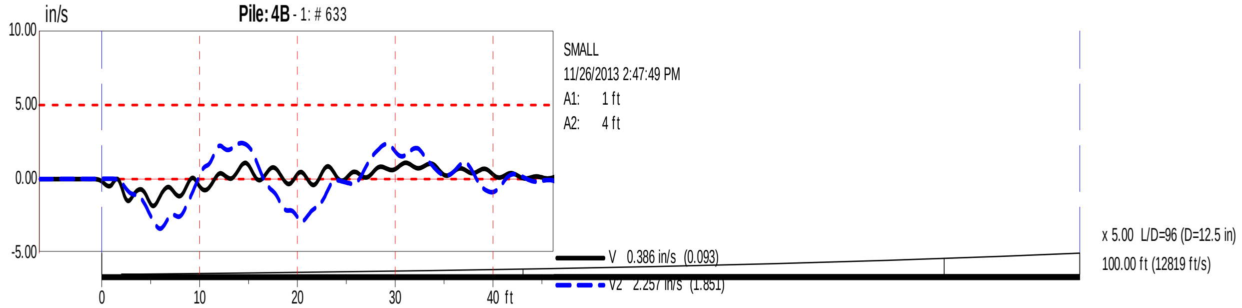



in/s
Pile: 4B - 1: # 637
16.00
8.00
0.00
-8.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:48:39 PM
A1: 1 ft
A2: 4 ft
V 0.540 in/s (0.160)
V2 3.664 in/s (2.923)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4B - 1: # 636
10.00
5.00
0.00
-5.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:48:38 PM
A1: 1 ft
A2: 4 ft
V 0.464 in/s (0.130)
V2 2.115 in/s (1.704)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4B - 1: # 635
8.00
4.00
0.00
-4.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:48:37 PM
A1: 1 ft
A2: 4 ft
V 0.402 in/s (0.113)
V2 2.146 in/s (1.762)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4B - 1: # 634
10.00
5.00
0.00
-5.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:47:51 PM
A1: 1 ft
A2: 4 ft
V 2.075 in/s (1.463)
V2 1.914 in/s (1.446)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4B - 1: # 633
10.00
5.00
0.00
-5.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:47:49 PM
A1: 1 ft
A2: 4 ft
V 0.386 in/s (0.093)
V2 2.257 in/s (1.851)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

Pile Dynamics, Inc. 12/29/2013

PIT Raw data

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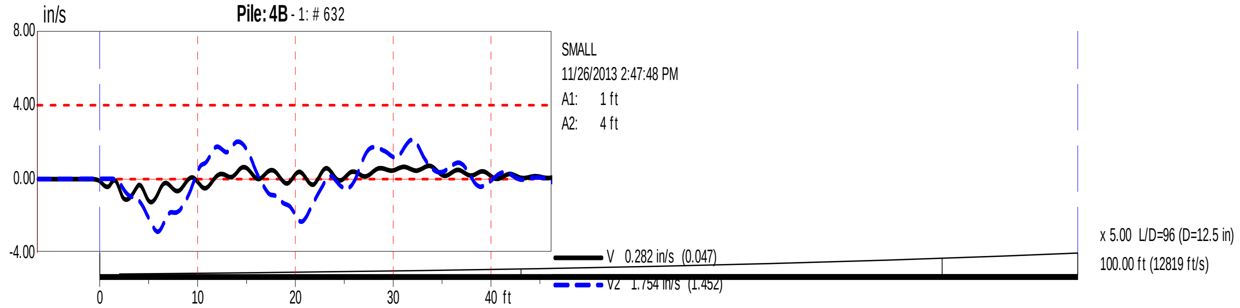
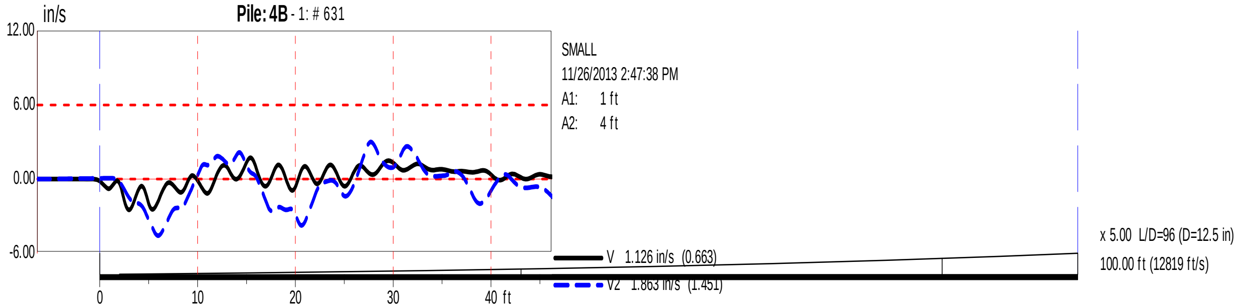
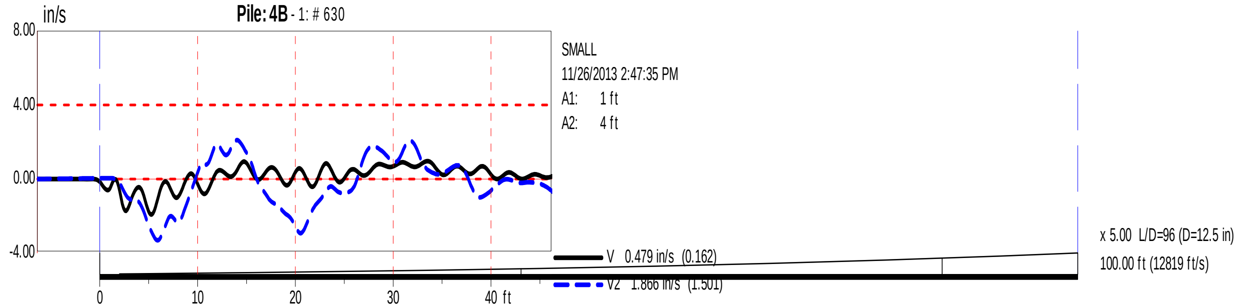
Pile: 4B - 1: # 632



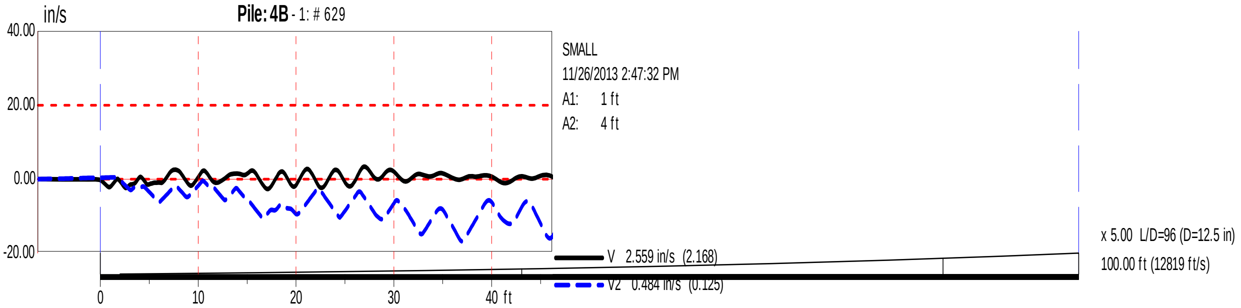
Pile: 4B - 1: # 631



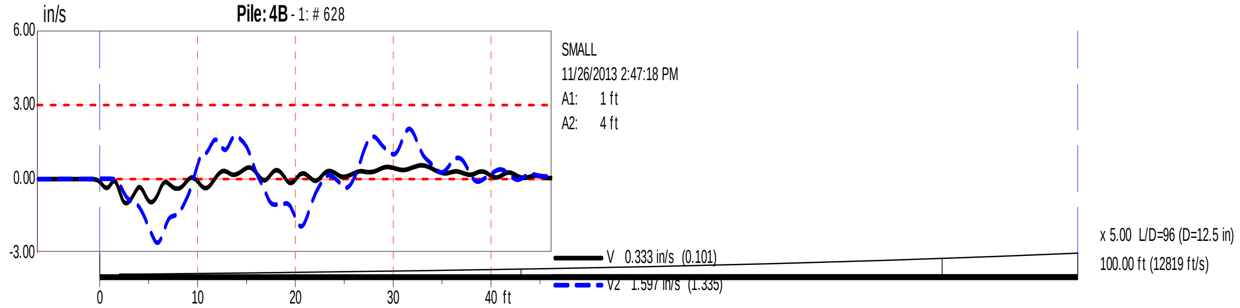
Pile: 4B - 1: # 630

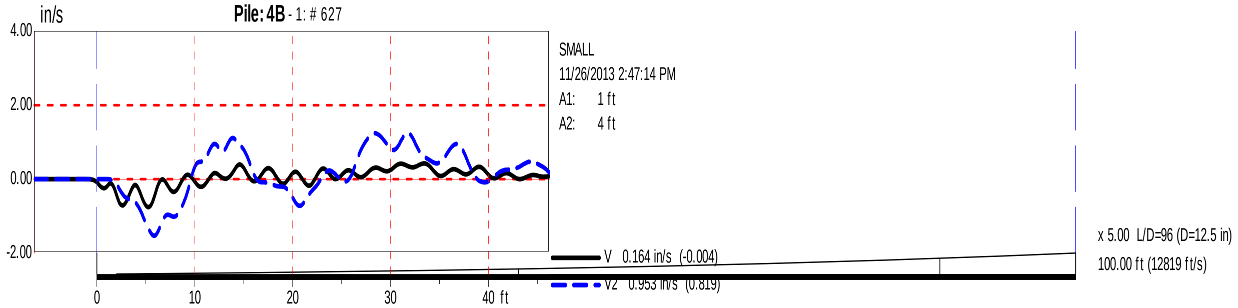


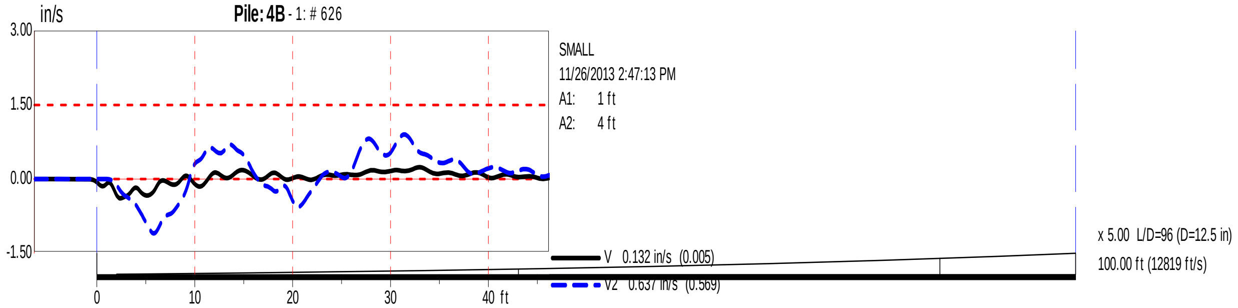
Pile: 4B - 1: # 629

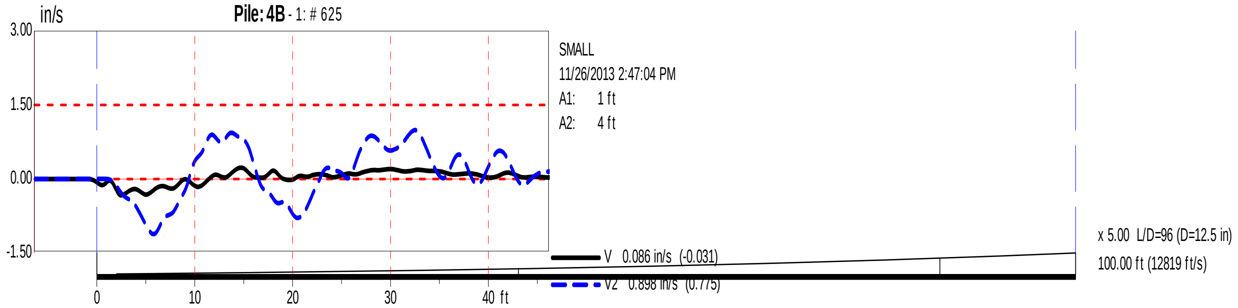


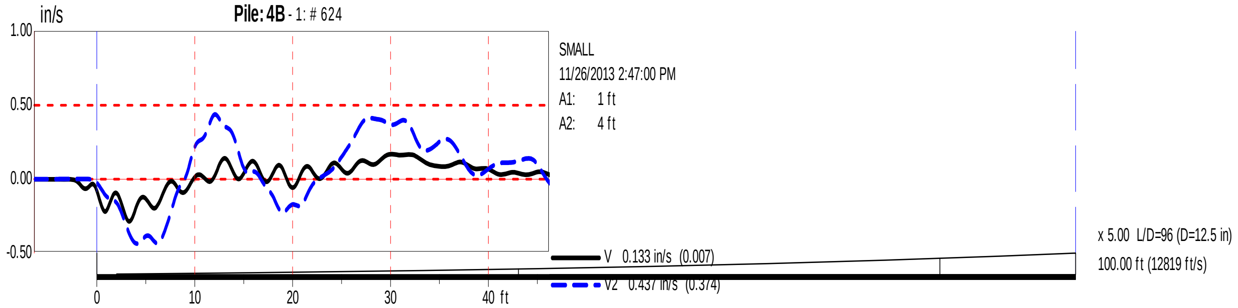
Pile: 4B - 1: # 628

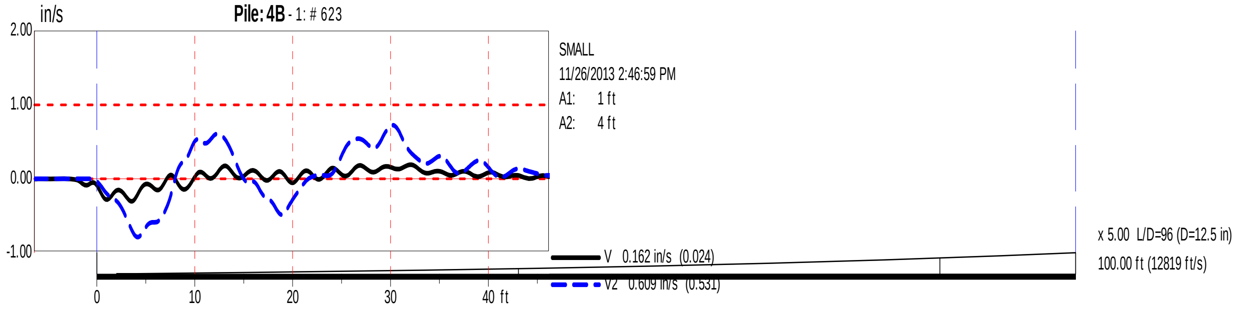



Pile: 4B - 1: # 627


Pile: 4B - 1: # 626


Pile: 4B - 1: # 625


Pile: 4B - 1: # 624


Pile: 4B - 1: # 623

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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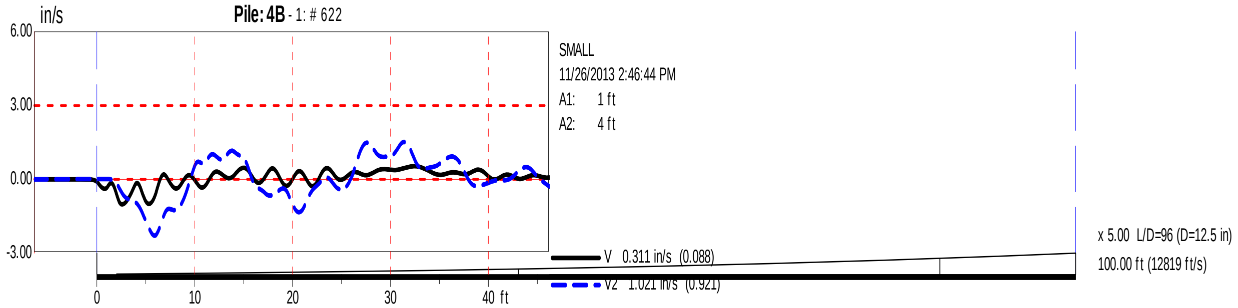
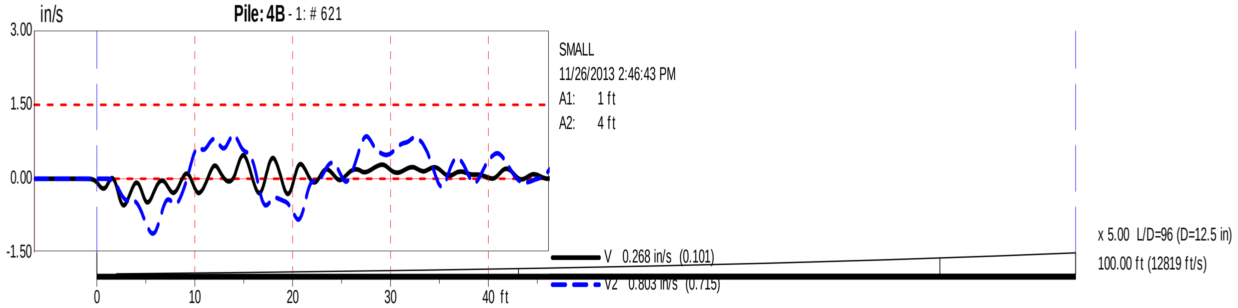
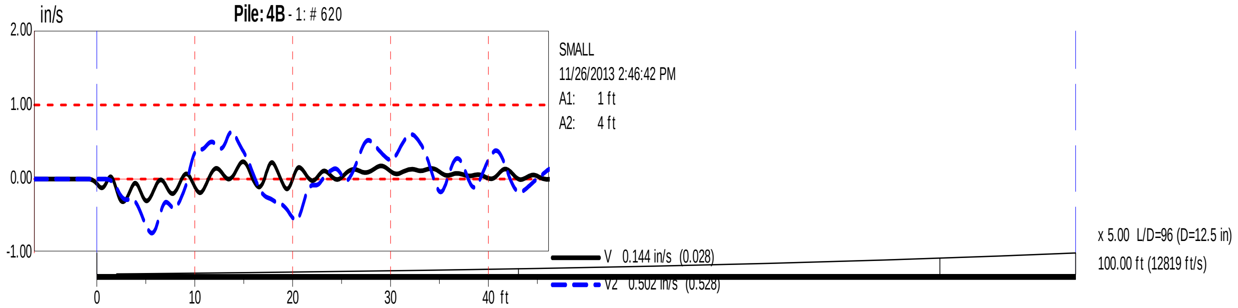
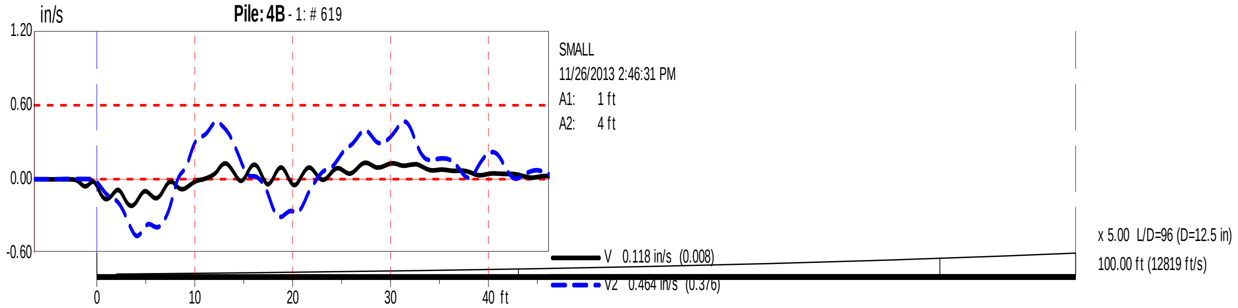
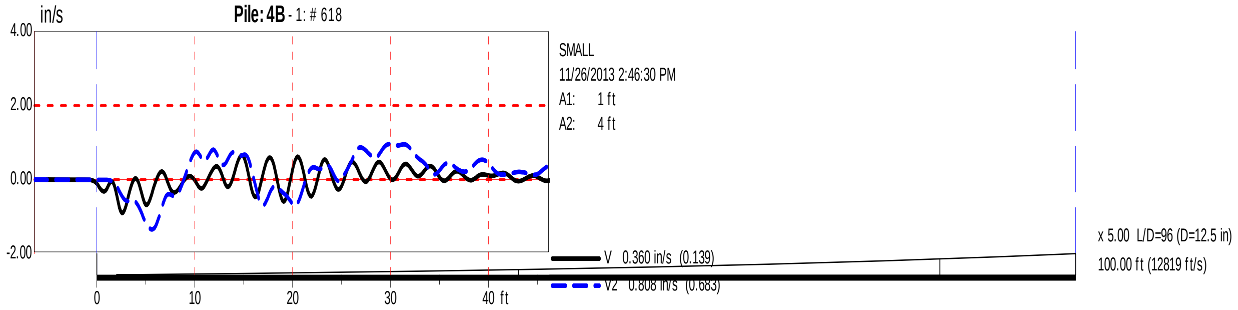


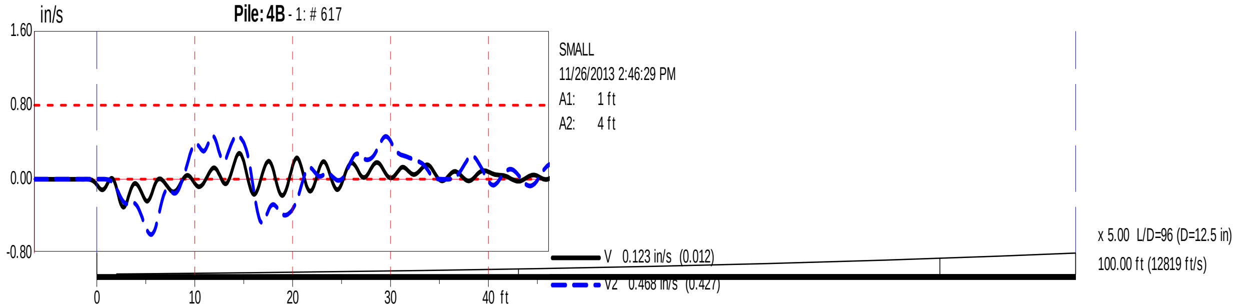


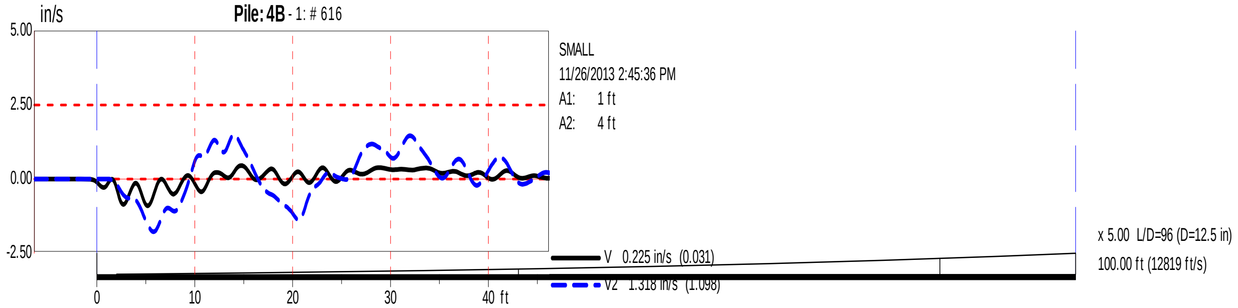


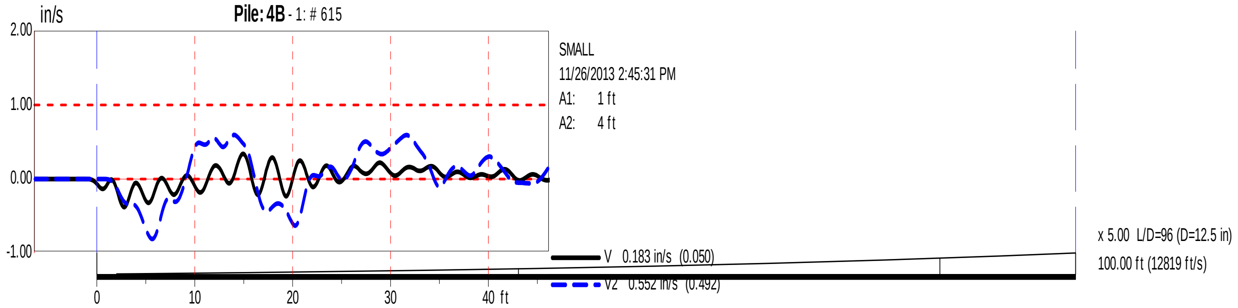


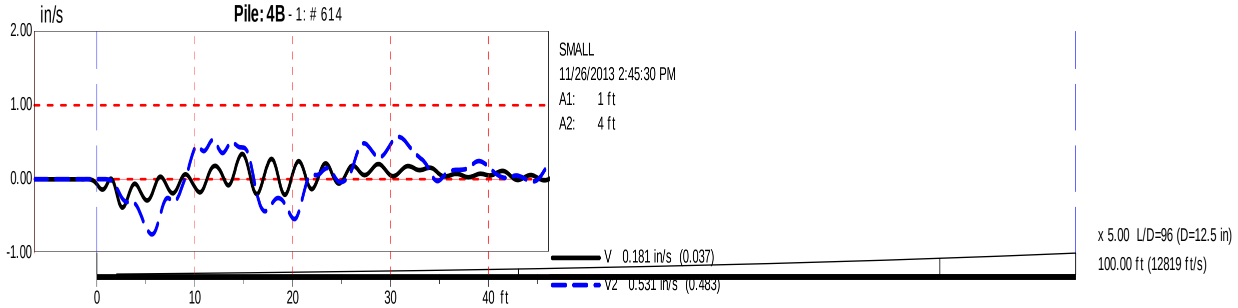


Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

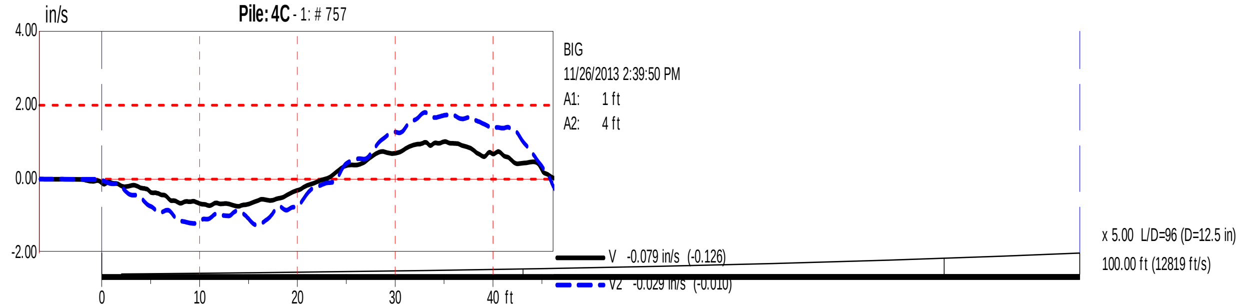


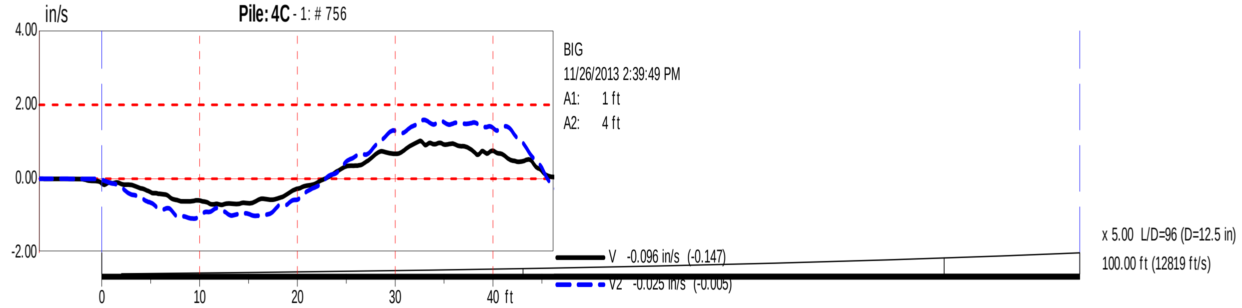


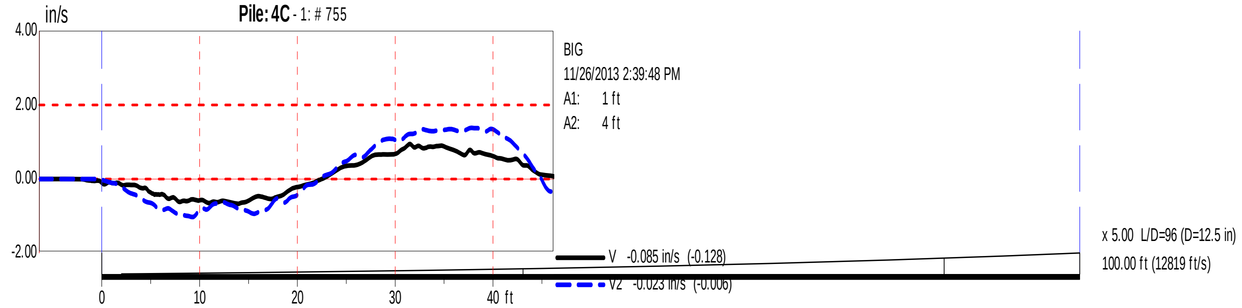


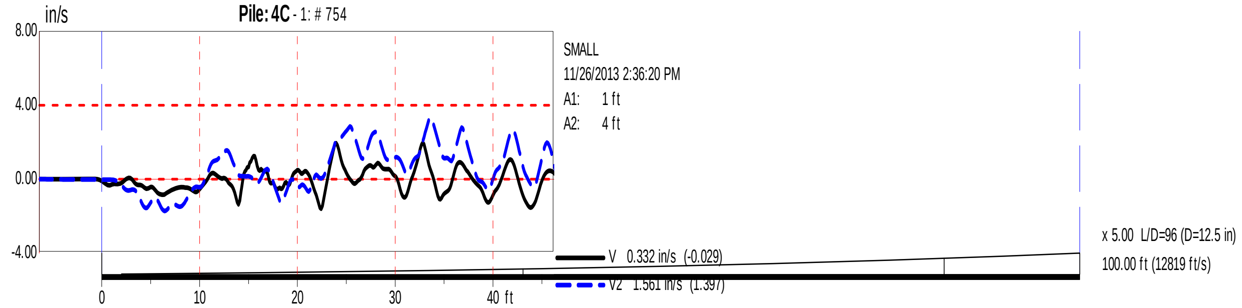


Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 4C - 1: # 757


Pile: 4C - 1: # 756


Pile: 4C - 1: # 755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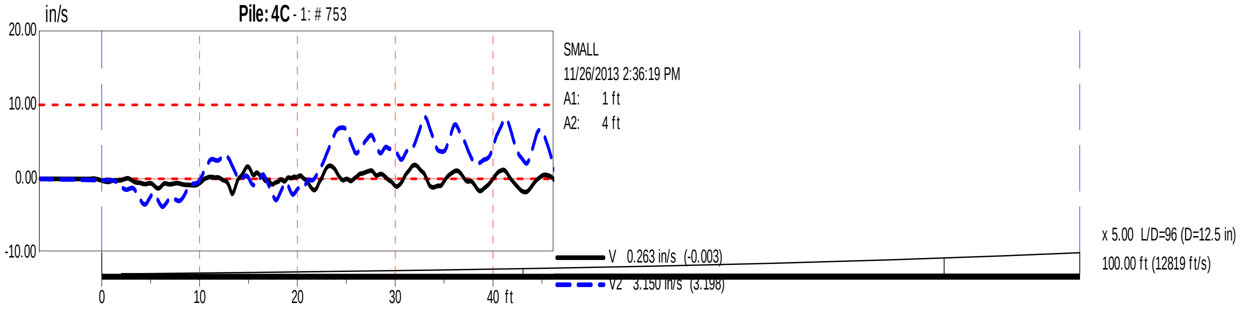
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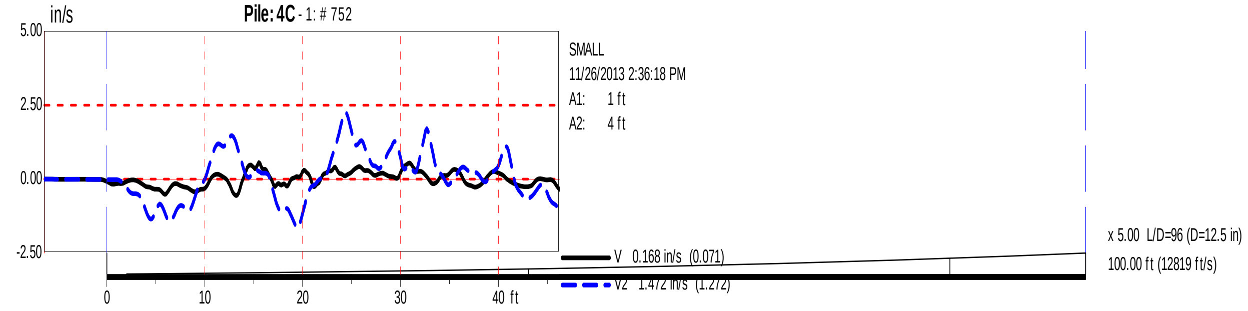
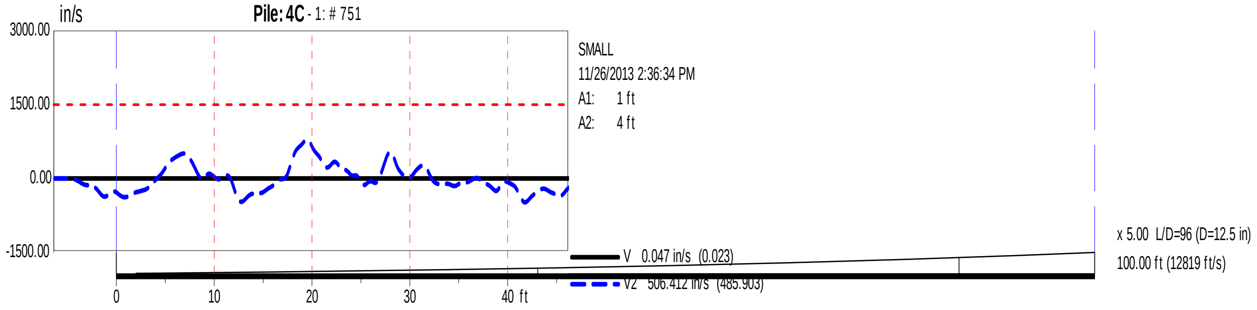
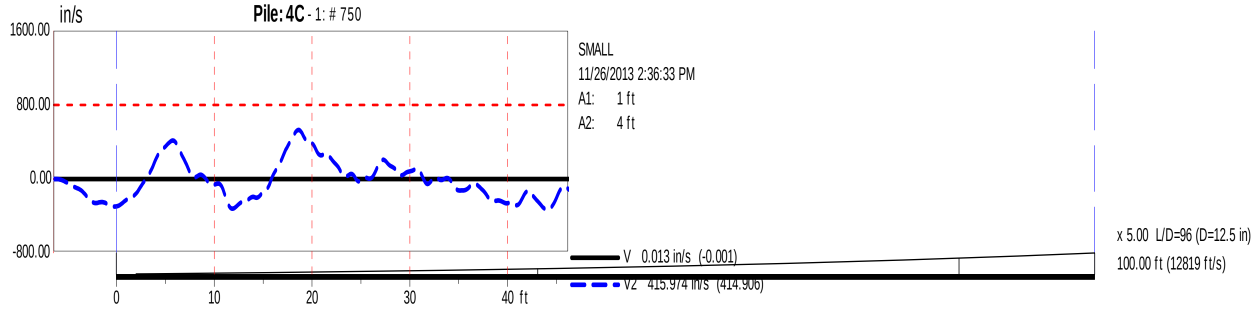
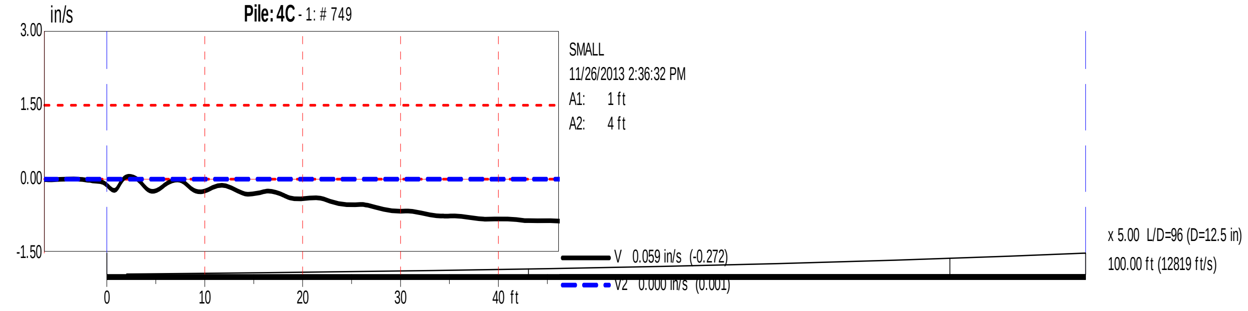
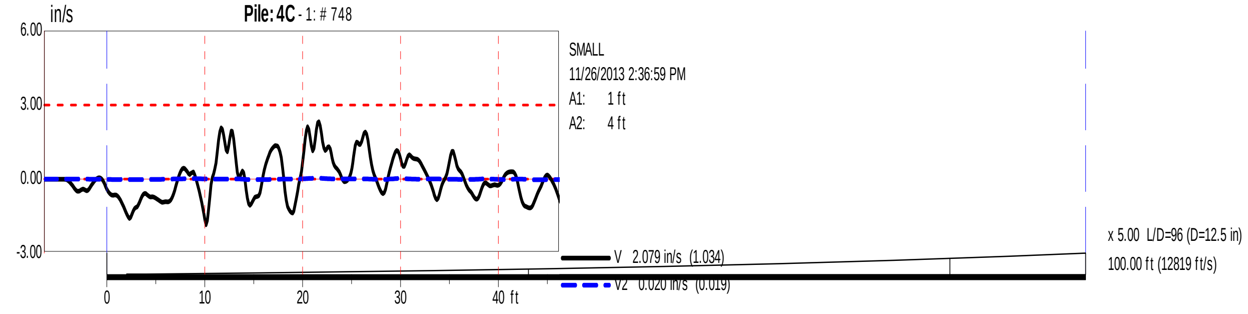

in/s
Pile: 4C - 1: # 752
5.00
2.50
0.00
-2.50
0
10
20
30
40 ft
SMALL
11/26/2013 2:36:18 PM
A1: 1 ft
A2: 4 ft
V 0.168 in/s (0.071)
V2 1.472 in/s (1.272)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4C - 1: # 751
3000.00
1500.00
0.00
-1500.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:36:34 PM
A1: 1 ft
A2: 4 ft
V 0.047 in/s (0.023)
V2 506.412 in/s (485.903)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4C - 1: # 750
1600.00
800.00
0.00
-800.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:36:33 PM
A1: 1 ft
A2: 4 ft
V 0.013 in/s (-0.001)
V2 415.974 in/s (414.906)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

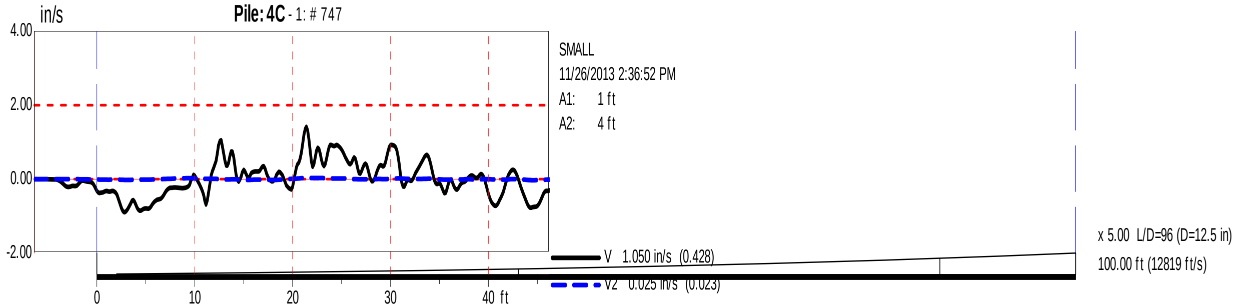

in/s
Pile: 4C - 1: # 749
3.00
1.50
0.00
-1.50
0
10
20
30
40 ft
SMALL
11/26/2013 2:36:32 PM
A1: 1 ft
A2: 4 ft
V 0.059 in/s (-0.272)
V2 0.000 in/s (0.001)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 4C - 1: # 748
6.00
3.00
0.00
-3.00
0
10
20
30
40 ft
SMALL
11/26/2013 2:36:59 PM
A1: 1 ft
A2: 4 ft
V 2.079 in/s (1.034)
V2 0.020 in/s (0.019)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

Pile Dynamics, Inc. 12/29/2013

PIT Raw data

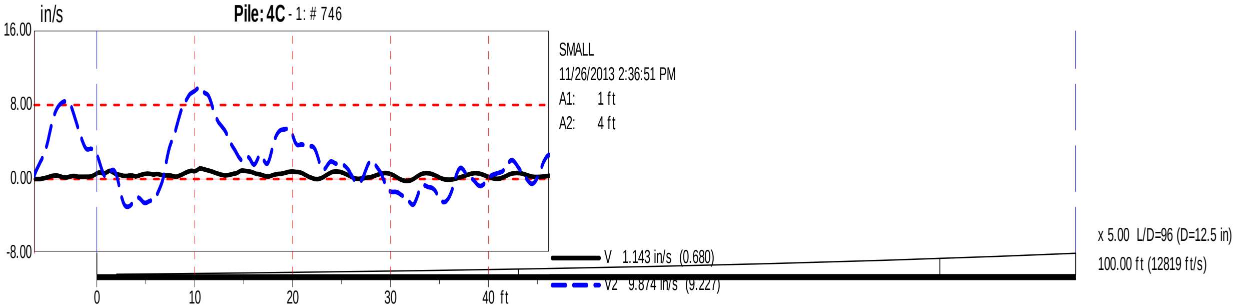
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 4C - 1: # 747

SMALL
11/26/2013 2:36:52 PM
A1: 1 ft
A2: 4 ft

V 1.050 in/s (0.428)
V2 0.025 in/s (0.023)

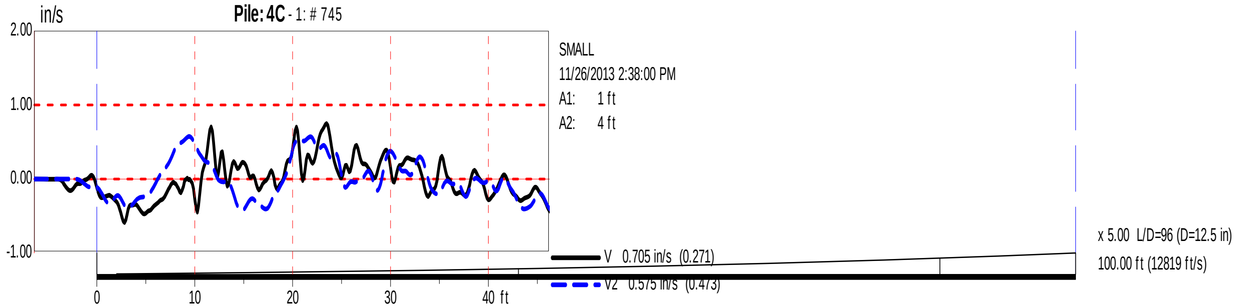
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


Pile: 4C - 1: # 746

SMALL
11/26/2013 2:36:51 PM
A1: 1 ft
A2: 4 ft

V 1.143 in/s (0.680)
V2 9.874 in/s (9.227)

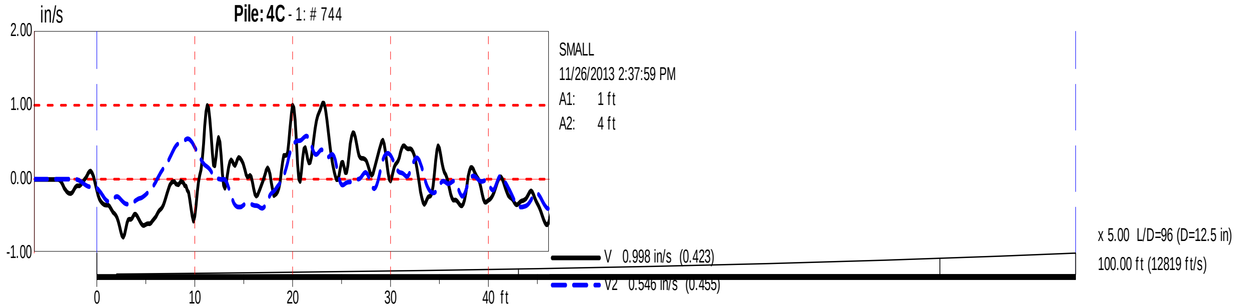
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


Pile: 4C - 1: # 745

SMALL
11/26/2013 2:38:00 PM
A1: 1 ft
A2: 4 ft

V 0.705 in/s (0.271)
V2 0.575 in/s (0.473)

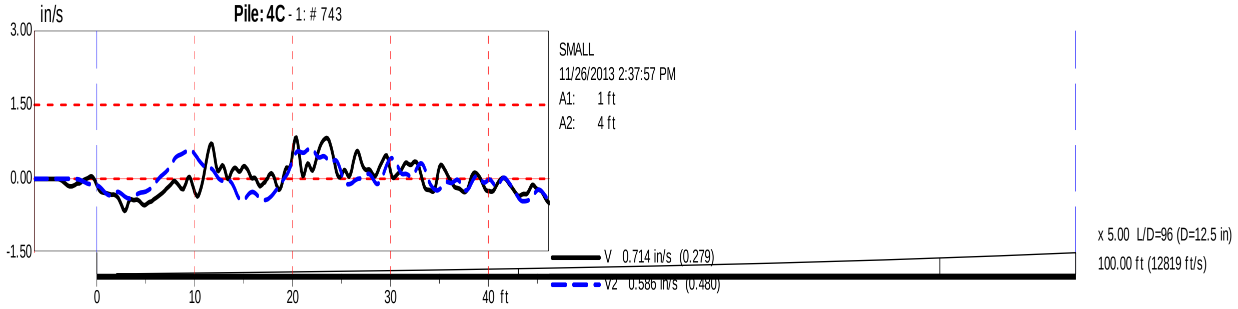
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


Pile: 4C - 1: # 744

SMALL
11/26/2013 2:37:59 PM
A1: 1 ft
A2: 4 ft

V 0.998 in/s (0.423)
V2 0.546 in/s (0.455)

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

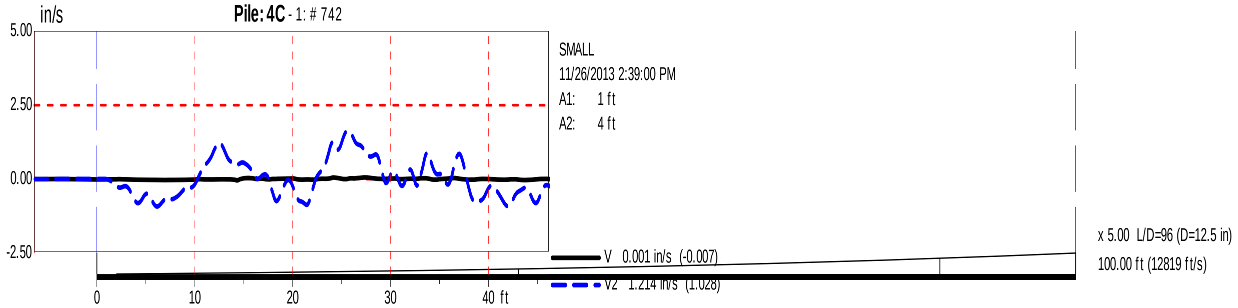

Pile: 4C - 1: # 743

SMALL
11/26/2013 2:37:57 PM
A1: 1 ft
A2: 4 ft

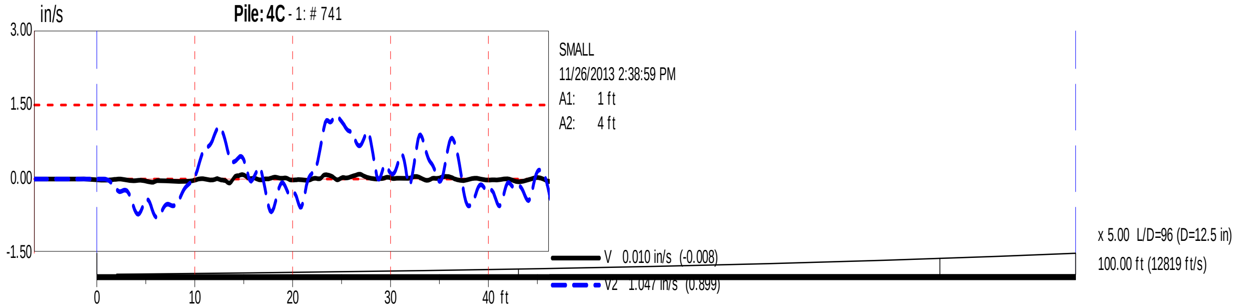
V 0.714 in/s (0.279)
V2 0.586 in/s (0.480)

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

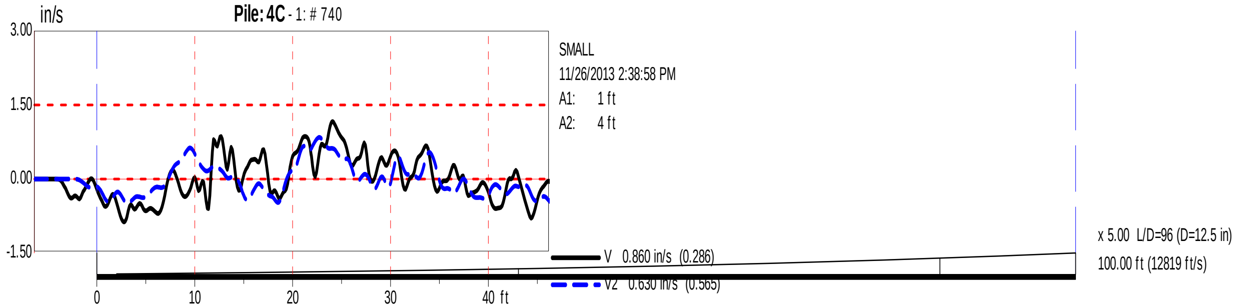
Pile: 4C - 1: # 742



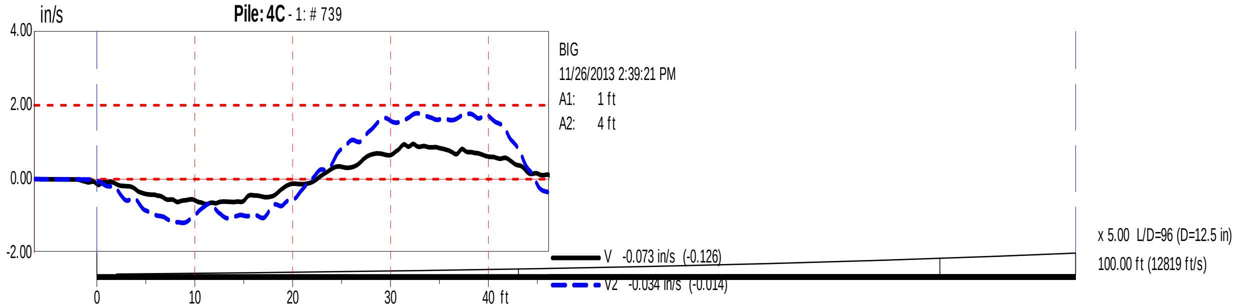
Pile: 4C - 1: # 741



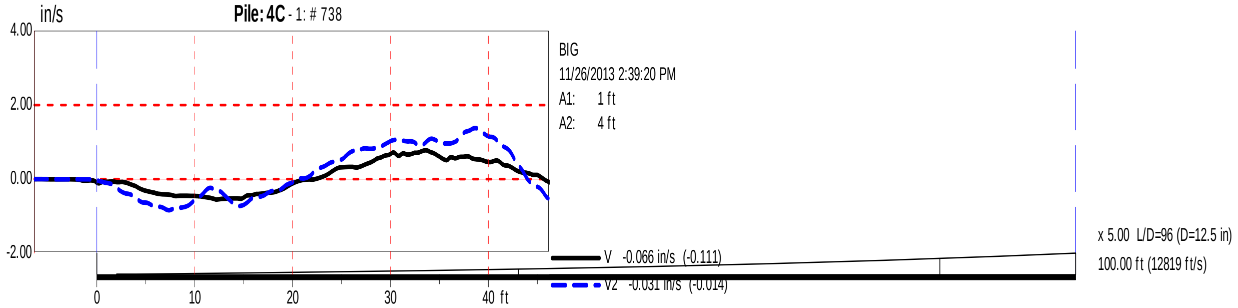
Pile: 4C - 1: # 740



Pile: 4C - 1: # 739



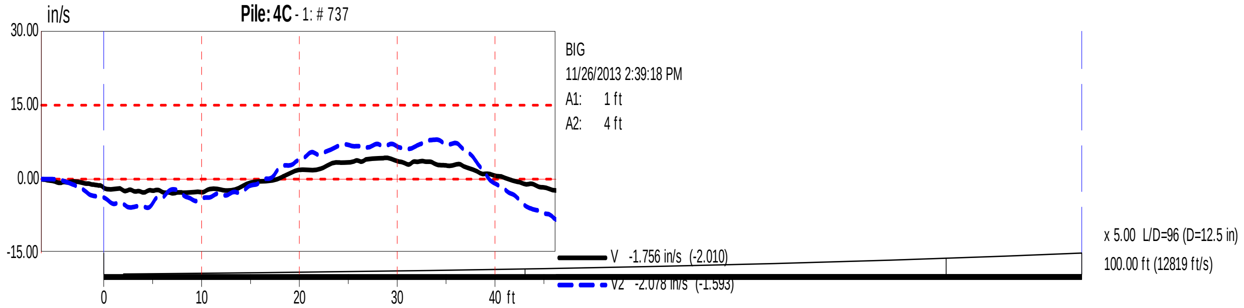
Pile: 4C - 1: # 738

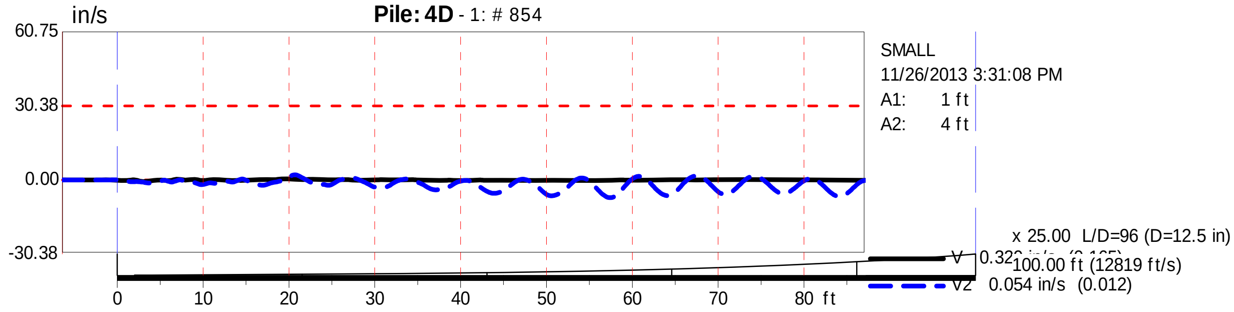


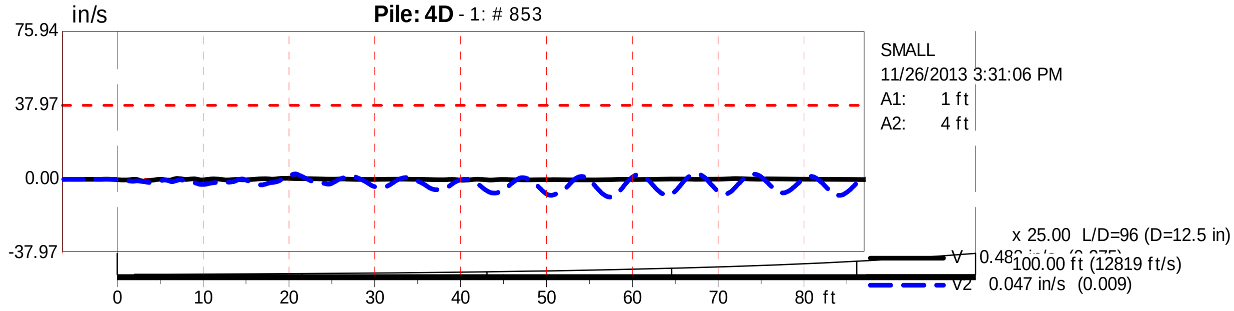
Pile Dynamics, Inc. 12/29/2013

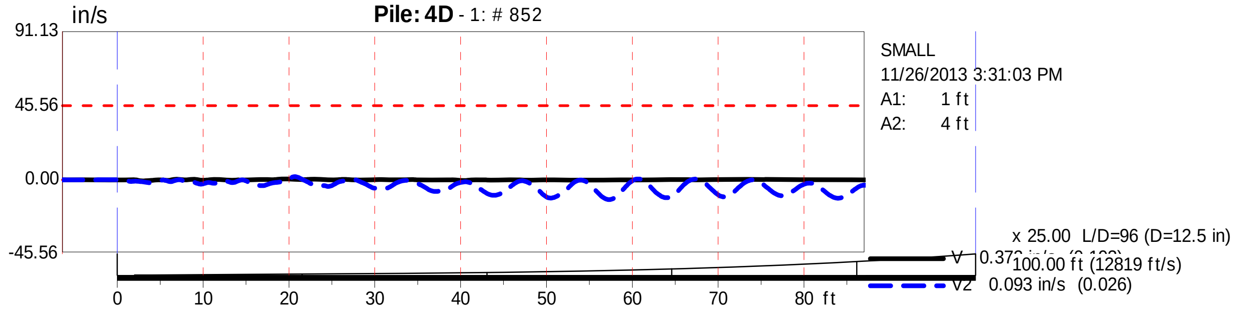
PIT Raw data

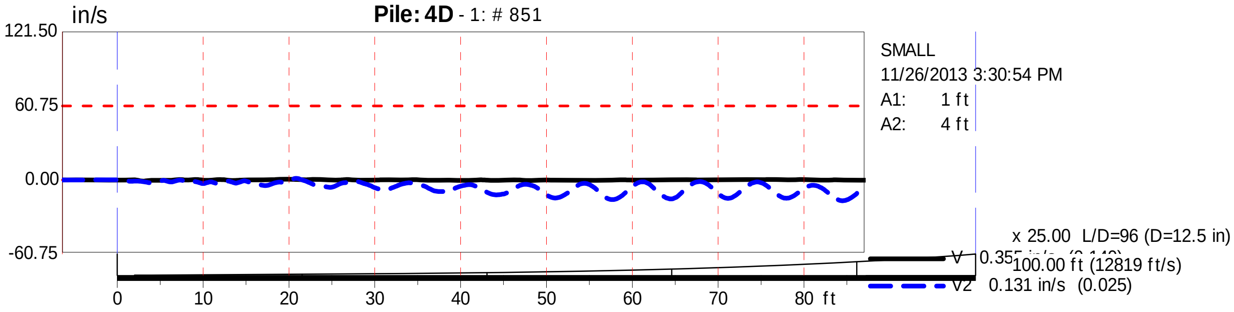
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

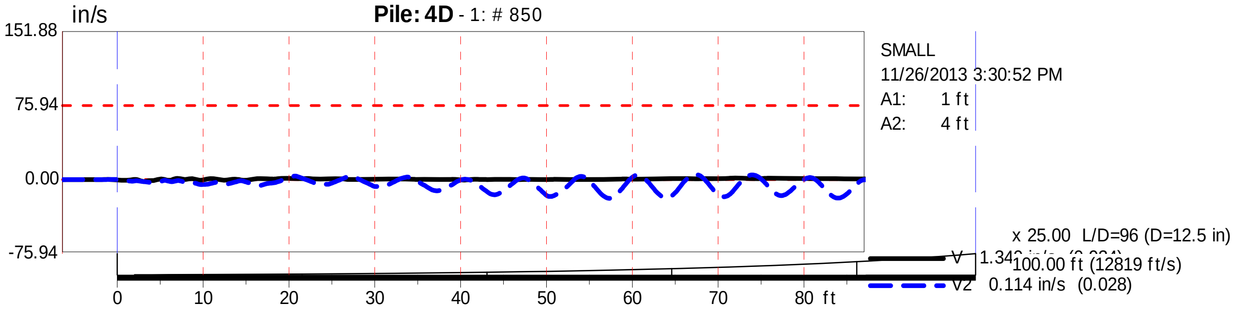



in/s
Pile: 4D - 1: # 854
60.75
30.38
0.00
-30.38
0 10 20 30 40 50 60 70 80 ft
SMALL
11/26/2013 3:31:08 PM
A1: 1 ft
A2: 4 ft
x 25.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V 0.32
V2 0.054 in/s (0.012)

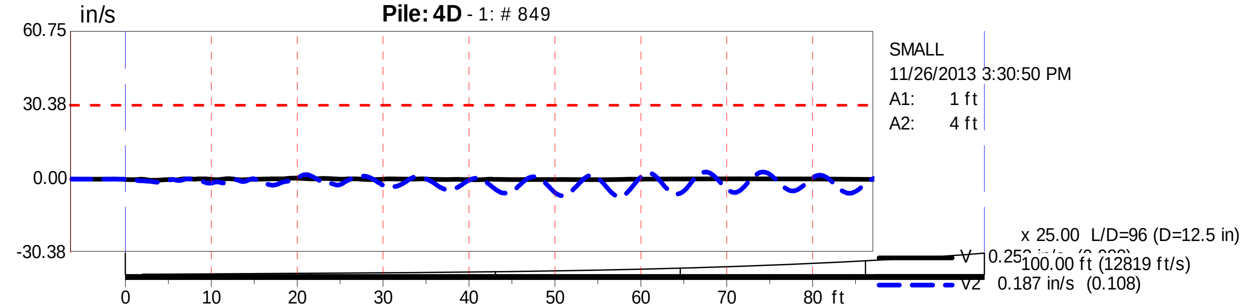

in/s
Pile: 4D - 1: # 853
75.94
37.97
0.00
-37.97
0 10 20 30 40 50 60 70 80 ft
SMALL
11/26/2013 3:31:06 PM
A1: 1 ft
A2: 4 ft
x 25.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V 0.48
V2 0.047 in/s (0.009)

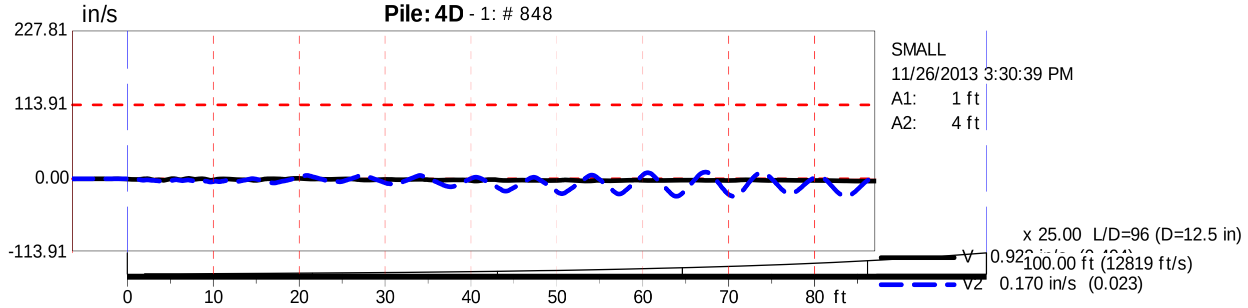

in/s
Pile: 4D - 1: # 852
91.13
45.56
0.00
-45.56
0 10 20 30 40 50 60 70 80 ft
SMALL
11/26/2013 3:31:03 PM
A1: 1 ft
A2: 4 ft
x 25.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V 0.37
V2 0.093 in/s (0.026)

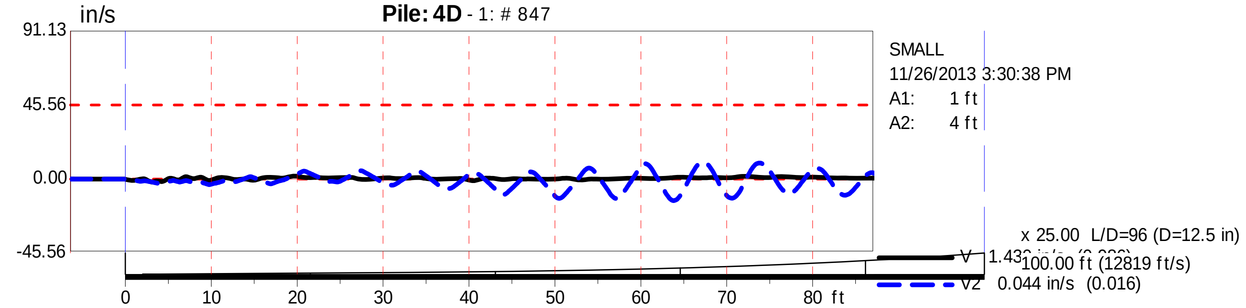

in/s
Pile: 4D - 1: # 851
121.50
60.75
0.00
-60.75
0 10 20 30 40 50 60 70 80 ft
SMALL
11/26/2013 3:30:54 PM
A1: 1 ft
A2: 4 ft
x 25.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V 0.35
V2 0.131 in/s (0.025)

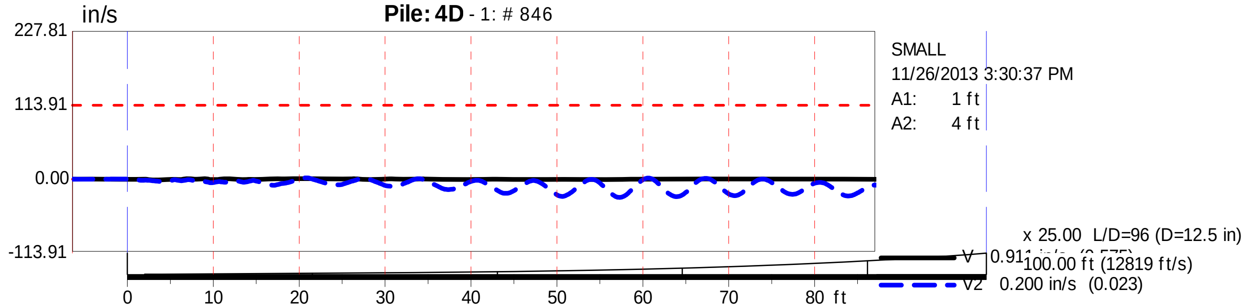

in/s
Pile: 4D - 1: # 850
151.88
75.94
0.00
-75.94
0 10 20 30 40 50 60 70 80 ft
SMALL
11/26/2013 3:30:52 PM
A1: 1 ft
A2: 4 ft
x 25.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V 1.34
V2 0.114 in/s (0.028)

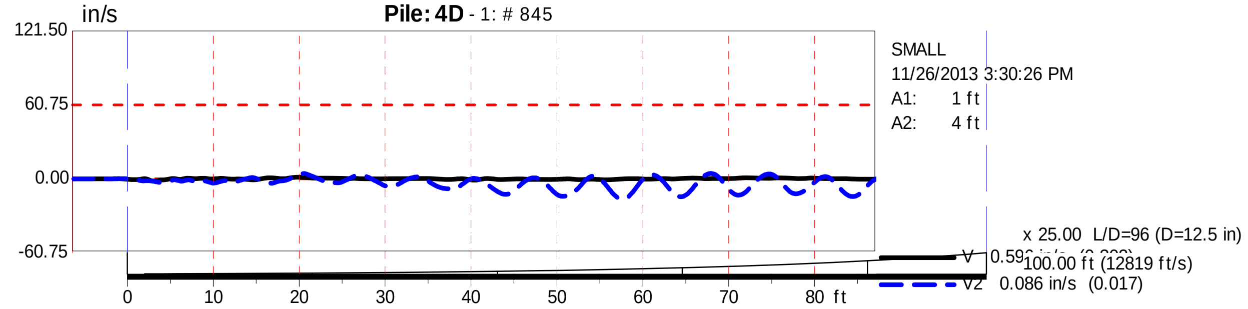
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO





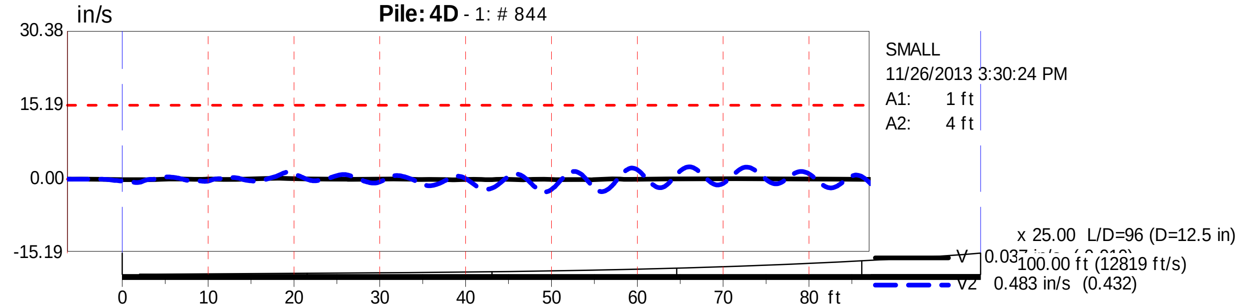






Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

Pile: 4D - 1: # 844



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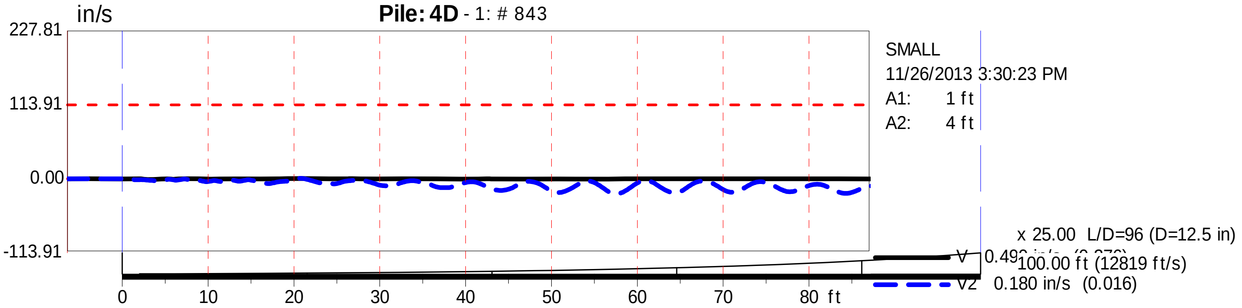
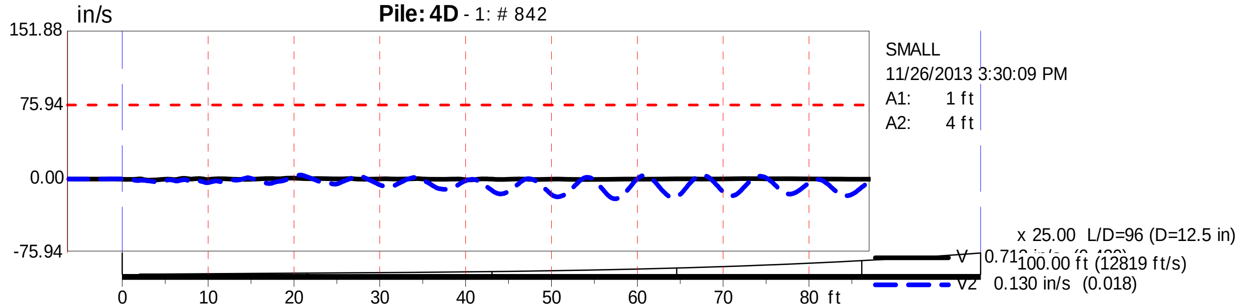
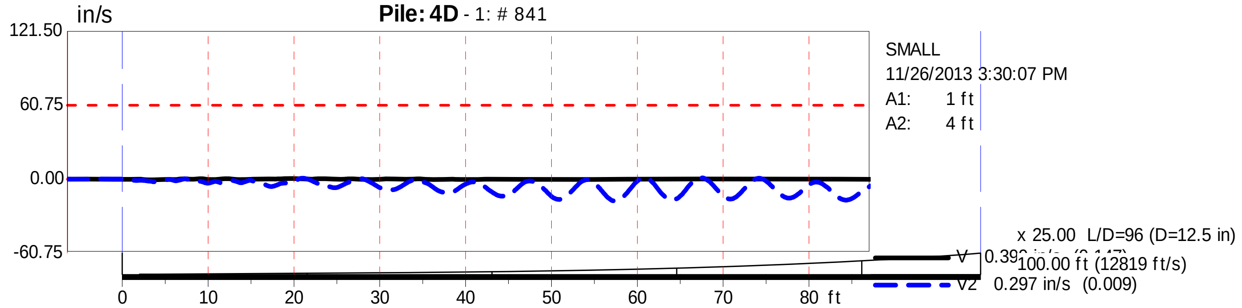


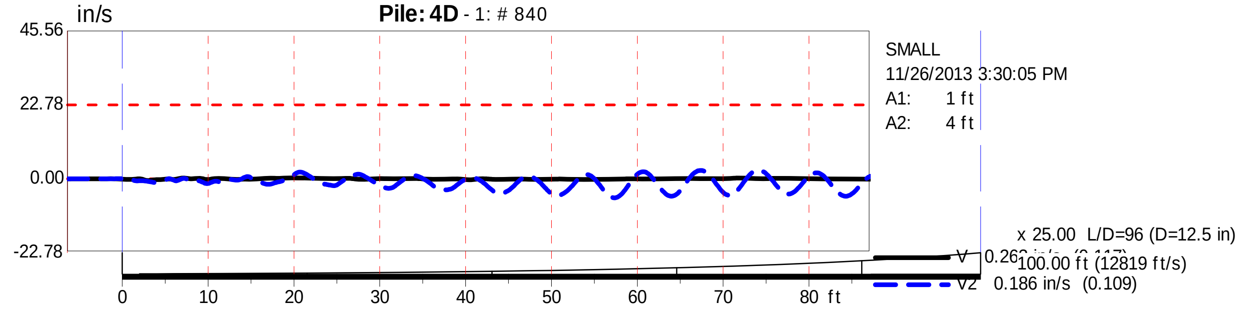
Pile: 4D - 1: # 842



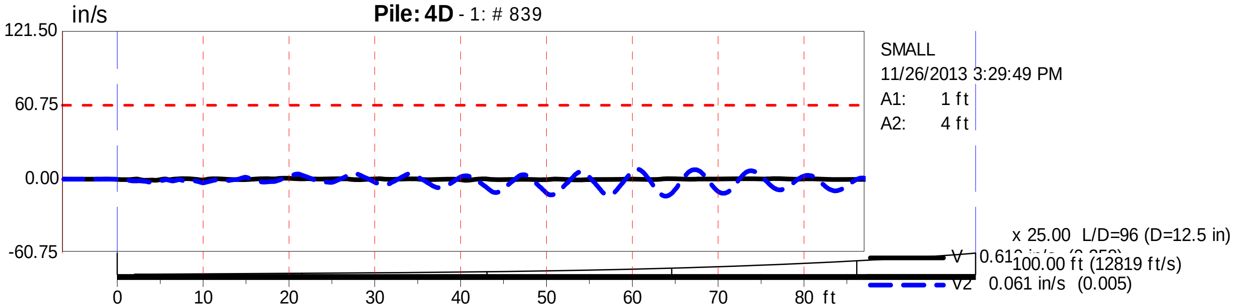
Pile: 4D - 1: # 841



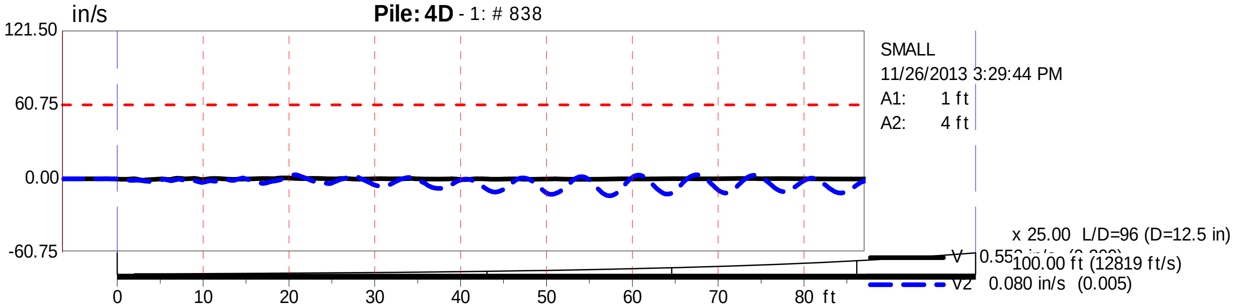
Pile: 4D - 1: # 840



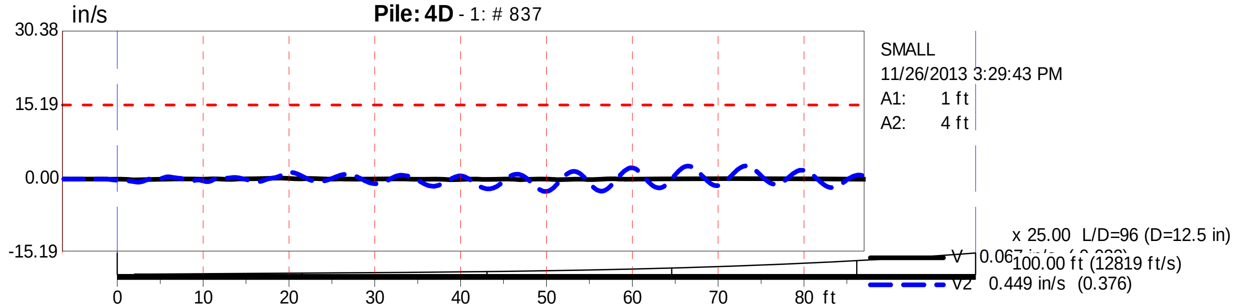
Pile: 4D - 1: # 839



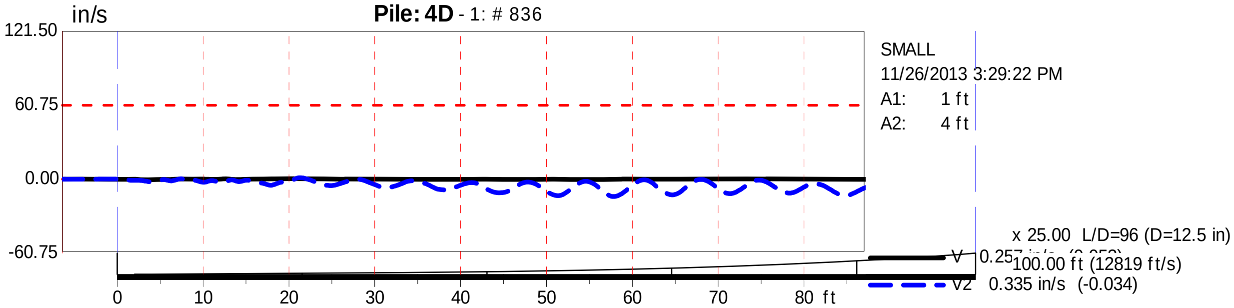
Pile: 4D - 1: # 838



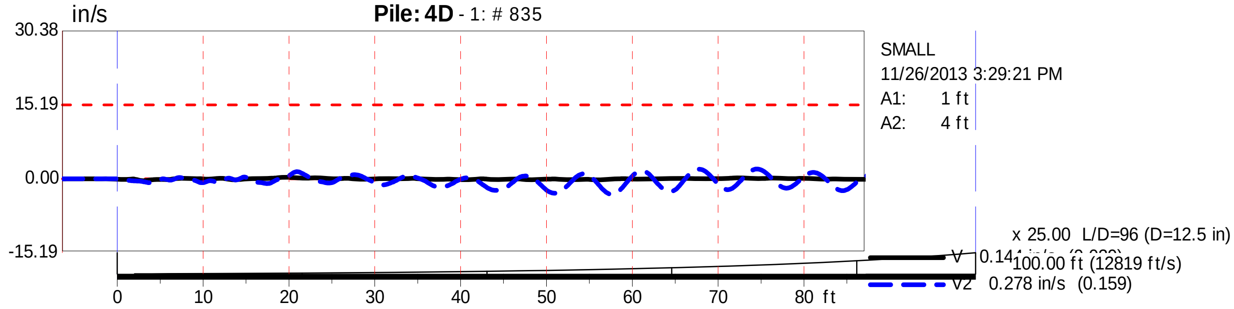
Pile: 4D - 1: # 837

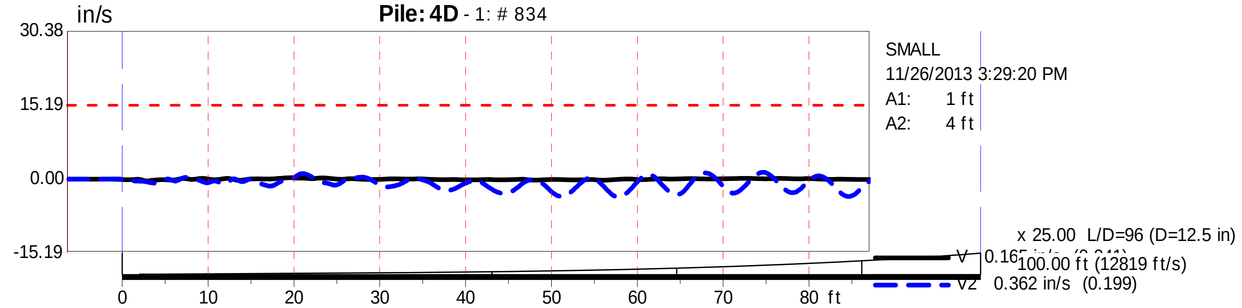


Pile: 4D - 1: # 836

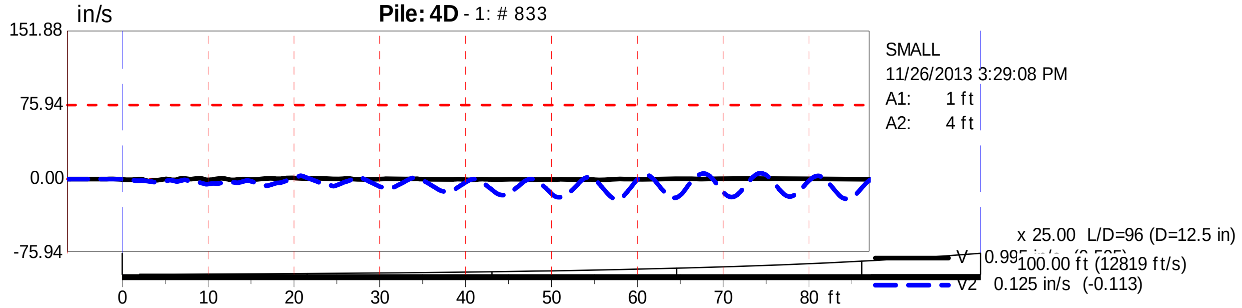


Pile: 4D - 1: # 835

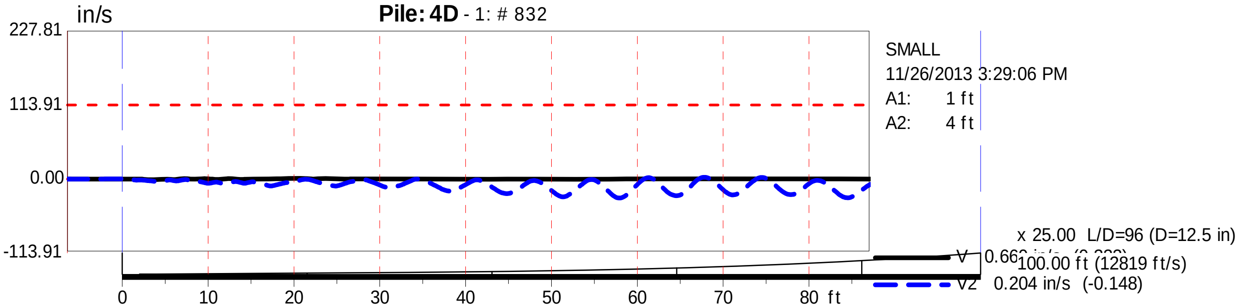




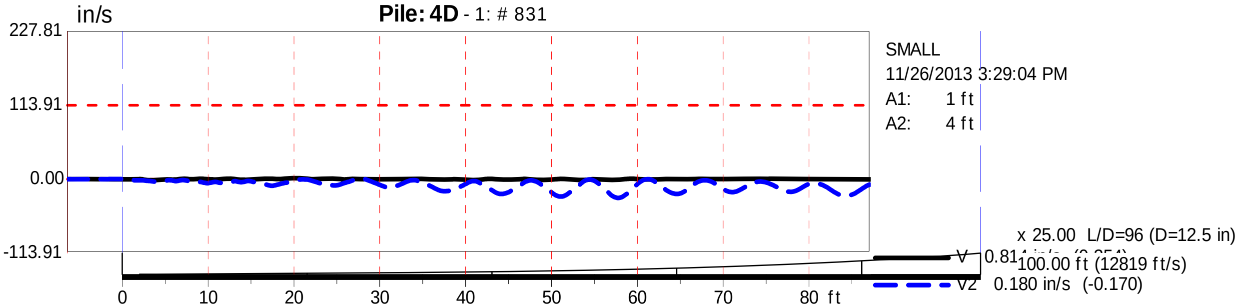
Pile: 4D - 1: # 834



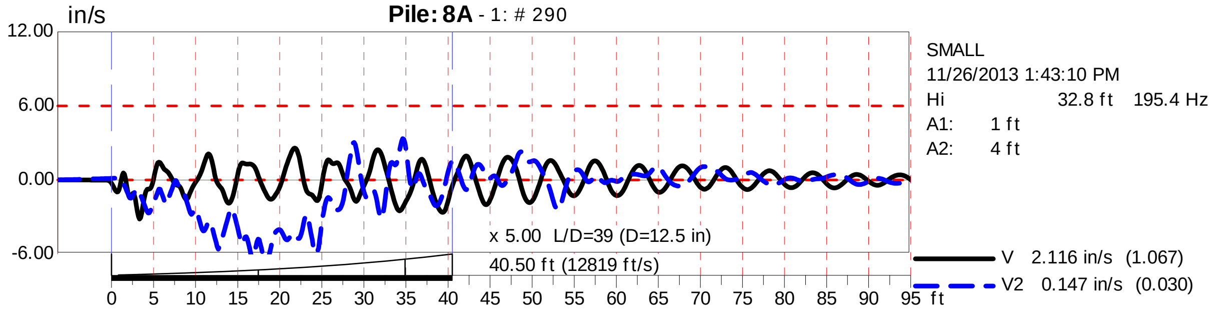
Pile: 4D - 1: # 833

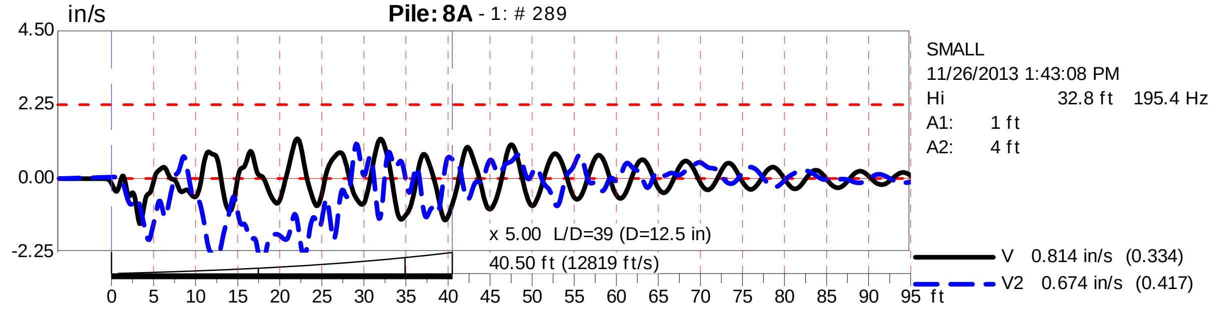


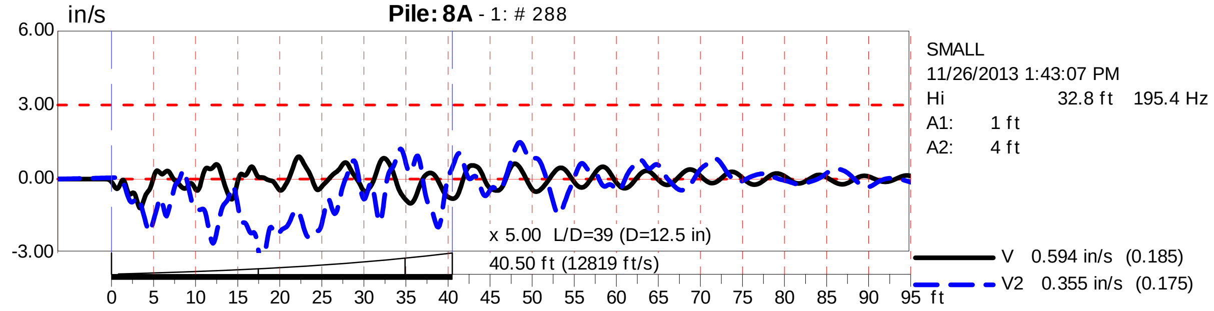
Pile: 4D - 1: # 832

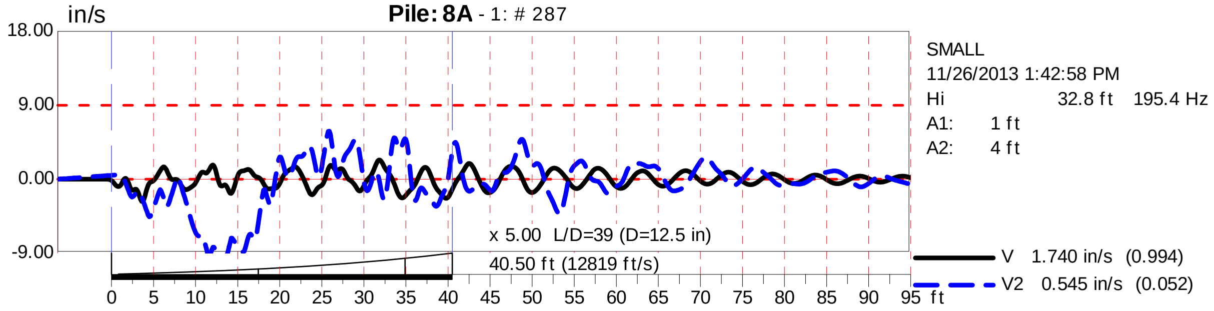


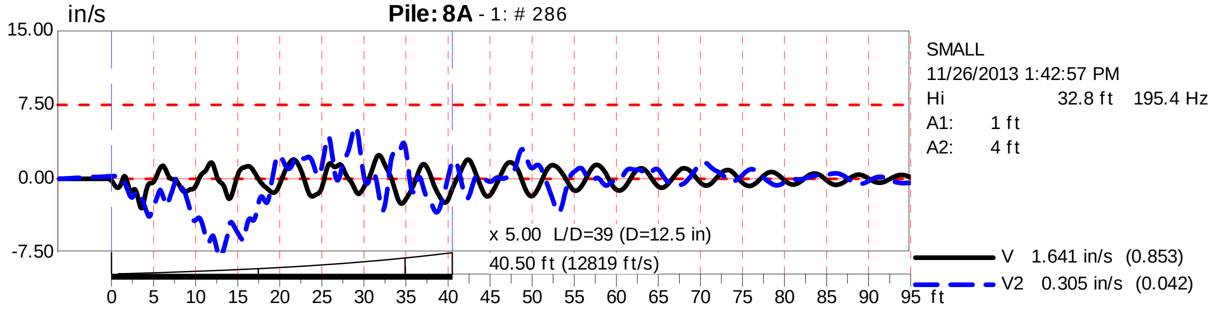
Pile: 4D - 1: # 831

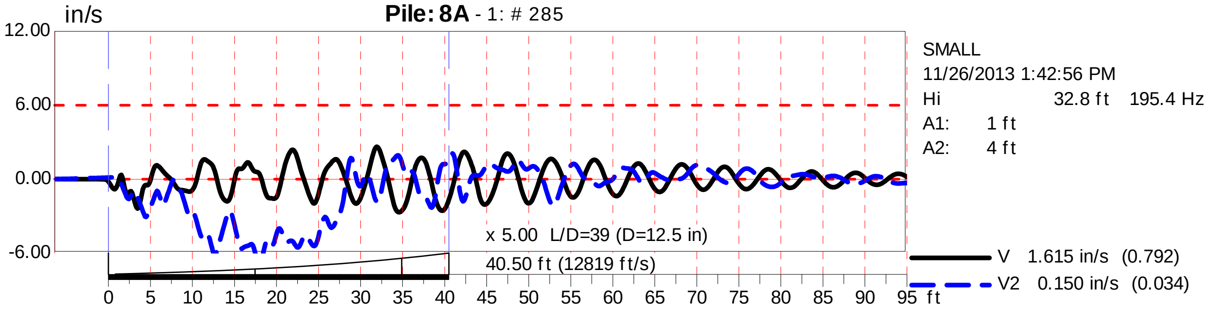

Pile: 8A - 1: # 290

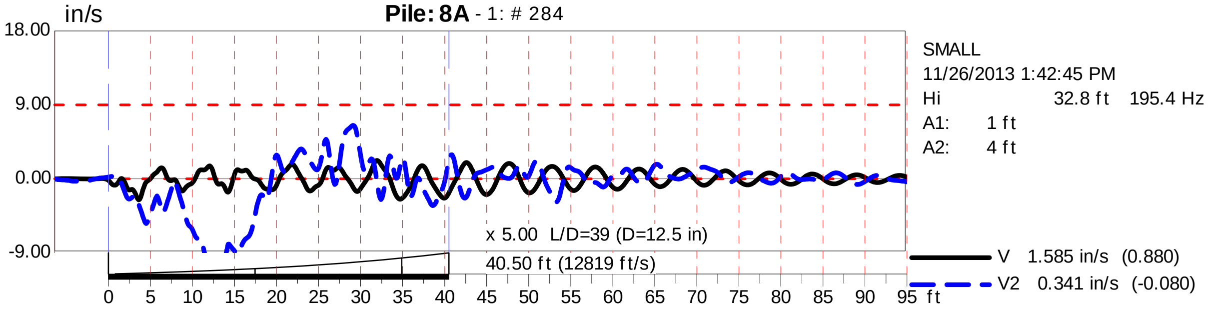

Pile: 8A - 1: # 289

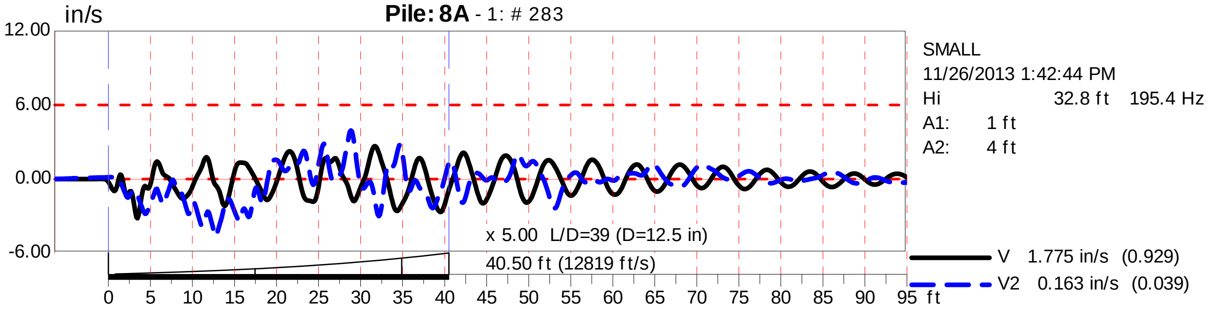

Pile: 8A - 1: # 288

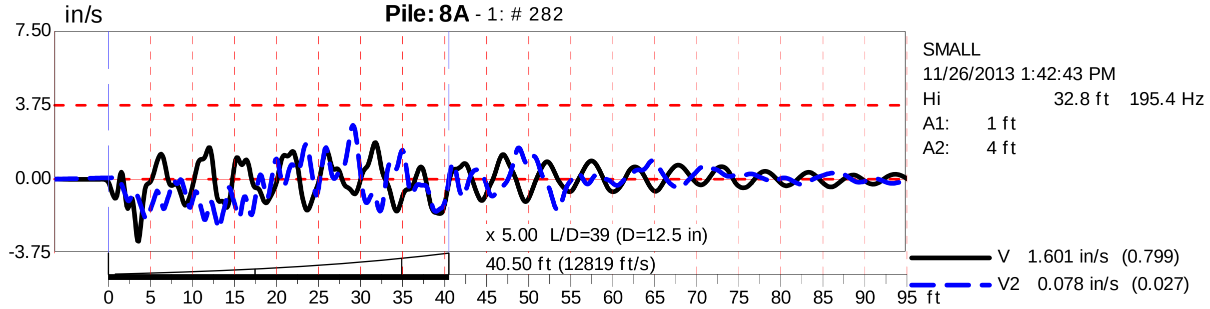

Pile: 8A - 1: # 287

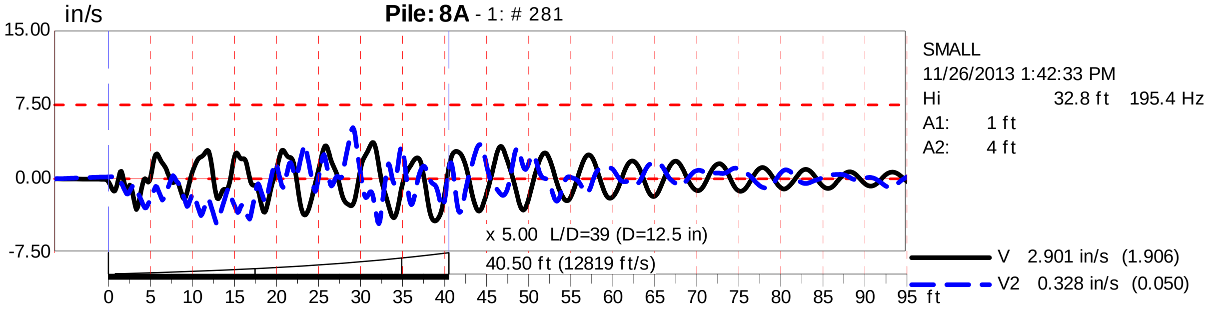

Pile: 8A - 1: # 286


Pile: 8A - 1: # 285

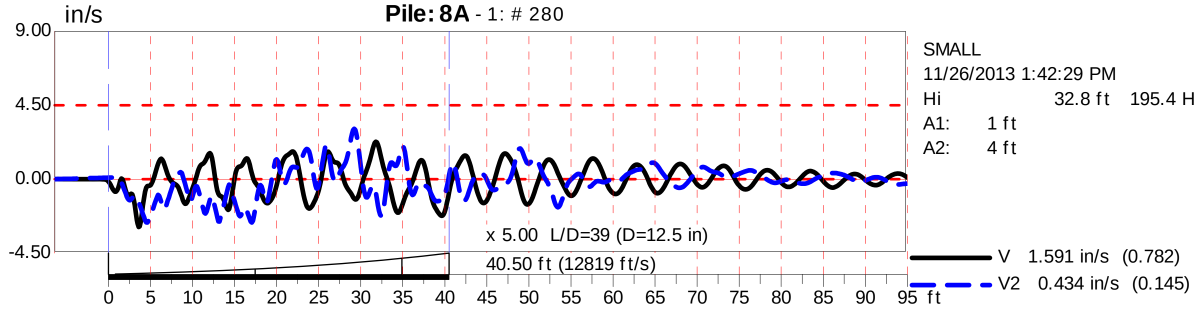

Pile: 8A - 1: # 284


Pile: 8A - 1: # 283


Pile: 8A - 1: # 282

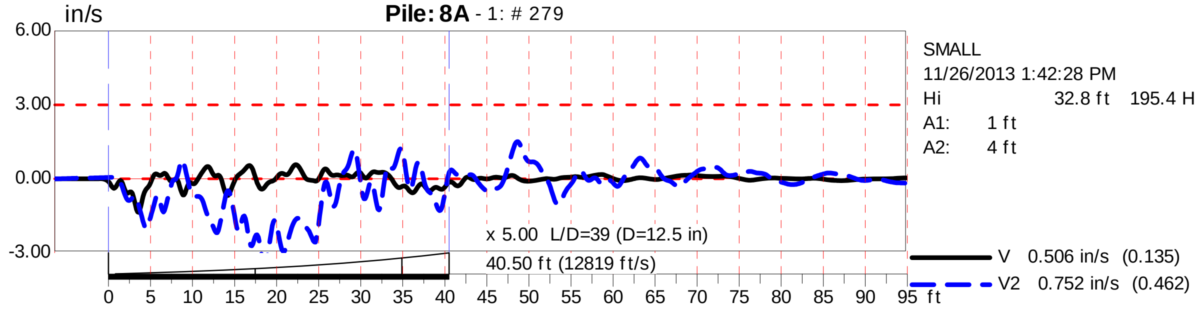

Pile: 8A - 1: # 281

Pile: 8A - 1: # 280



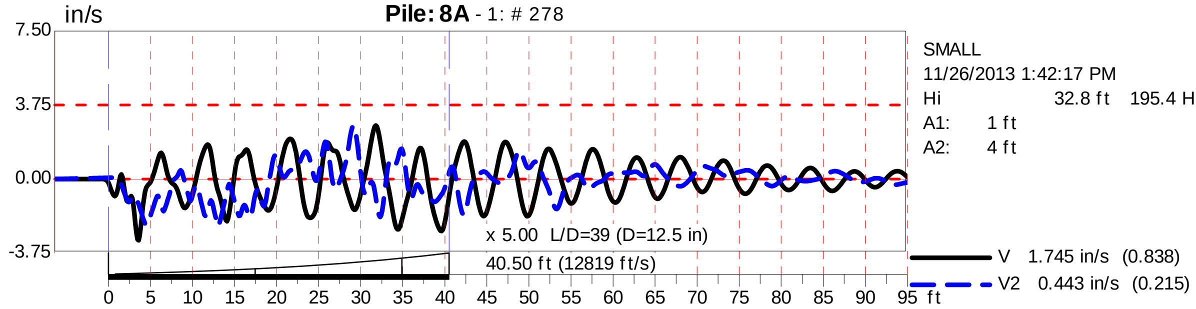
SMALL
11/26/2013 1:42:29 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 8A - 1: # 279



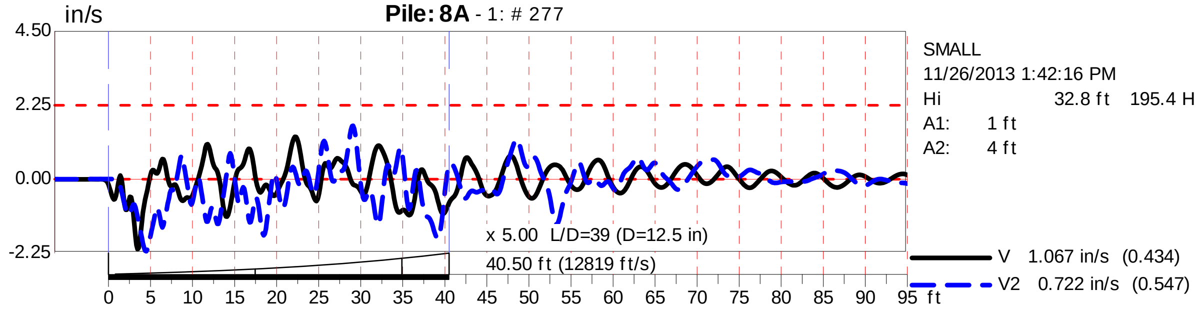
SMALL
11/26/2013 1:42:28 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 8A - 1: # 278



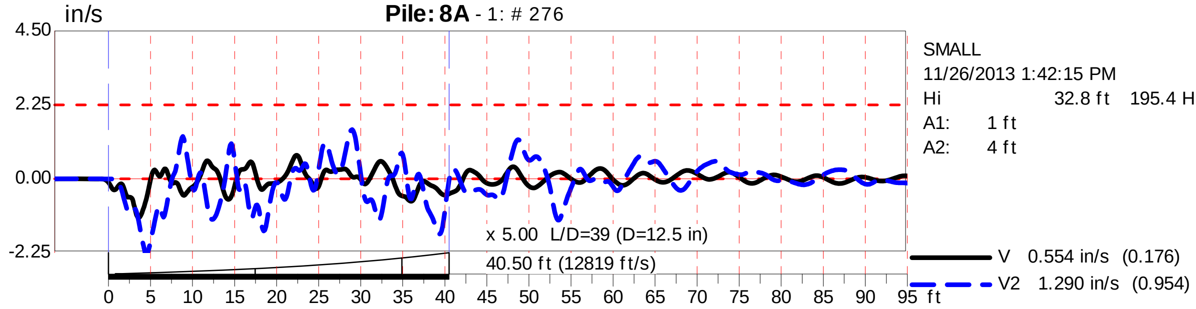
SMALL
11/26/2013 1:42:17 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 8A - 1: # 277

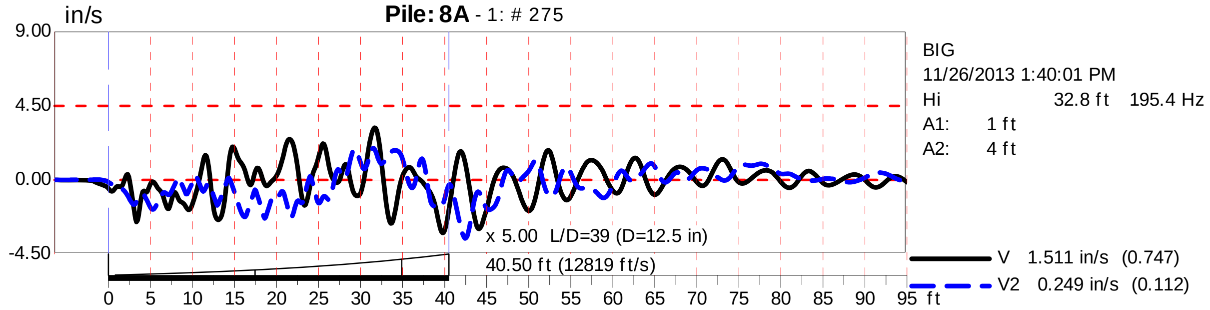


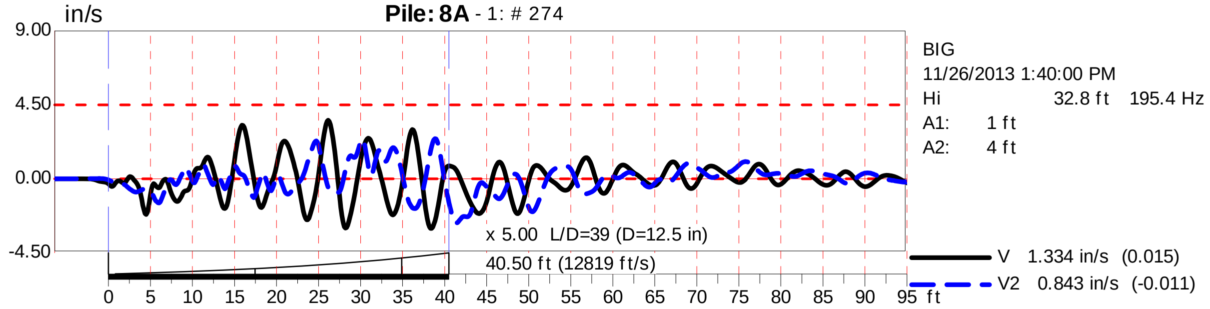
SMALL
11/26/2013 1:42:16 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

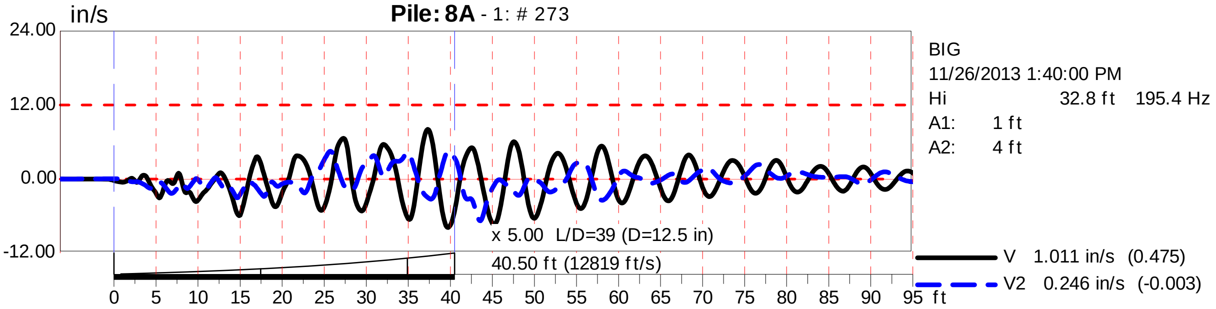
Pile: 8A - 1: # 276

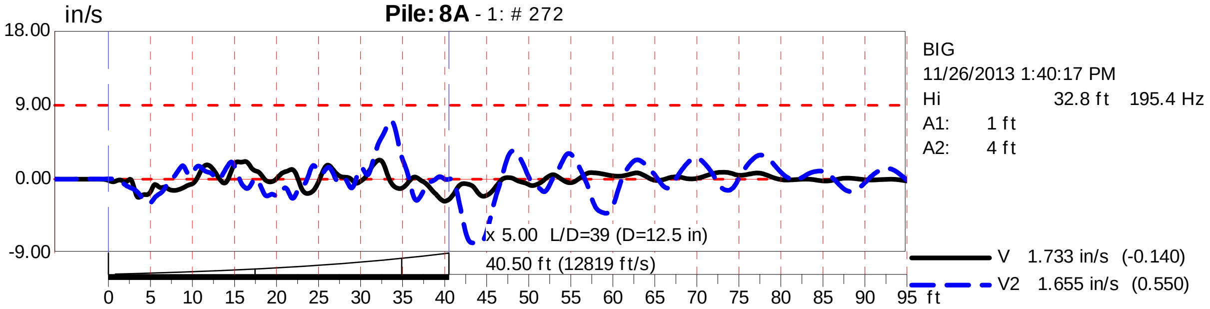


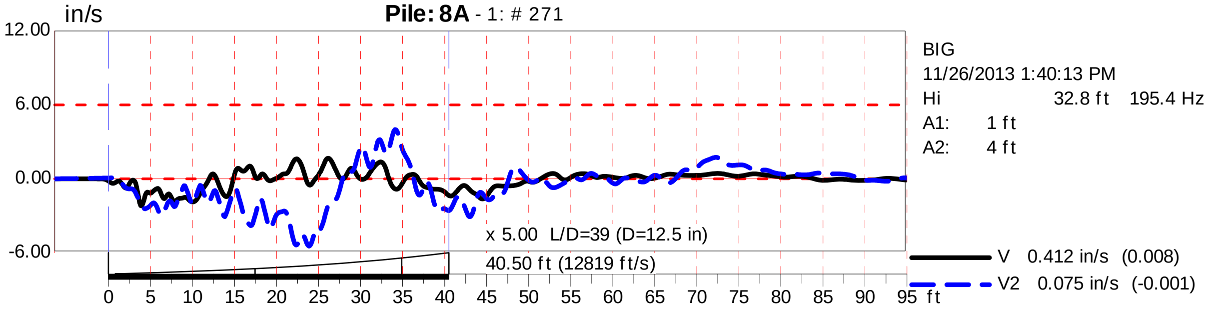
SMALL
11/26/2013 1:42:15 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft


in/s
Pile: 8A - 1: # 275
9.00
4.50
0.00
-4.50
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
BIG
11/26/2013 1:40:01 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.511 in/s (0.747)
V2 0.249 in/s (0.112)


in/s
Pile: 8A - 1: # 274
9.00
4.50
0.00
-4.50
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
BIG
11/26/2013 1:40:00 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.334 in/s (0.015)
V2 0.843 in/s (-0.011)


in/s
Pile: 8A - 1: # 273
24.00
12.00
0.00
-12.00
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
BIG
11/26/2013 1:40:00 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.011 in/s (0.475)
V2 0.246 in/s (-0.003)


in/s
Pile: 8A - 1: # 272
18.00
9.00
0.00
-9.00
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
BIG
11/26/2013 1:40:17 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.733 in/s (-0.140)
V2 1.655 in/s (0.550)


in/s
Pile: 8A - 1: # 271
12.00
6.00
0.00
-6.00
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
BIG
11/26/2013 1:40:13 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.412 in/s (0.008)
V2 0.075 in/s (-0.001)

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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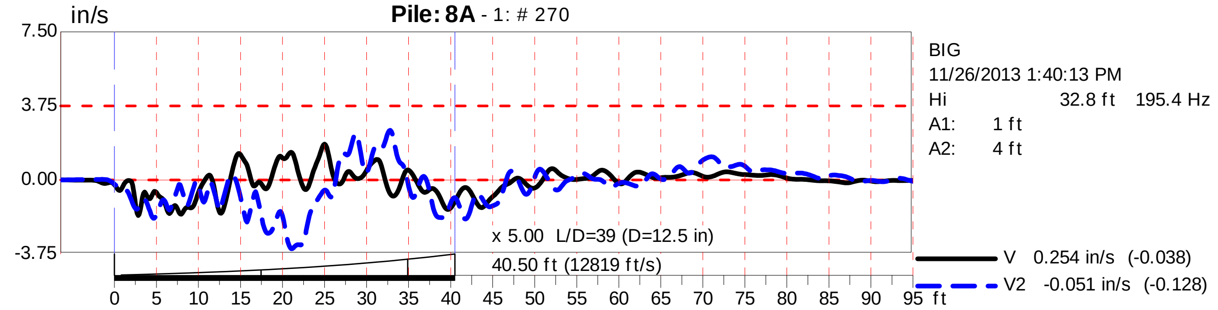
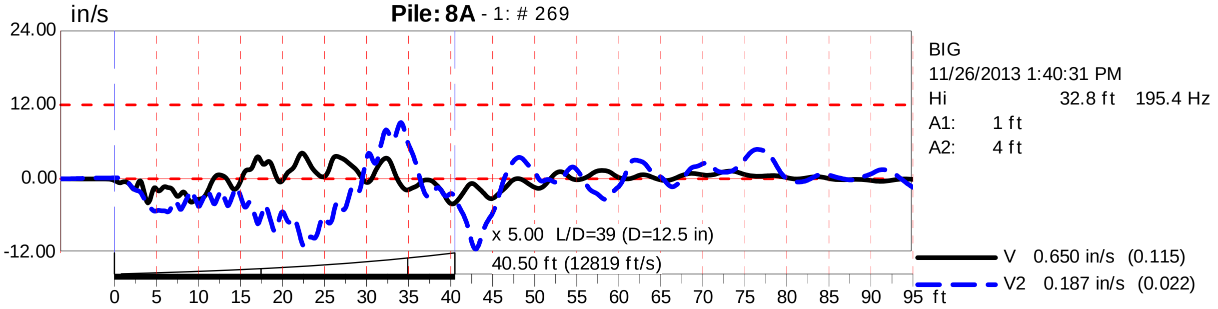
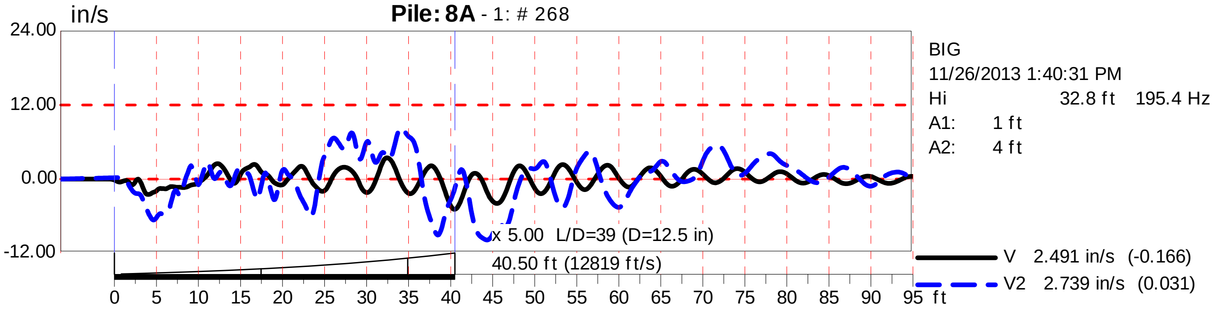
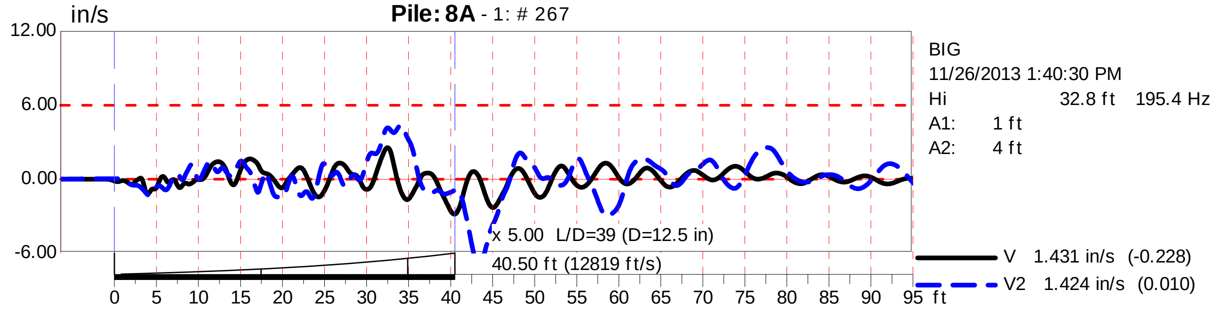
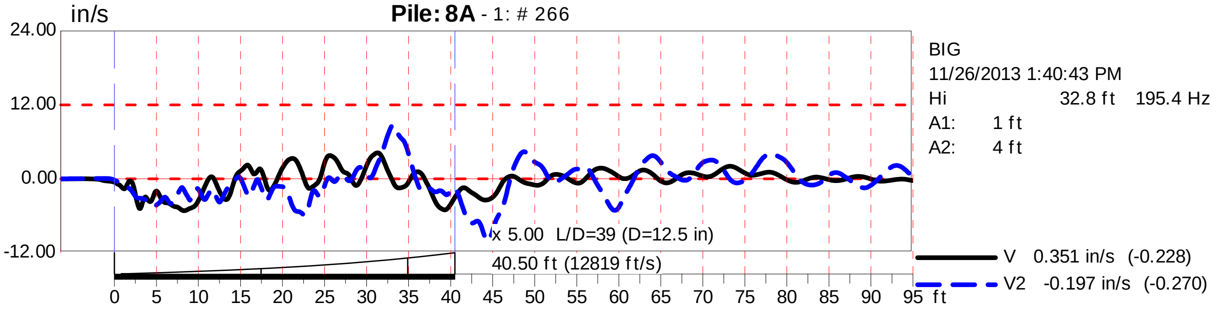
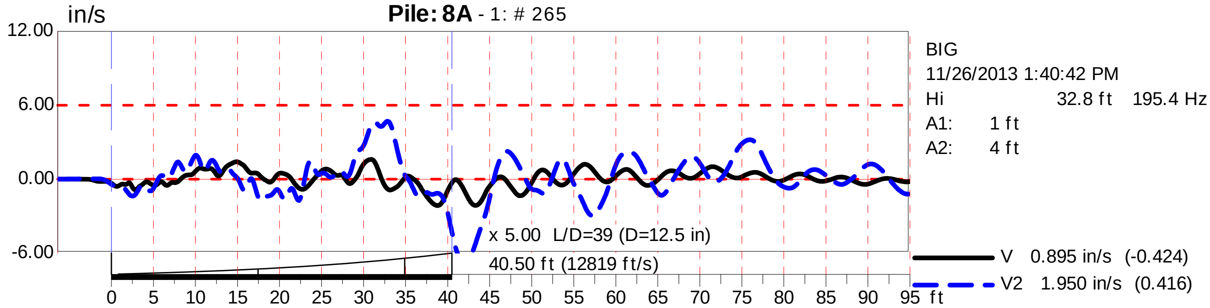

Pile: 8A - 1: # 270

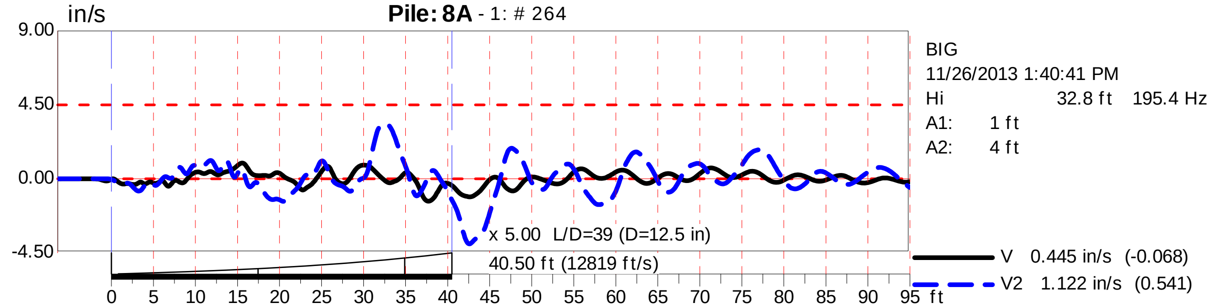

Pile: 8A - 1: # 269

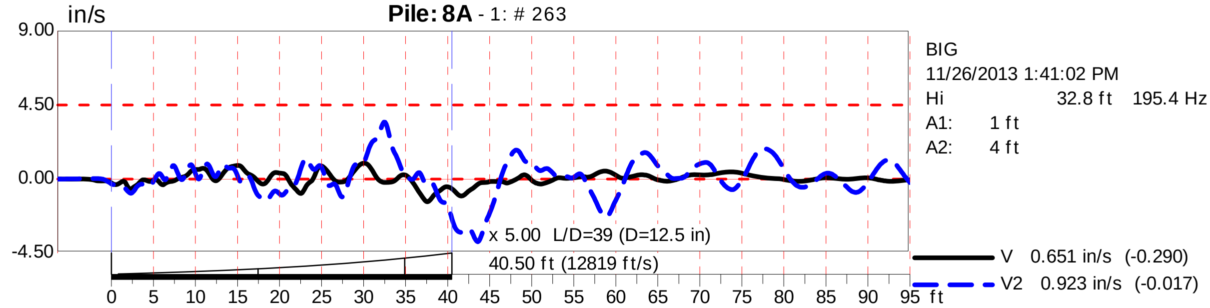

Pile: 8A - 1: # 268

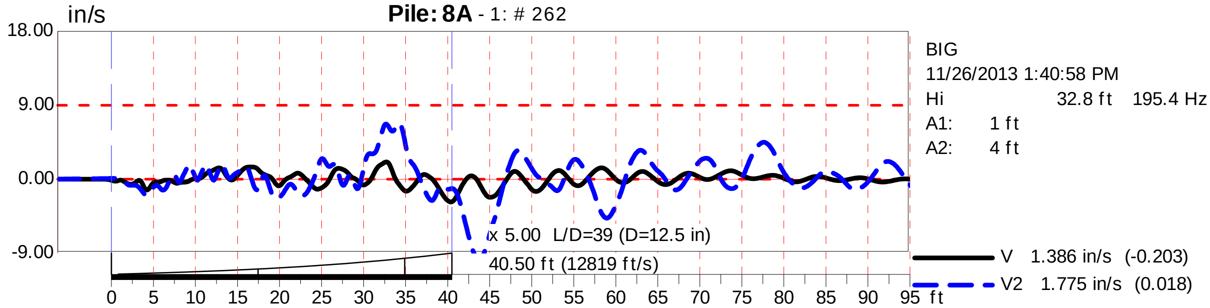

Pile: 8A - 1: # 267

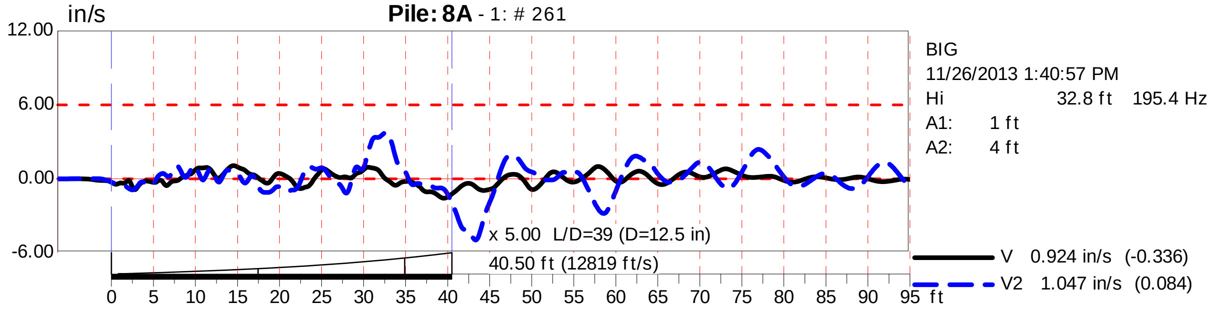

Pile: 8A - 1: # 266


in/s
Pile: 8A - 1: # 265
12.00
6.00
0.00
-6.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
BIG
11/26/2013 1:40:42 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.895 in/s (-0.424)
V2 1.950 in/s (0.416)

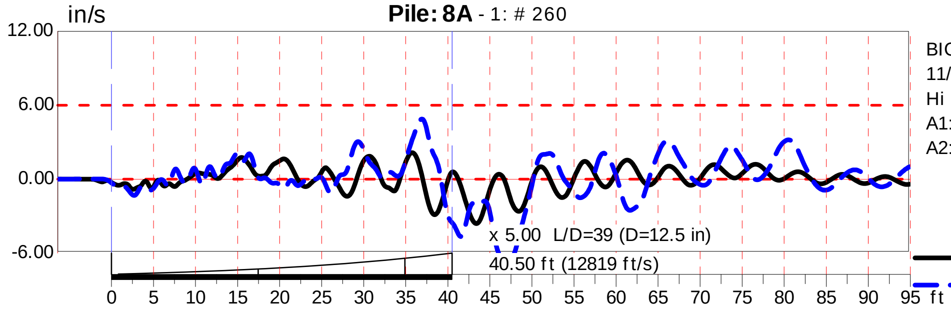

in/s
Pile: 8A - 1: # 264
9.00
4.50
0.00
-4.50
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
BIG
11/26/2013 1:40:41 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.445 in/s (-0.068)
V2 1.122 in/s (0.541)


in/s
Pile: 8A - 1: # 263
9.00
4.50
0.00
-4.50
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
BIG
11/26/2013 1:41:02 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.651 in/s (-0.290)
V2 0.923 in/s (-0.017)


in/s
Pile: 8A - 1: # 262
18.00
9.00
0.00
-9.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
BIG
11/26/2013 1:40:58 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.386 in/s (-0.203)
V2 1.775 in/s (0.018)


in/s
Pile: 8A - 1: # 261
12.00
6.00
0.00
-6.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 ft
x 5.00 L/D=39 (D=12.5 in)
40.50 ft (12819 ft/s)
BIG
11/26/2013 1:40:57 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.924 in/s (-0.336)
V2 1.047 in/s (0.084)

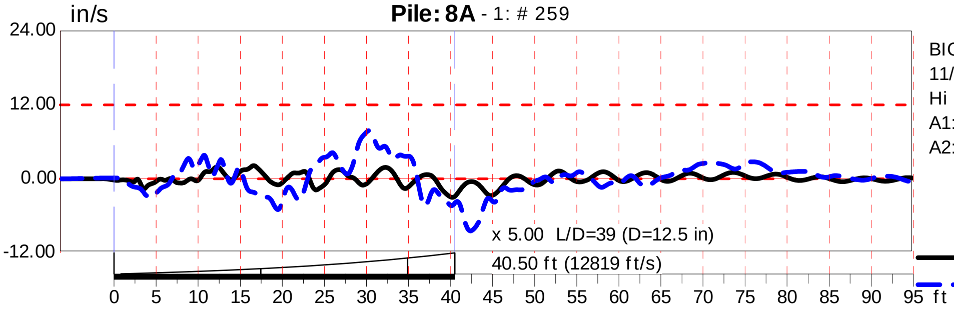
Pile: 8A - 1: # 260



BIG
11/26/2013 1:41:19 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 0.510 in/s (-0.368)
V2 1.035 in/s (-0.307)

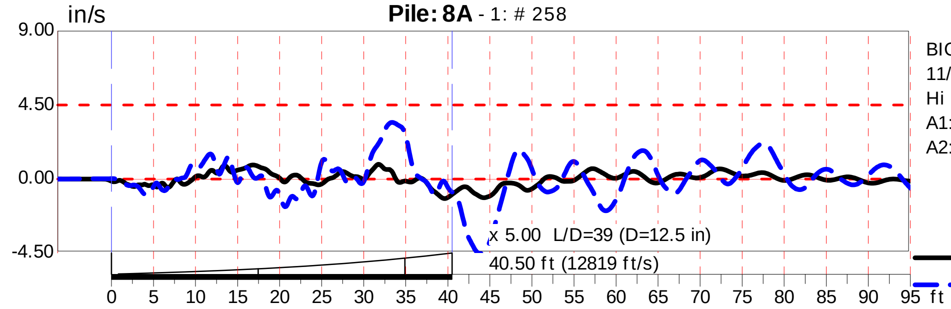
Pile: 8A - 1: # 259



BIG
11/26/2013 1:41:15 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 1.923 in/s (-0.317)
V2 3.828 in/s (0.385)

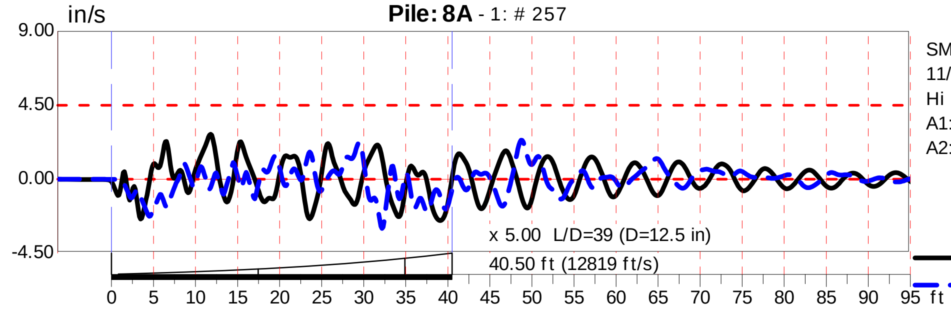
Pile: 8A - 1: # 258



BIG
11/26/2013 1:41:14 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 0.539 in/s (-0.152)
V2 1.531 in/s (0.339)

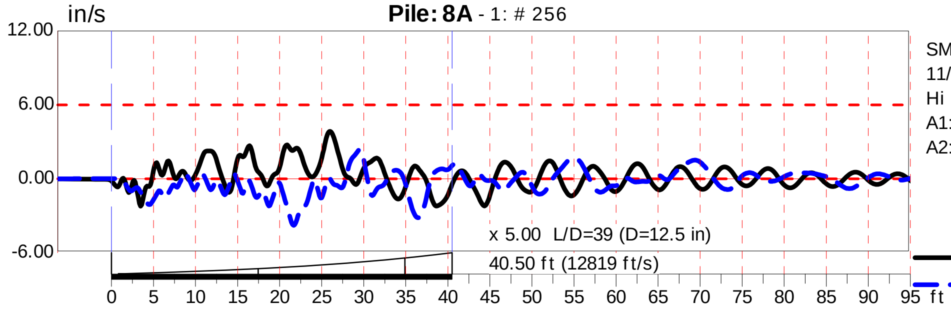
Pile: 8A - 1: # 257



SMALL
11/26/2013 1:41:41 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 2.738 in/s (1.651)
V2 0.938 in/s (0.713)

Pile: 8A - 1: # 256



SMALL
11/26/2013 1:41:36 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 2.264 in/s (1.309)
V2 0.494 in/s (0.334)

Pile Dynamics, Inc.
PIT Raw data
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12/29/2013

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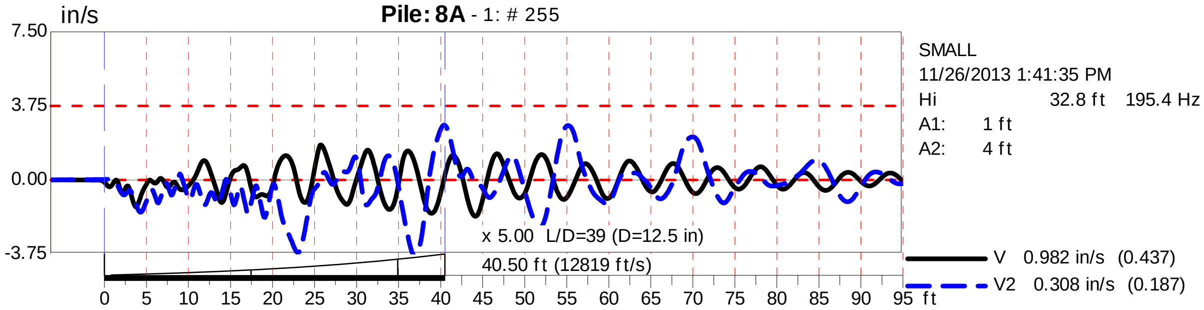
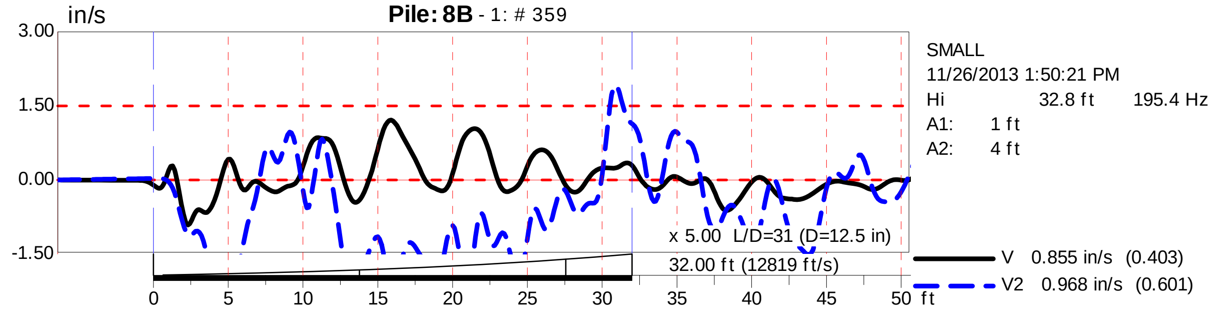
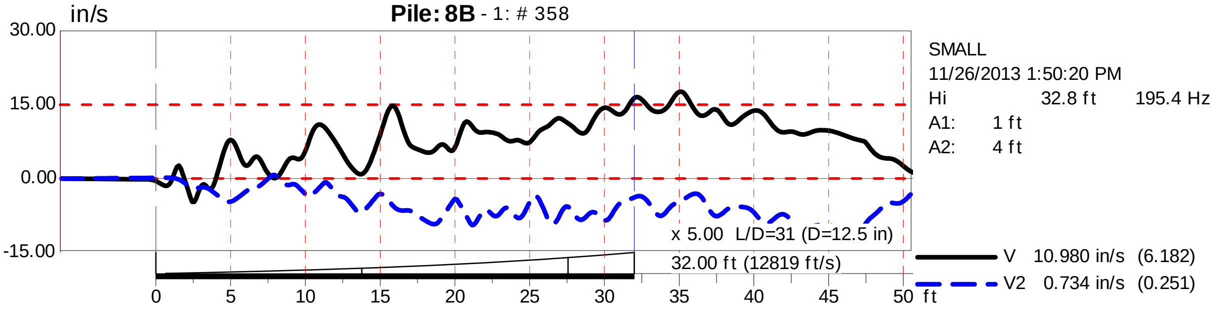
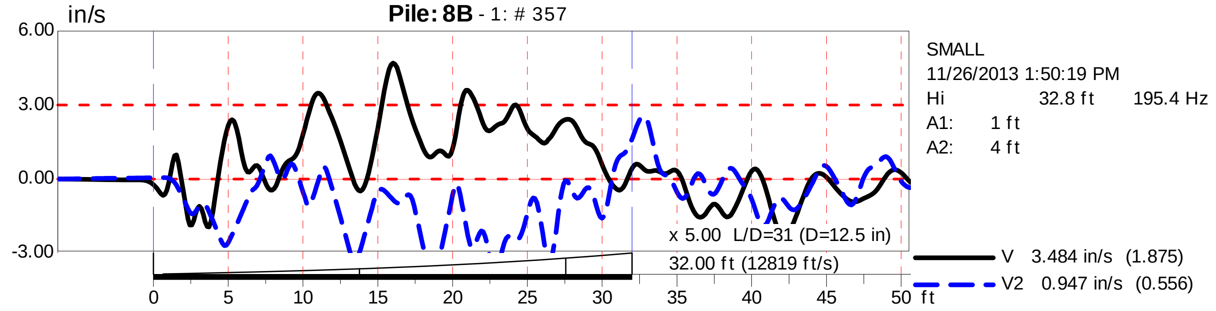




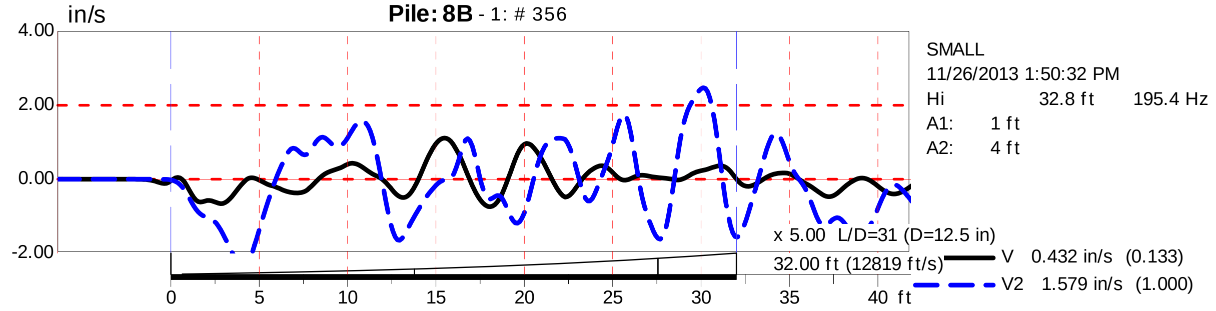
Pile: 8B - 1: # 359



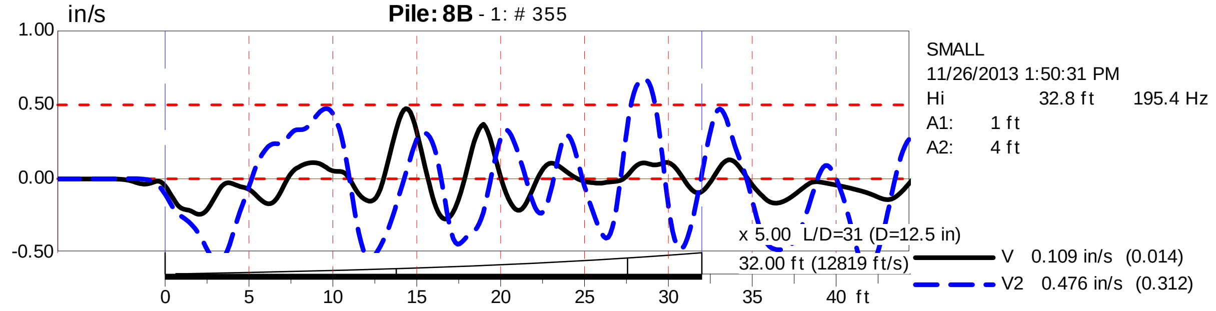
Pile: 8B - 1: # 358



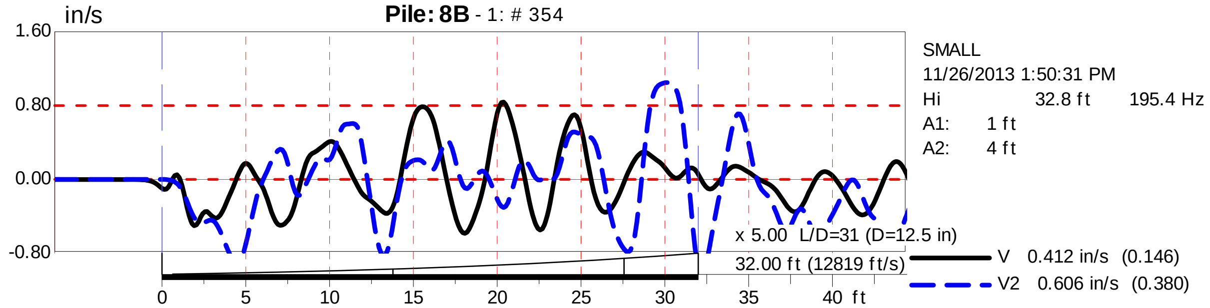
Pile: 8B - 1: # 357

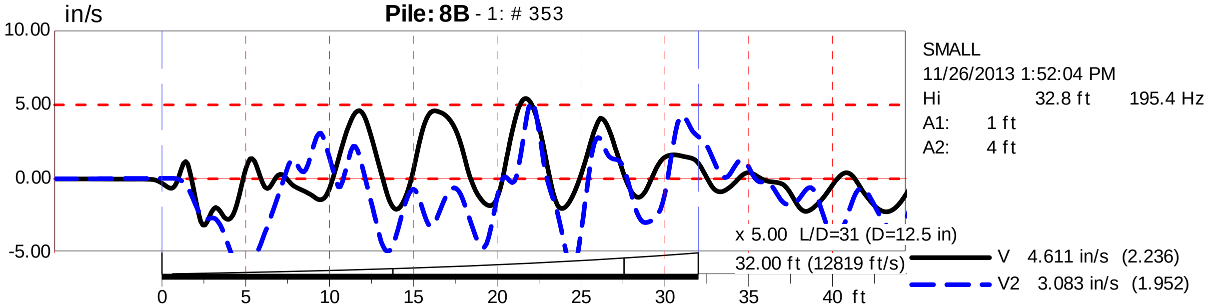


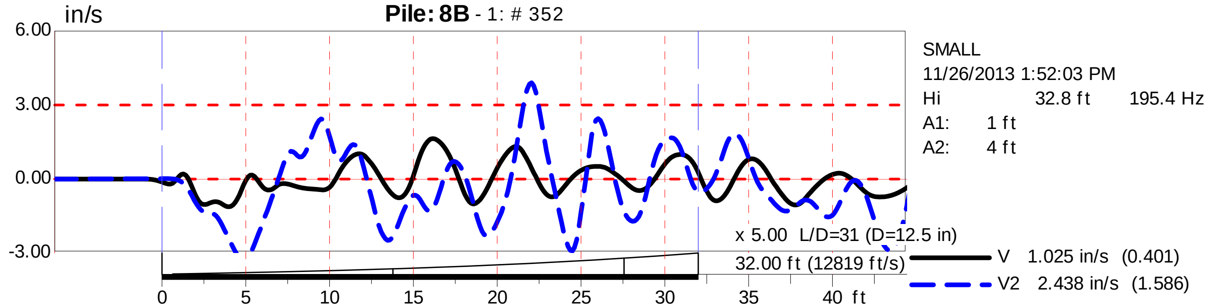
Pile: 8B - 1: # 356

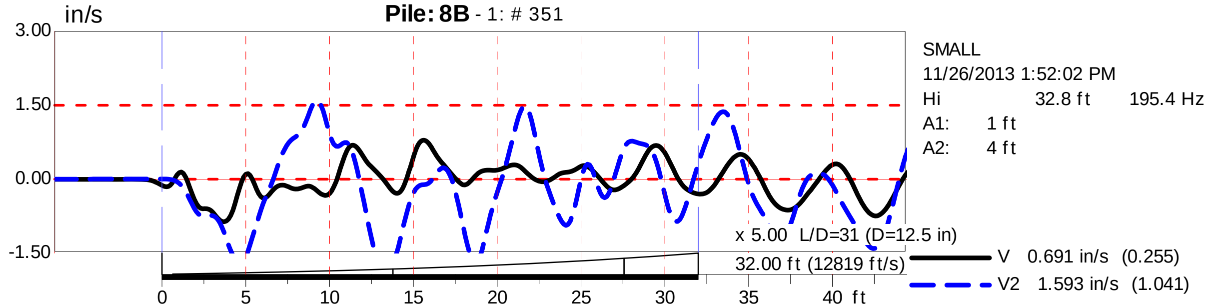


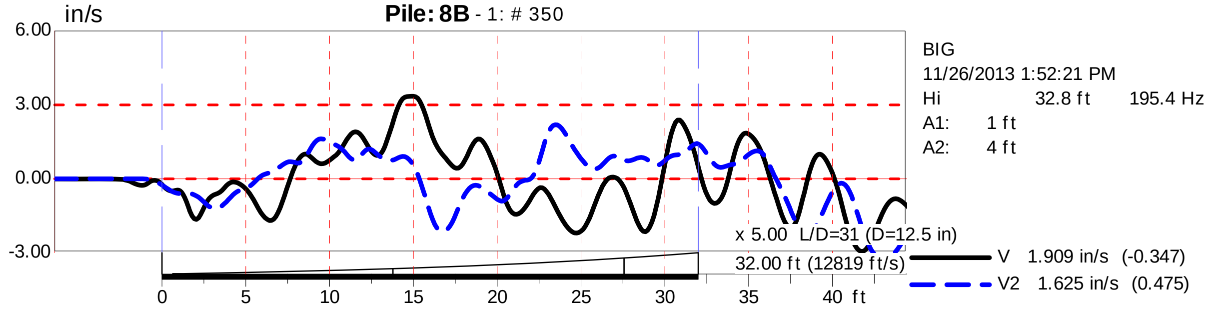
Pile: 8B - 1: # 355


in/s
Pile: 8B - 1: # 354
1.60
0.80
0.00
-0.80
0 5 10 15 20 25 30 35 40 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
SMALL
11/26/2013 1:50:31 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.412 in/s (0.146)
V2 0.606 in/s (0.380)


in/s
Pile: 8B - 1: # 353
10.00
5.00
0.00
-5.00
0 5 10 15 20 25 30 35 40 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
SMALL
11/26/2013 1:52:04 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 4.611 in/s (2.236)
V2 3.083 in/s (1.952)

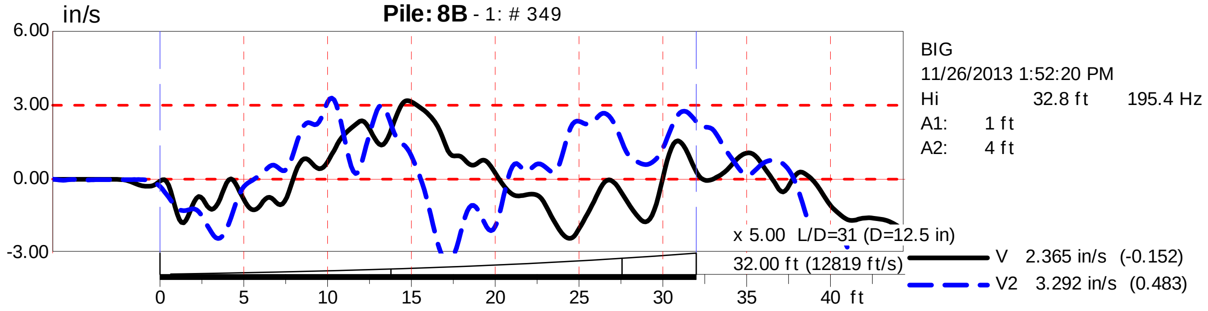

in/s
Pile: 8B - 1: # 352
6.00
3.00
0.00
-3.00
0 5 10 15 20 25 30 35 40 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
SMALL
11/26/2013 1:52:03 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.025 in/s (0.401)
V2 2.438 in/s (1.586)

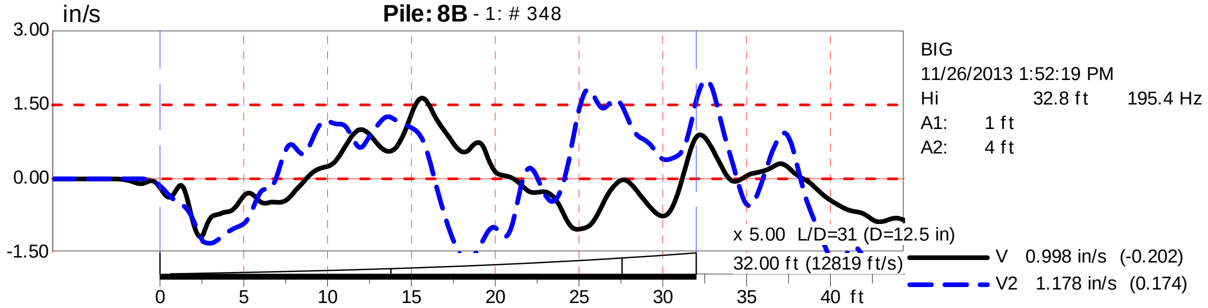

in/s
Pile: 8B - 1: # 351
3.00
1.50
0.00
-1.50
0 5 10 15 20 25 30 35 40 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
SMALL
11/26/2013 1:52:02 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.691 in/s (0.255)
V2 1.593 in/s (1.041)

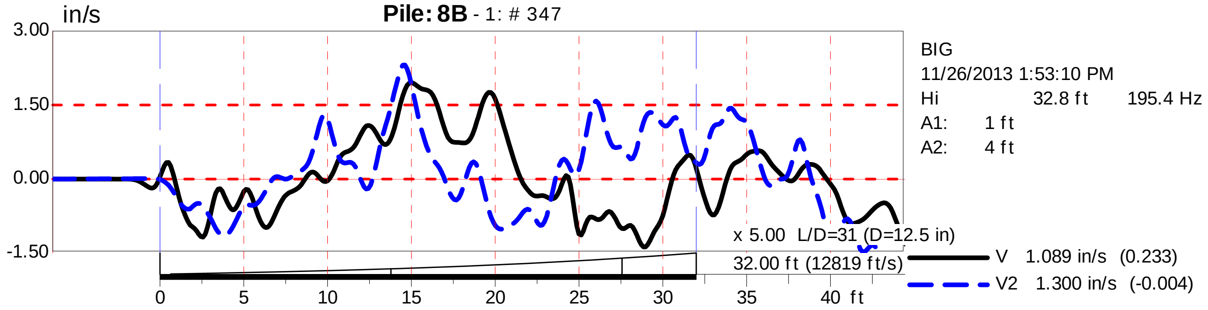

in/s
Pile: 8B - 1: # 350
6.00
3.00
0.00
-3.00
0 5 10 15 20 25 30 35 40 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
BIG
11/26/2013 1:52:21 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.909 in/s (-0.347)
V2 1.625 in/s (0.475)

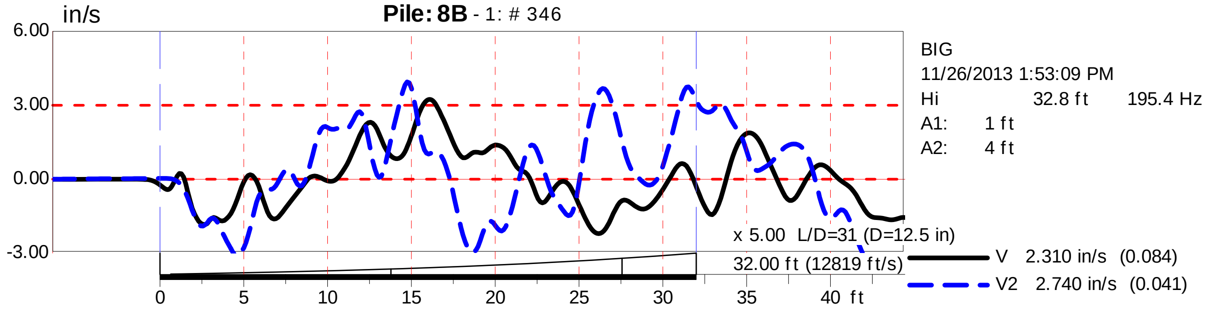
Pile Dynamics, Inc.
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT

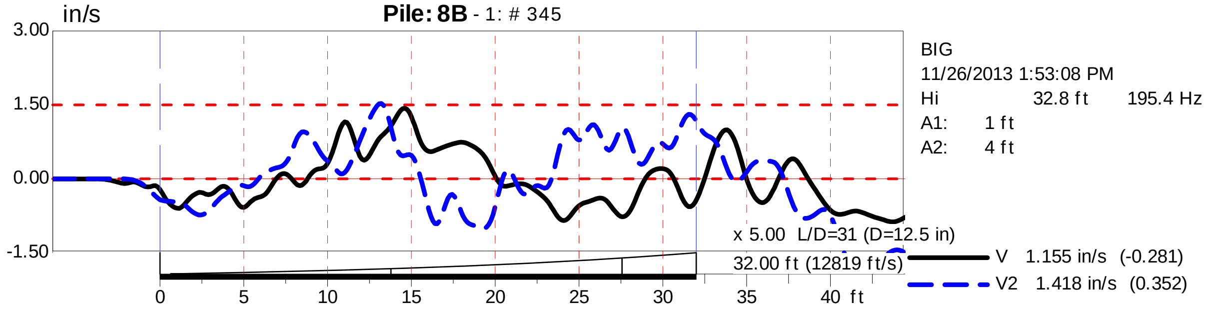
12/29/2013
PIT-W 2009-2.DEMO

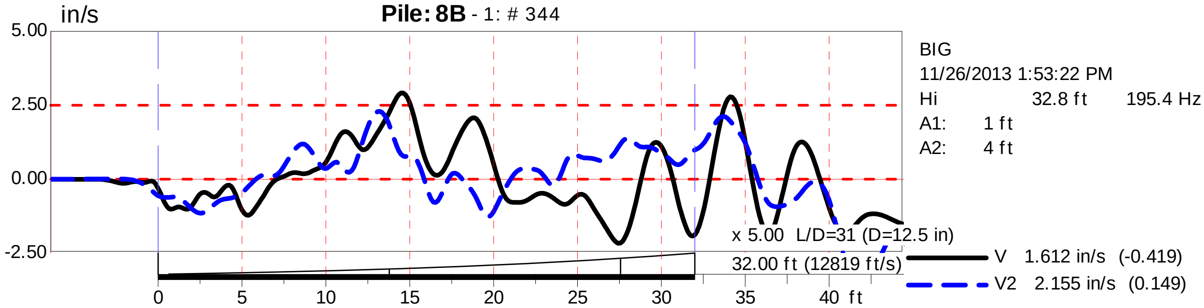

Pile: 8B - 1: # 349


Pile: 8B - 1: # 348


Pile: 8B - 1: # 347


Pile: 8B - 1: # 346

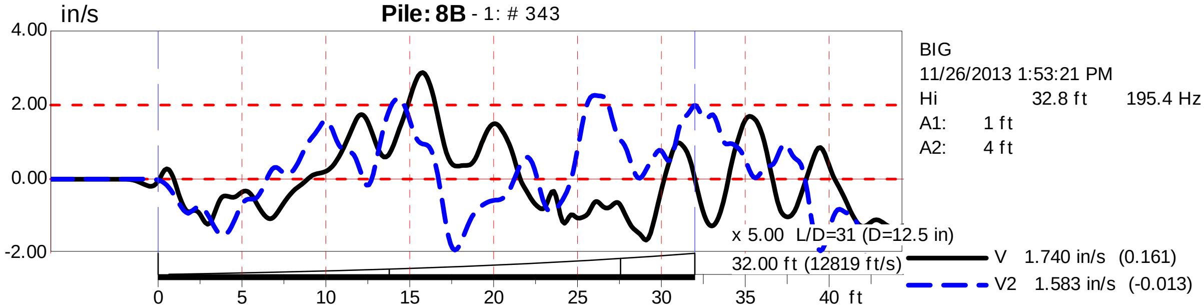

Pile: 8B - 1: # 345



Pile: 8B - 1: # 344

BIG
11/26/2013 1:53:22 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

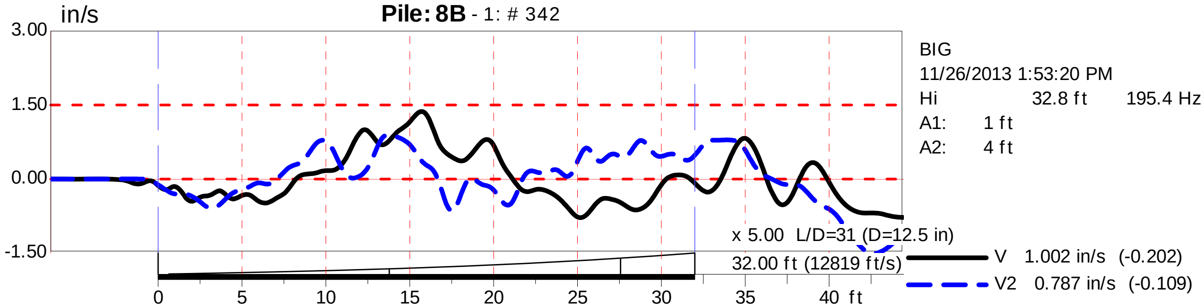
V 1.612 in/s (-0.419)
V2 2.155 in/s (0.149)



Pile: 8B - 1: # 343

BIG
11/26/2013 1:53:21 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

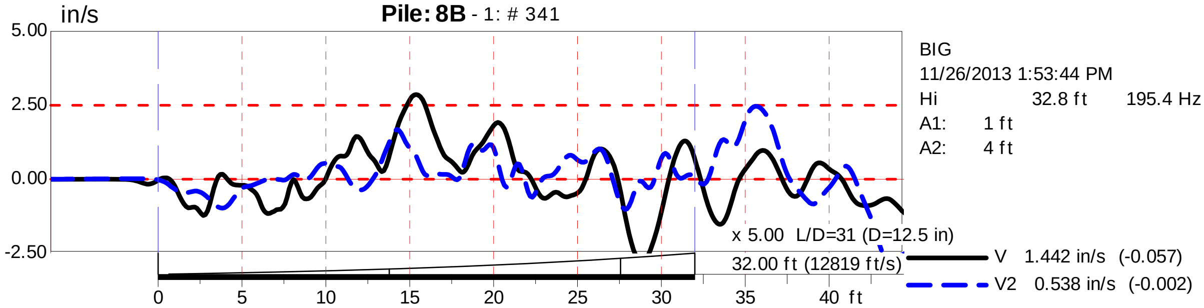
V 1.740 in/s (0.161)
V2 1.583 in/s (-0.013)



Pile: 8B - 1: # 342

BIG
11/26/2013 1:53:20 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

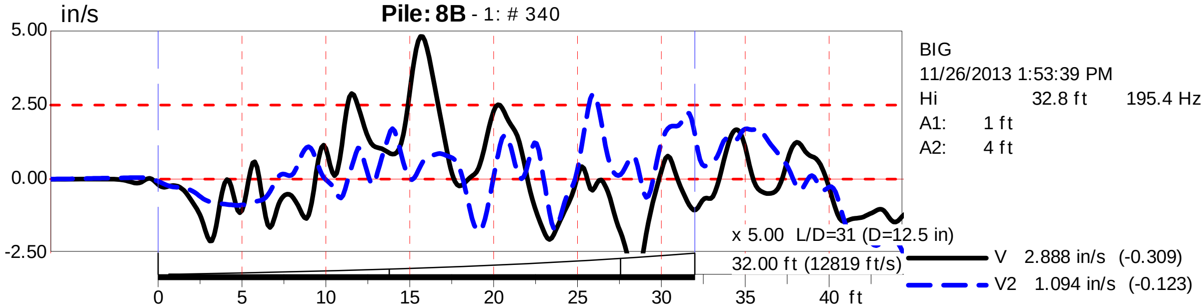
V 1.002 in/s (-0.202)
V2 0.787 in/s (-0.109)



Pile: 8B - 1: # 341

BIG
11/26/2013 1:53:44 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 1.442 in/s (-0.057)
V2 0.538 in/s (-0.002)

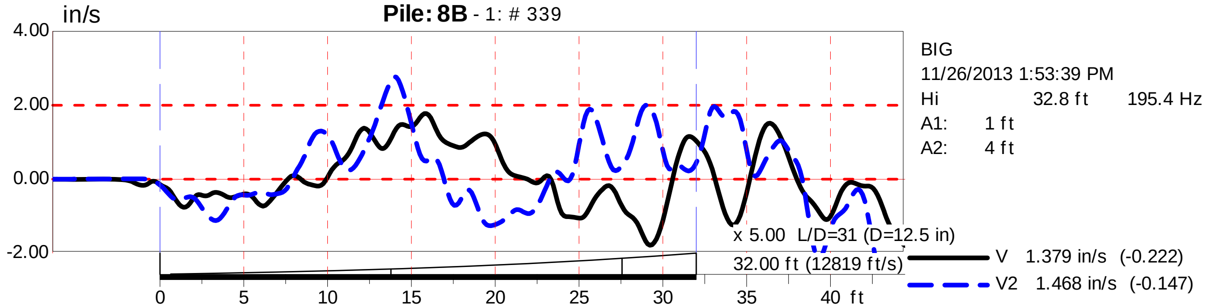


Pile: 8B - 1: # 340

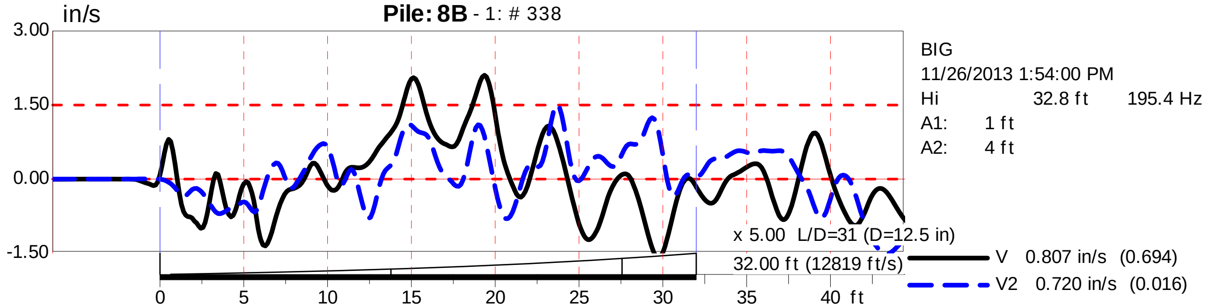
BIG
11/26/2013 1:53:39 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 2.888 in/s (-0.309)
V2 1.094 in/s (-0.123)

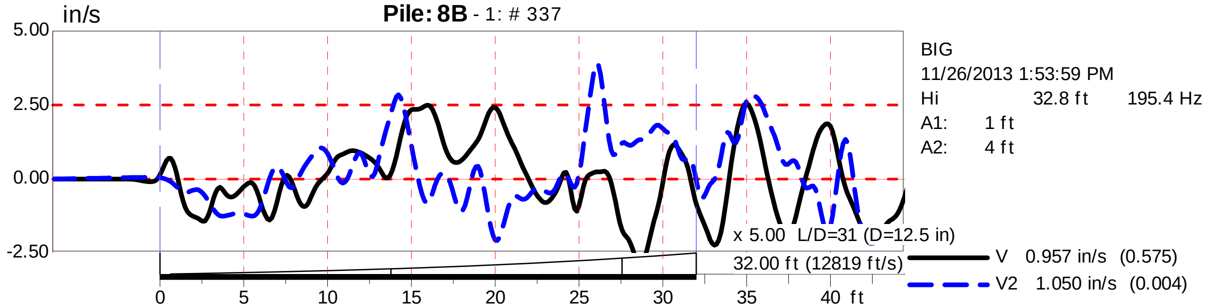
Pile: 8B - 1: # 339



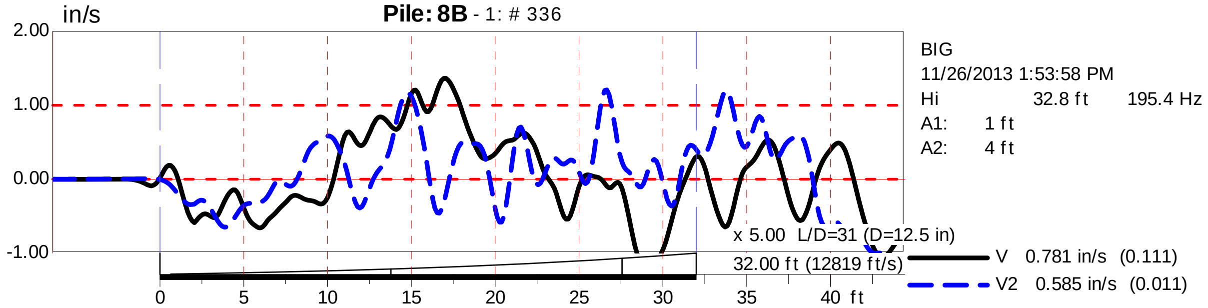
Pile: 8B - 1: # 338



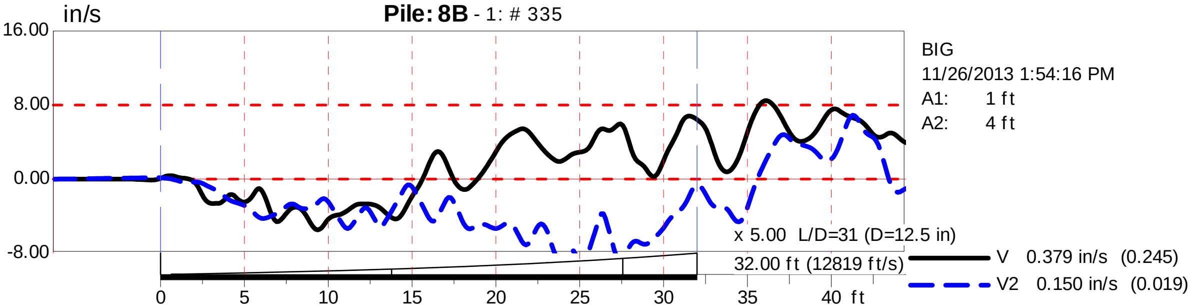
Pile: 8B - 1: # 337

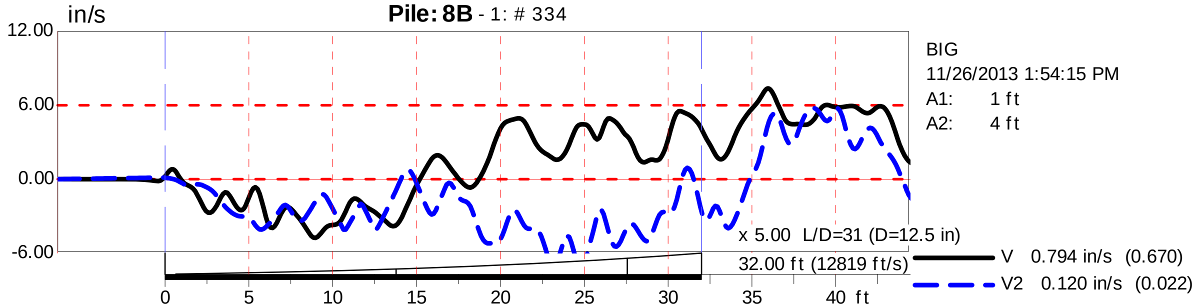


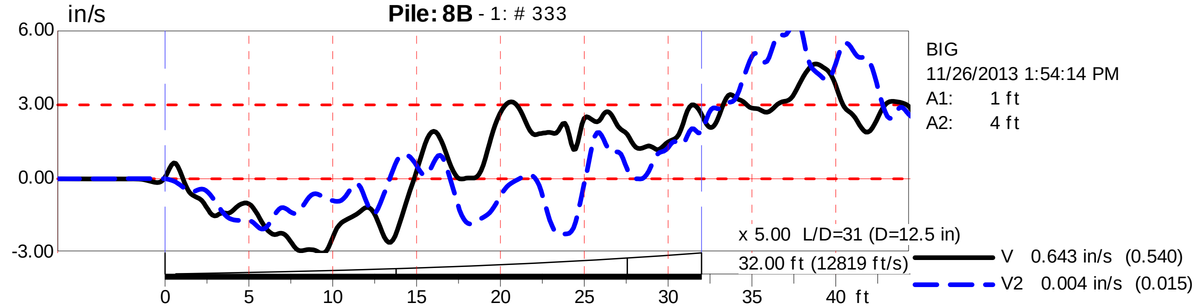
Pile: 8B - 1: # 336



Pile: 8B - 1: # 335

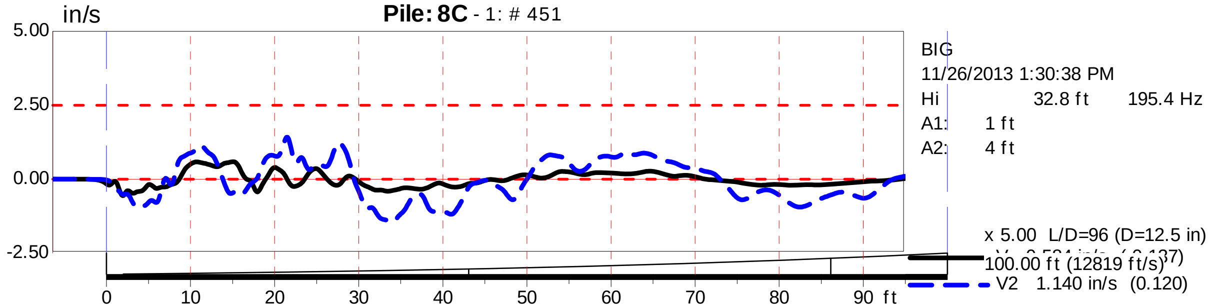



in/s
Pile: 8B - 1: # 334
12.00
6.00
0.00
-6.00
BIG
11/26/2013 1:54:15 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
V 0.794 in/s (0.670)
V2 0.120 in/s (0.022)
0
5
10
15
20
25
30
35
40 ft


in/s
Pile: 8B - 1: # 333
6.00
3.00
0.00
-3.00
BIG
11/26/2013 1:54:14 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
V 0.643 in/s (0.540)
V2 0.004 in/s (0.015)
0
5
10
15
20
25
30
35
40 ft

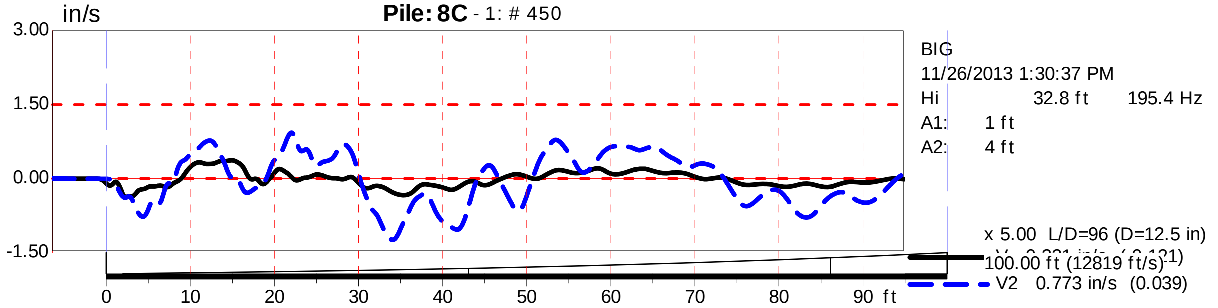
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

Pile: 8C - 1: # 451



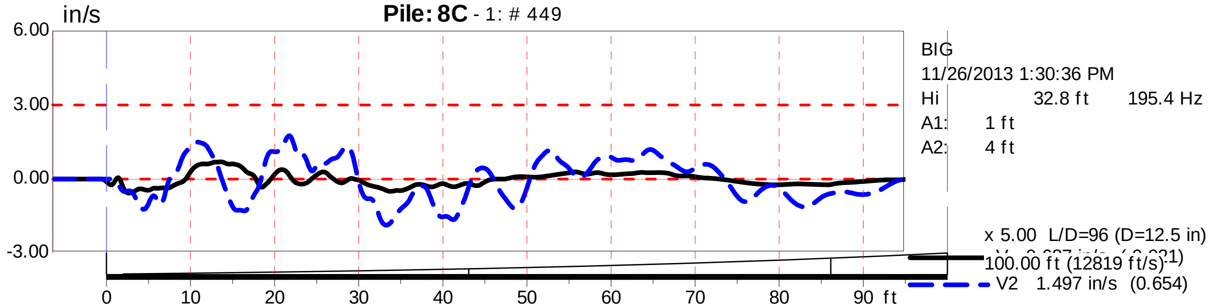
BIG
11/26/2013 1:30:38 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 1.140 in/s (0.120)

Pile: 8C - 1: # 450



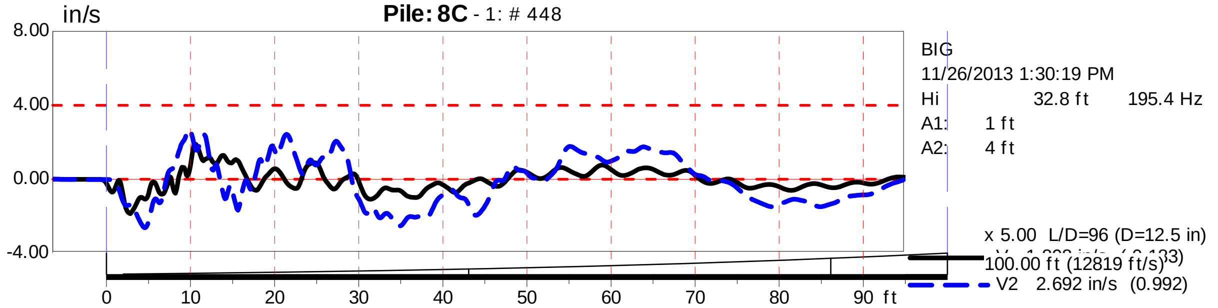
BIG
11/26/2013 1:30:37 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.773 in/s (0.039)

Pile: 8C - 1: # 449



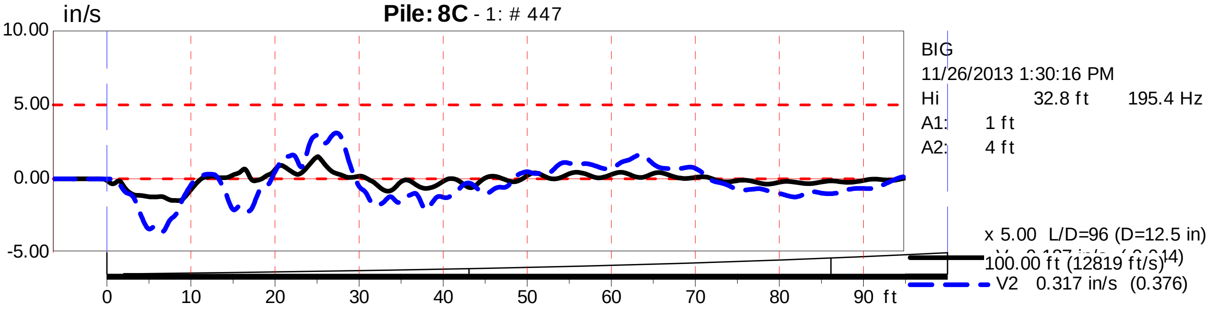
BIG
11/26/2013 1:30:36 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 1.497 in/s (0.654)

Pile: 8C - 1: # 448

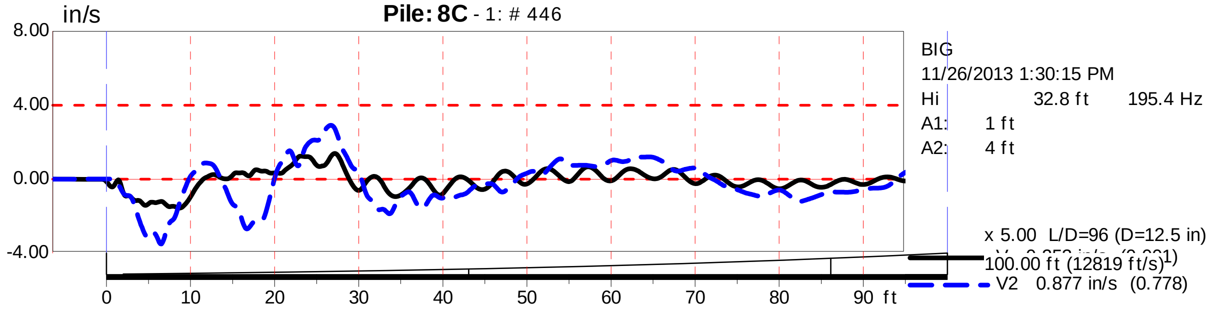


BIG
11/26/2013 1:30:19 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 2.692 in/s (0.992)

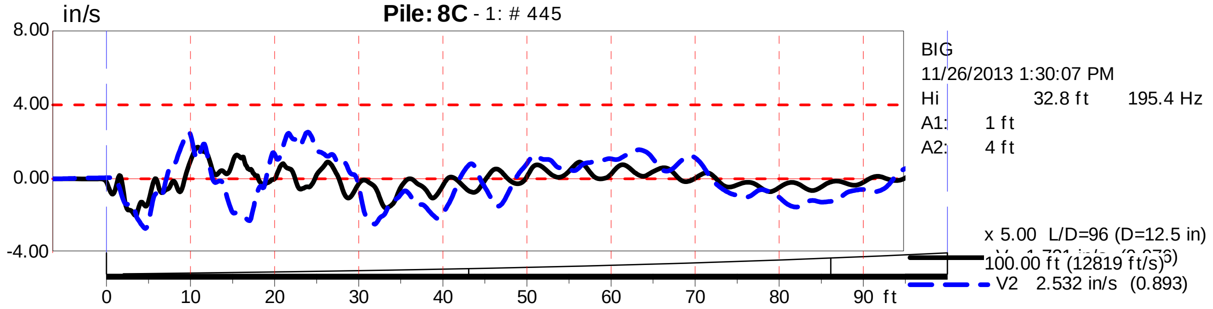
Pile: 8C - 1: # 447



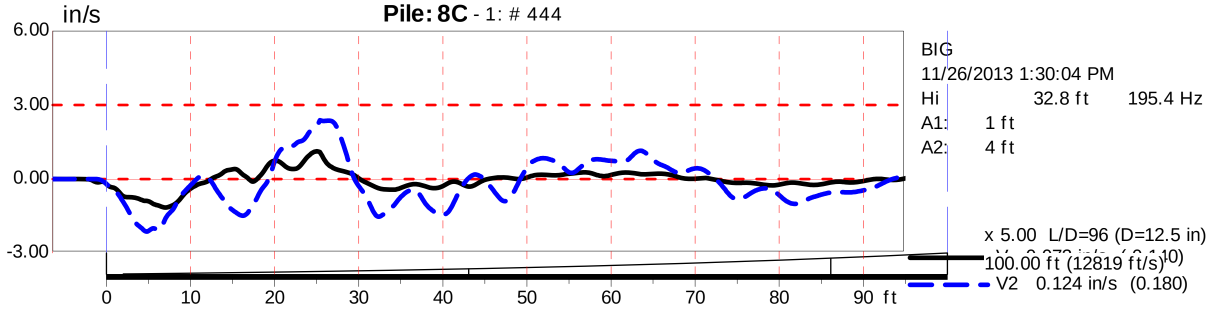
BIG
11/26/2013 1:30:16 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.317 in/s (0.376)



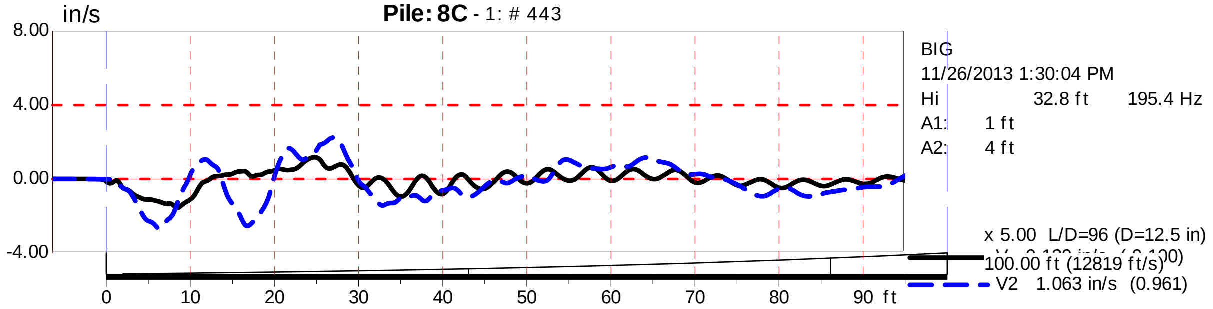
Pile: 8C - 1: # 446



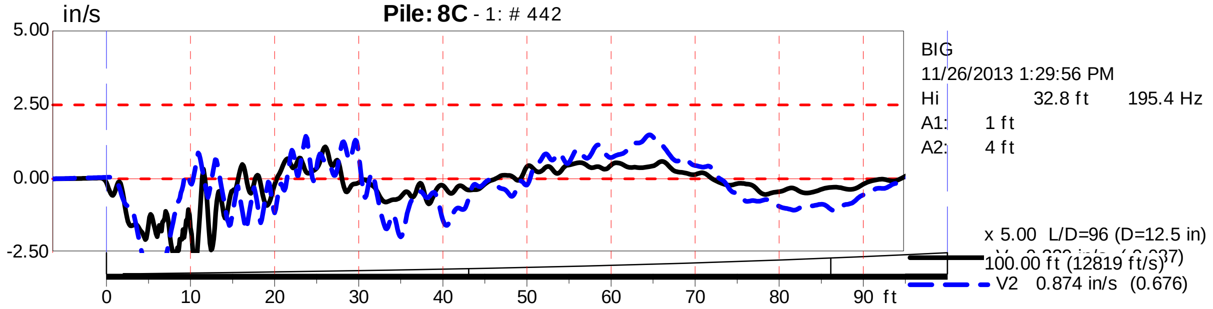
Pile: 8C - 1: # 445



Pile: 8C - 1: # 444

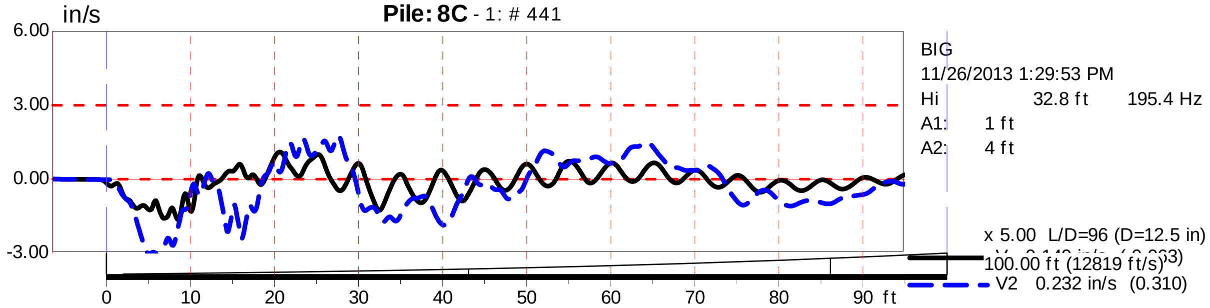


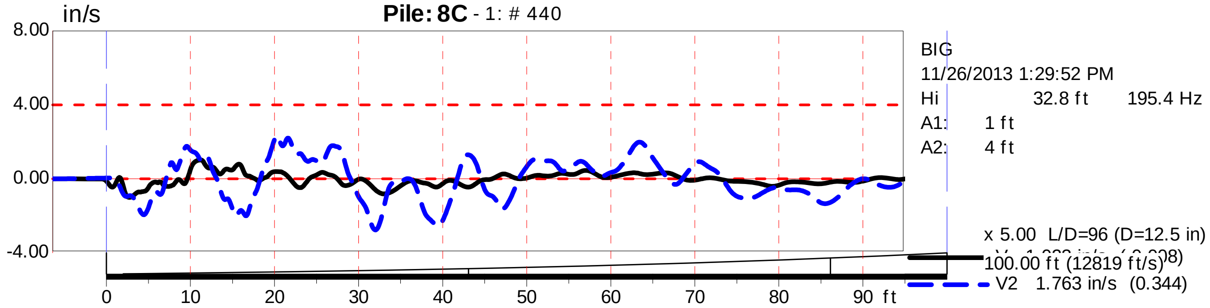
Pile: 8C - 1: # 443

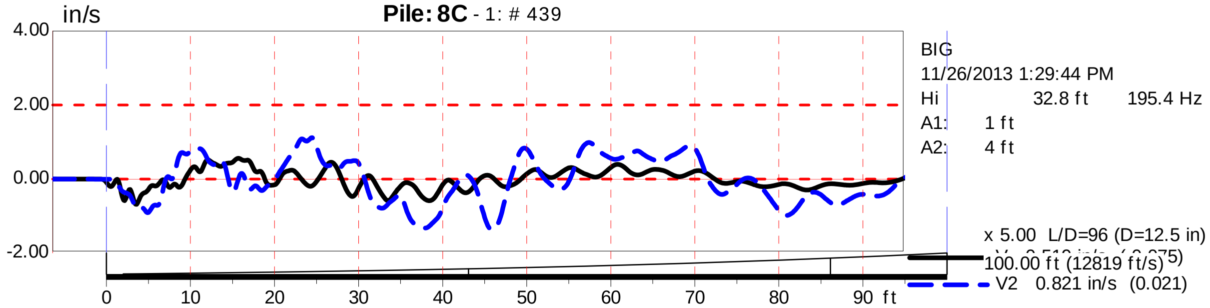


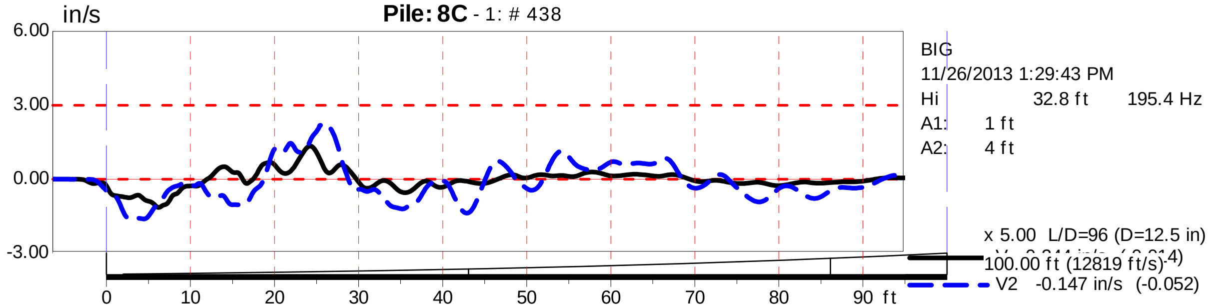
Pile: 8C - 1: # 442

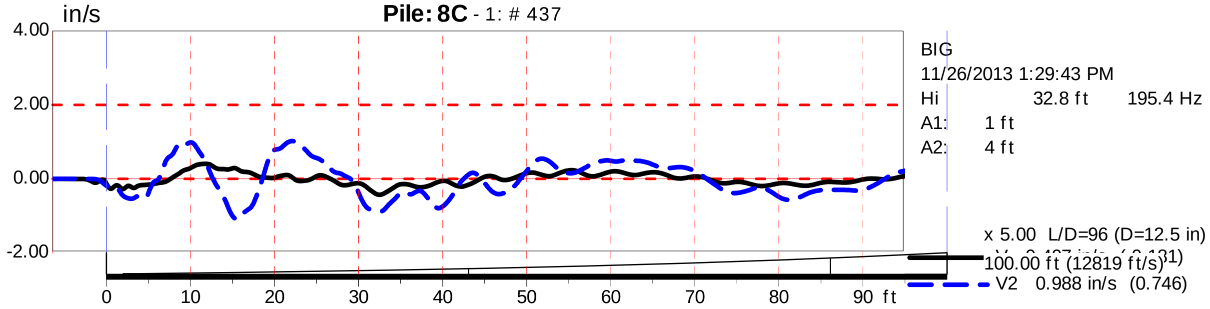
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

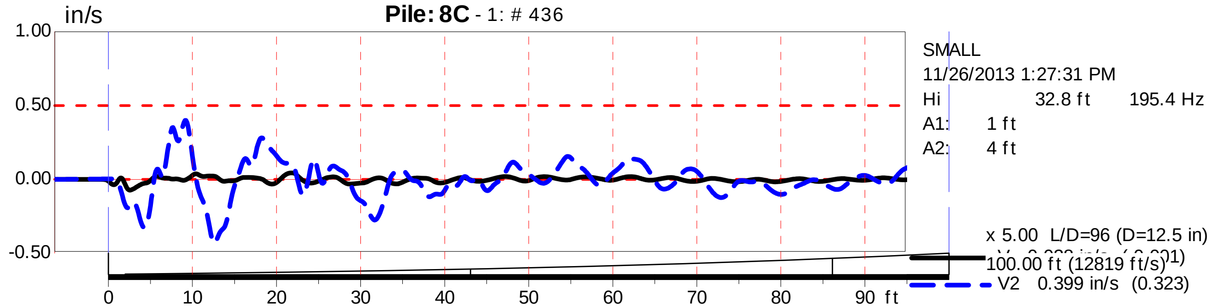


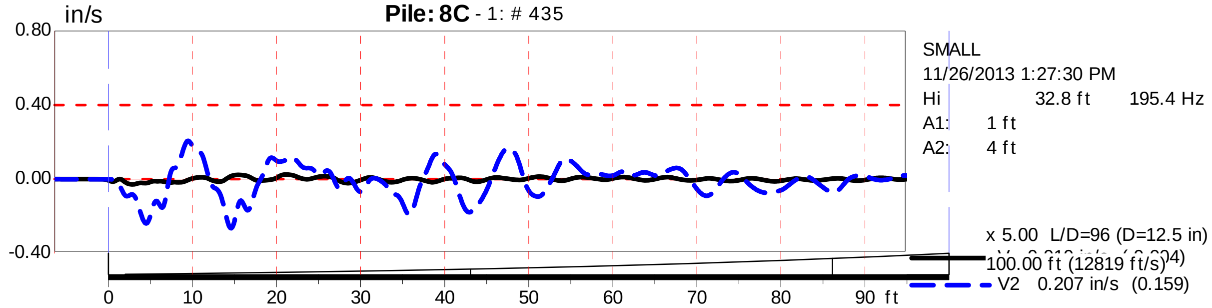


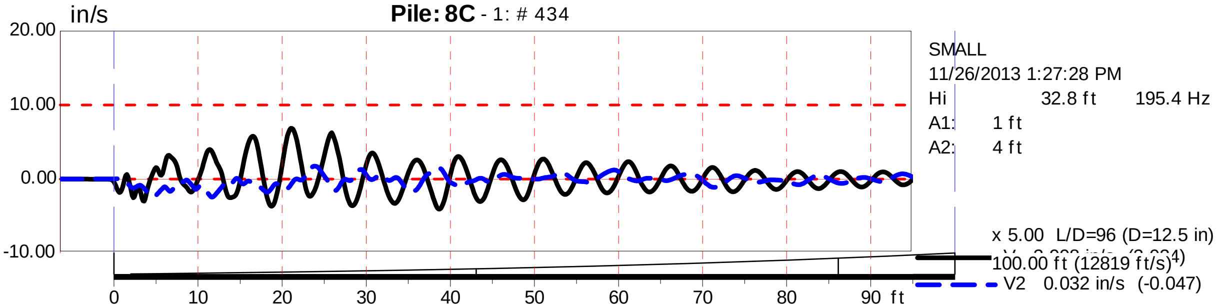


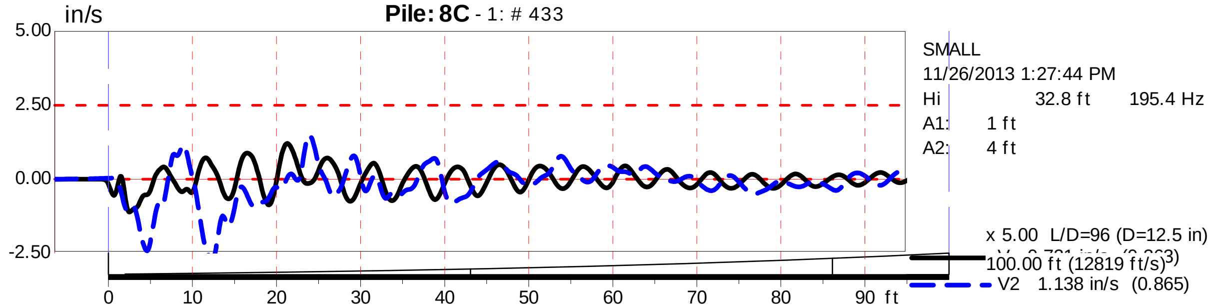


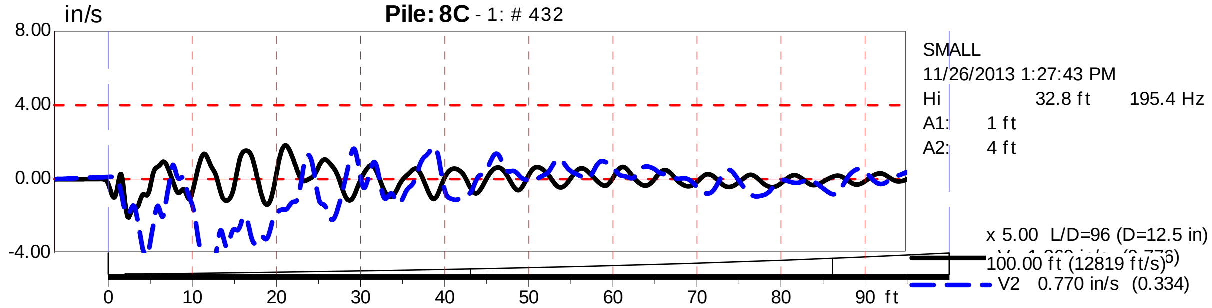



in/s
Pile: 8C - 1: # 436
1.00
0.50
0.00
-0.50
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:27:31 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.399 in/s (0.323)

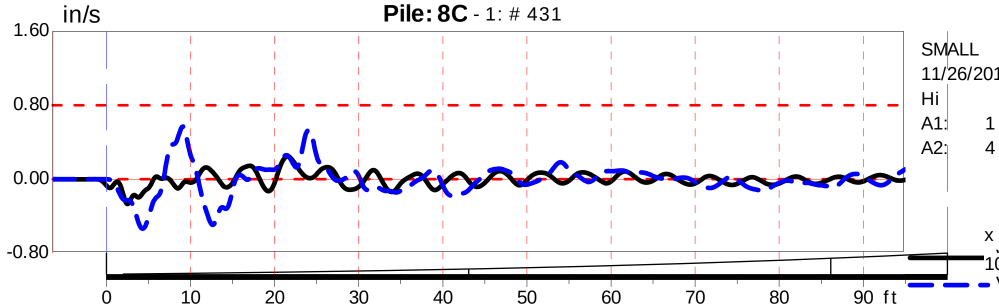

in/s
Pile: 8C - 1: # 435
0.80
0.40
0.00
-0.40
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:27:30 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.207 in/s (0.159)


in/s
Pile: 8C - 1: # 434
20.00
10.00
0.00
-10.00
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:27:28 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.032 in/s (-0.047)


in/s
Pile: 8C - 1: # 433
5.00
2.50
0.00
-2.50
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:27:44 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 1.138 in/s (0.865)


in/s
Pile: 8C - 1: # 432
8.00
4.00
0.00
-4.00
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:27:43 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.770 in/s (0.334)

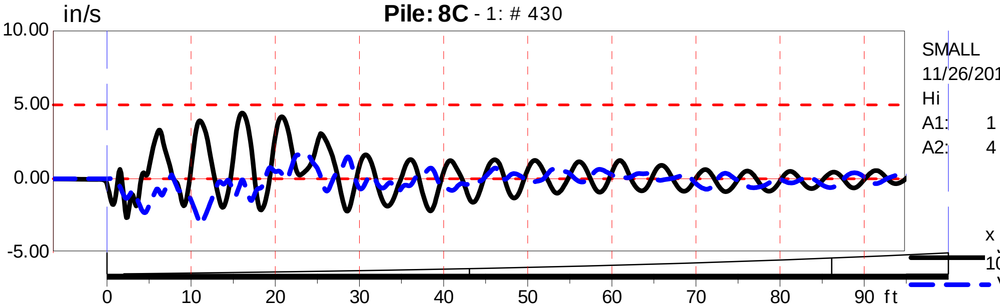
Pile: 8C - 1: # 431



SMALL
11/26/2013 1:27:42 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.568 in/s (0.474)

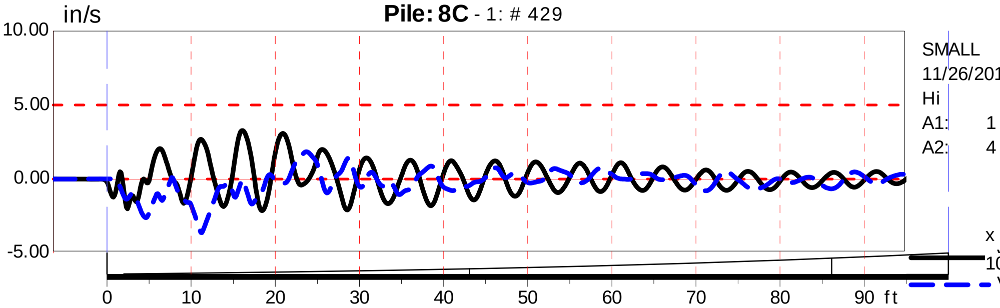
Pile: 8C - 1: # 430



SMALL
11/26/2013 1:28:01 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.268 in/s (0.226)

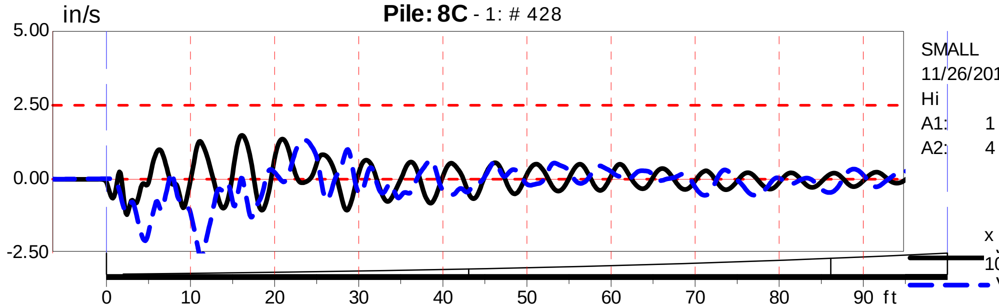
Pile: 8C - 1: # 429



SMALL
11/26/2013 1:28:01 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.103 in/s (0.084)

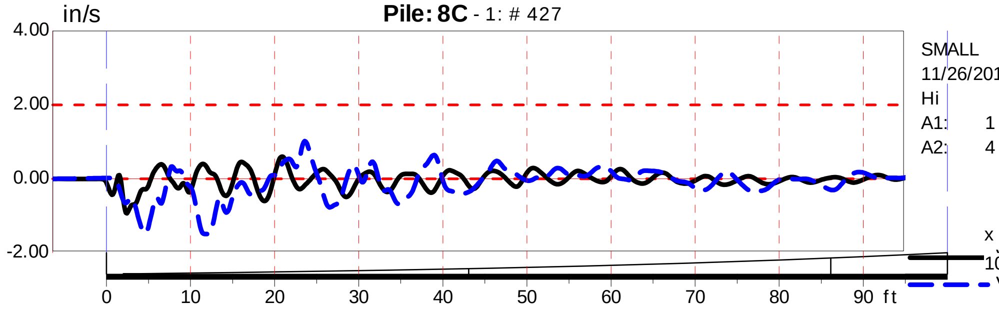
Pile: 8C - 1: # 428



SMALL
11/26/2013 1:28:00 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.234 in/s (0.189)

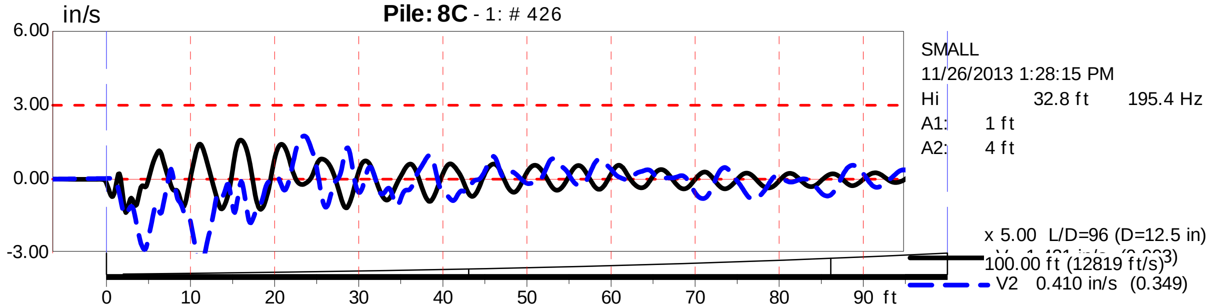
Pile: 8C - 1: # 427



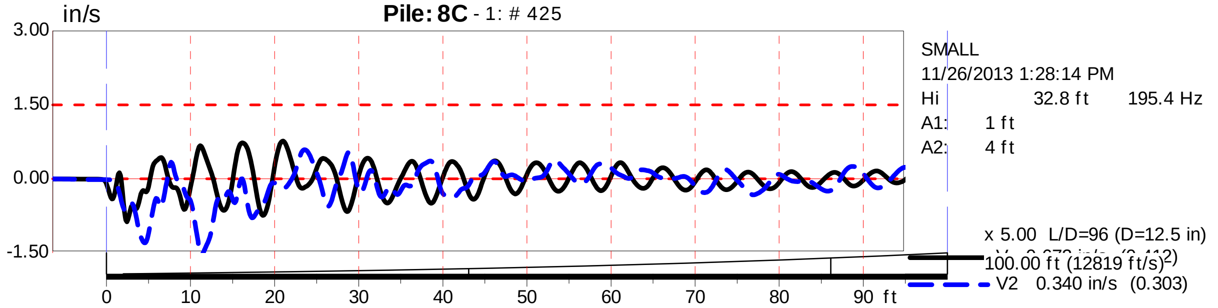
SMALL
11/26/2013 1:28:18 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.336 in/s (0.285)

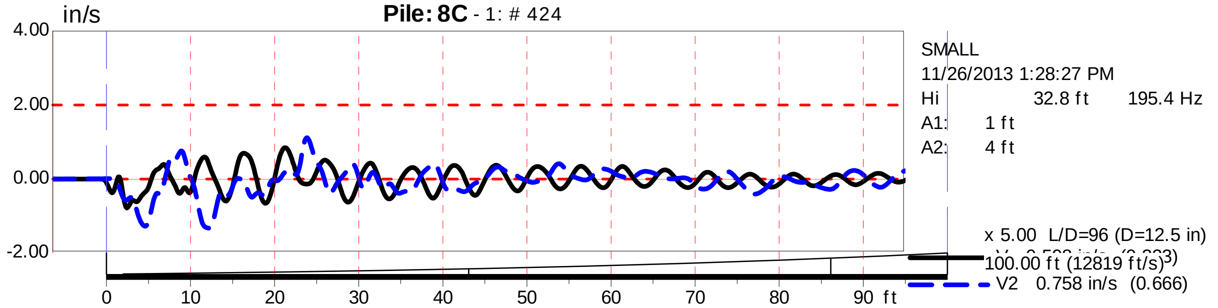
Pile: 8C - 1: # 426



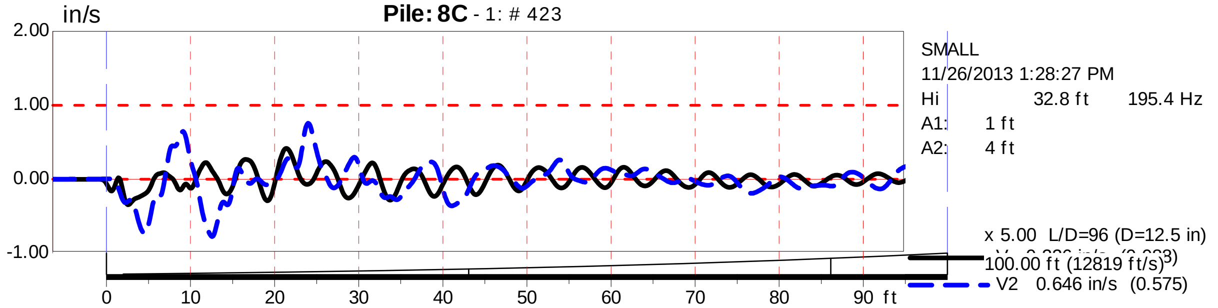
Pile: 8C - 1: # 425



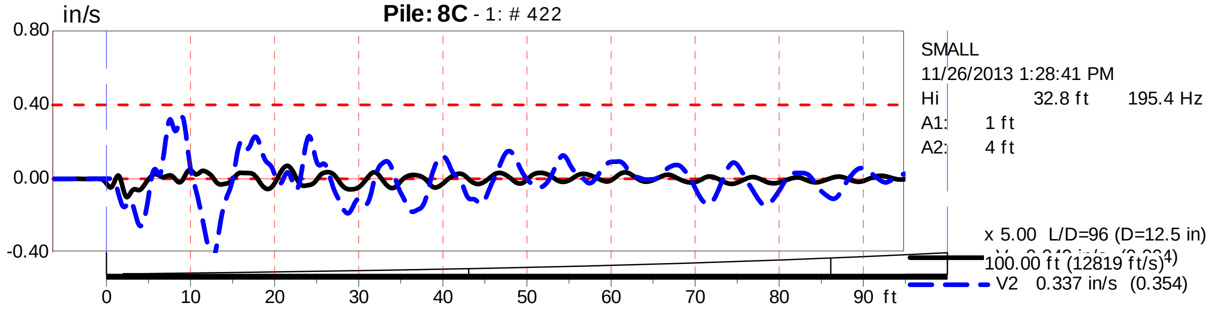
Pile: 8C - 1: # 424

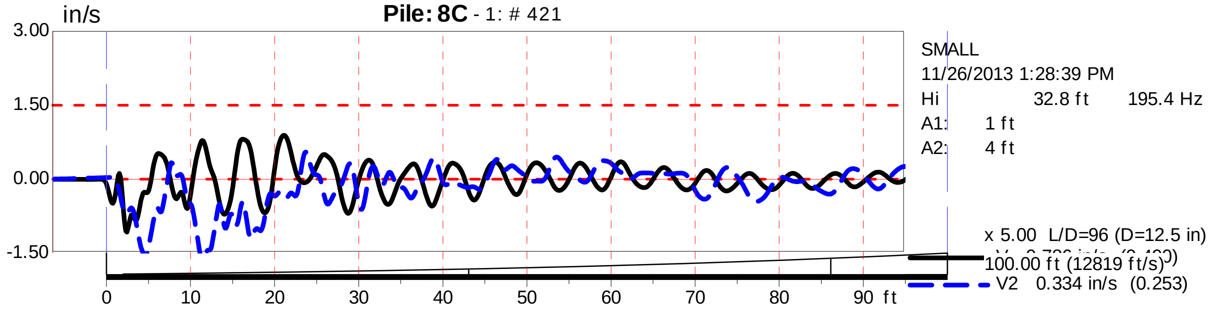


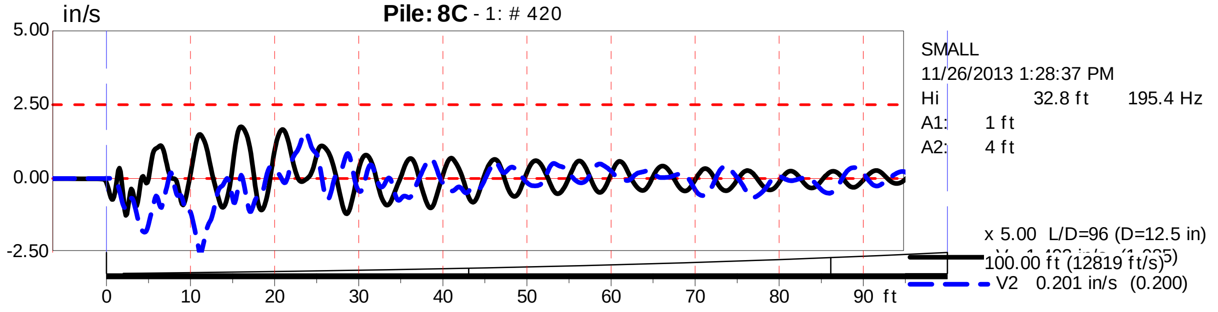
Pile: 8C - 1: # 423

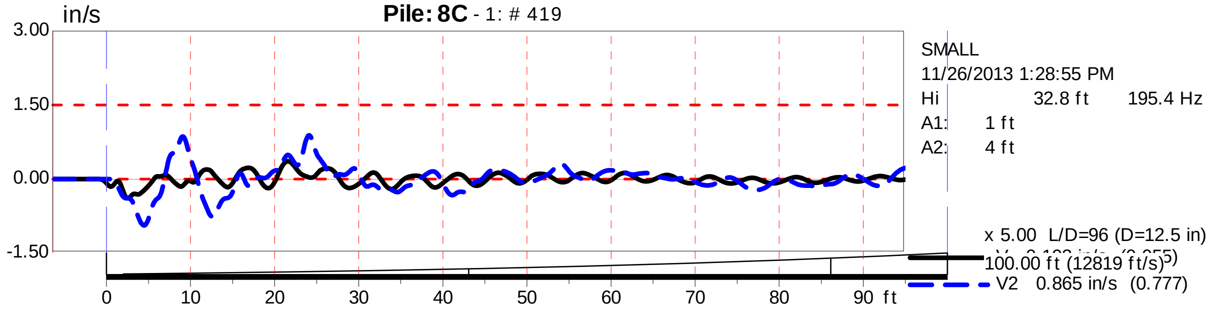


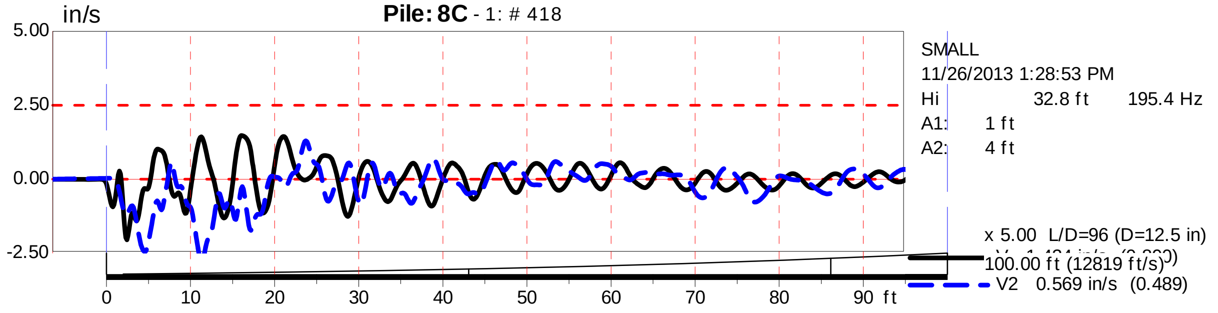
Pile: 8C - 1: # 422

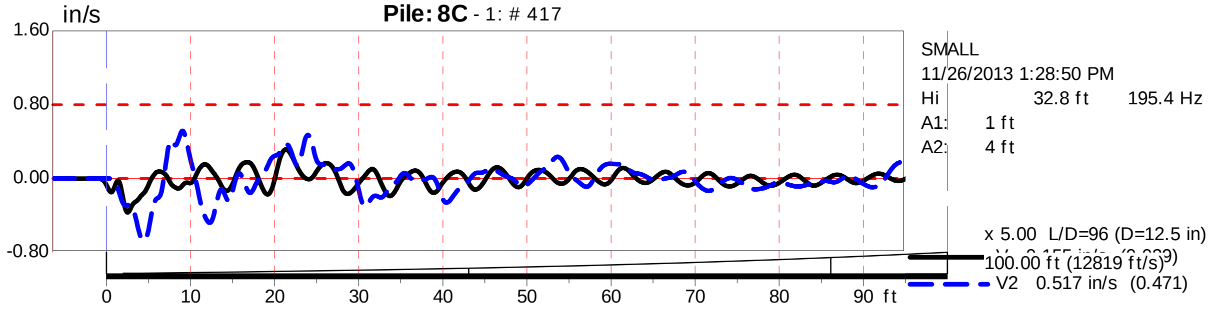



in/s
Pile: 8C - 1: # 421
3.00
1.50
0.00
-1.50
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:28:39 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.334 in/s (0.253)

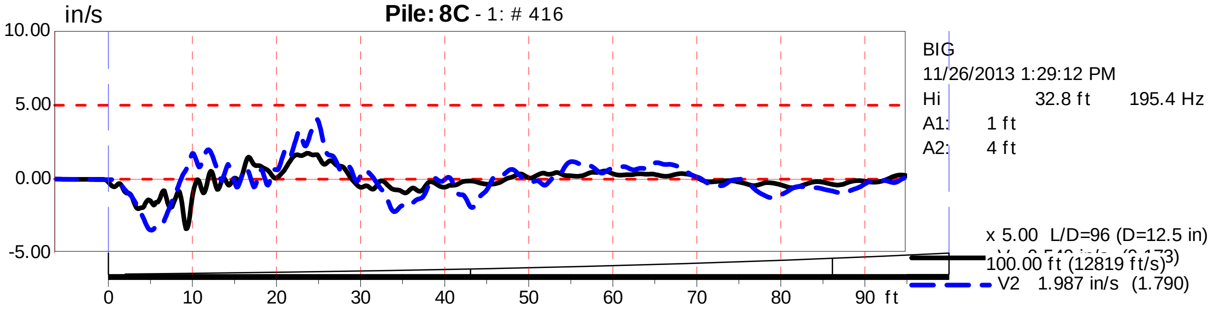

in/s
Pile: 8C - 1: # 420
5.00
2.50
0.00
-2.50
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:28:37 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.201 in/s (0.200)


in/s
Pile: 8C - 1: # 419
3.00
1.50
0.00
-1.50
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:28:55 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.865 in/s (0.777)

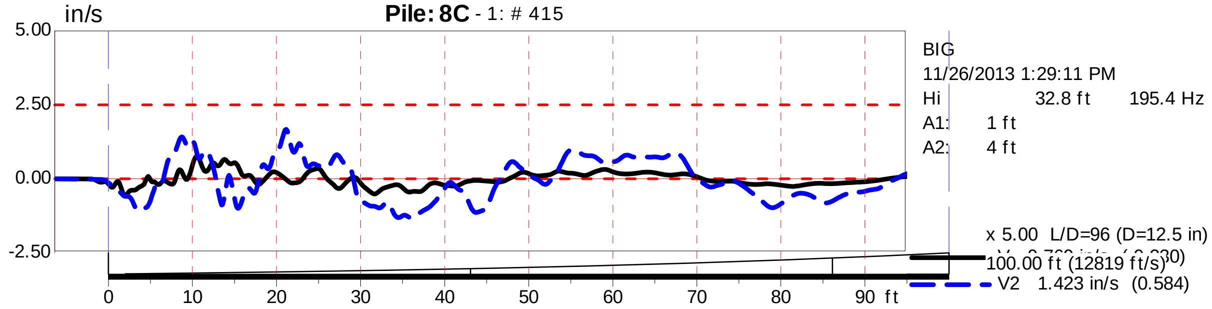

in/s
Pile: 8C - 1: # 418
5.00
2.50
0.00
-2.50
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:28:53 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.569 in/s (0.489)


in/s
Pile: 8C - 1: # 417
1.60
0.80
0.00
-0.80
0
10
20
30
40
50
60
70
80
90 ft
SMALL
11/26/2013 1:28:50 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
V2 0.517 in/s (0.471)

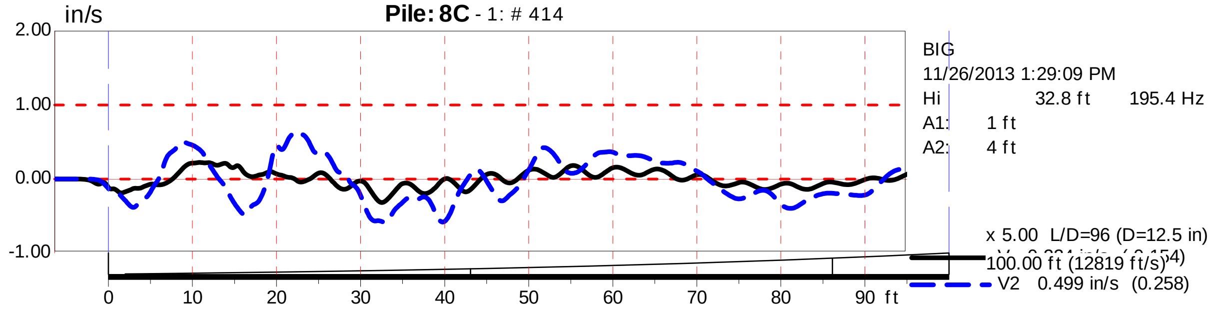
Pile: 8C - 1: # 416

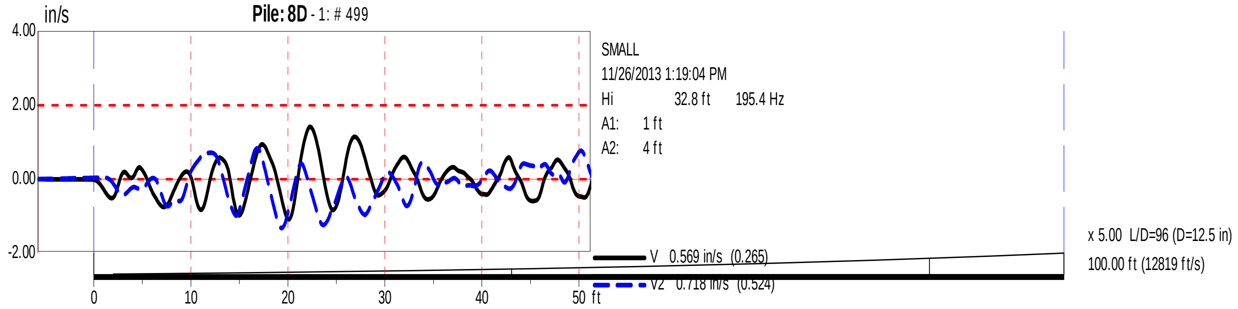


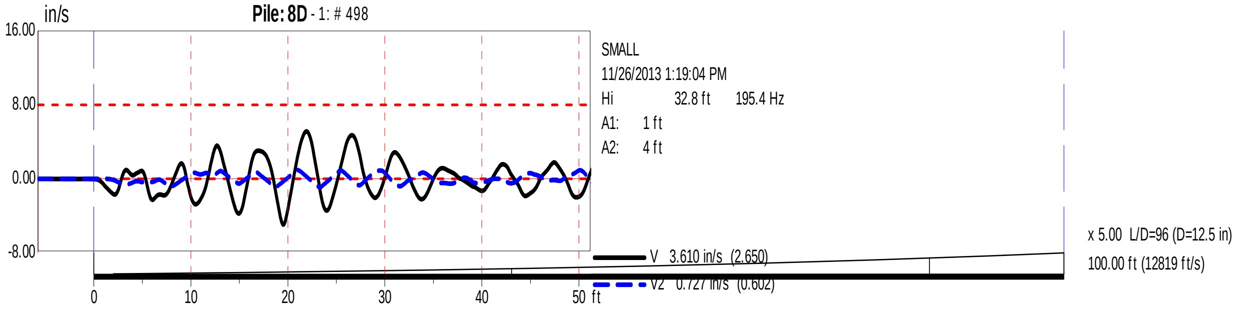
Pile: 8C - 1: # 415

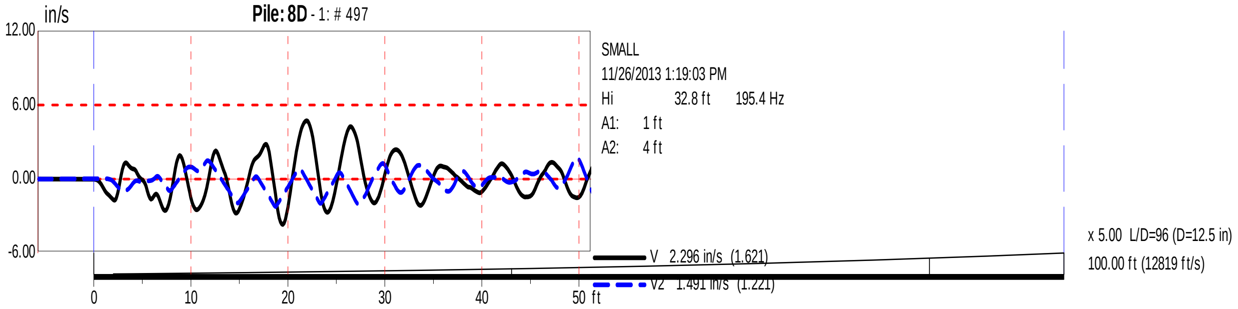


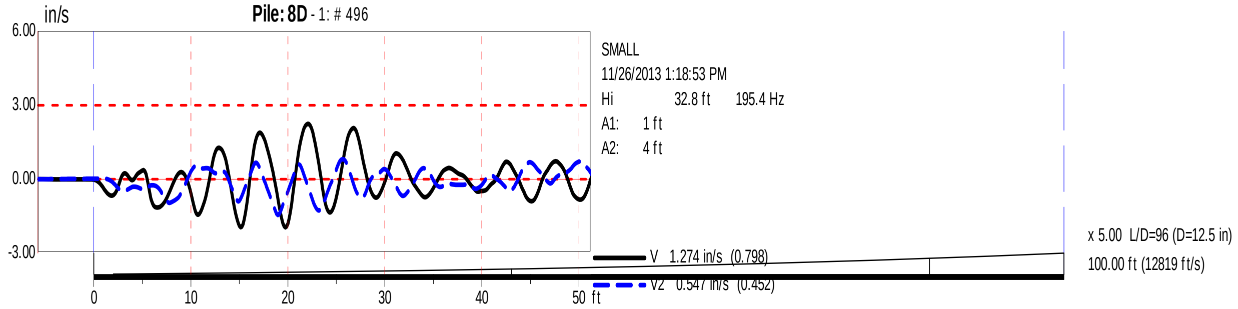
Pile: 8C - 1: # 414

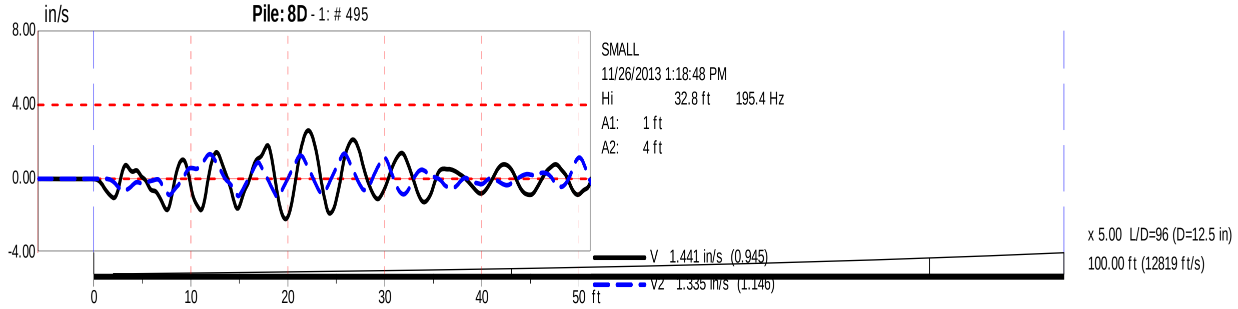



Pile: 8D - 1: # 499

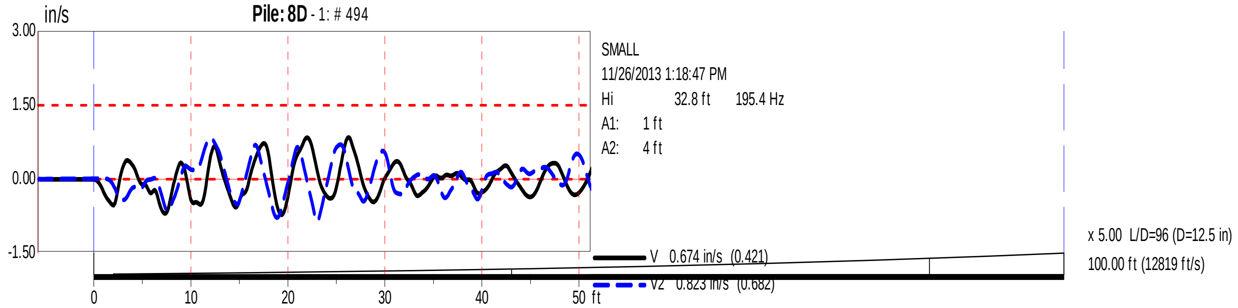

Pile: 8D - 1: # 498

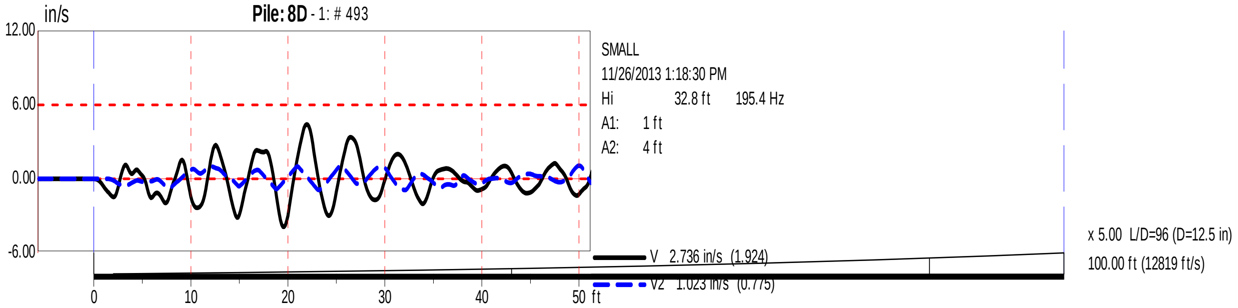

Pile: 8D - 1: # 497

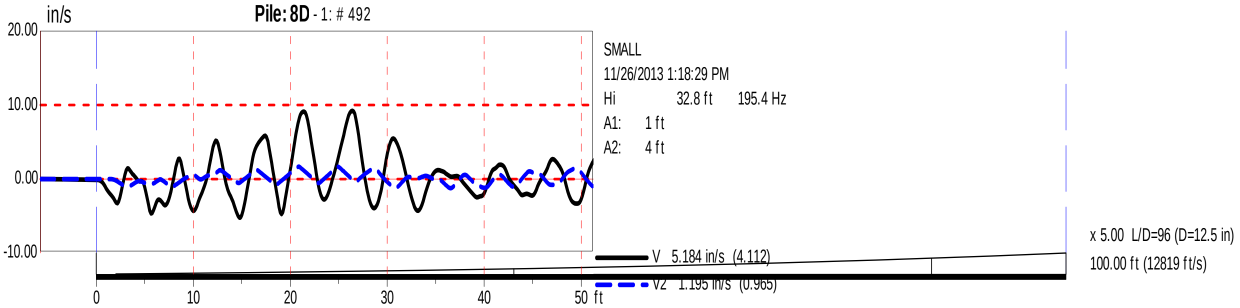

Pile: 8D - 1: # 496

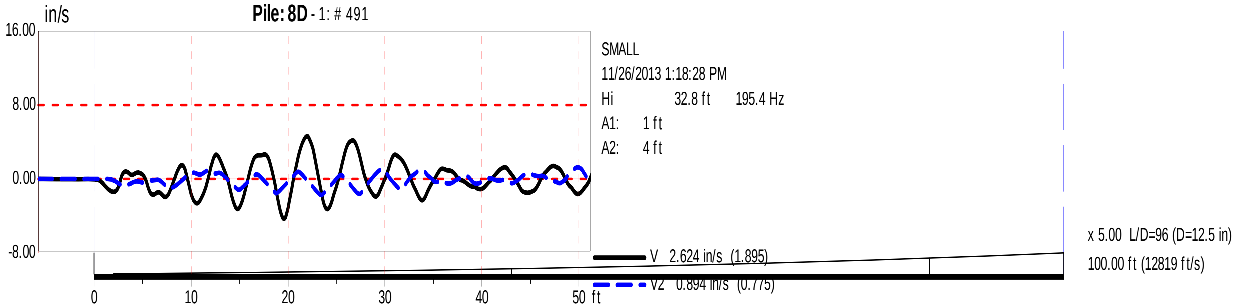

Pile: 8D - 1: # 495

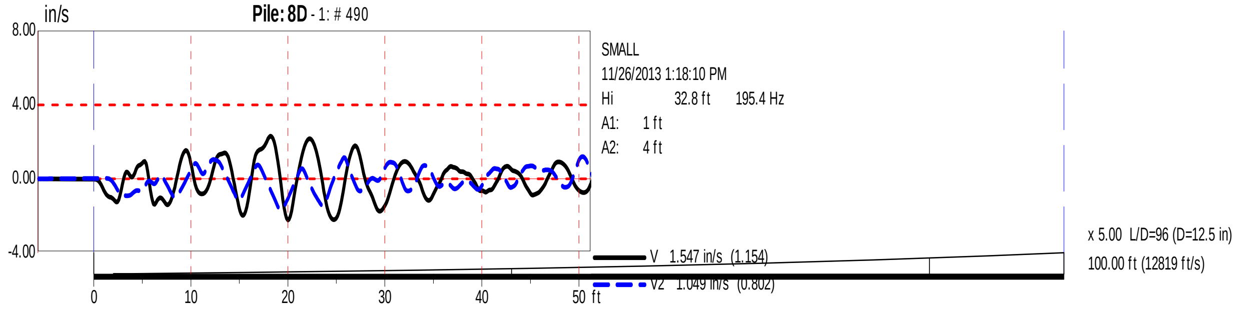
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

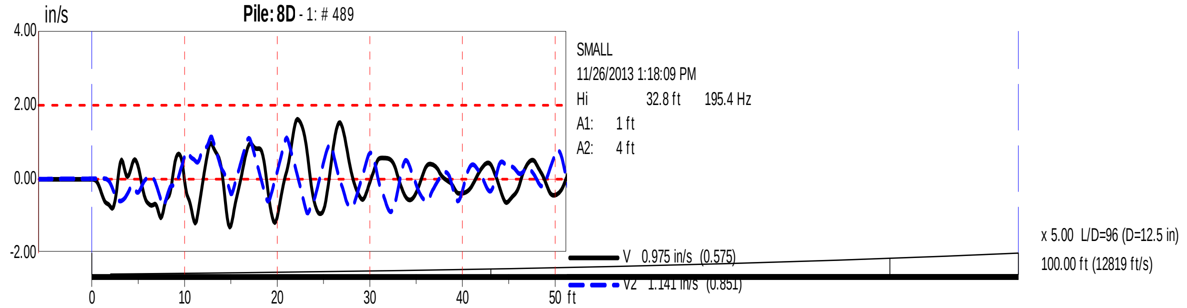


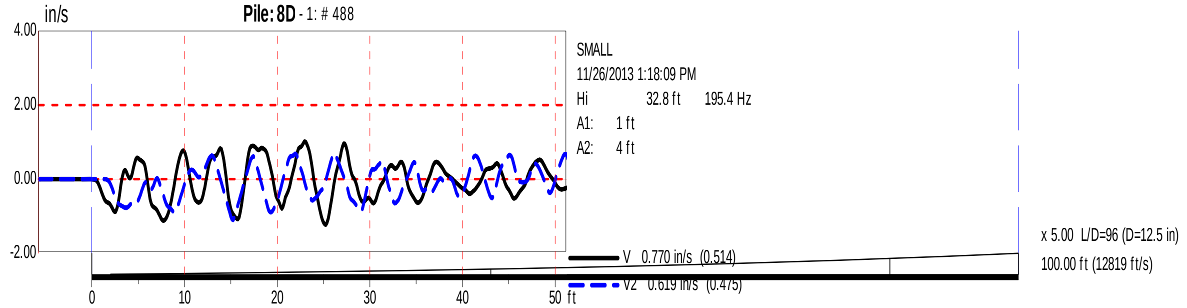


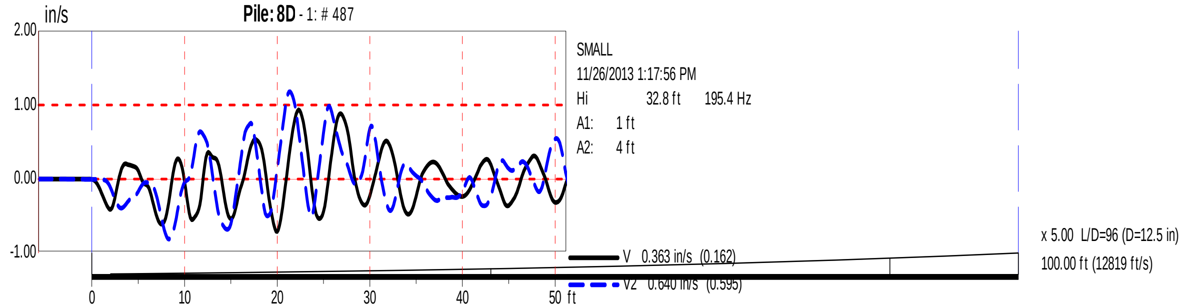


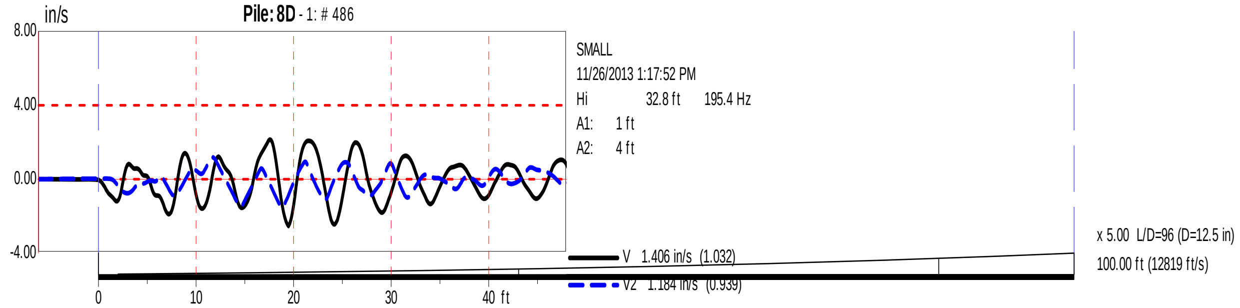


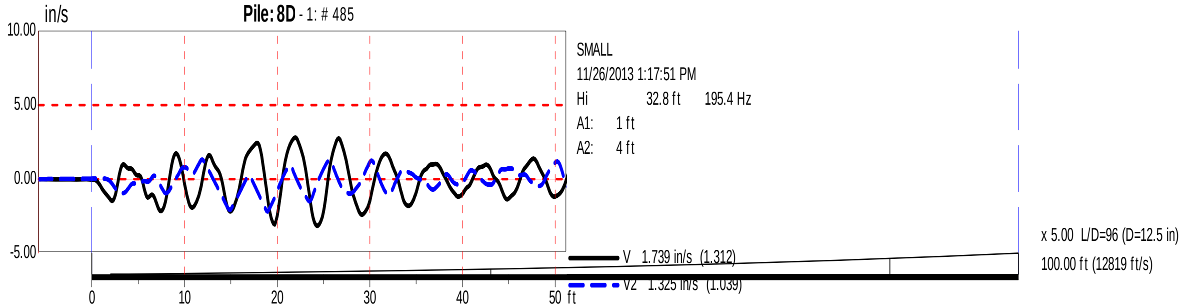


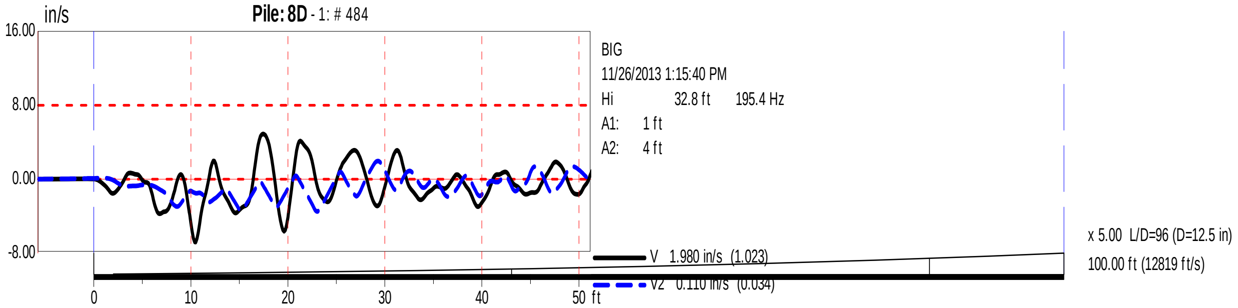

in/s
Pile: 8D - 1: # 489
4.00
2.00
0.00
-2.00
0
10
20
30
40
50 ft
SMALL
11/26/2013 1:18:09 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.975 in/s (0.575)
V2 1.141 in/s (0.851)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

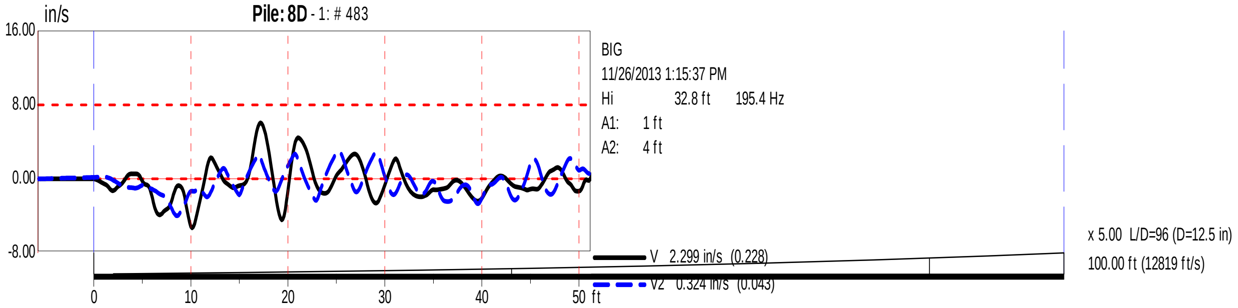

in/s
Pile: 8D - 1: # 488
4.00
2.00
0.00
-2.00
0
10
20
30
40
50 ft
SMALL
11/26/2013 1:18:09 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.770 in/s (0.514)
V2 0.619 in/s (0.475)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

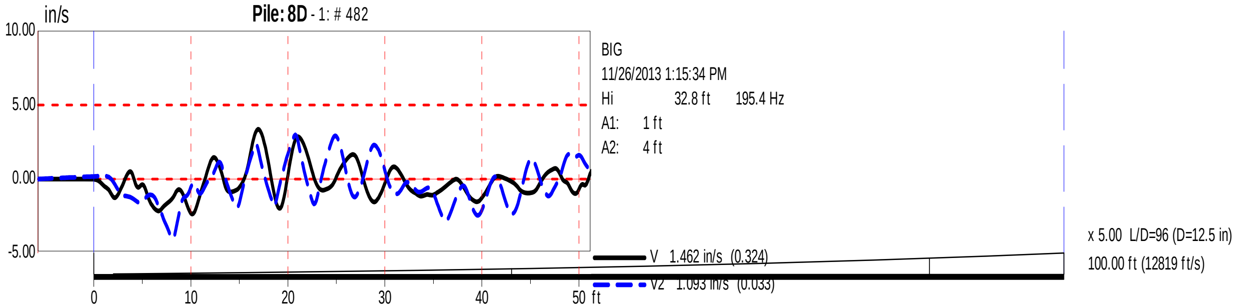

in/s
Pile: 8D - 1: # 487
2.00
1.00
0.00
-1.00
0
10
20
30
40
50 ft
SMALL
11/26/2013 1:17:56 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.363 in/s (0.162)
V2 0.640 in/s (0.595)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

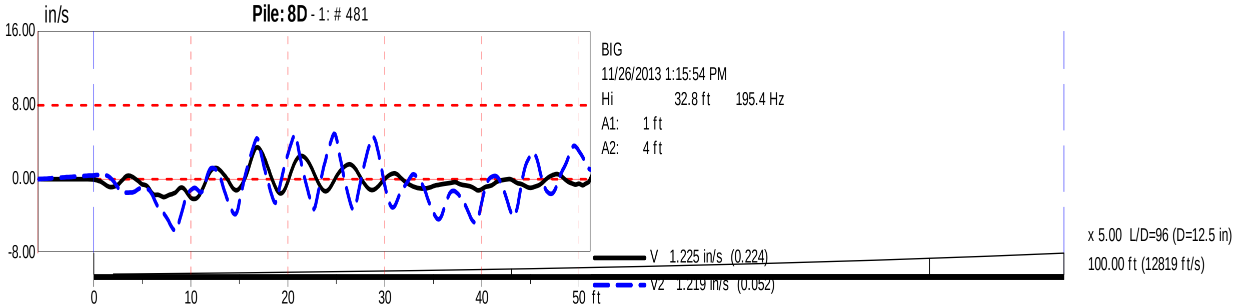

in/s
Pile: 8D - 1: # 486
8.00
4.00
0.00
-4.00
0
10
20
30
40 ft
SMALL
11/26/2013 1:17:52 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.406 in/s (1.032)
V2 1.184 in/s (0.939)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

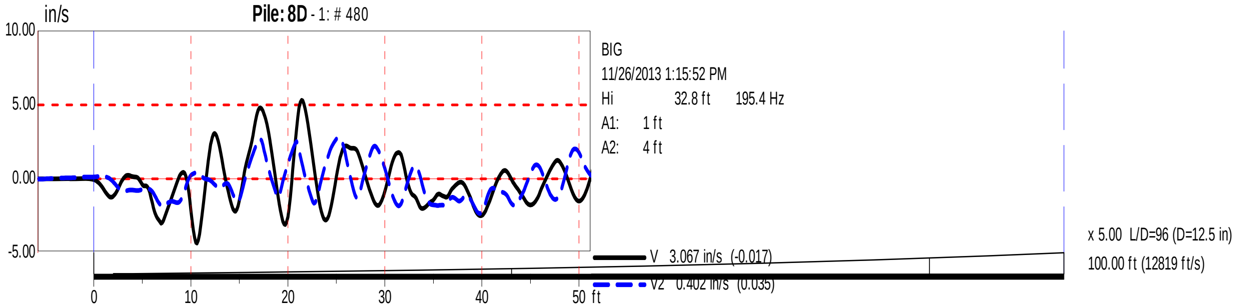

in/s
Pile: 8D - 1: # 485
10.00
5.00
0.00
-5.00
0
10
20
30
40
50 ft
SMALL
11/26/2013 1:17:51 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.739 in/s (1.312)
V2 1.325 in/s (1.039)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

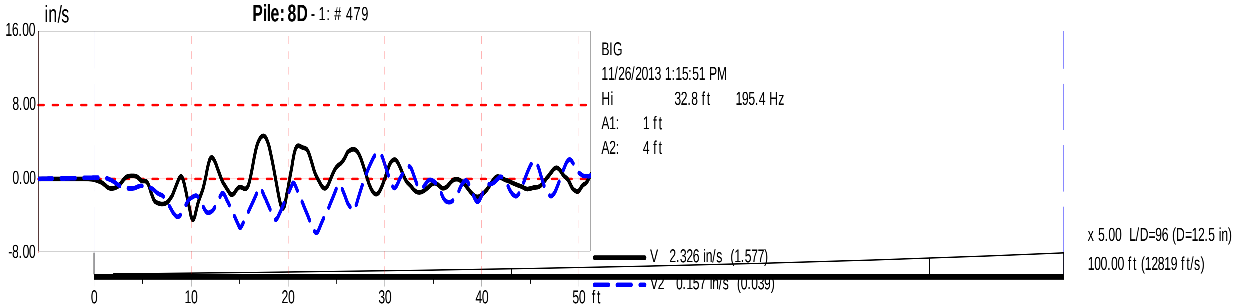

in/s
Pile: 8D - 1: # 484
16.00
8.00
0.00
-8.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:15:40 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.980 in/s (1.023)
V2 0.110 in/s (0.034)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

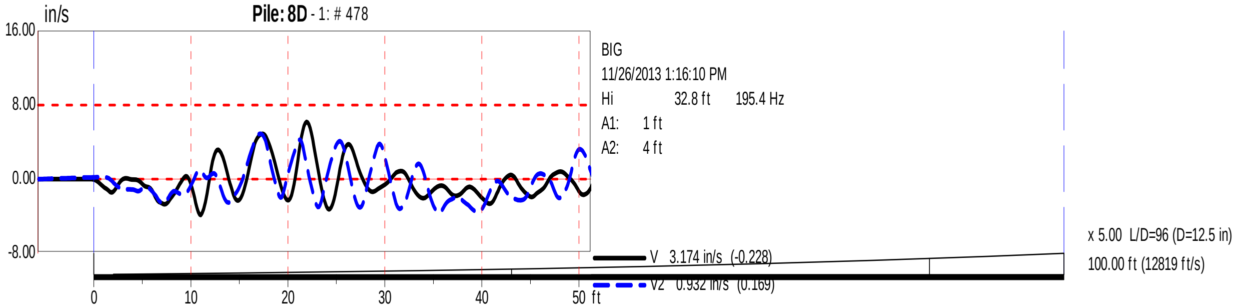

in/s
Pile: 8D - 1: # 483
16.00
8.00
0.00
-8.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:15:37 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 2.299 in/s (0.228)
V2 0.324 in/s (0.043)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

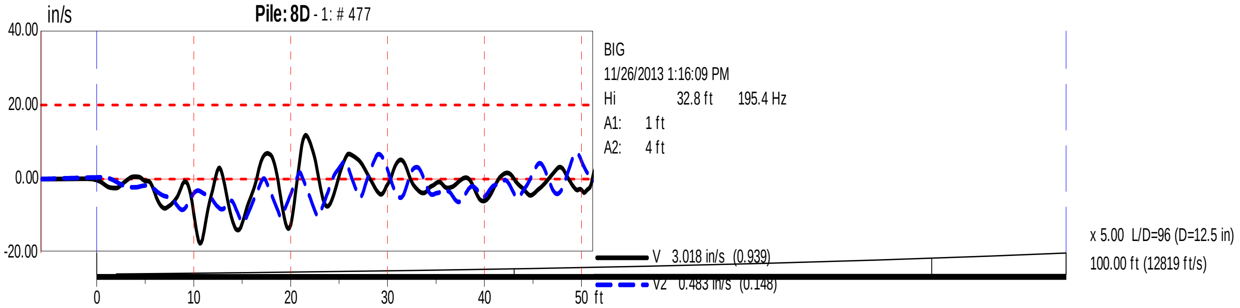

in/s
Pile: 8D - 1: # 482
10.00
5.00
0.00
-5.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:15:34 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.462 in/s (0.324)
V2 1.093 in/s (0.033)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

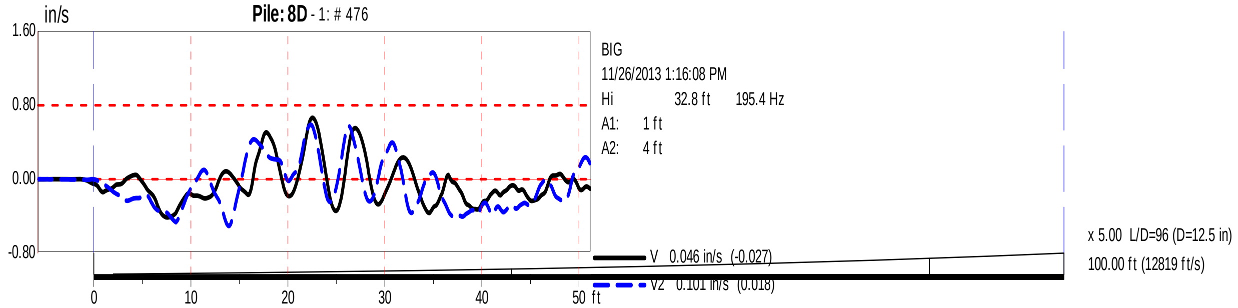

in/s
Pile: 8D - 1: # 481
16.00
8.00
0.00
-8.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:15:54 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.225 in/s (0.224)
V2 1.219 in/s (0.052)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

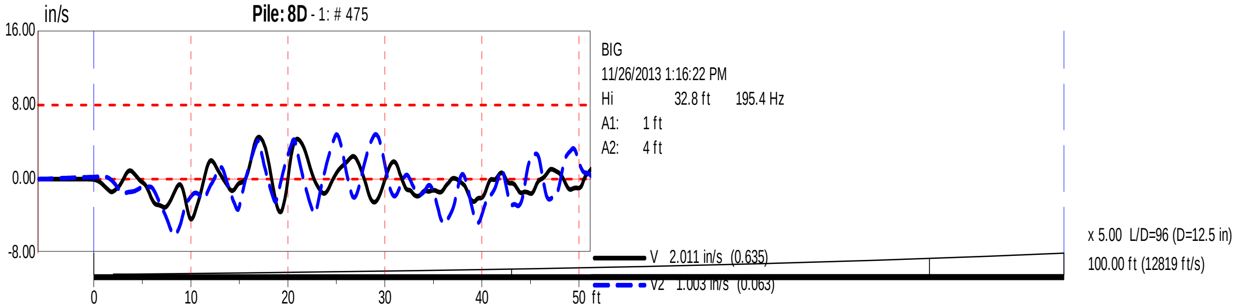

in/s
Pile: 8D - 1: # 480
10.00
5.00
0.00
-5.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:15:52 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 3.067 in/s (-0.017)
V2 0.402 in/s (0.035)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 8D - 1: # 479
16.00
8.00
0.00
-8.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:15:51 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 2.326 in/s (1.577)
V2 0.157 in/s (0.039)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

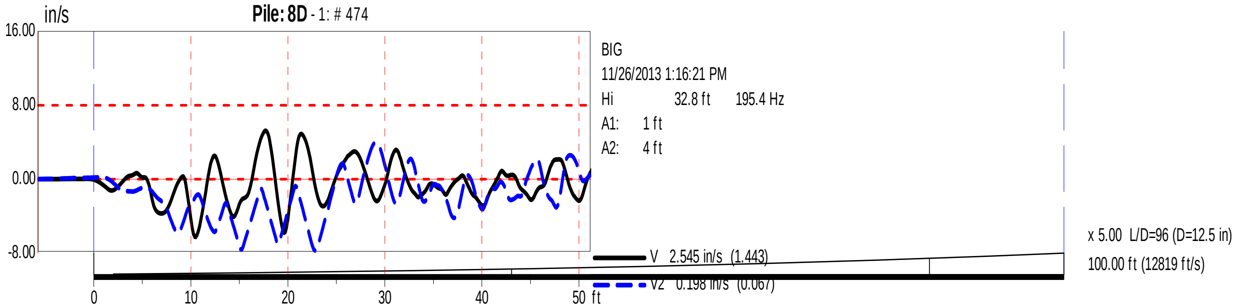

in/s
Pile: 8D - 1: # 478
16.00
8.00
0.00
-8.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:16:10 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 3.174 in/s (-0.228)
V2 0.932 in/s (0.169)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

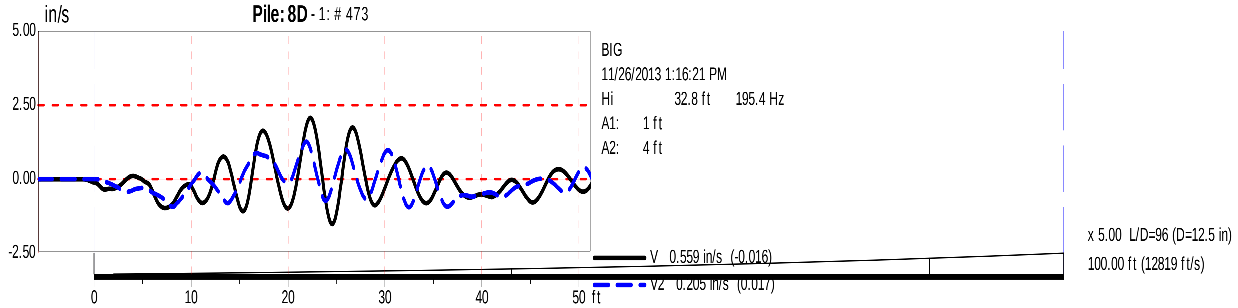

in/s
Pile: 8D - 1: # 477
40.00
20.00
0.00
-20.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:16:09 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 3.018 in/s (0.939)
V2 0.483 in/s (0.148)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

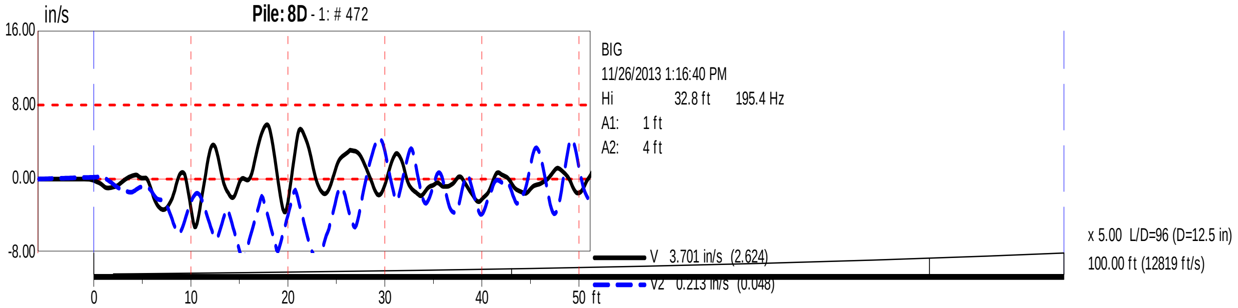

in/s
Pile: 8D - 1: # 476
1.60
0.80
0.00
-0.80
0
10
20
30
40
50 ft
BIG
11/26/2013 1:16:08 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.046 in/s (-0.027)
V2 0.101 in/s (0.018)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

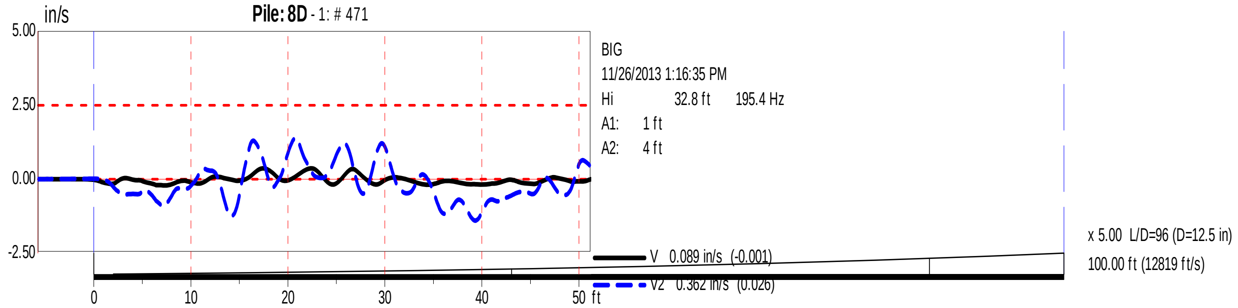

in/s
Pile: 8D - 1: # 475
16.00
8.00
0.00
-8.00
0
10
20
30
40
50 ft
BIG
11/26/2013 1:16:22 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 2.011 in/s (0.635)
V2 1.003 in/s (0.063)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

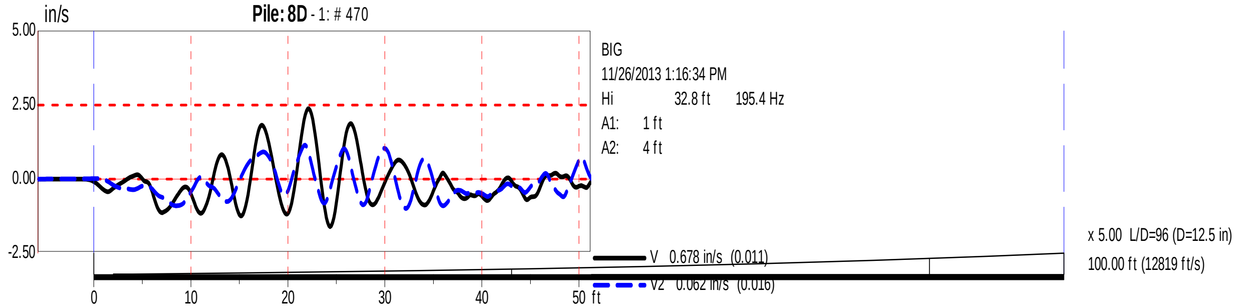
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



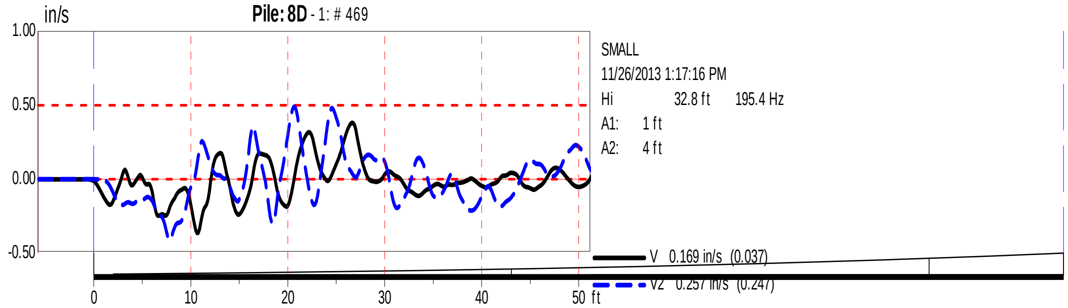








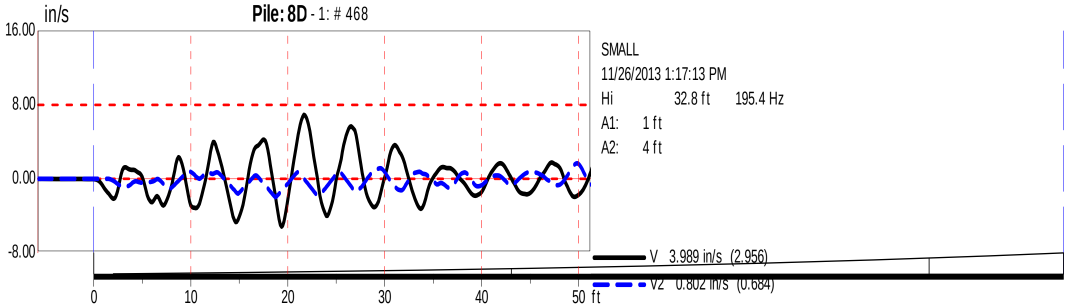
Pile: 8D - 1: # 469



SMALL
11/26/2013 1:17:16 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

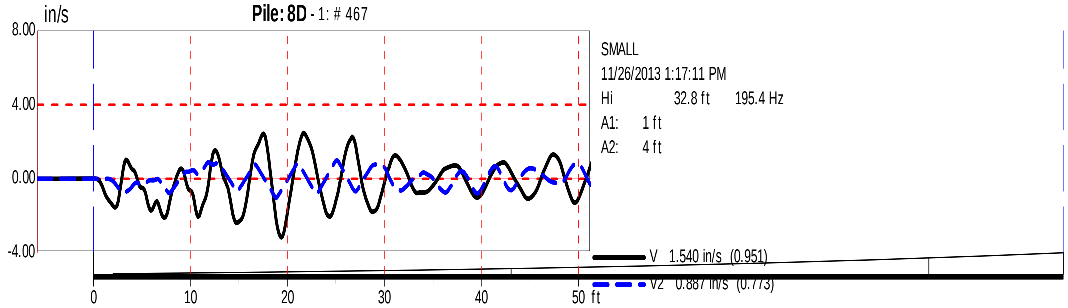
Pile: 8D - 1: # 468



SMALL
11/26/2013 1:17:13 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

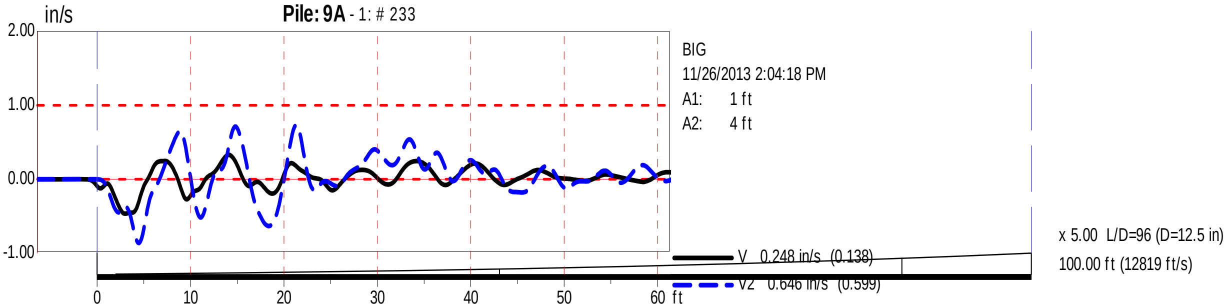
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

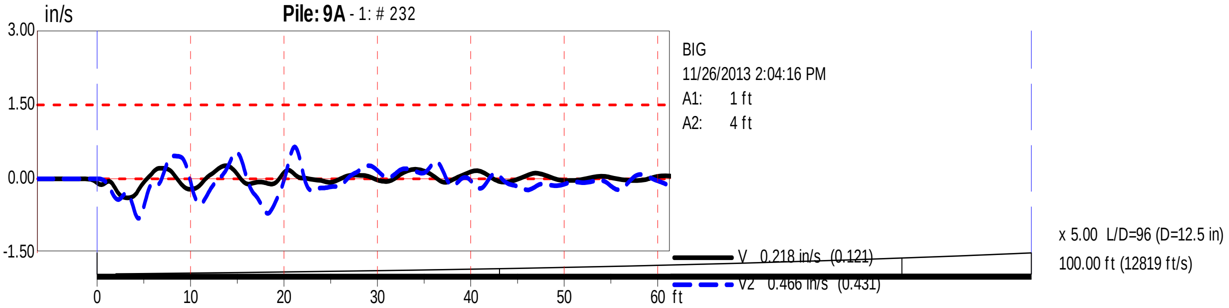
Pile: 8D - 1: # 467

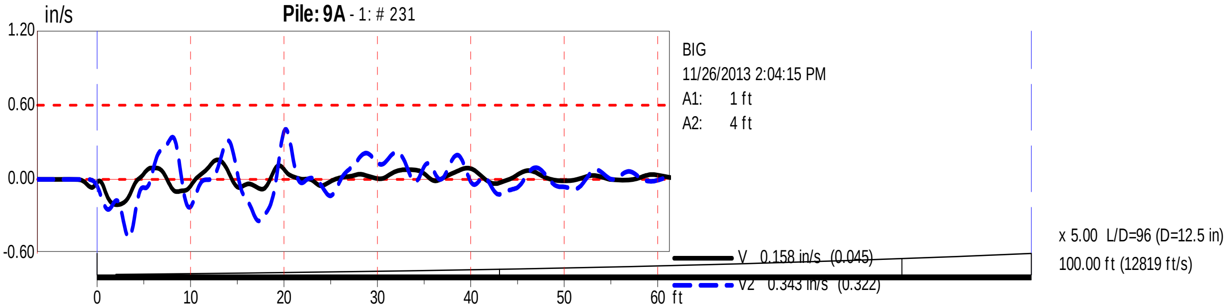


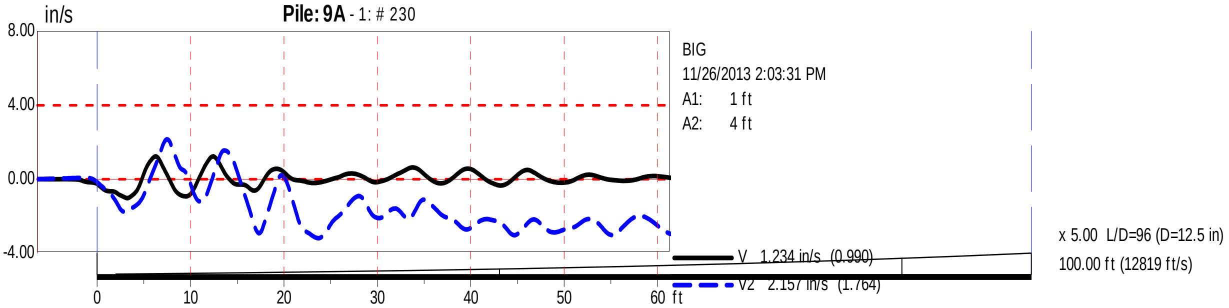
SMALL
11/26/2013 1:17:11 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

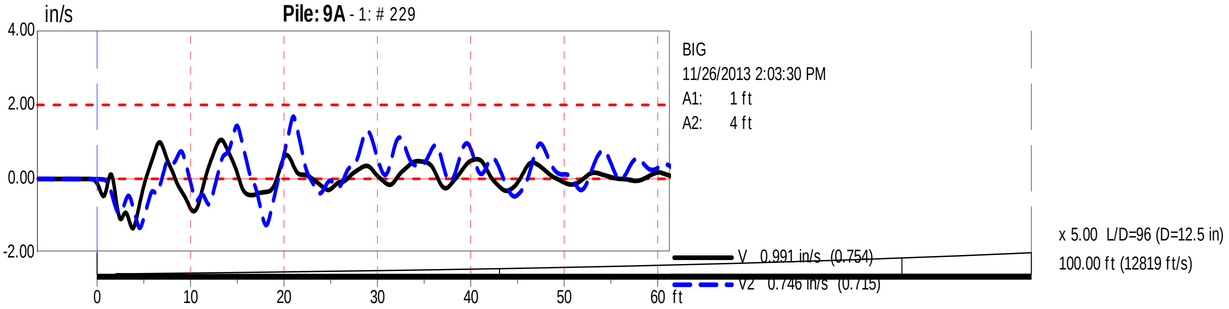
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

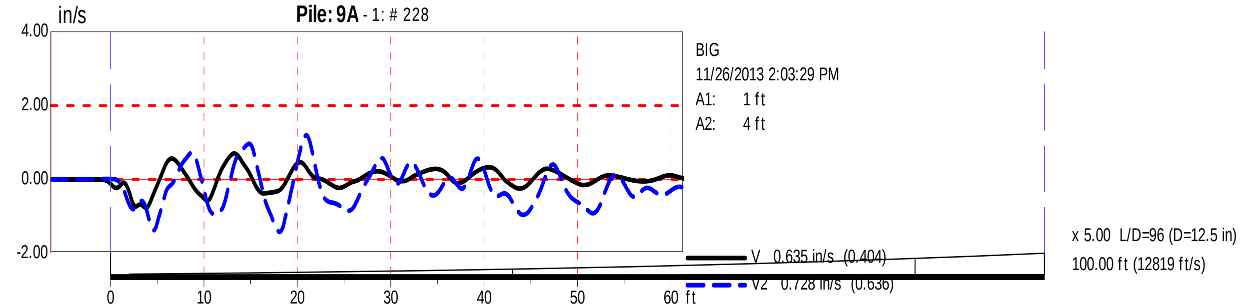

in/s
Pile: 9A - 1: # 233
2.00
1.00
0.00
-1.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:04:18 PM
A1: 1 ft
A2: 4 ft
V 0.248 in/s (0.138)
V2 0.646 in/s (0.599)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

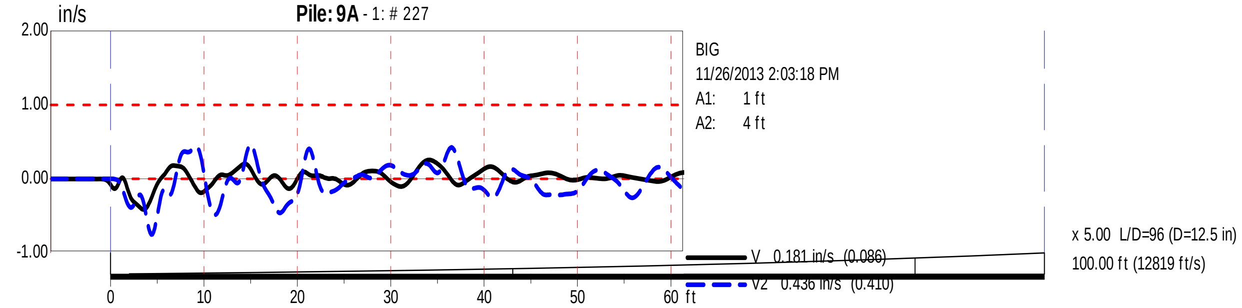

in/s
Pile: 9A - 1: # 232
3.00
1.50
0.00
-1.50
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:04:16 PM
A1: 1 ft
A2: 4 ft
V 0.218 in/s (0.121)
V2 0.466 in/s (0.431)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

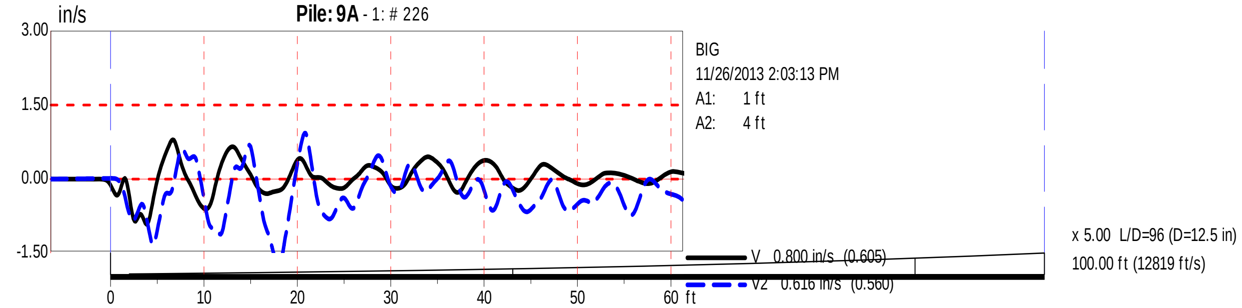

in/s
Pile: 9A - 1: # 231
1.20
0.60
0.00
-0.60
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:04:15 PM
A1: 1 ft
A2: 4 ft
V 0.158 in/s (0.045)
V2 0.343 in/s (0.322)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

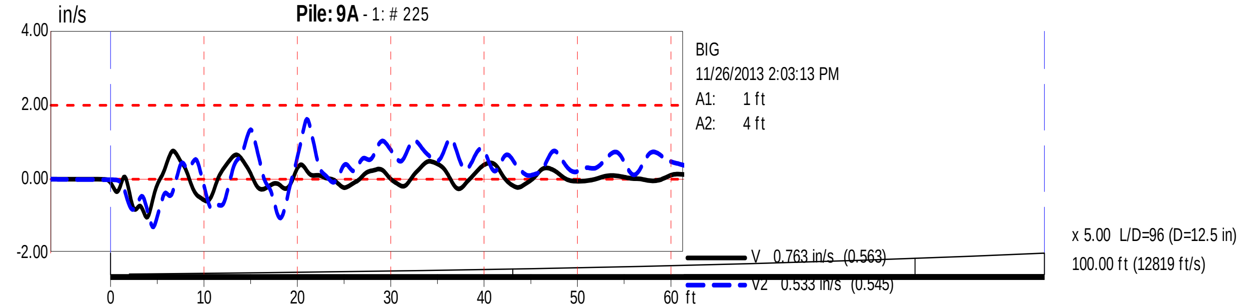

in/s
Pile: 9A - 1: # 230
8.00
4.00
0.00
-4.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:03:31 PM
A1: 1 ft
A2: 4 ft
V 1.234 in/s (0.990)
V2 2.157 in/s (1.764)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

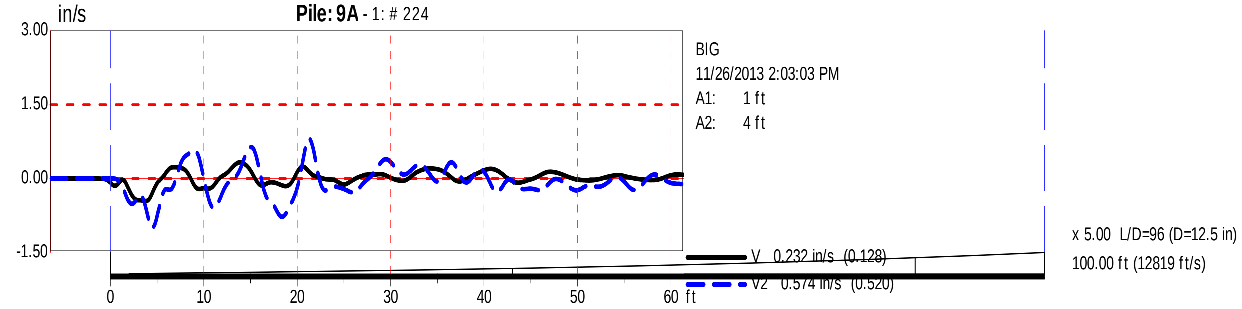

in/s
Pile: 9A - 1: # 229
4.00
2.00
0.00
-2.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:03:30 PM
A1: 1 ft
A2: 4 ft
V 0.991 in/s (0.754)
V2 0.746 in/s (0.715)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

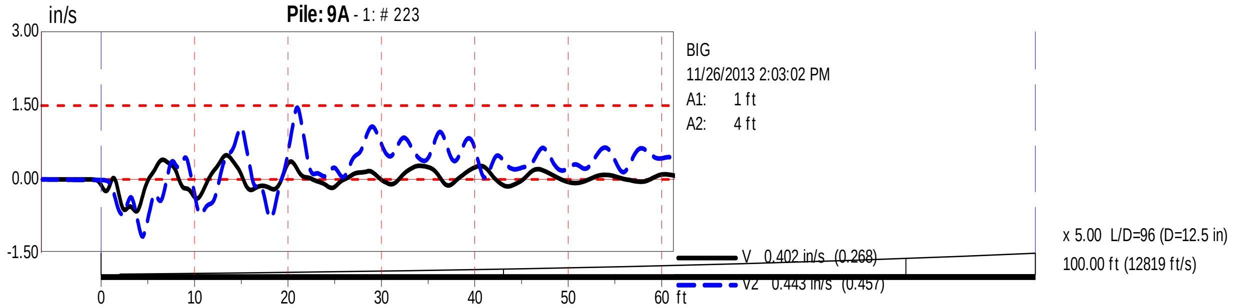

Pile: 9A - 1: # 228

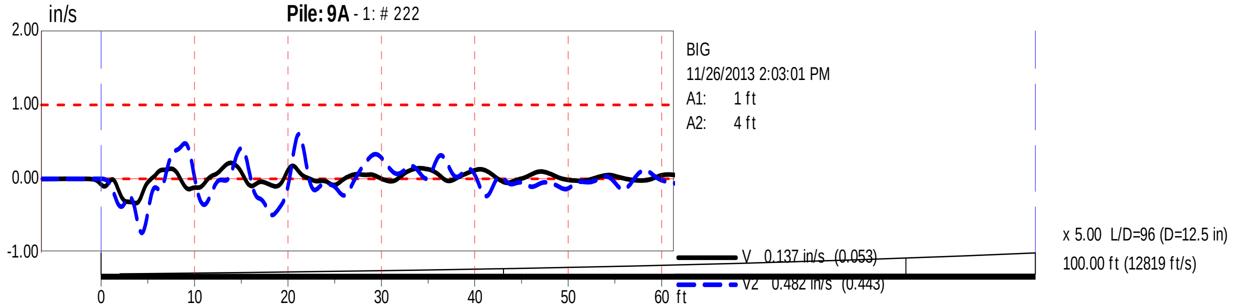

Pile: 9A - 1: # 227

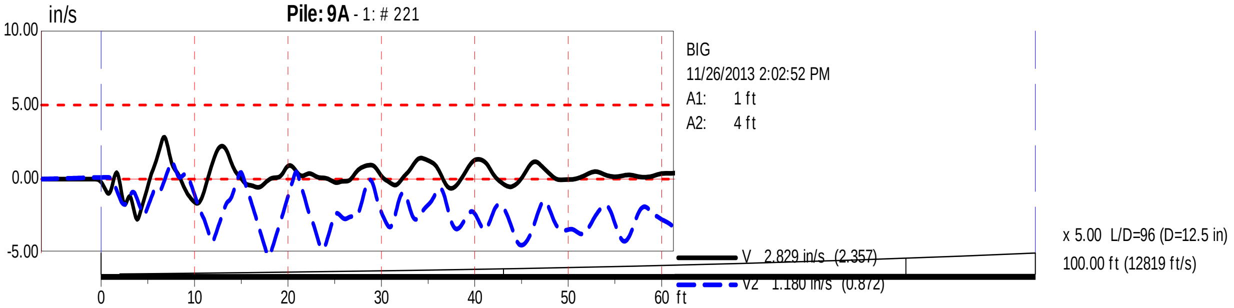

Pile: 9A - 1: # 226

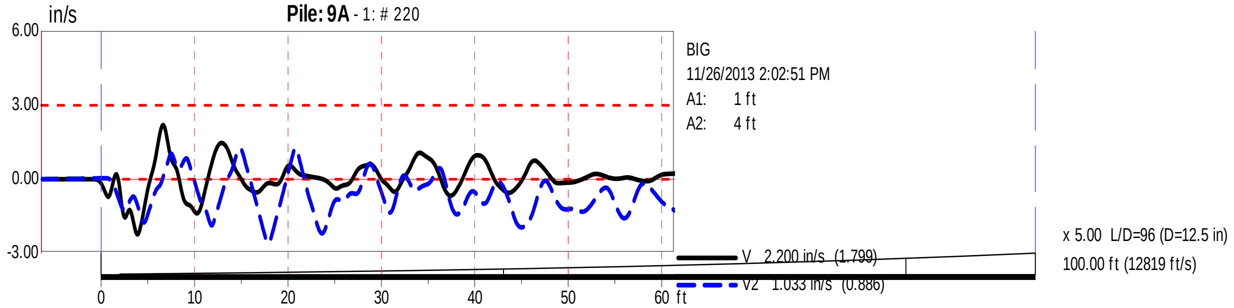

Pile: 9A - 1: # 225

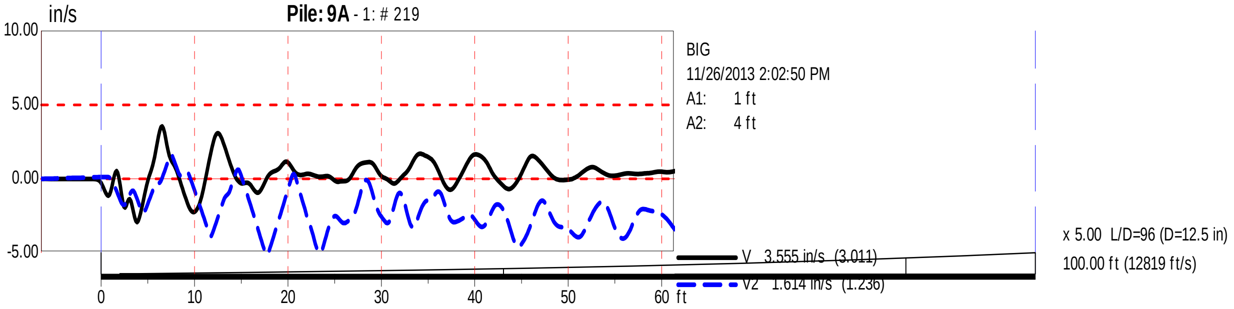

Pile: 9A - 1: # 224

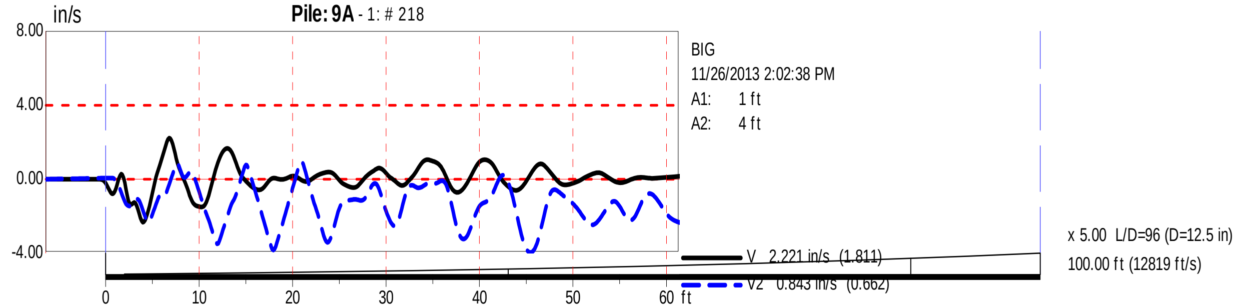

in/s
Pile: 9A - 1: # 223
3.00
1.50
0.00
-1.50
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:03:02 PM
A1: 1 ft
A2: 4 ft
V 0.402 in/s (0.268)
V2 0.443 in/s (0.457)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

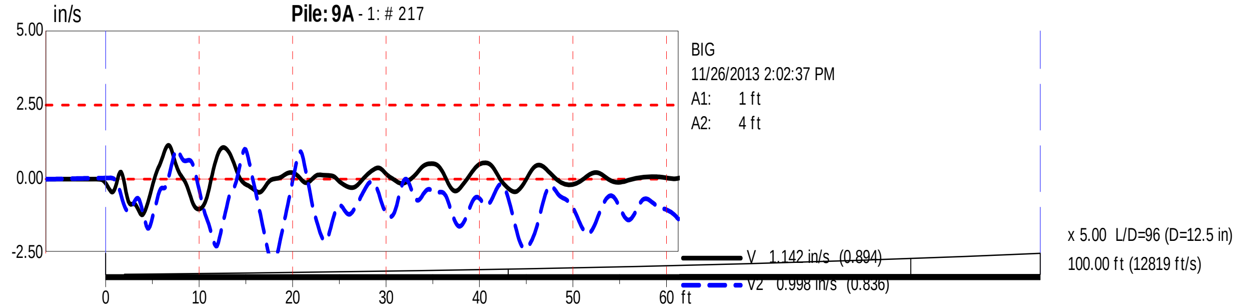

in/s
Pile: 9A - 1: # 222
2.00
1.00
0.00
-1.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:03:01 PM
A1: 1 ft
A2: 4 ft
V 0.137 in/s (0.053)
V2 0.482 in/s (0.443)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

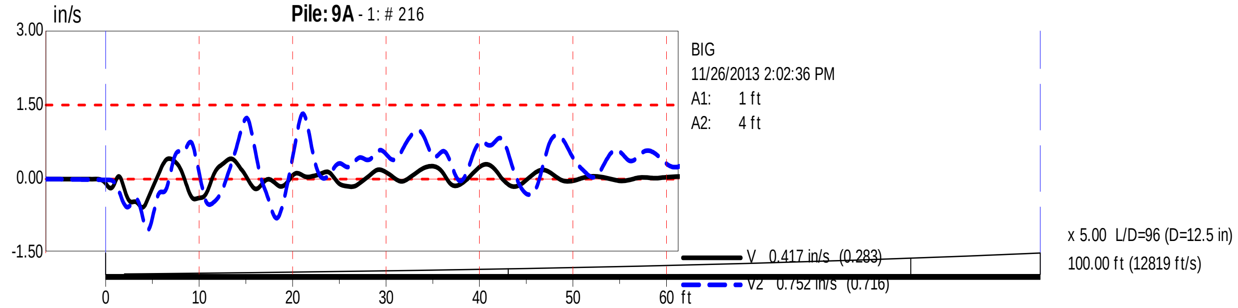

in/s
Pile: 9A - 1: # 221
10.00
5.00
0.00
-5.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:02:52 PM
A1: 1 ft
A2: 4 ft
V 2.829 in/s (2.357)
V2 1.180 in/s (0.872)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

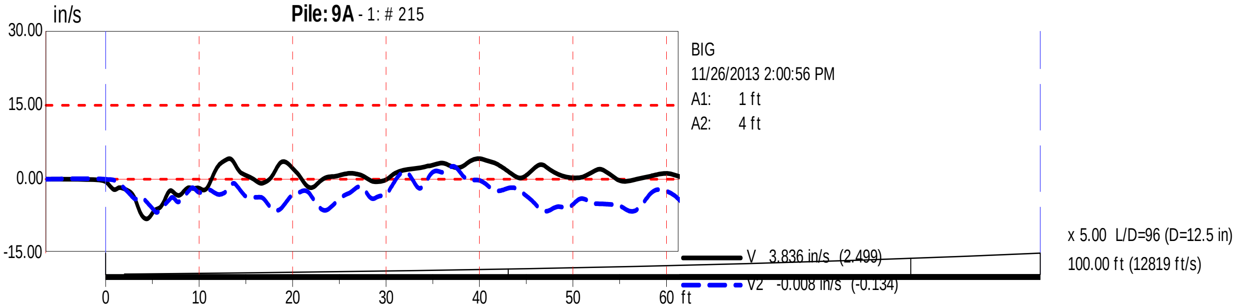

in/s
Pile: 9A - 1: # 220
6.00
3.00
0.00
-3.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:02:51 PM
A1: 1 ft
A2: 4 ft
V 2.200 in/s (1.799)
V2 1.033 in/s (0.886)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

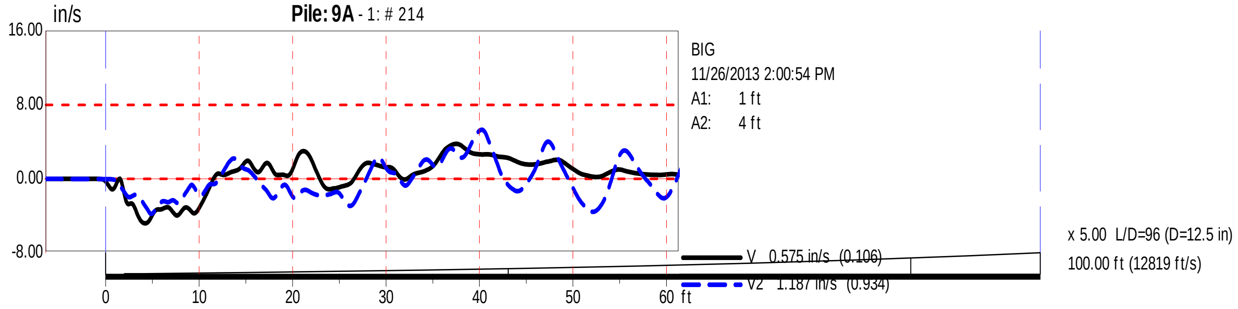

in/s
Pile: 9A - 1: # 219
10.00
5.00
0.00
-5.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:02:50 PM
A1: 1 ft
A2: 4 ft
V 3.555 in/s (3.011)
V2 1.614 in/s (1.236)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 9A - 1: # 218
8.00
4.00
0.00
-4.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:02:38 PM
A1: 1 ft
A2: 4 ft
V 2.221 in/s (1.811)
V2 0.843 in/s (0.662)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

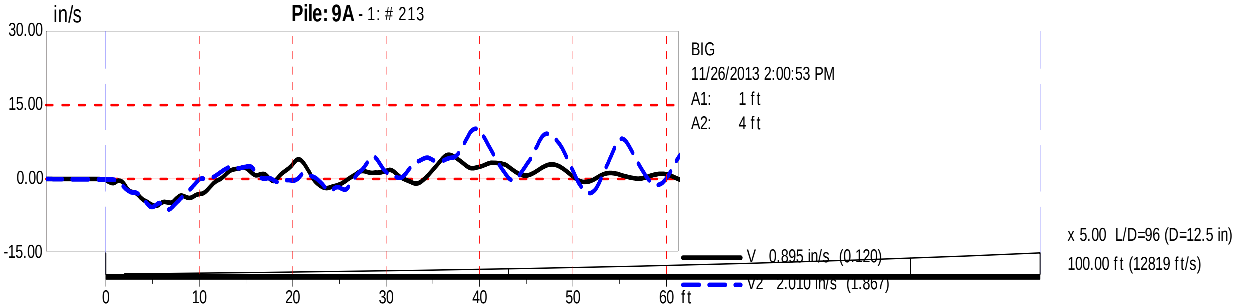

in/s
Pile: 9A - 1: # 217
5.00
2.50
0.00
-2.50
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:02:37 PM
A1: 1 ft
A2: 4 ft
V 1.142 in/s (0.894)
V2 0.998 in/s (0.836)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

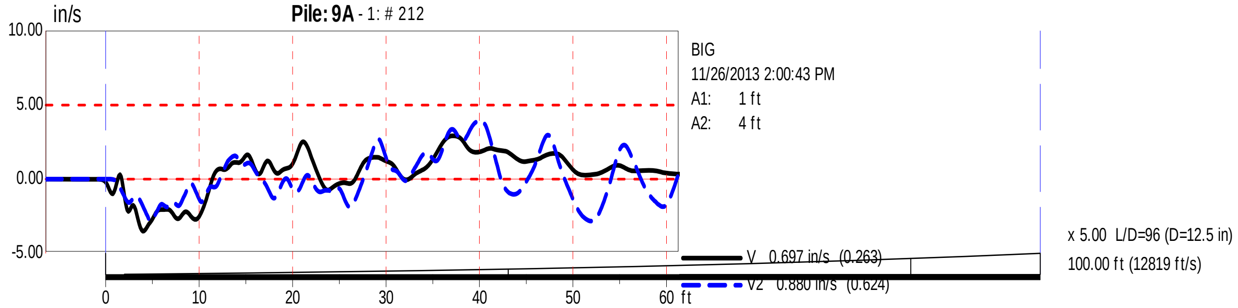

in/s
Pile: 9A - 1: # 216
3.00
1.50
0.00
-1.50
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:02:36 PM
A1: 1 ft
A2: 4 ft
V 0.417 in/s (0.283)
V2 0.752 in/s (0.716)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

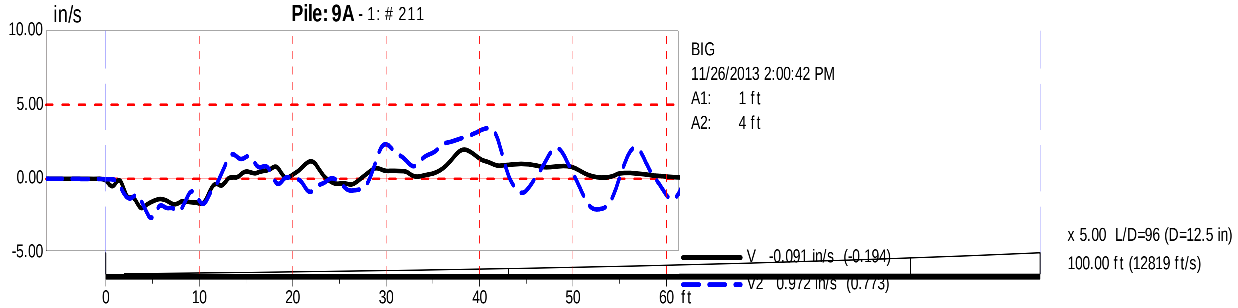

in/s
Pile: 9A - 1: # 215
30.00
15.00
0.00
-15.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:00:56 PM
A1: 1 ft
A2: 4 ft
V 3.836 in/s (2.499)
V2 -0.008 in/s (-0.134)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

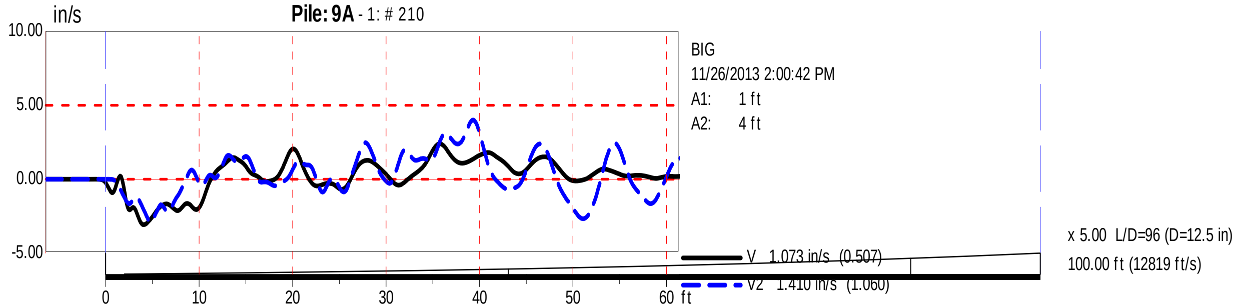

in/s
Pile: 9A - 1: # 214
16.00
8.00
0.00
-8.00
0
10
20
30
40
50
60 ft
BIG
11/26/2013 2:00:54 PM
A1: 1 ft
A2: 4 ft
V 0.575 in/s (0.106)
V2 1.187 in/s (0.934)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

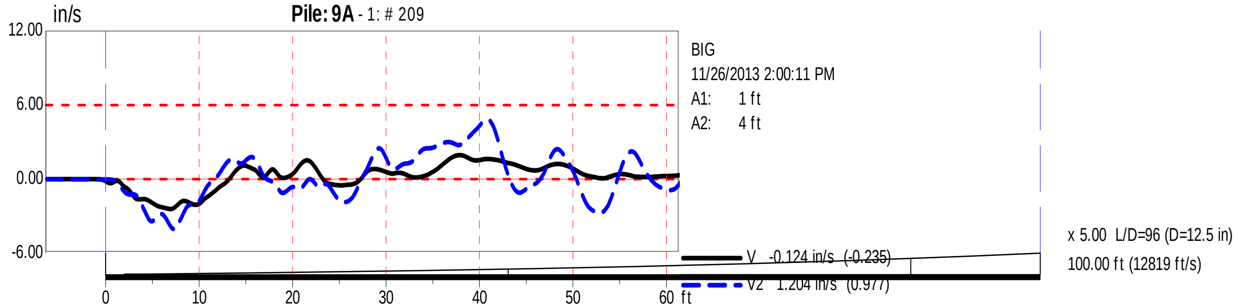
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 9A - 1: # 213

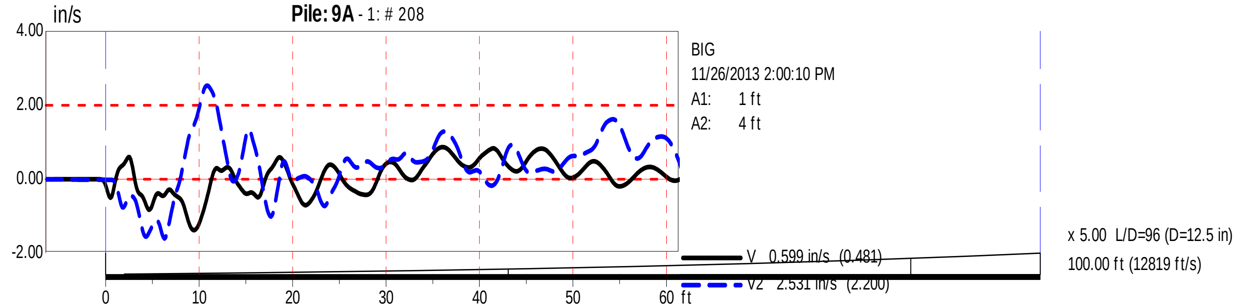

Pile: 9A - 1: # 212

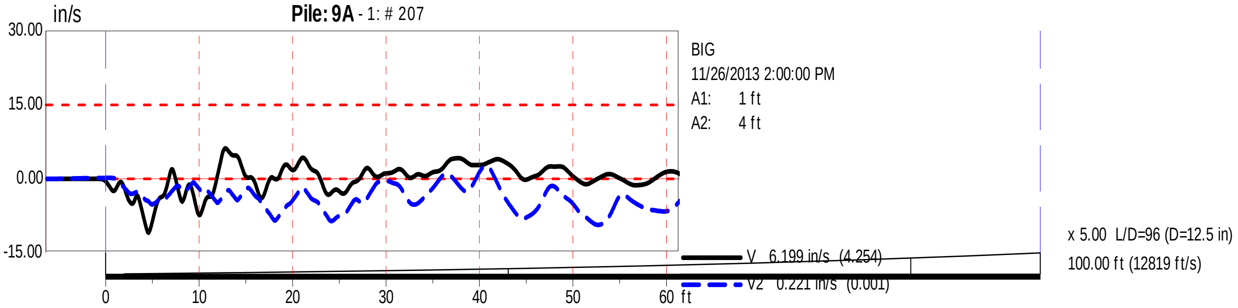

Pile: 9A - 1: # 211

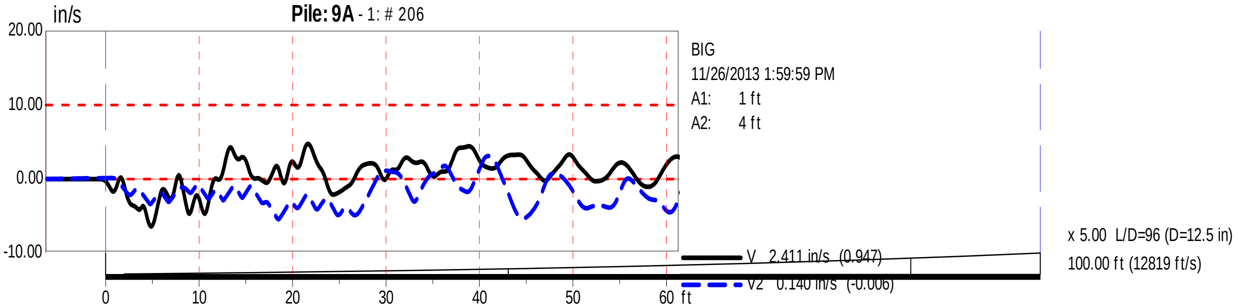

Pile: 9A - 1: # 210

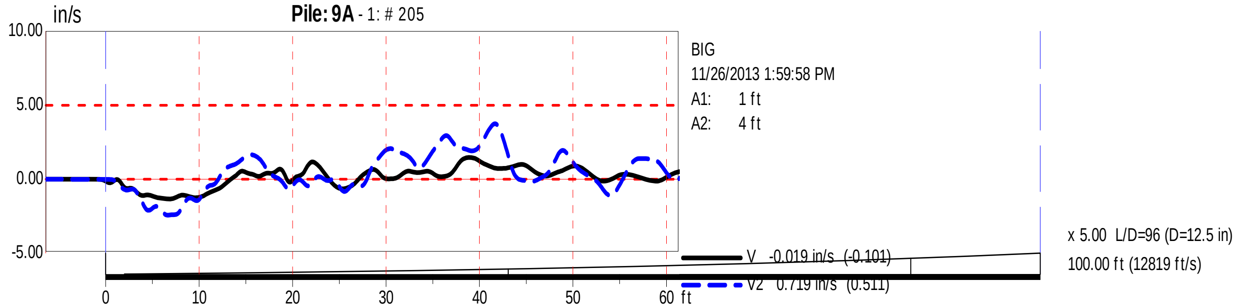

Pile: 9A - 1: # 209

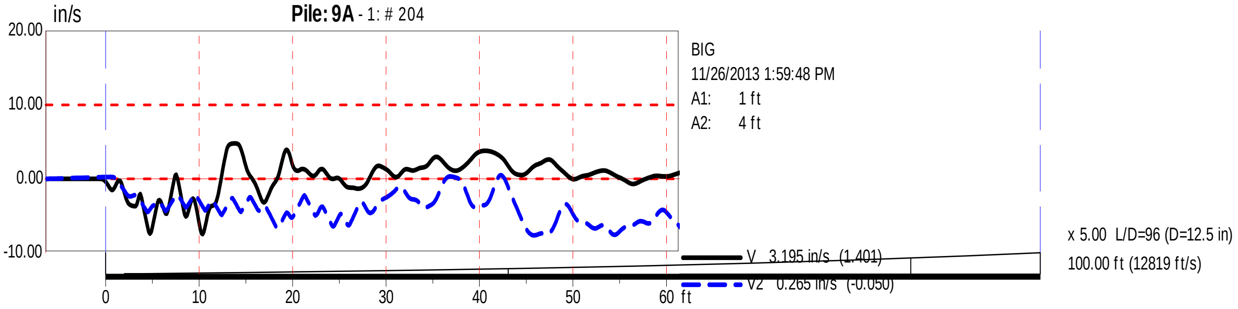
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

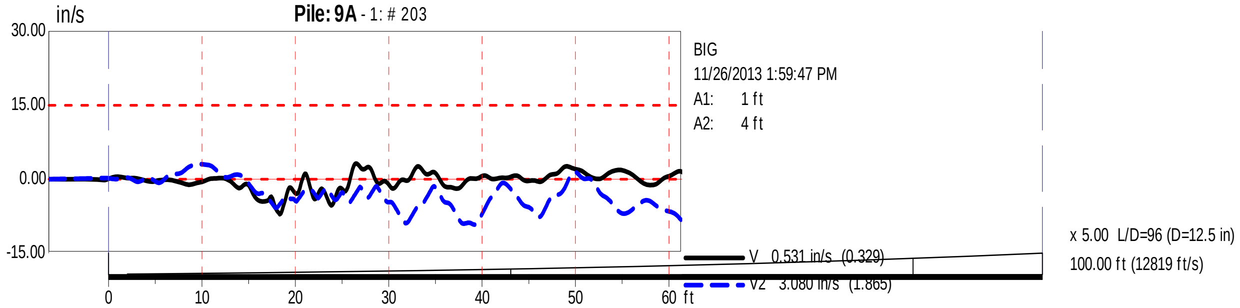


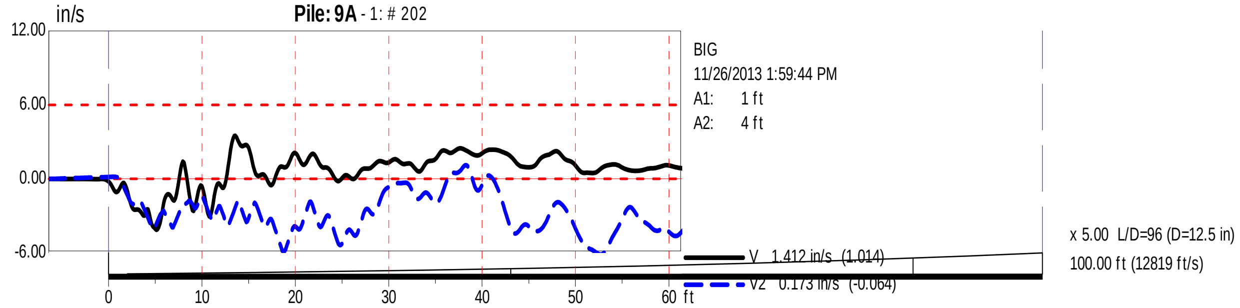




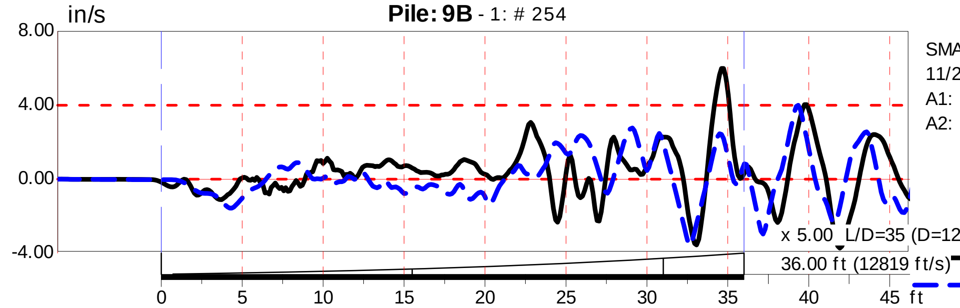





in/s
Pile: 9A - 1: # 203
30.00
15.00
0.00
-15.00
BIG
11/26/2013 1:59:47 PM
A1: 1 ft
A2: 4 ft
V 0.531 in/s (0.329)
V2 3.080 in/s (1.865)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50
60
ft


in/s
Pile: 9A - 1: # 202
12.00
6.00
0.00
-6.00
BIG
11/26/2013 1:59:44 PM
A1: 1 ft
A2: 4 ft
V 1.412 in/s (1.014)
V2 0.173 in/s (-0.064)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50
60
ft

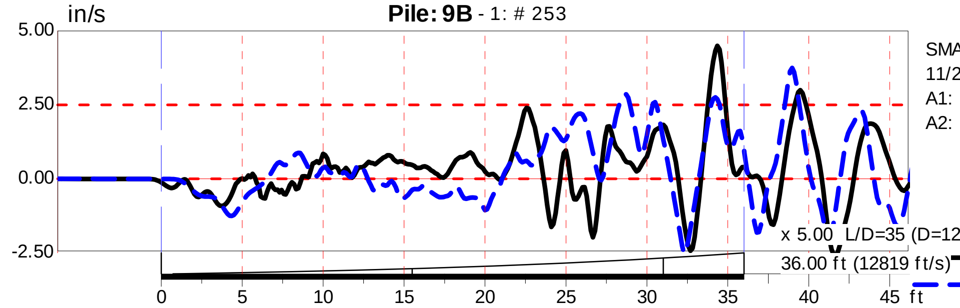
Pile: 9B - 1: # 254



SMALL
11/26/2013 2:11:16 PM
A1: 1 ft
A2: 4 ft

V 1.134 in/s (0.565)
V2 0.898 in/s (0.715)

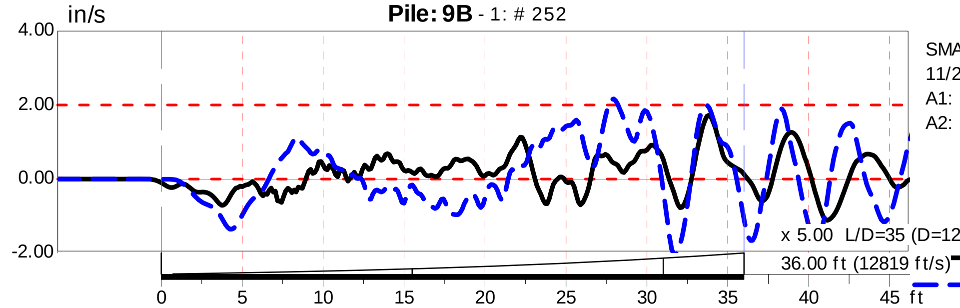
Pile: 9B - 1: # 253



SMALL
11/26/2013 2:11:15 PM
A1: 1 ft
A2: 4 ft

V 0.850 in/s (0.399)
V2 0.878 in/s (0.647)

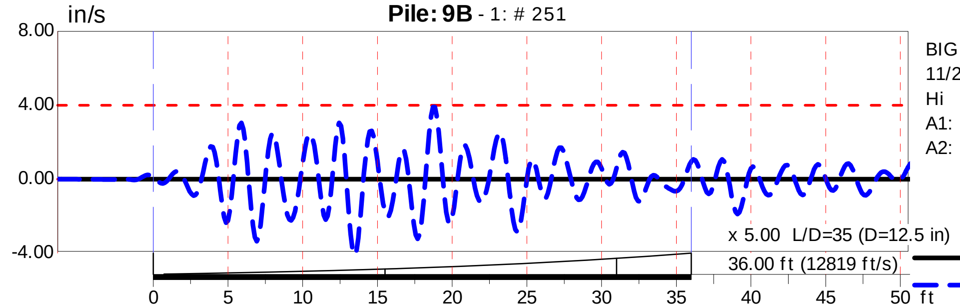
Pile: 9B - 1: # 252



SMALL
11/26/2013 2:11:14 PM
A1: 1 ft
A2: 4 ft

V 0.476 in/s (0.196)
V2 1.130 in/s (0.825)

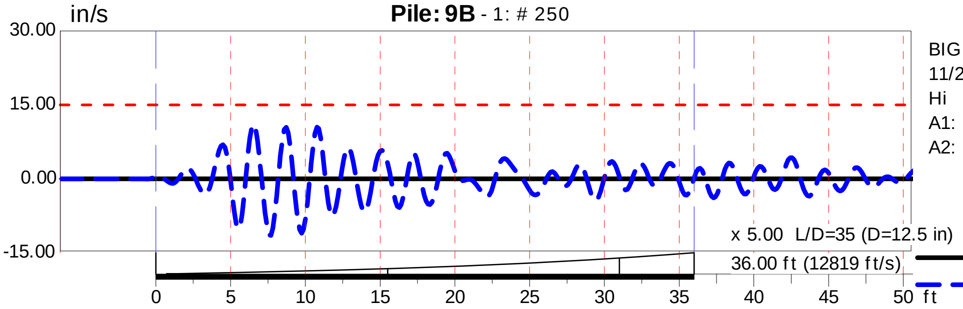
Pile: 9B - 1: # 251



BIG
11/26/2013 1:02:55 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 0.000 in/s (0.000)
V2 3.046 in/s (3.017)

Pile: 9B - 1: # 250



BIG
11/26/2013 1:02:54 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 0.000 in/s (0.000)
V2 11.059 in/s (9.717)

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PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT

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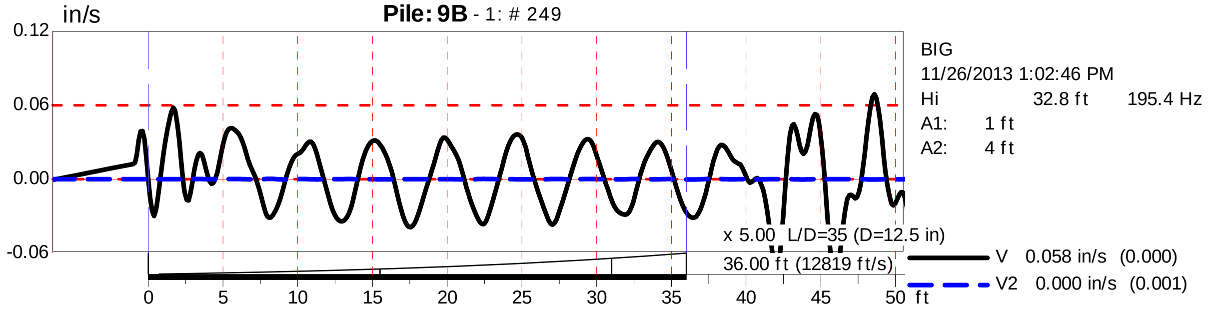
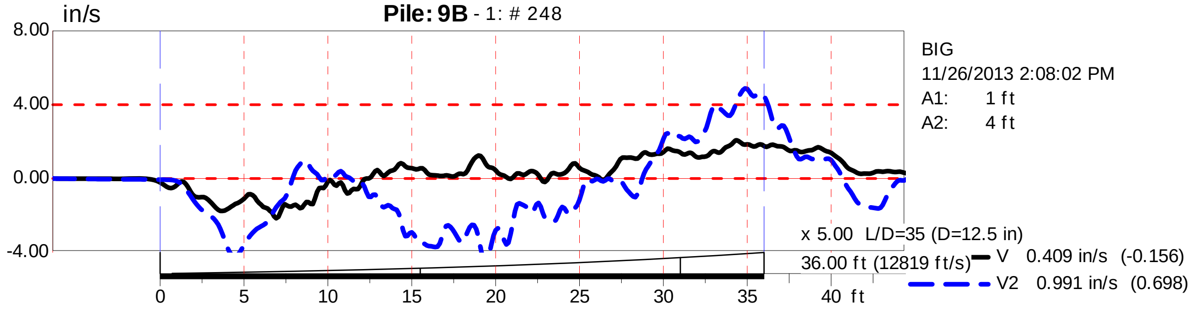
PIT-W 2009-2.DEMO

Pile: 9B - 1: # 249



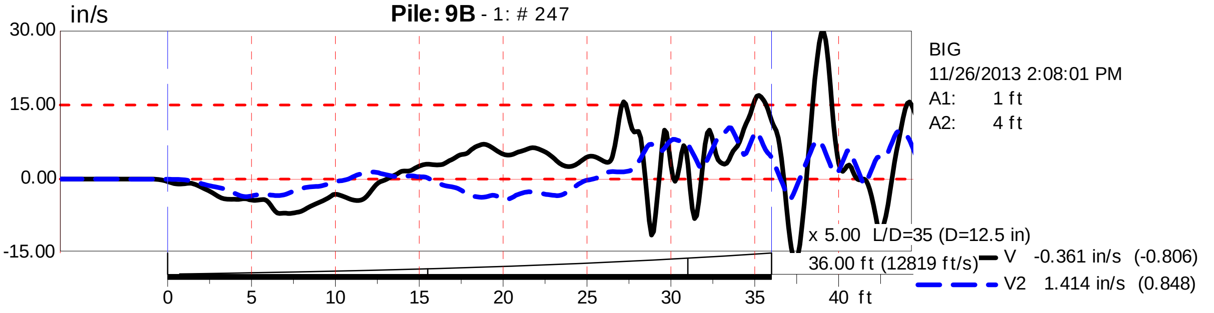
BIG
11/26/2013 1:02:46 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9B - 1: # 248



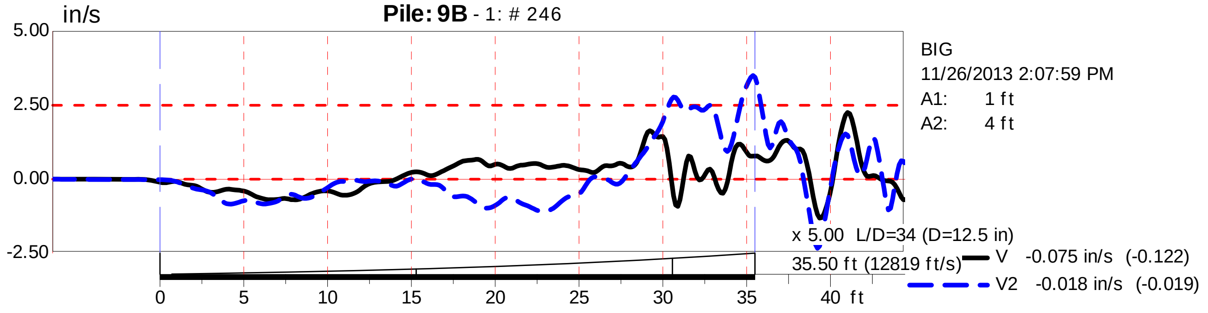
BIG
11/26/2013 2:08:02 PM
A1: 1 ft
A2: 4 ft

Pile: 9B - 1: # 247



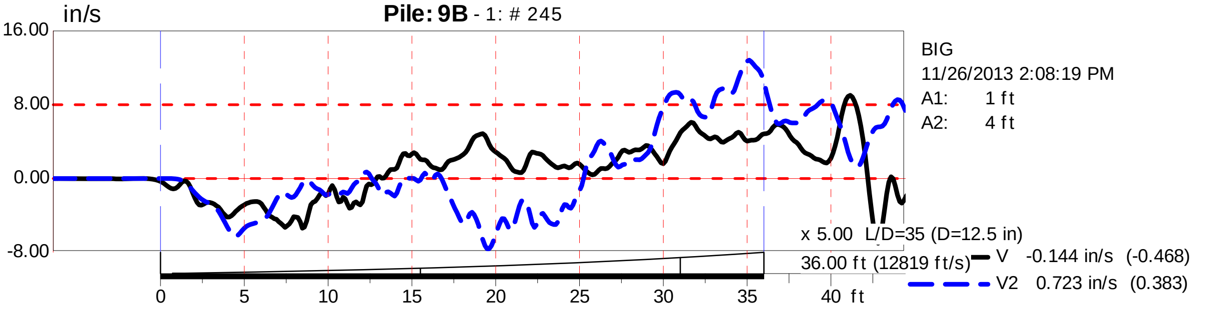
BIG
11/26/2013 2:08:01 PM
A1: 1 ft
A2: 4 ft

Pile: 9B - 1: # 246

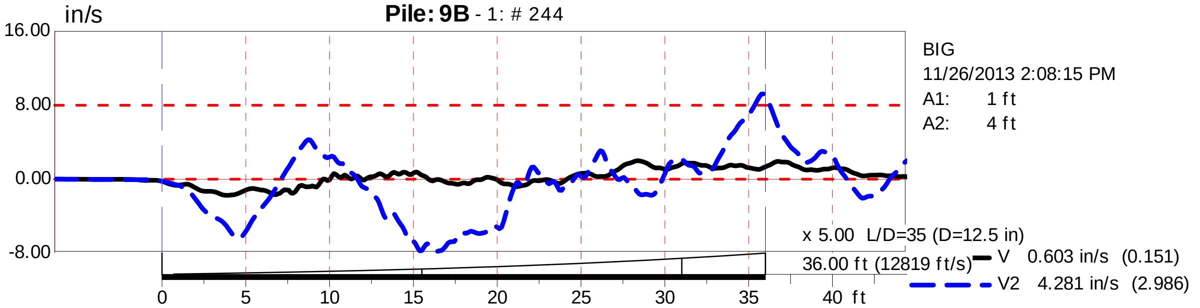


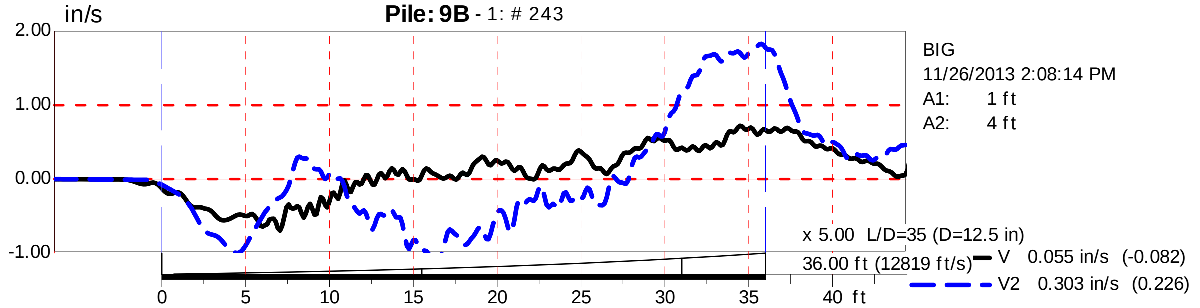
BIG
11/26/2013 2:07:59 PM
A1: 1 ft
A2: 4 ft

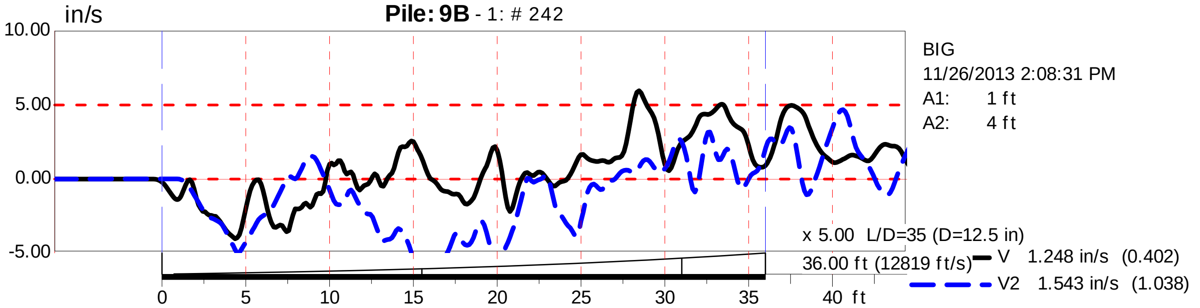
Pile: 9B - 1: # 245

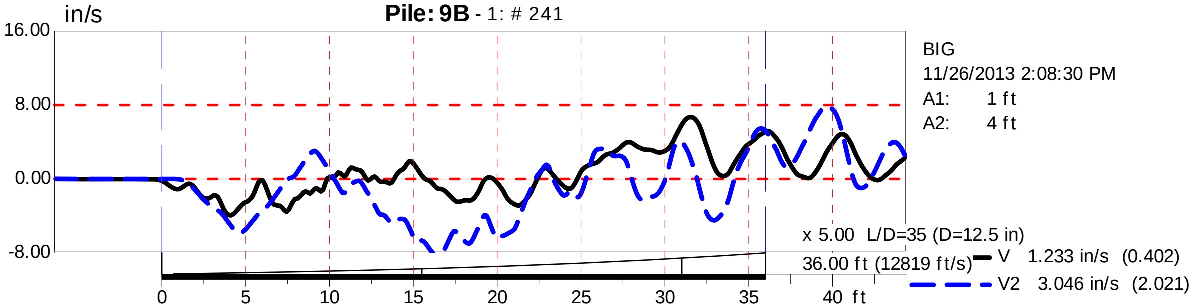


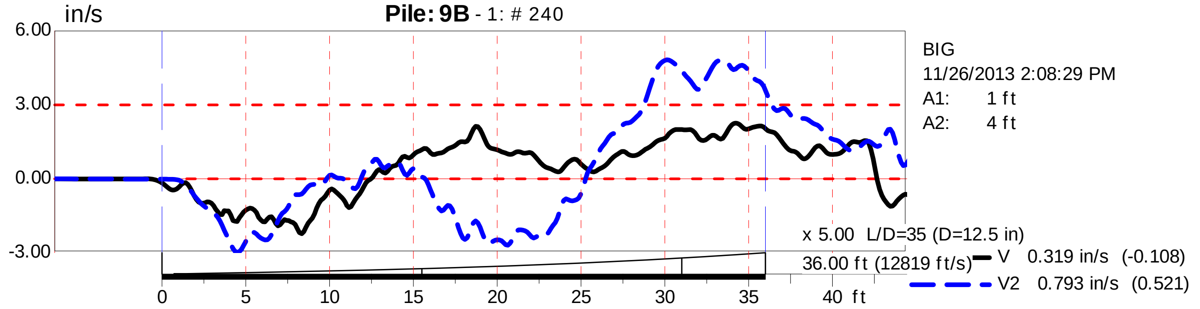
BIG
11/26/2013 2:08:19 PM
A1: 1 ft
A2: 4 ft


in/s
Pile: 9B - 1: # 244
16.00
8.00
0.00
-8.00
0
5
10
15
20
25
30
35
40 ft
BIG
11/26/2013 2:08:15 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.603 in/s (0.151)
V2 4.281 in/s (2.986)

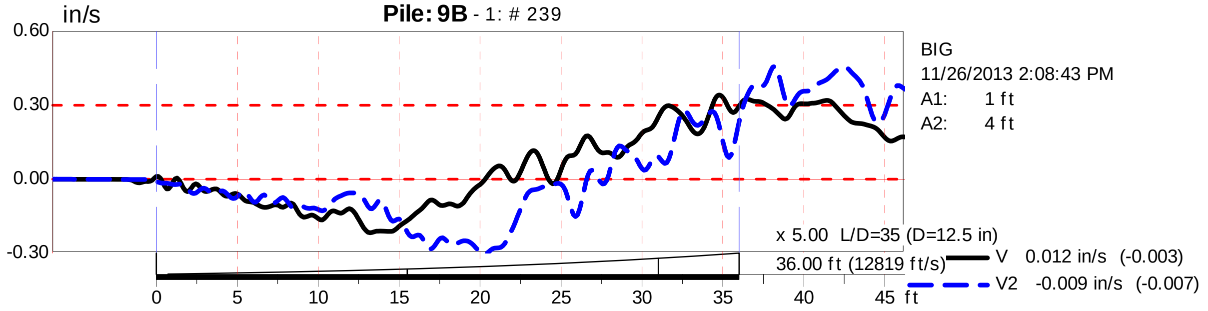

in/s
Pile: 9B - 1: # 243
2.00
1.00
0.00
-1.00
0
5
10
15
20
25
30
35
40 ft
BIG
11/26/2013 2:08:14 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.055 in/s (-0.082)
V2 0.303 in/s (0.226)


in/s
Pile: 9B - 1: # 242
10.00
5.00
0.00
-5.00
0
5
10
15
20
25
30
35
40 ft
BIG
11/26/2013 2:08:31 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.248 in/s (0.402)
V2 1.543 in/s (1.038)

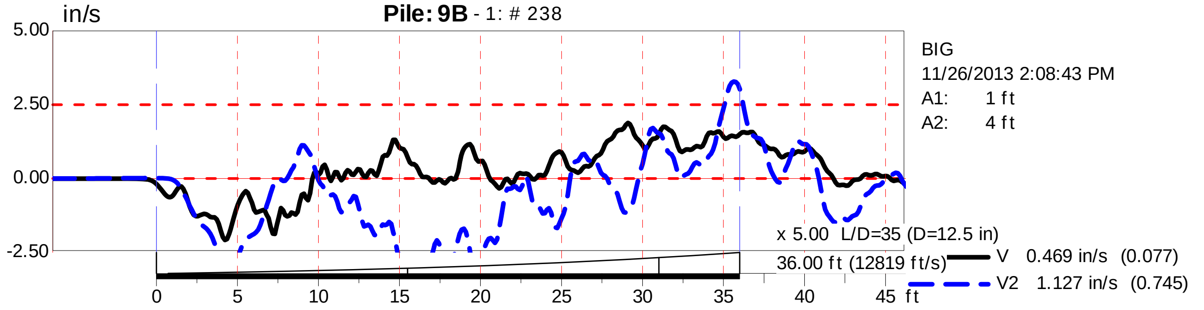

in/s
Pile: 9B - 1: # 241
16.00
8.00
0.00
-8.00
0
5
10
15
20
25
30
35
40 ft
BIG
11/26/2013 2:08:30 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.233 in/s (0.402)
V2 3.046 in/s (2.021)


in/s
Pile: 9B - 1: # 240
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40 ft
BIG
11/26/2013 2:08:29 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.319 in/s (-0.108)
V2 0.793 in/s (0.521)

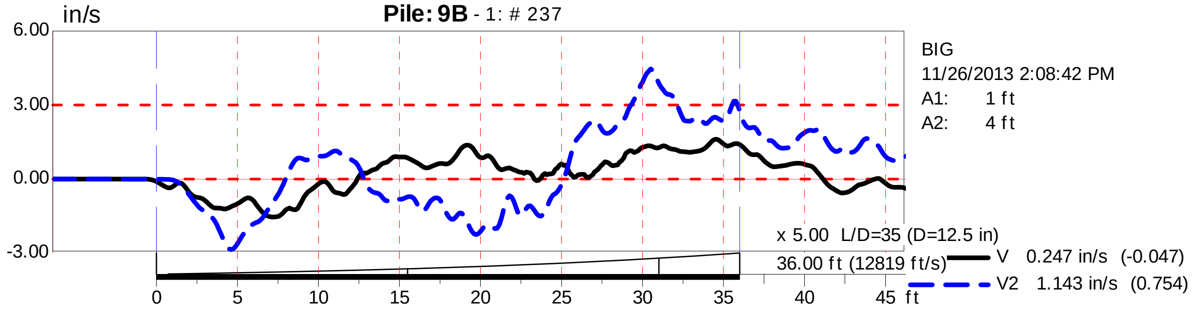
Pile: 9B - 1: # 239



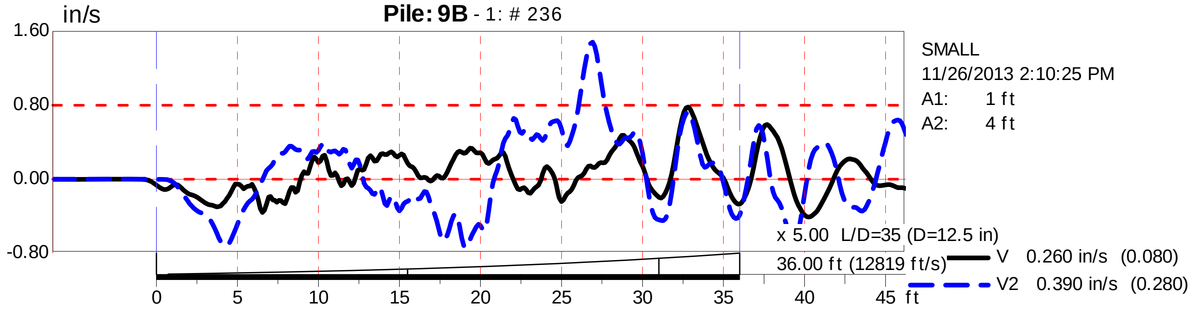
Pile: 9B - 1: # 238



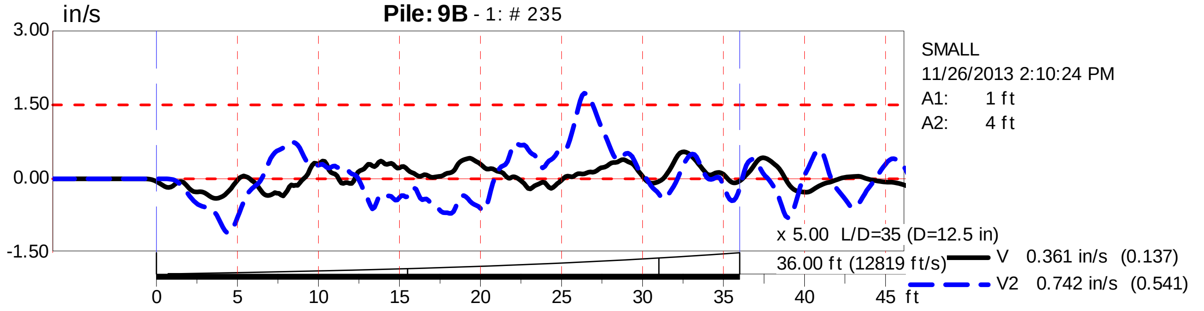
Pile: 9B - 1: # 237



Pile: 9B - 1: # 236



Pile: 9B - 1: # 235



Pile Dynamics, Inc.
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT

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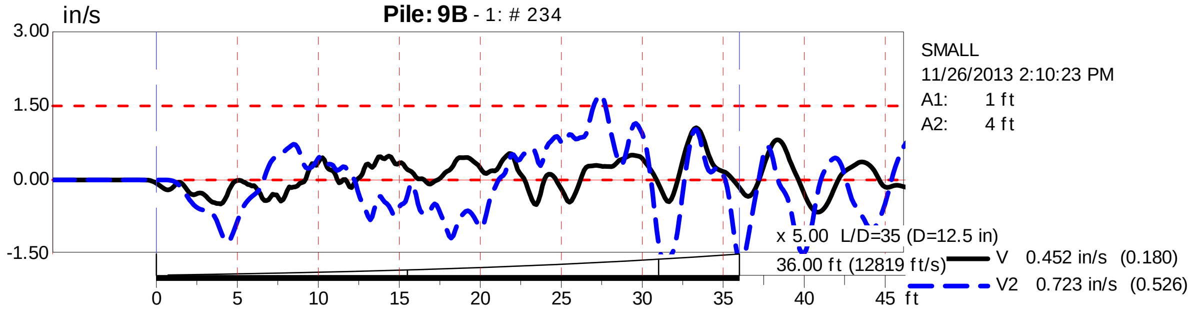
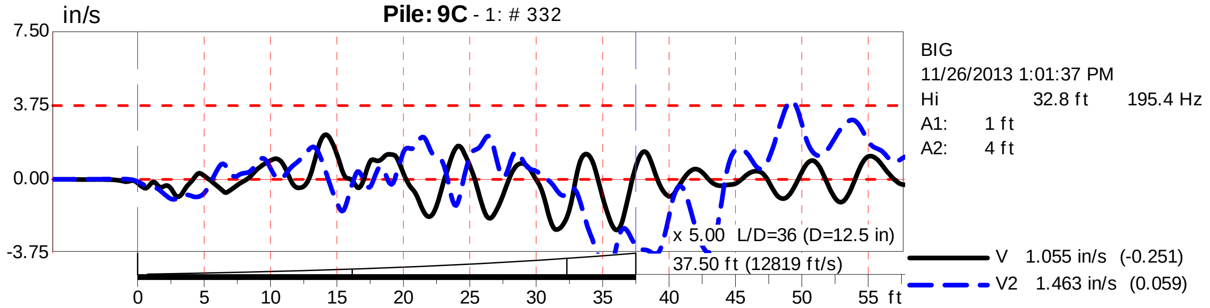
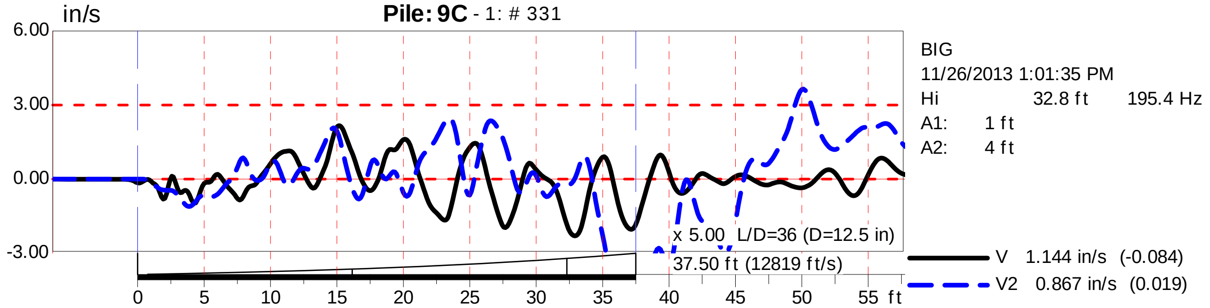
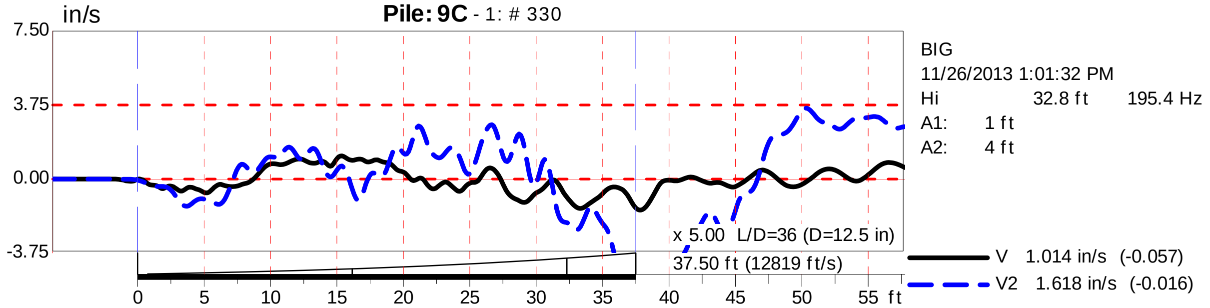
Pile: 9B - 1: # 234

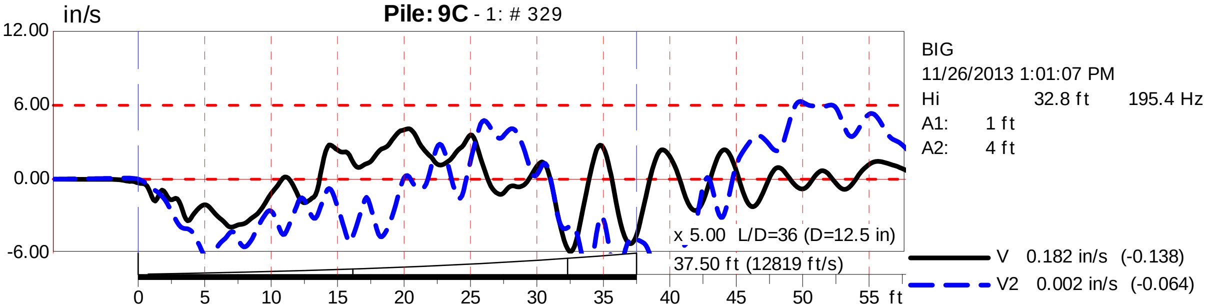


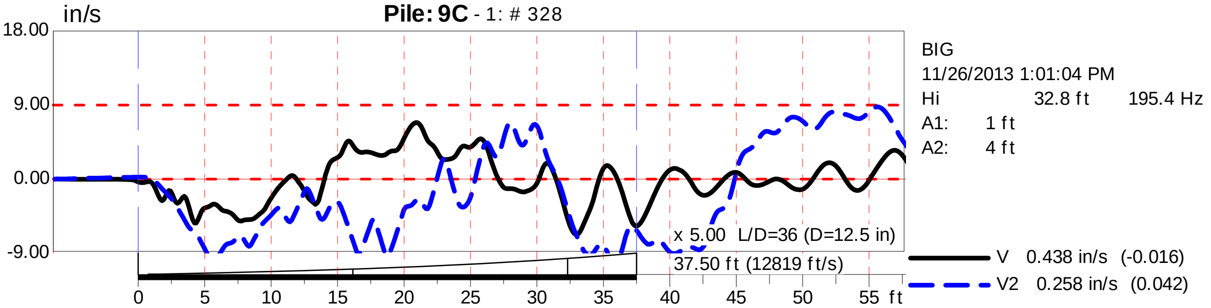
SMALL
11/26/2013 2:10:23 PM
A1: 1 ft
A2: 4 ft


in/s
Pile: 9C - 1: # 332
7.50
3.75
0.00
-3.75
0
5
10
15
20
25
30
35
40
45
50
55 ft
x 5.00 L/D=36 (D=12.5 in)
37.50 ft (12819 ft/s)
BIG
11/26/2013 1:01:37 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.055 in/s (-0.251)
V2 1.463 in/s (0.059)

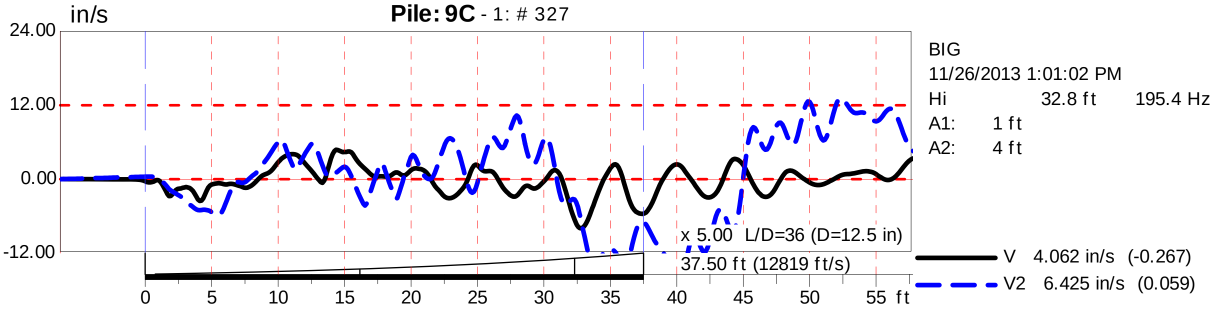

in/s
Pile: 9C - 1: # 331
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45
50
55 ft
x 5.00 L/D=36 (D=12.5 in)
37.50 ft (12819 ft/s)
BIG
11/26/2013 1:01:35 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.144 in/s (-0.084)
V2 0.867 in/s (0.019)


in/s
Pile: 9C - 1: # 330
7.50
3.75
0.00
-3.75
0
5
10
15
20
25
30
35
40
45
50
55 ft
x 5.00 L/D=36 (D=12.5 in)
37.50 ft (12819 ft/s)
BIG
11/26/2013 1:01:32 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 1.014 in/s (-0.057)
V2 1.618 in/s (-0.016)


in/s
Pile: 9C - 1: # 329
12.00
6.00
0.00
-6.00
0
5
10
15
20
25
30
35
40
45
50
55 ft
x 5.00 L/D=36 (D=12.5 in)
37.50 ft (12819 ft/s)
BIG
11/26/2013 1:01:07 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.182 in/s (-0.138)
V2 0.002 in/s (-0.064)

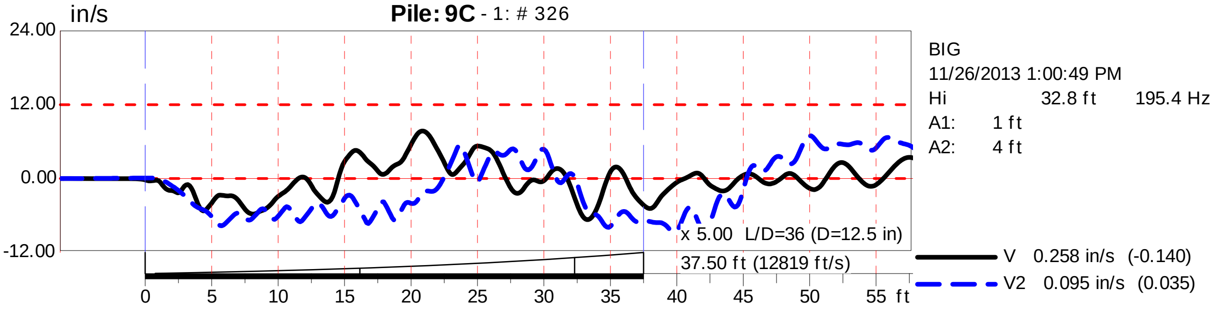

in/s
Pile: 9C - 1: # 328
18.00
9.00
0.00
-9.00
0
5
10
15
20
25
30
35
40
45
50
55 ft
x 5.00 L/D=36 (D=12.5 in)
37.50 ft (12819 ft/s)
BIG
11/26/2013 1:01:04 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft
V 0.438 in/s (-0.016)
V2 0.258 in/s (0.042)

Pile: 9C - 1: # 327



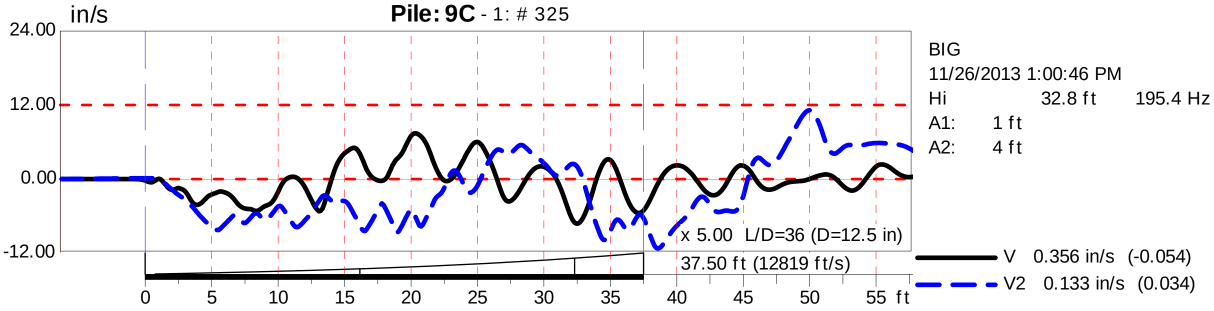
BIG
11/26/2013 1:01:02 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 326



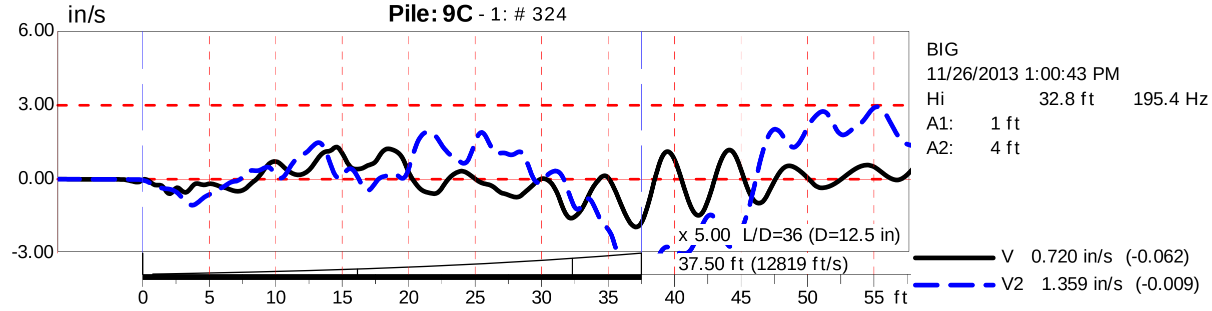
BIG
11/26/2013 1:00:49 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 325



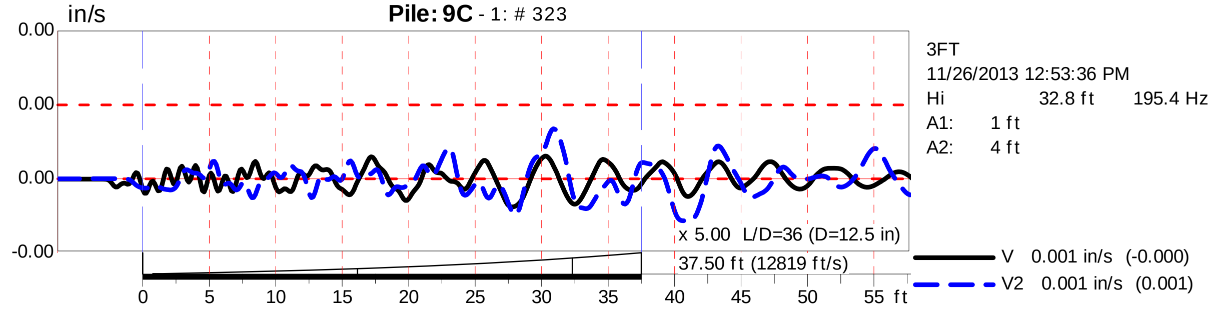
BIG
11/26/2013 1:00:46 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 324



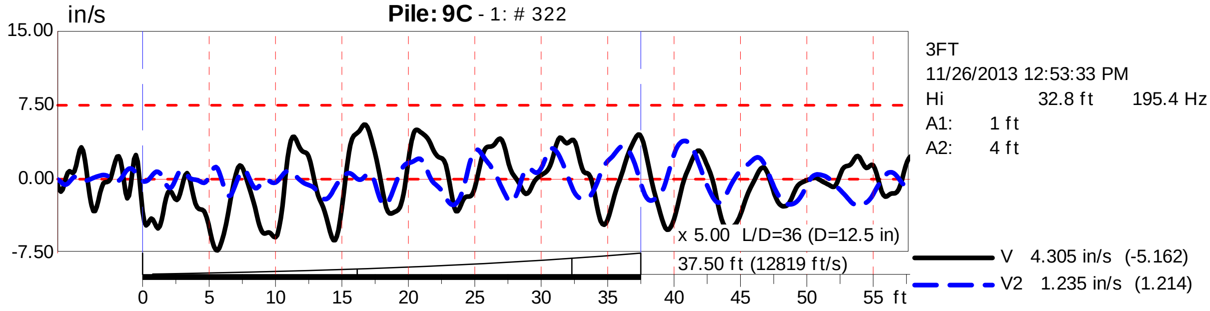
BIG
11/26/2013 1:00:43 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 323



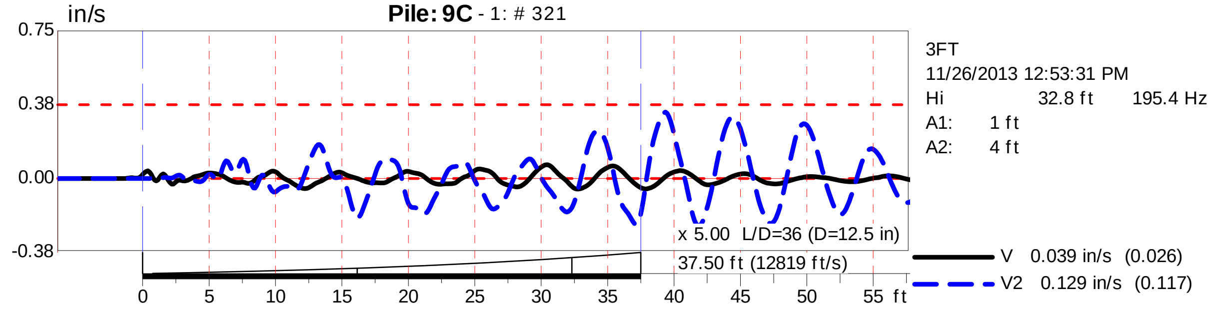
3FT
11/26/2013 12:53:36 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 322



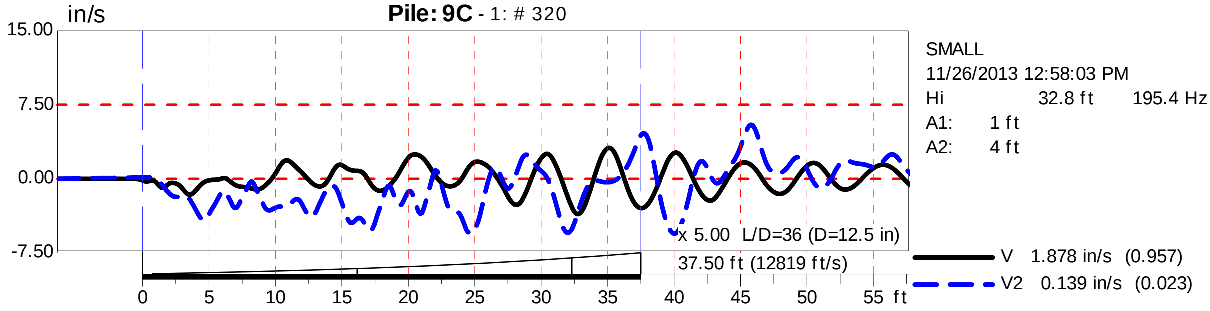
3FT
11/26/2013 12:53:33 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 321



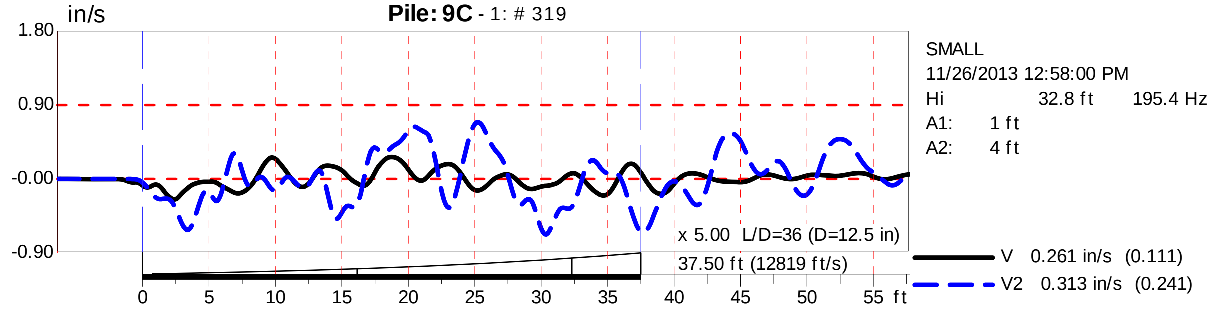
3FT
11/26/2013 12:53:31 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 320



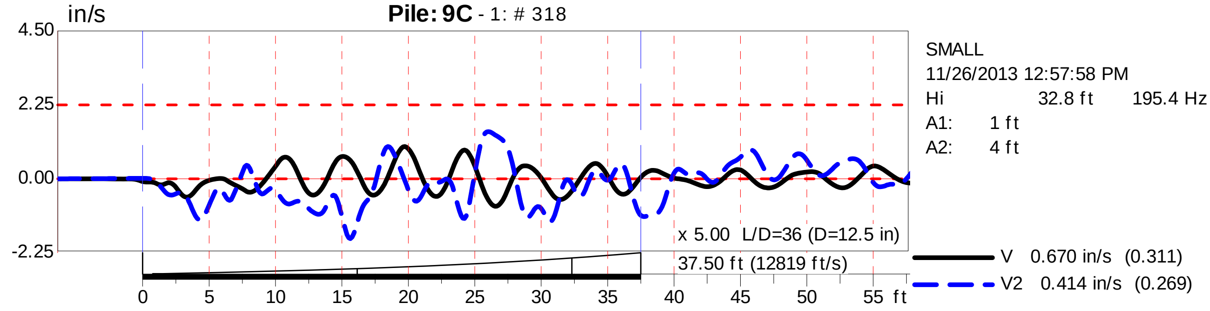
SMALL
11/26/2013 12:58:03 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 319



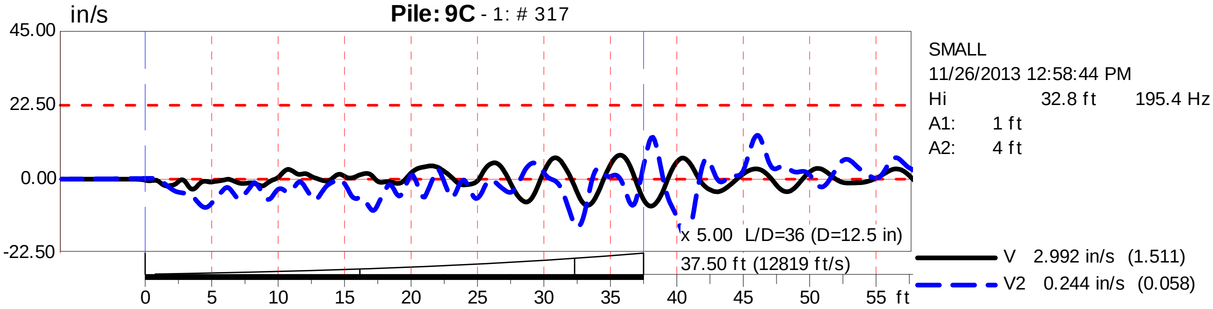
SMALL
11/26/2013 12:58:00 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 318



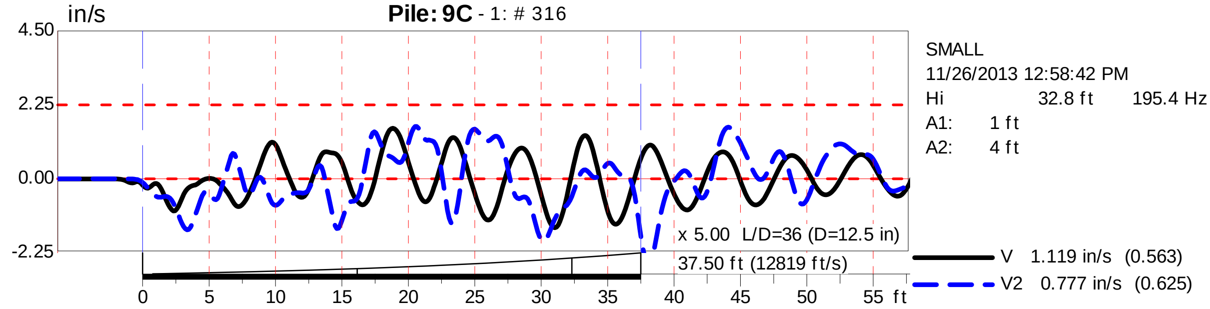
SMALL
11/26/2013 12:57:58 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 317



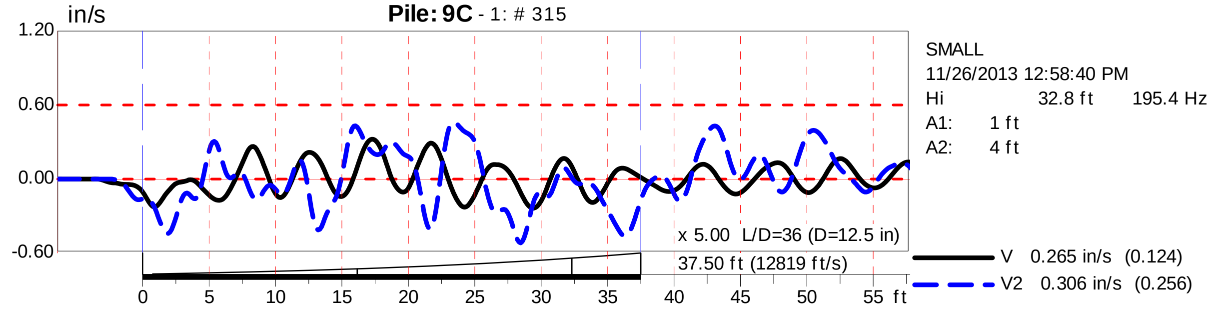
SMALL
11/26/2013 12:58:44 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 316



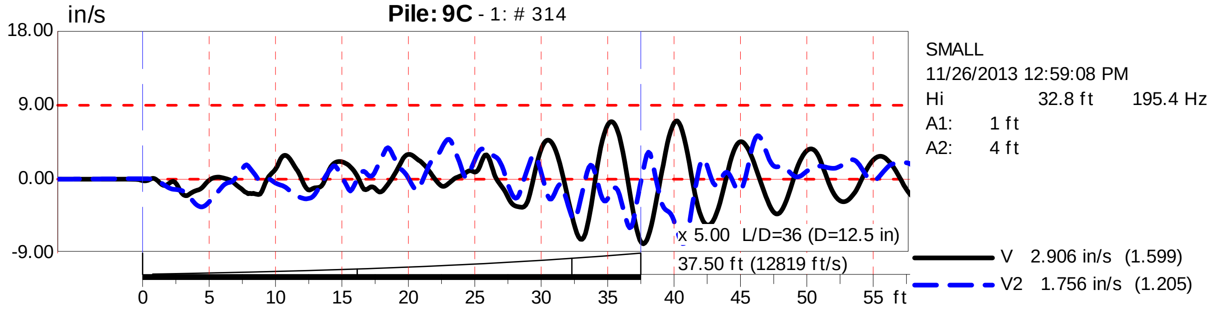
SMALL
11/26/2013 12:58:42 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 315



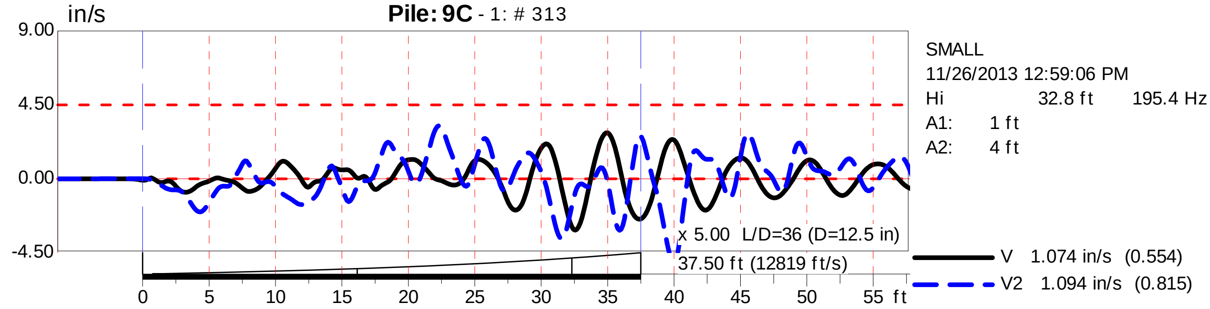
SMALL
11/26/2013 12:58:40 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 314



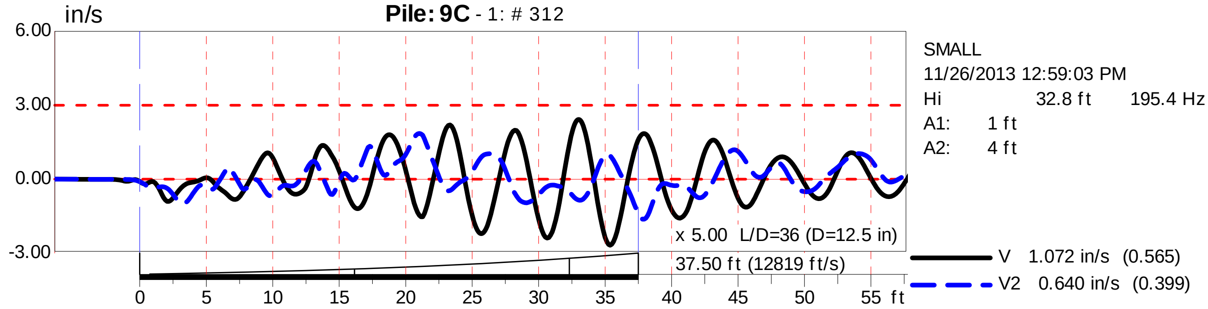
SMALL
11/26/2013 12:59:08 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 313



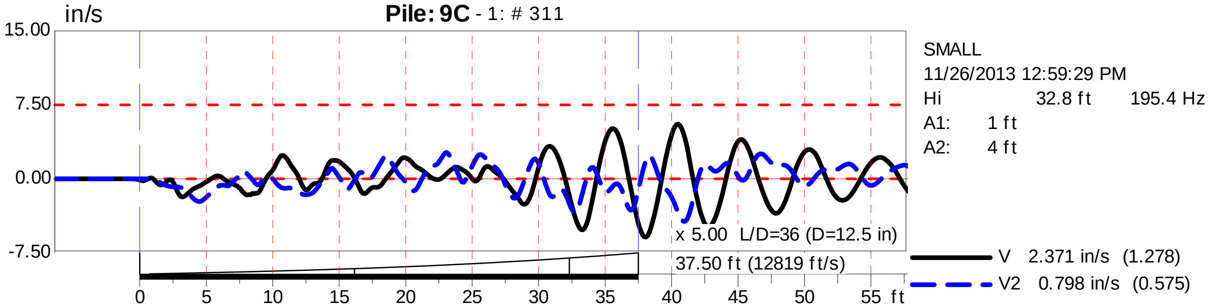
SMALL
11/26/2013 12:59:06 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 312



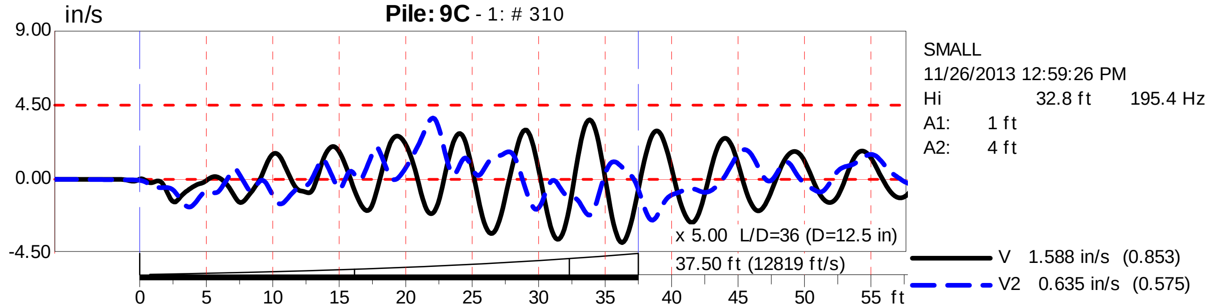
SMALL
11/26/2013 12:59:03 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 311



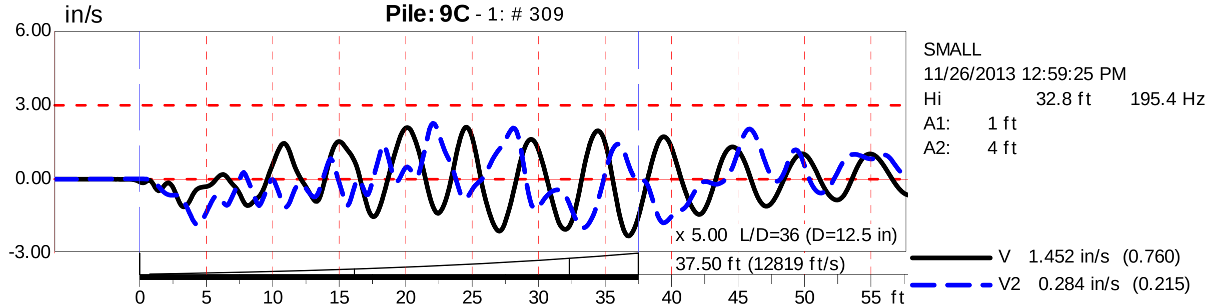
SMALL
11/26/2013 12:59:29 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 310



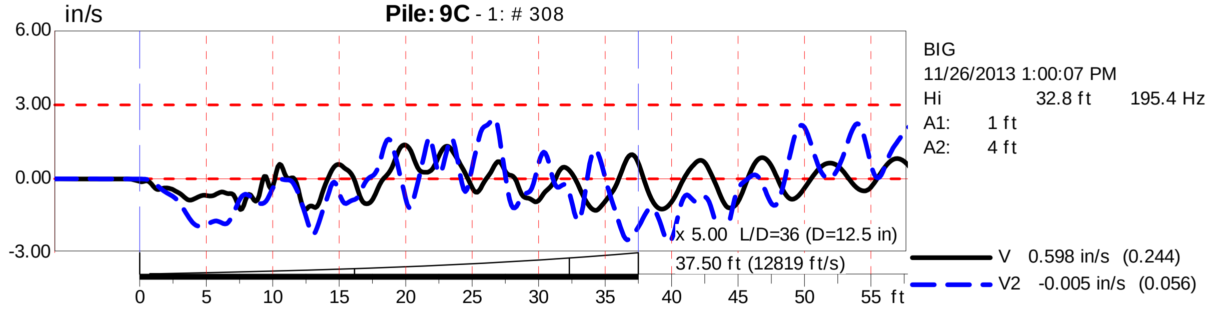
SMALL
11/26/2013 12:59:26 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile: 9C - 1: # 309



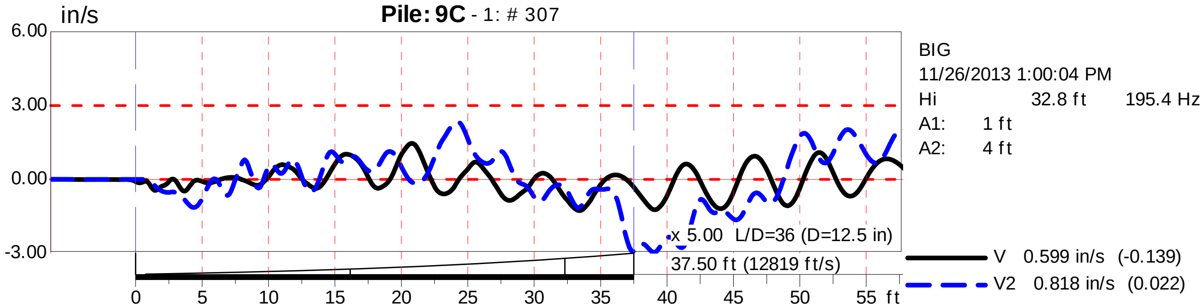
SMALL
11/26/2013 12:59:25 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

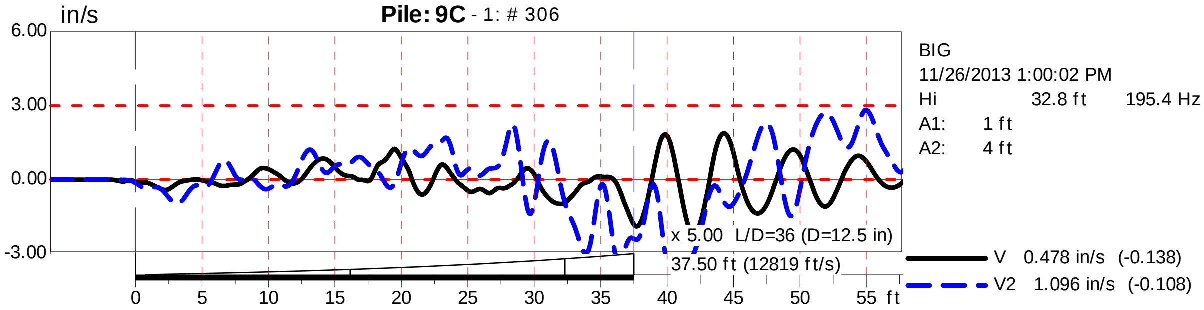
Pile: 9C - 1: # 308



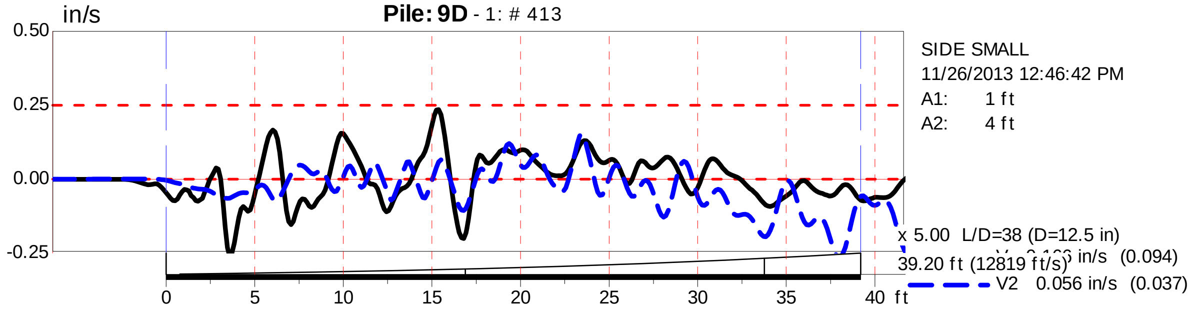
BIG
11/26/2013 1:00:07 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 9C - 1: # 307


Pile: 9C - 1: # 306

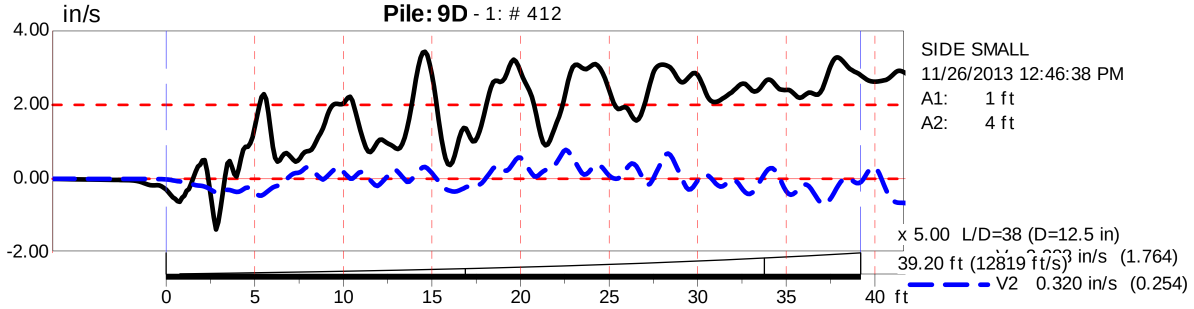
Pile: 9D - 1: # 413



SIDE SMALL
11/26/2013 12:46:42 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 0.166 in/s (0.094)
V2 0.056 in/s (0.037)

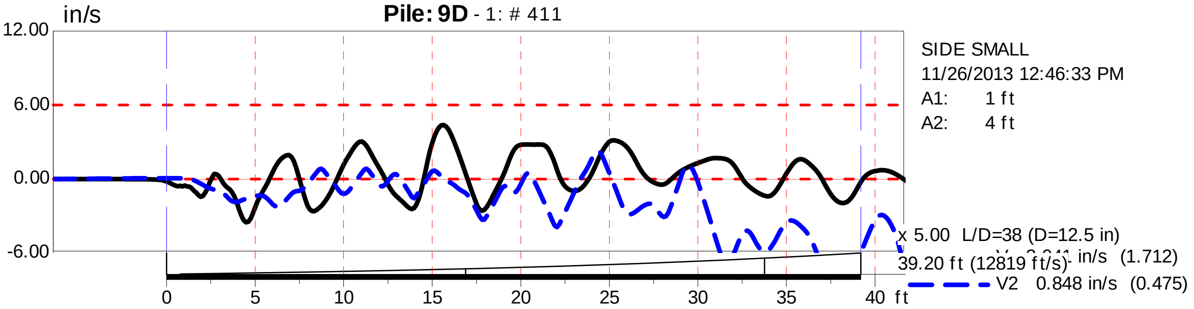
Pile: 9D - 1: # 412



SIDE SMALL
11/26/2013 12:46:38 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (1.764)
V2 0.320 in/s (0.254)

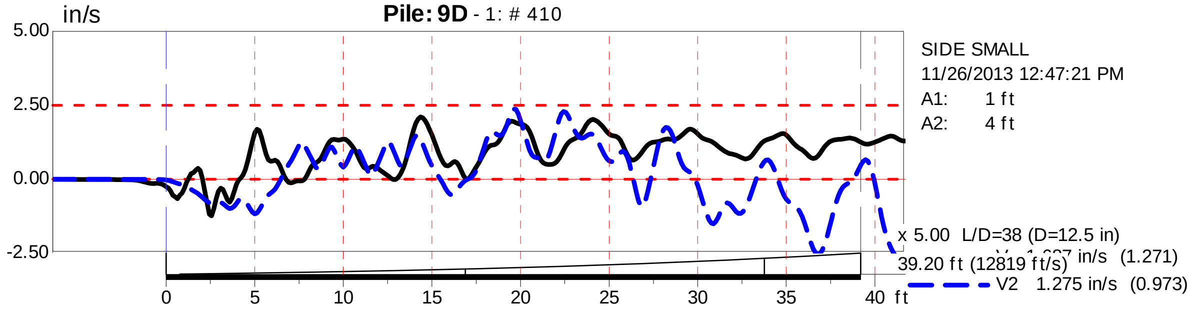
Pile: 9D - 1: # 411



SIDE SMALL
11/26/2013 12:46:33 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (1.712)
V2 0.848 in/s (0.475)

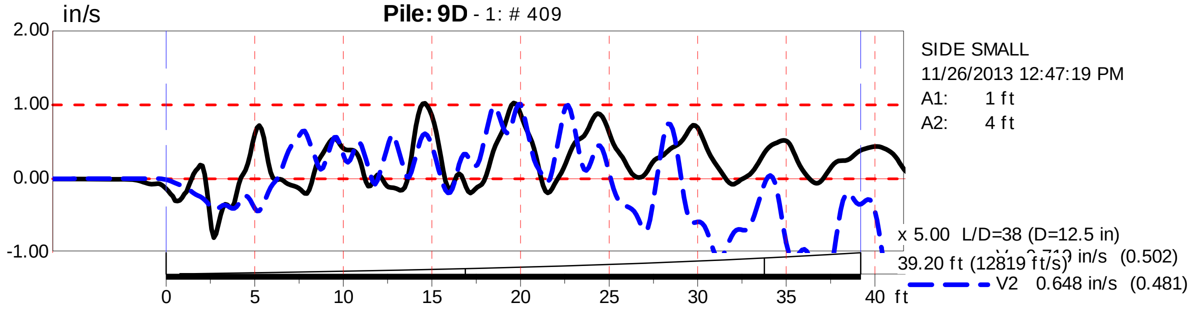
Pile: 9D - 1: # 410



SIDE SMALL
11/26/2013 12:47:21 PM
A1: 1 ft
A2: 4 ft

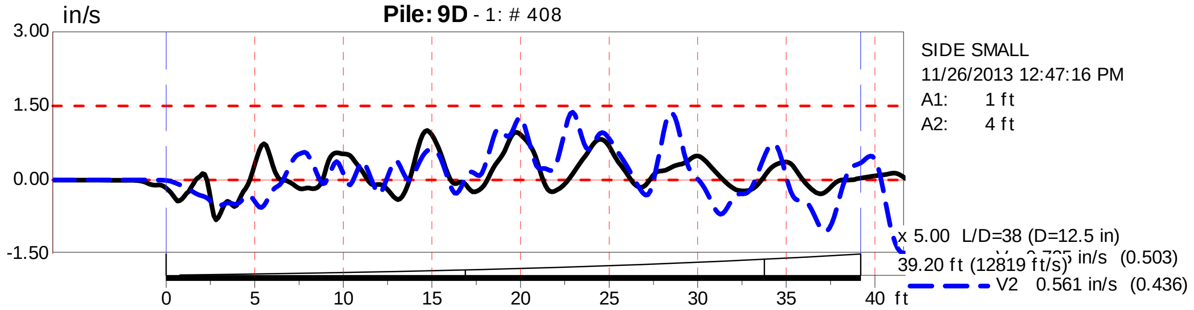
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (1.271)
V2 1.275 in/s (0.973)

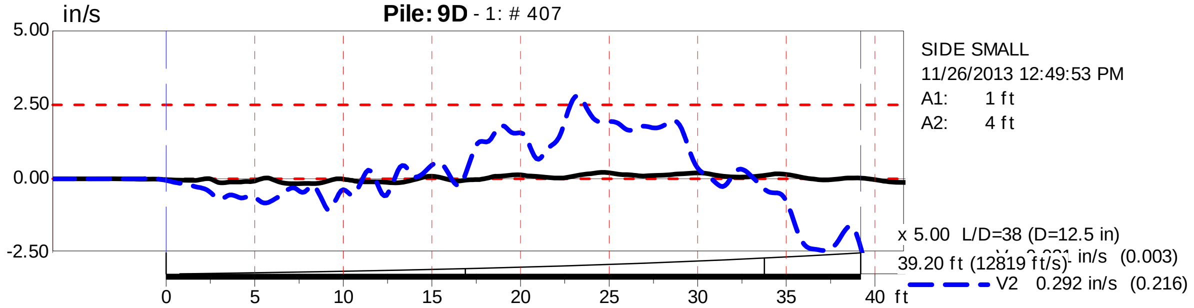
Pile: 9D - 1: # 409

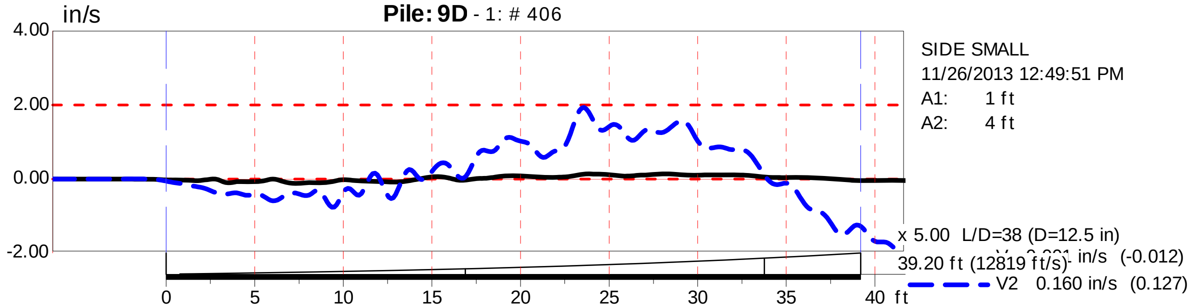


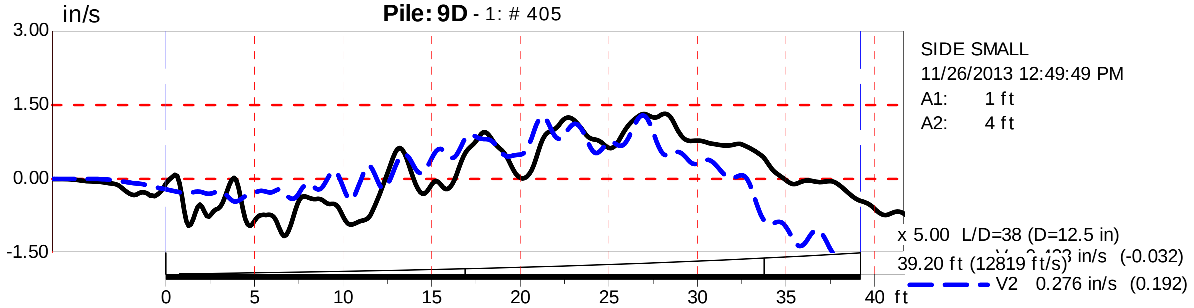
SIDE SMALL
11/26/2013 12:47:19 PM
A1: 1 ft
A2: 4 ft

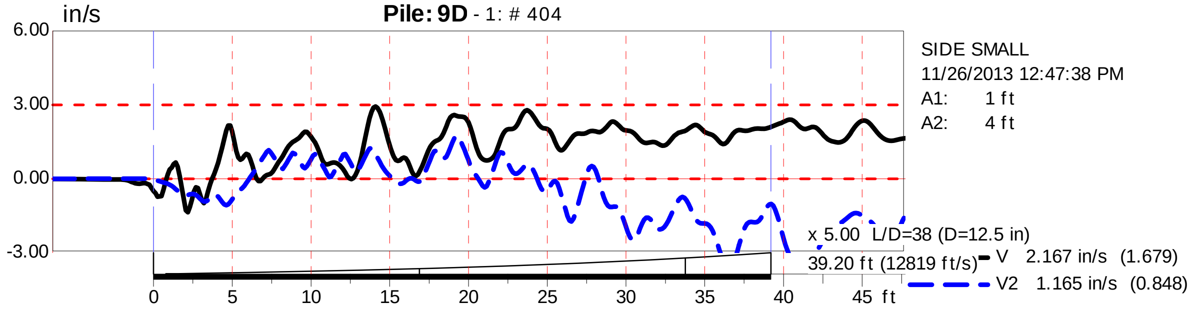
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.502)
V2 0.648 in/s (0.481)


in/s
Pile: 9D - 1: # 408
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40 ft
SIDE SMALL
11/26/2013 12:47:16 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
5 in/s (0.503)
V2 0.561 in/s (0.436)

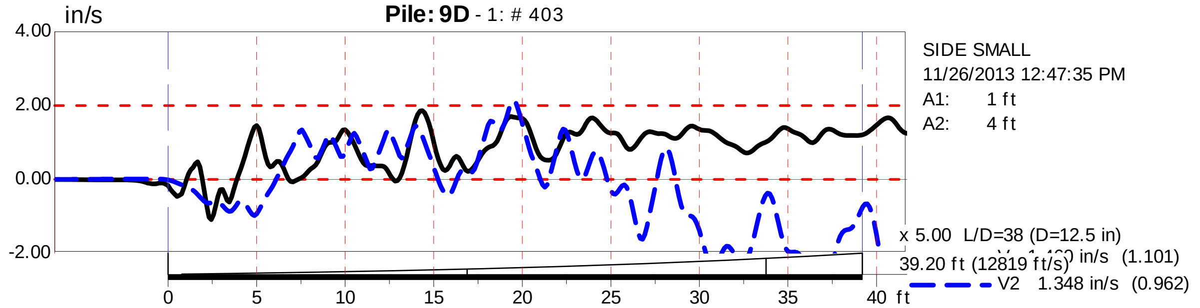

in/s
Pile: 9D - 1: # 407
5.00
2.50
0.00
-2.50
0
5
10
15
20
25
30
35
40 ft
SIDE SMALL
11/26/2013 12:49:53 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
in/s (0.003)
V2 0.292 in/s (0.216)

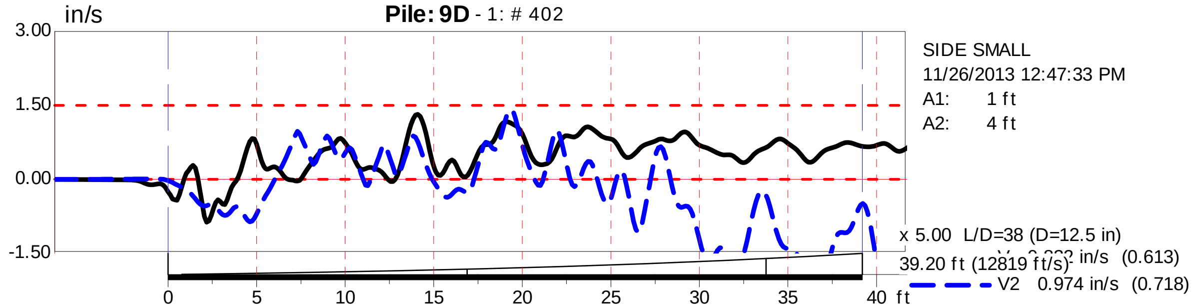

in/s
Pile: 9D - 1: # 406
4.00
2.00
0.00
-2.00
0
5
10
15
20
25
30
35
40 ft
SIDE SMALL
11/26/2013 12:49:51 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
in/s (-0.012)
V2 0.160 in/s (0.127)

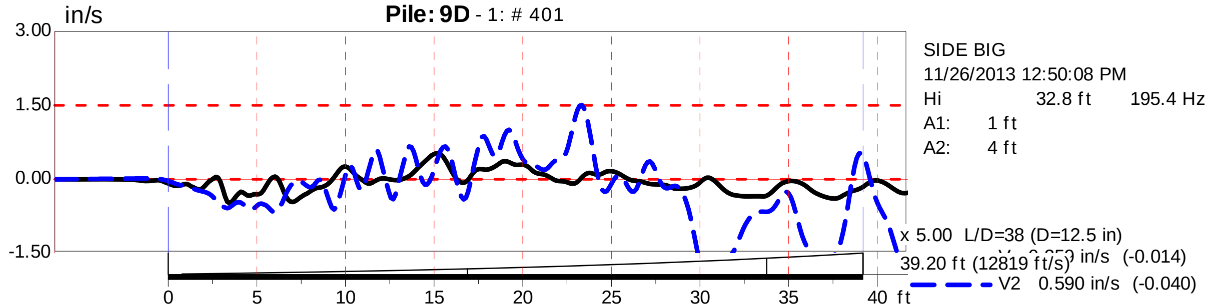

in/s
Pile: 9D - 1: # 405
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40 ft
SIDE SMALL
11/26/2013 12:49:49 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
in/s (-0.032)
V2 0.276 in/s (0.192)

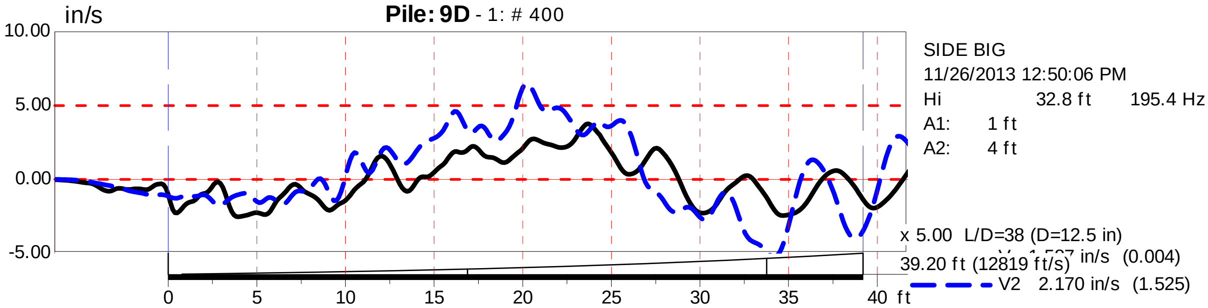

in/s
Pile: 9D - 1: # 404
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45 ft
SIDE SMALL
11/26/2013 12:47:38 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V 2.167 in/s (1.679)
V2 1.165 in/s (0.848)

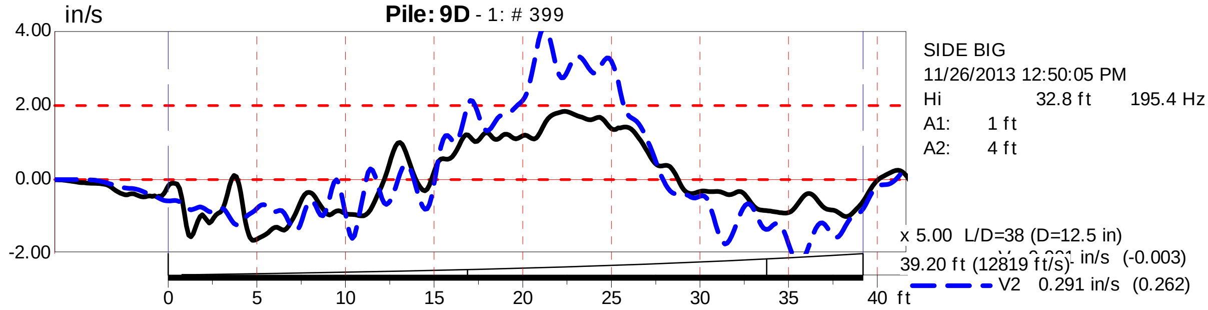
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



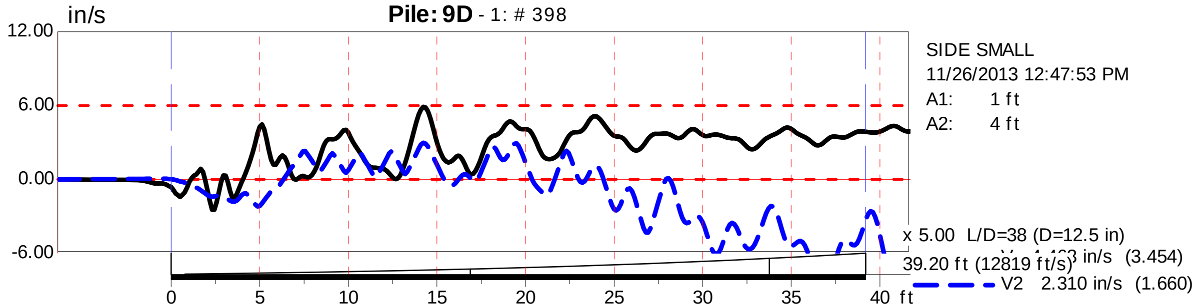


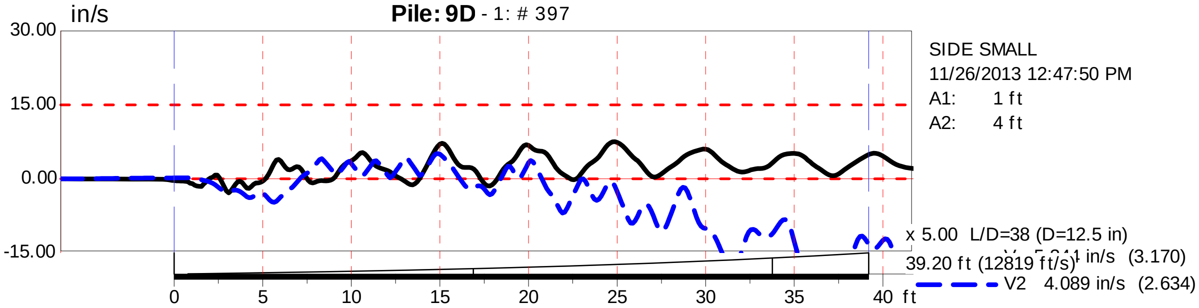


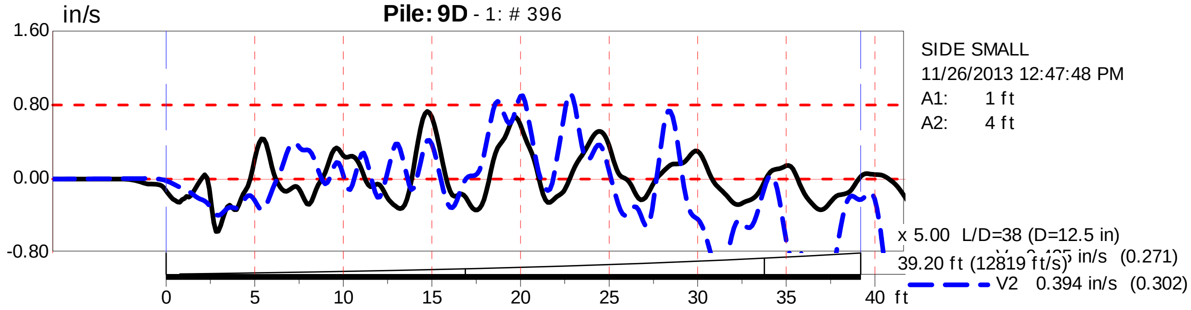


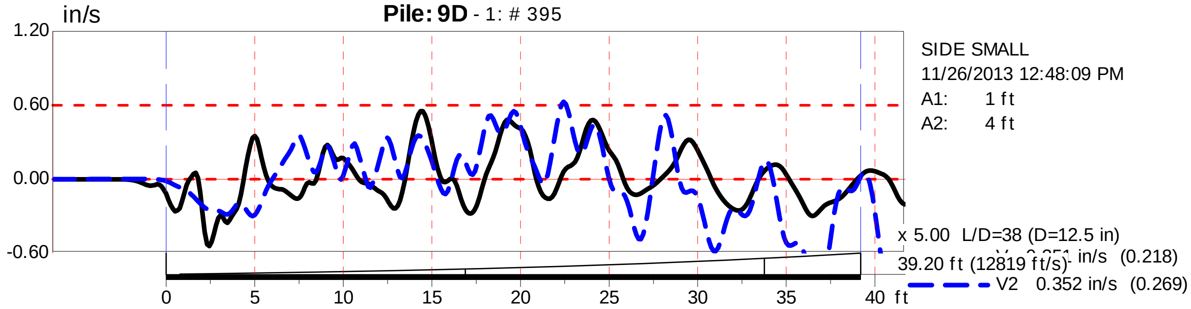


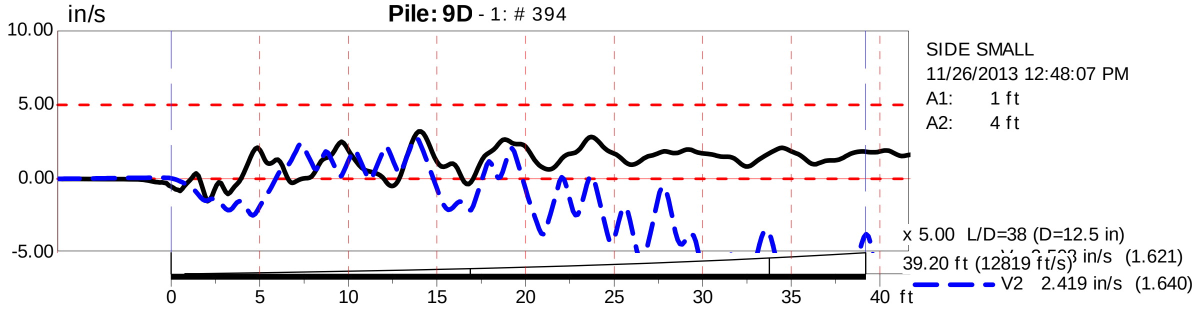
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

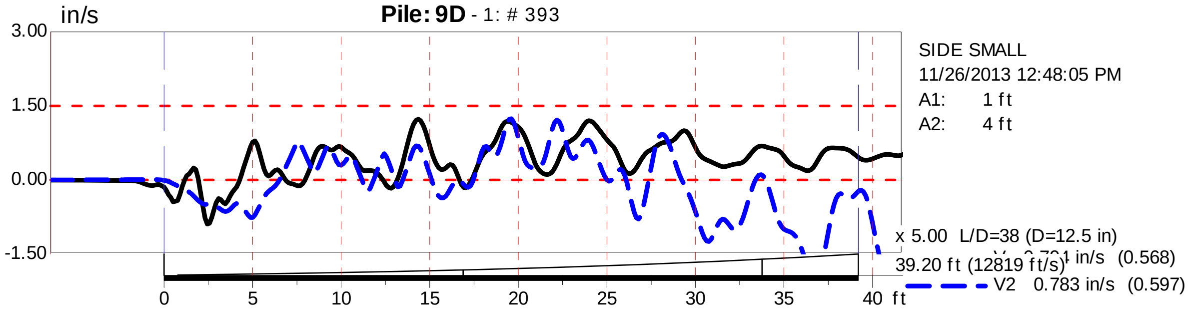








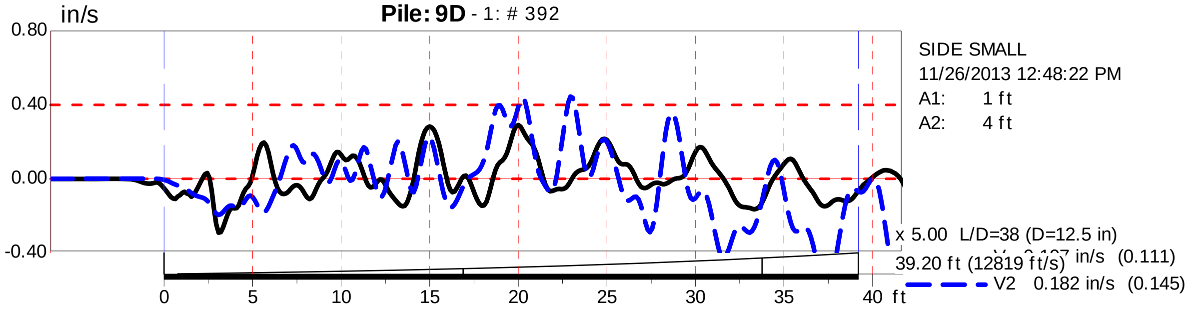




Pile: 9D - 1: # 393

SIDE SMALL
11/26/2013 12:48:05 PM
A1: 1 ft
A2: 4 ft

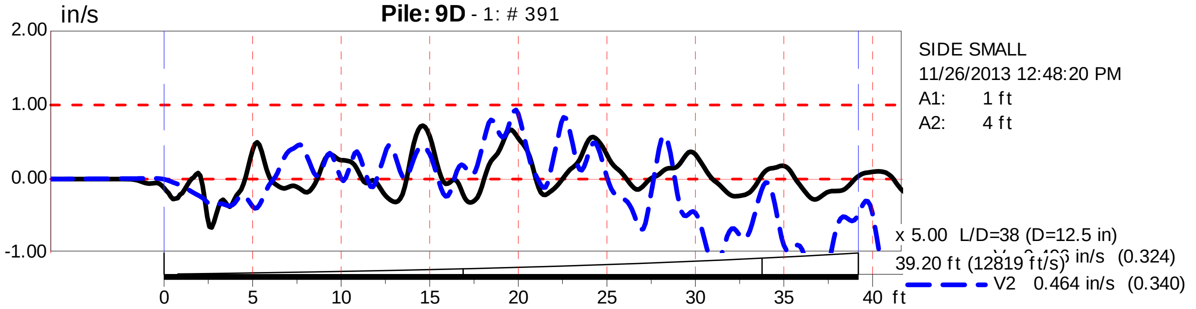
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.568)
V2 0.783 in/s (0.597)



Pile: 9D - 1: # 392

SIDE SMALL
11/26/2013 12:48:22 PM
A1: 1 ft
A2: 4 ft

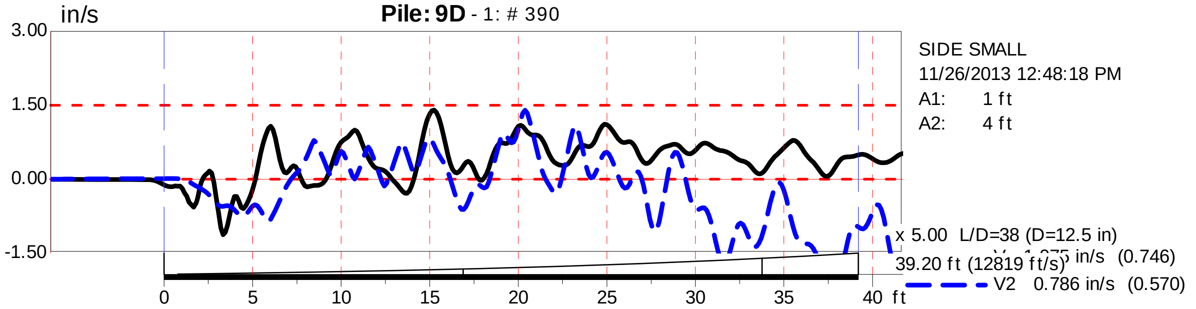
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.111)
V2 0.182 in/s (0.145)



Pile: 9D - 1: # 391

SIDE SMALL
11/26/2013 12:48:20 PM
A1: 1 ft
A2: 4 ft

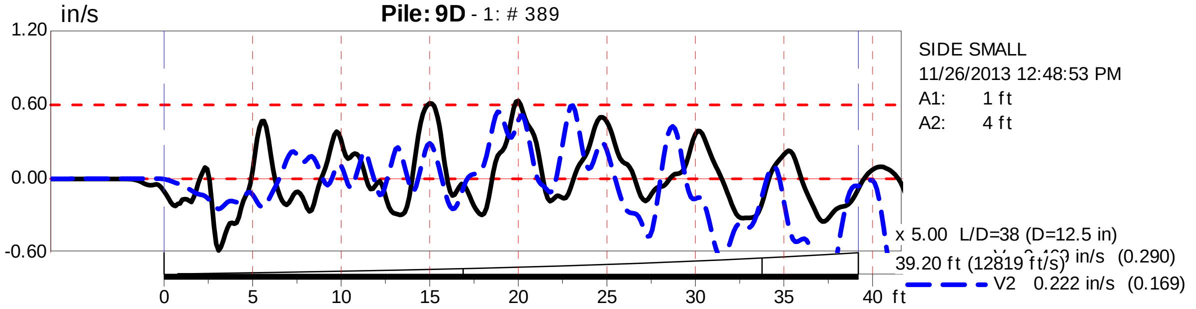
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.324)
V2 0.464 in/s (0.340)



Pile: 9D - 1: # 390

SIDE SMALL
11/26/2013 12:48:18 PM
A1: 1 ft
A2: 4 ft

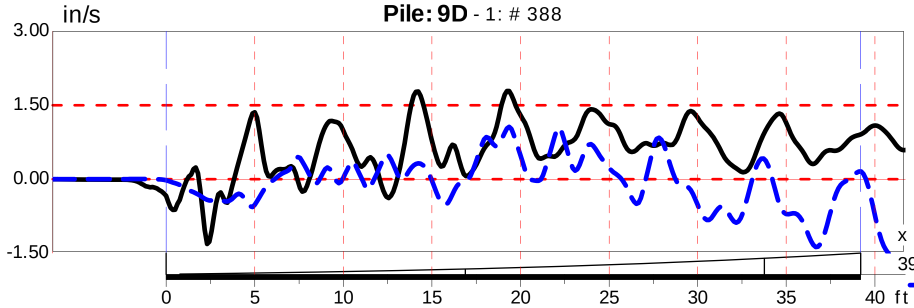
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.746)
V2 0.786 in/s (0.570)



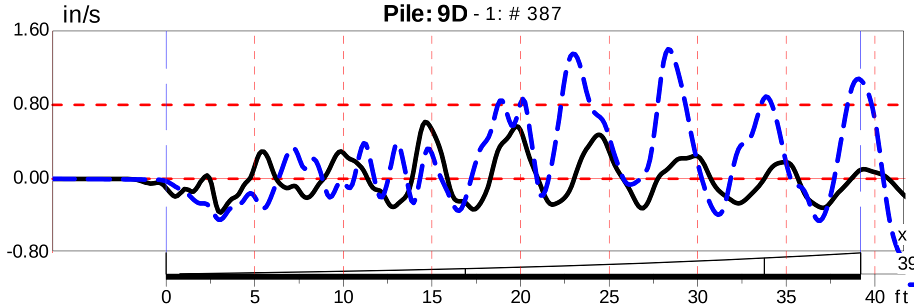
Pile: 9D - 1: # 389

SIDE SMALL
11/26/2013 12:48:53 PM
A1: 1 ft
A2: 4 ft

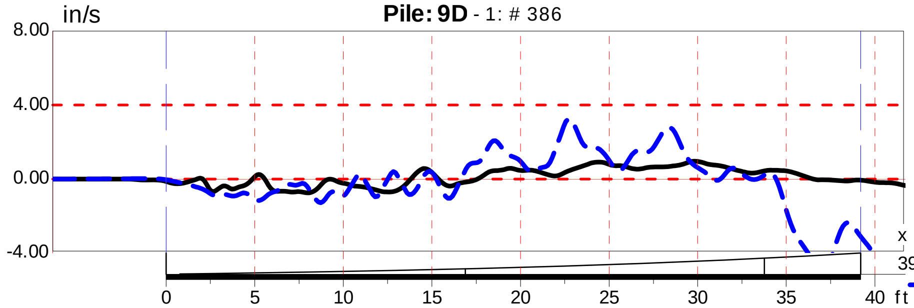
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.290)
V2 0.222 in/s (0.169)


Pile: 9D - 1: # 388

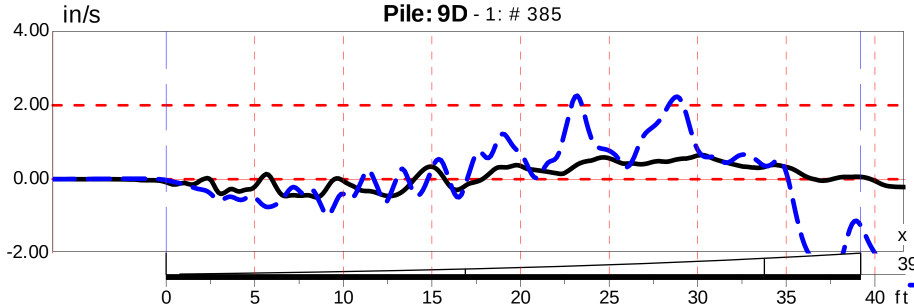
SIDE SMALL
11/26/2013 12:48:50 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.994)
V2 0.505 in/s (0.348)


Pile: 9D - 1: # 387

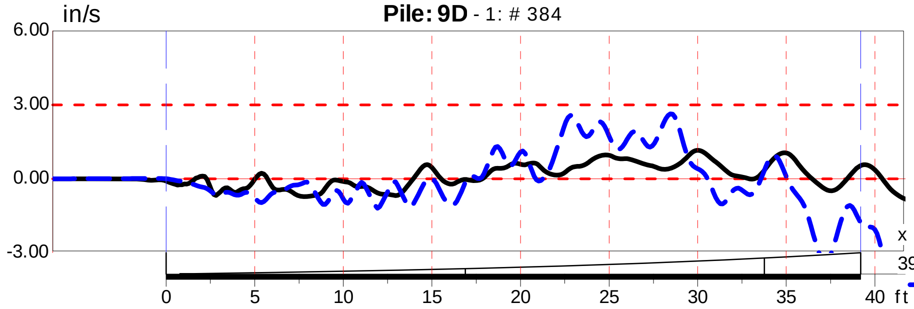
SIDE SMALL
11/26/2013 12:48:49 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.176)
V2 0.385 in/s (0.299)


Pile: 9D - 1: # 386

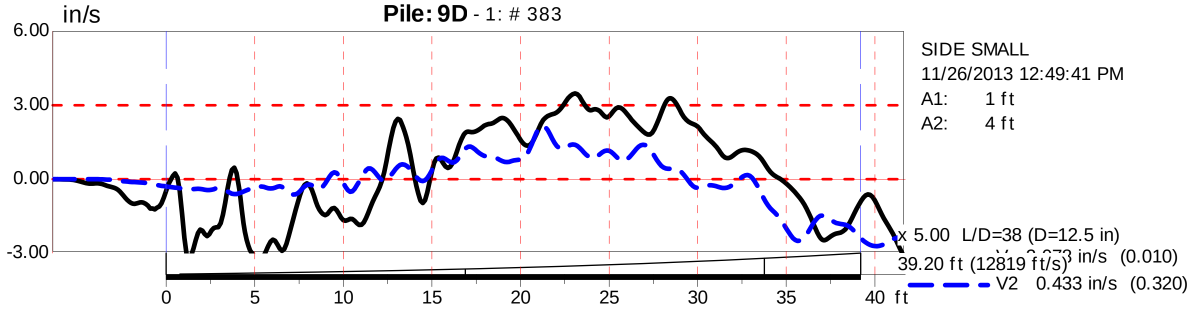
SIDE SMALL
11/26/2013 12:49:26 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.115)
V2 0.408 in/s (0.147)


Pile: 9D - 1: # 385

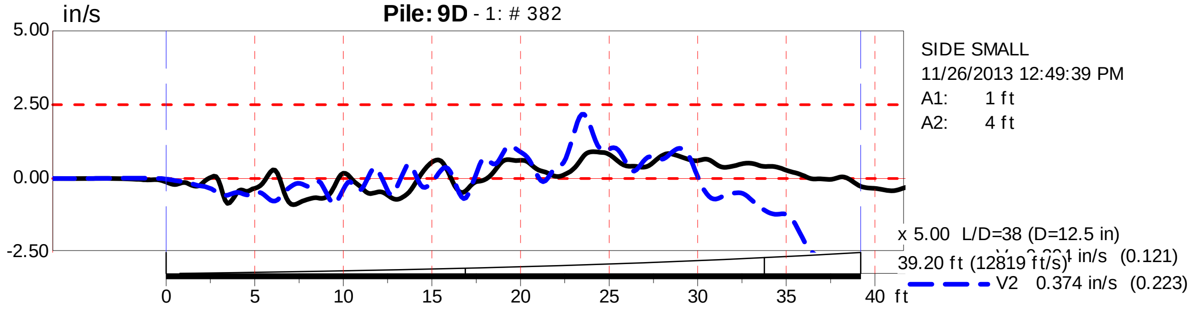
SIDE SMALL
11/26/2013 12:49:24 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.048)
V2 0.253 in/s (0.147)


Pile: 9D - 1: # 384

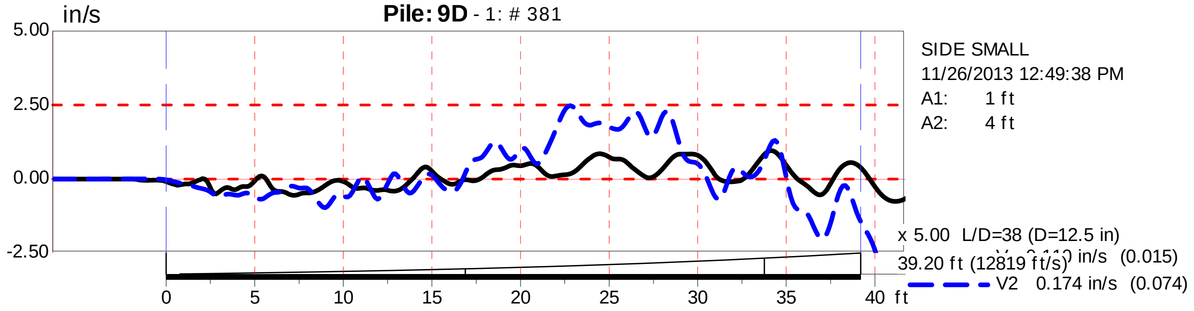
SIDE SMALL
11/26/2013 12:49:22 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=38 (D=12.5 in)
39.20 ft (12819 ft/s)
V1 [illegible] in/s (0.098)
V2 0.005 in/s (0.000)



Pile: 9D - 1: # 383

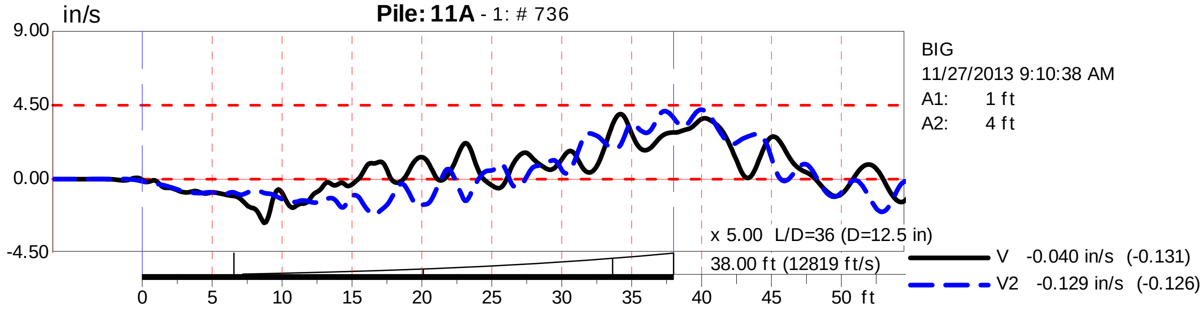


Pile: 9D - 1: # 382



Pile: 9D - 1: # 381

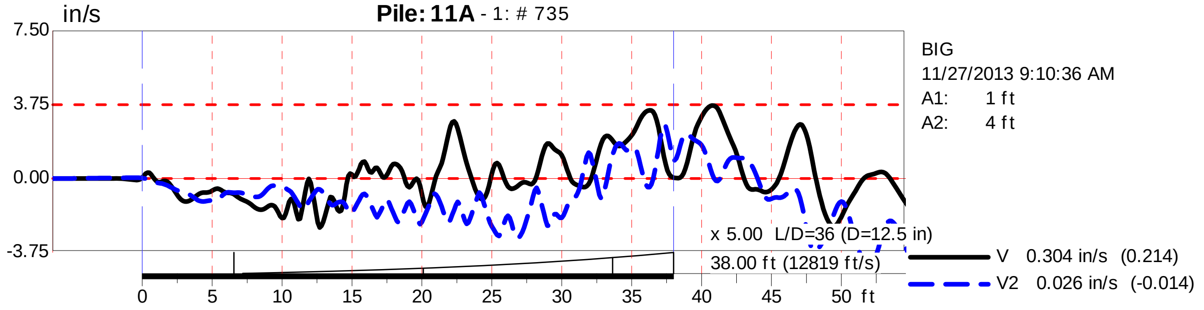
Pile: 11A - 1: # 736



BIG
11/27/2013 9:10:38 AM
A1: 1 ft
A2: 4 ft

V -0.040 in/s (-0.131)
V2 -0.129 in/s (-0.126)

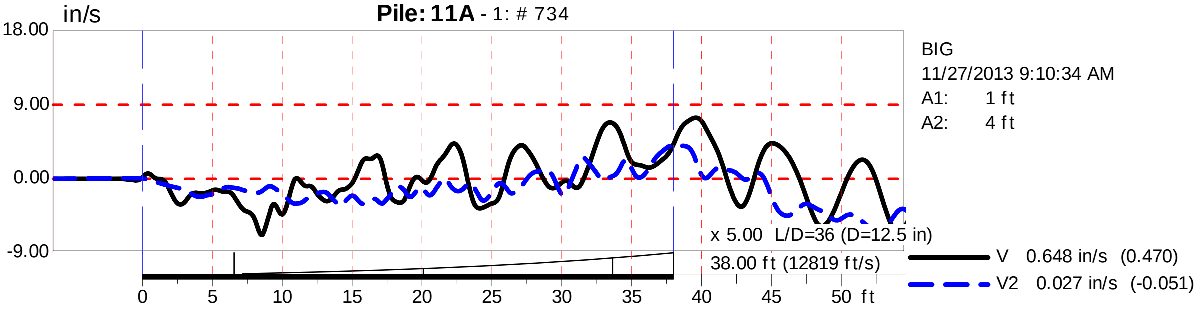
Pile: 11A - 1: # 735



BIG
11/27/2013 9:10:36 AM
A1: 1 ft
A2: 4 ft

V 0.304 in/s (0.214)
V2 0.026 in/s (-0.014)

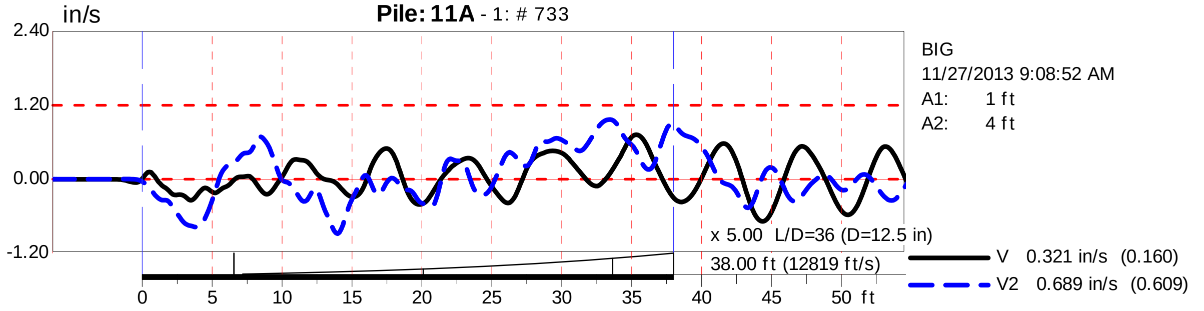
Pile: 11A - 1: # 734



BIG
11/27/2013 9:10:34 AM
A1: 1 ft
A2: 4 ft

V 0.648 in/s (0.470)
V2 0.027 in/s (-0.051)

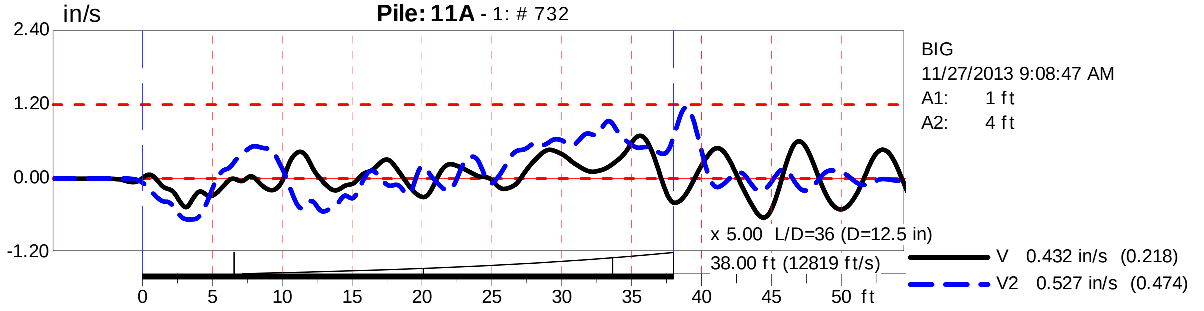
Pile: 11A - 1: # 733



BIG
11/27/2013 9:08:52 AM
A1: 1 ft
A2: 4 ft

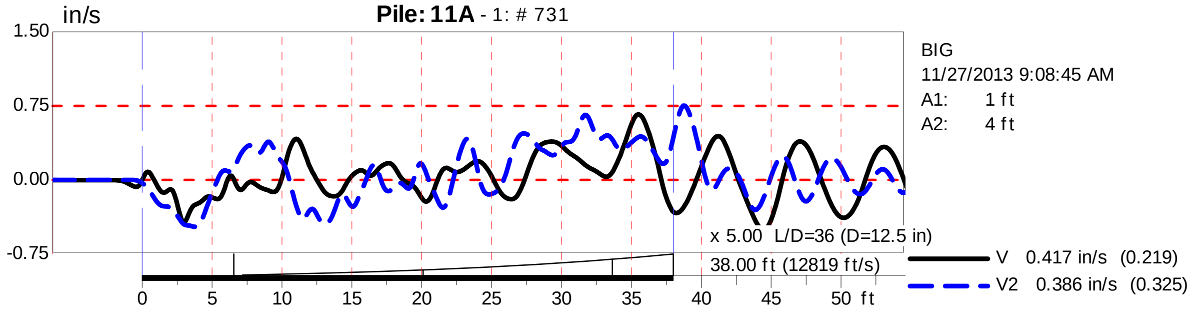
V 0.321 in/s (0.160)
V2 0.689 in/s (0.609)

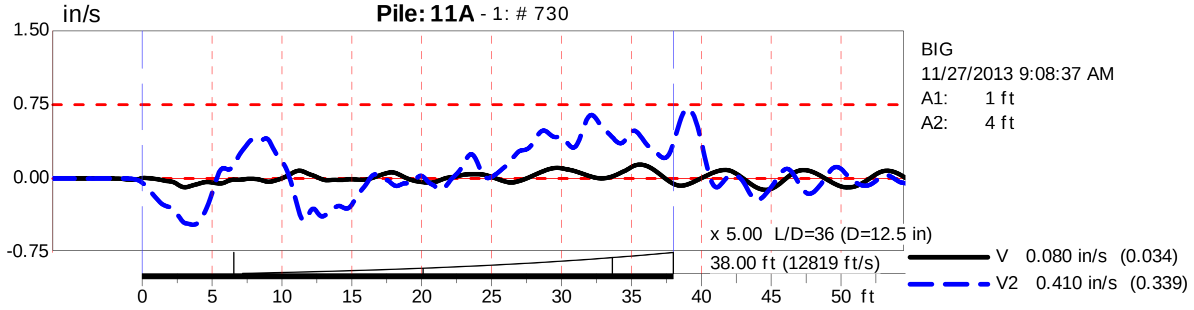
Pile: 11A - 1: # 732

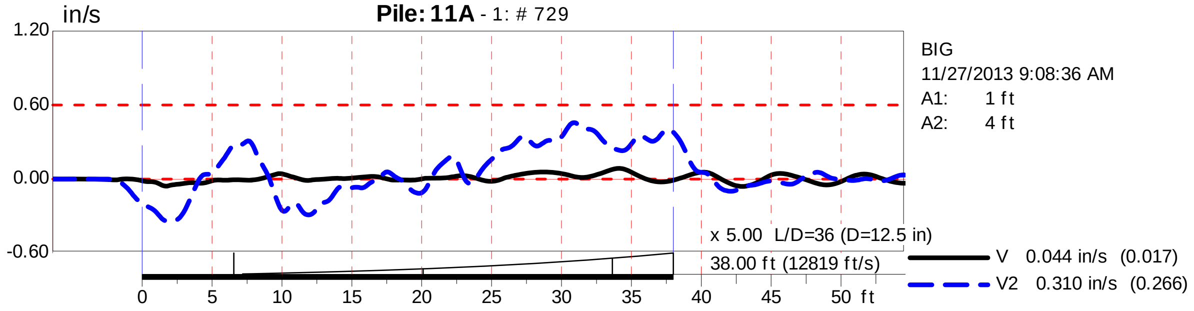


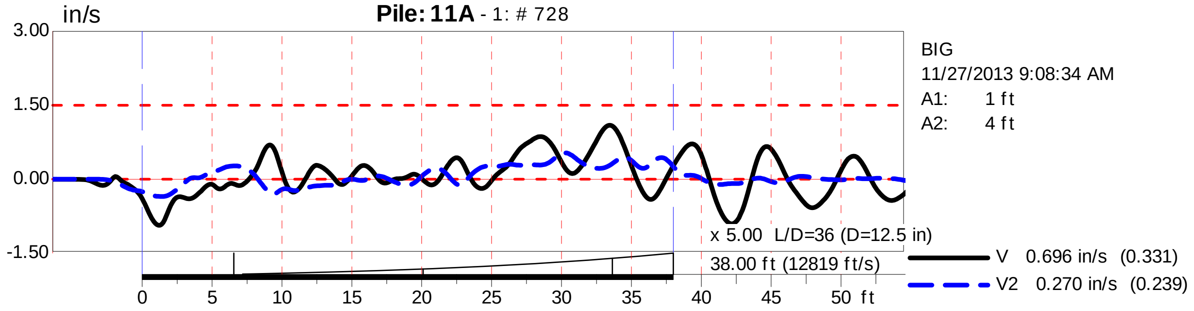
BIG
11/27/2013 9:08:47 AM
A1: 1 ft
A2: 4 ft

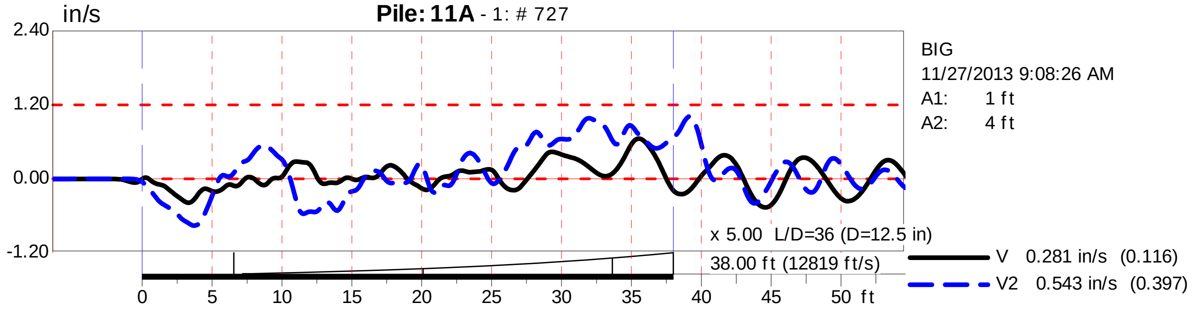
V 0.432 in/s (0.218)
V2 0.527 in/s (0.474)

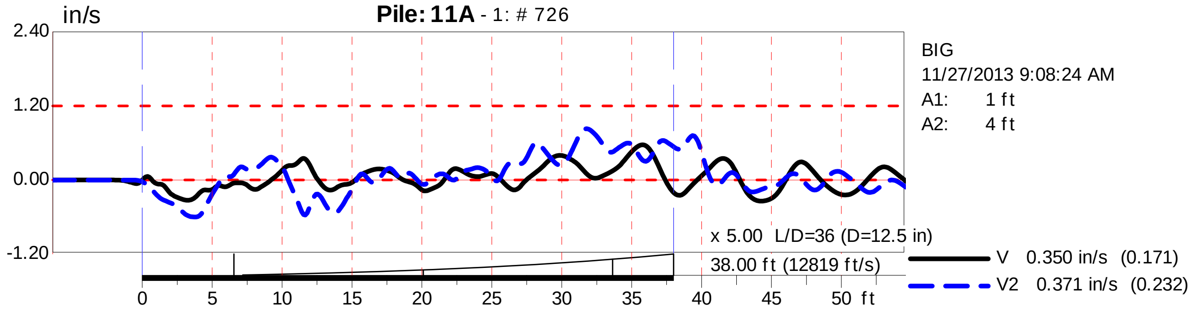

in/s
Pile: 11A - 1: # 731
1.50
0.75
0.00
-0.75
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:45 AM
A1: 1 ft
A2: 4 ft
V 0.417 in/s (0.219)
V2 0.386 in/s (0.325)

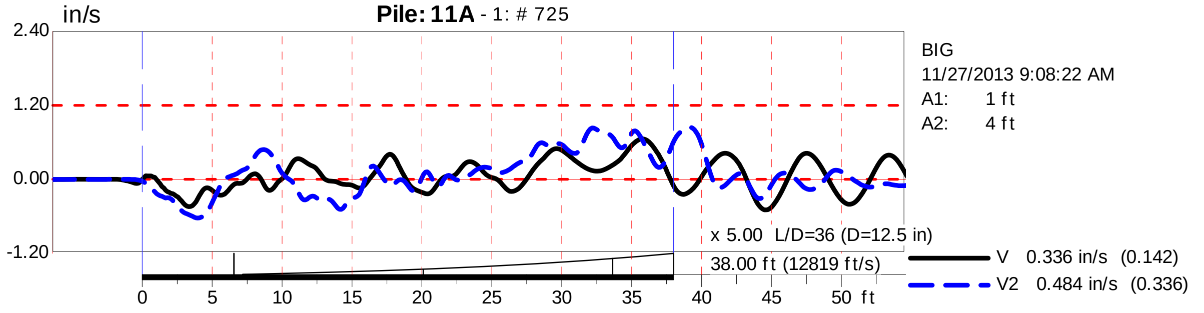

in/s
Pile: 11A - 1: # 730
1.50
0.75
0.00
-0.75
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:37 AM
A1: 1 ft
A2: 4 ft
V 0.080 in/s (0.034)
V2 0.410 in/s (0.339)

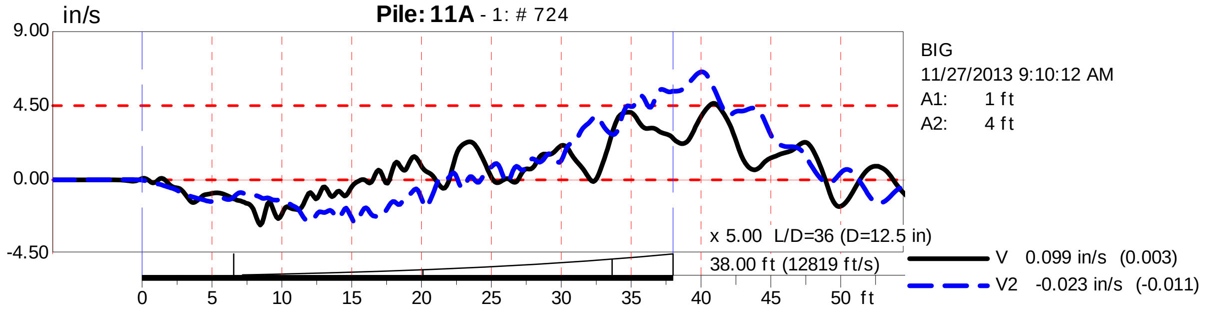

in/s
Pile: 11A - 1: # 729
1.20
0.60
0.00
-0.60
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:36 AM
A1: 1 ft
A2: 4 ft
V 0.044 in/s (0.017)
V2 0.310 in/s (0.266)

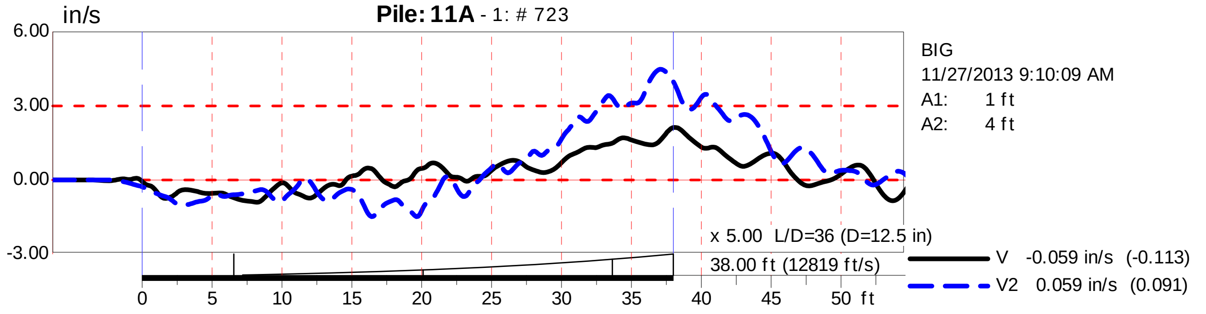

in/s
Pile: 11A - 1: # 728
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:34 AM
A1: 1 ft
A2: 4 ft
V 0.696 in/s (0.331)
V2 0.270 in/s (0.239)

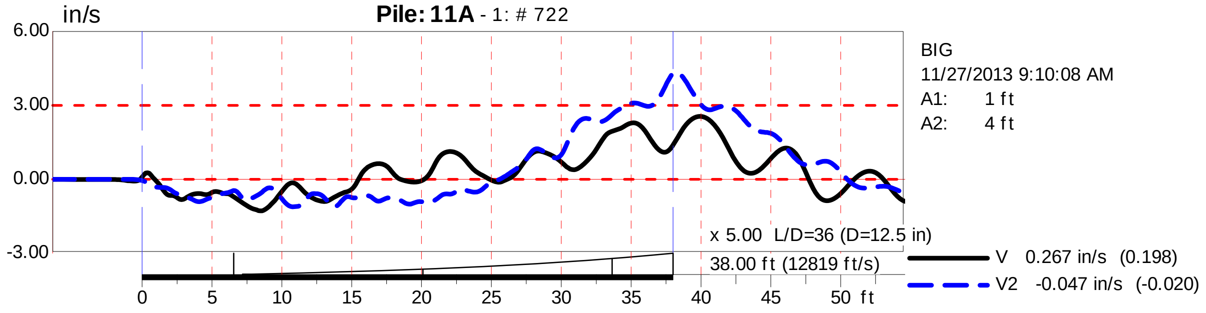

in/s
Pile: 11A - 1: # 727
2.40
1.20
0.00
-1.20
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:26 AM
A1: 1 ft
A2: 4 ft
V 0.281 in/s (0.116)
V2 0.543 in/s (0.397)

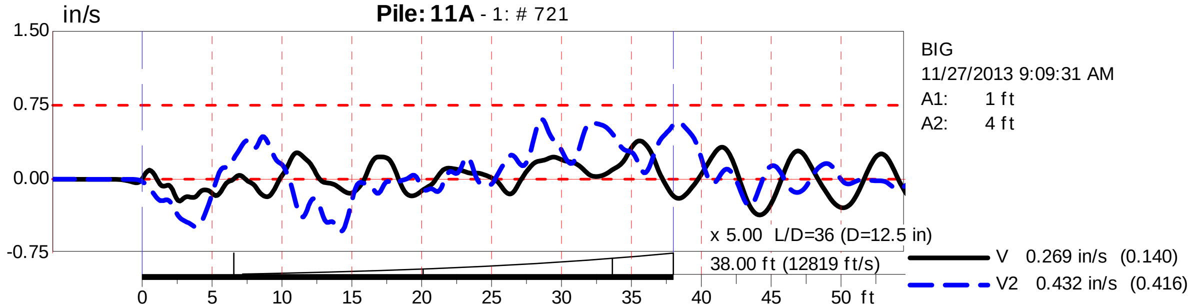

in/s
Pile: 11A - 1: # 726
2.40
1.20
0.00
-1.20
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:24 AM
A1: 1 ft
A2: 4 ft
V 0.350 in/s (0.171)
V2 0.371 in/s (0.232)

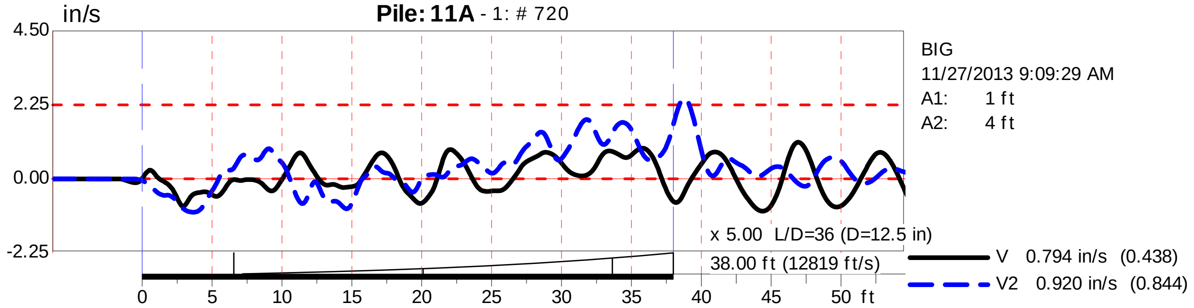

in/s
Pile: 11A - 1: # 725
2.40
1.20
0.00
-1.20
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:08:22 AM
A1: 1 ft
A2: 4 ft
V 0.336 in/s (0.142)
V2 0.484 in/s (0.336)

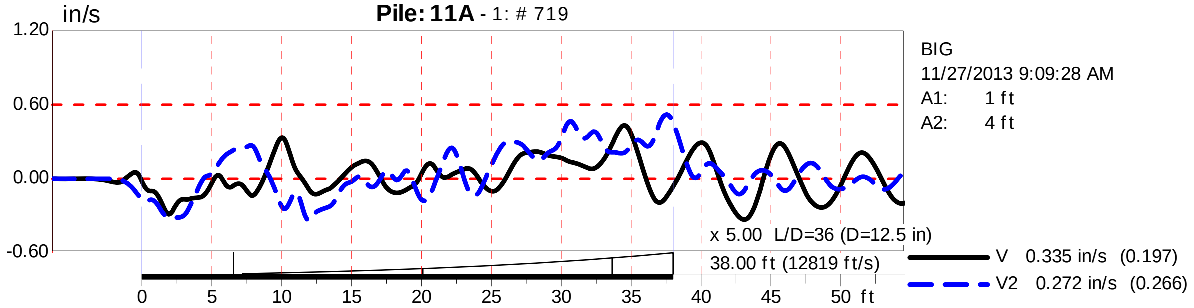

in/s
Pile: 11A - 1: # 724
9.00
4.50
0.00
-4.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:10:12 AM
A1: 1 ft
A2: 4 ft
V 0.099 in/s (0.003)
V2 -0.023 in/s (-0.011)

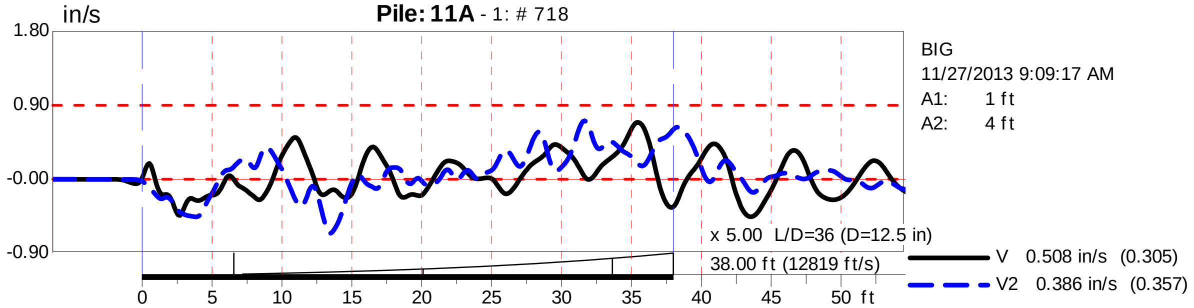

in/s
Pile: 11A - 1: # 723
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:10:09 AM
A1: 1 ft
A2: 4 ft
V -0.059 in/s (-0.113)
V2 0.059 in/s (0.091)

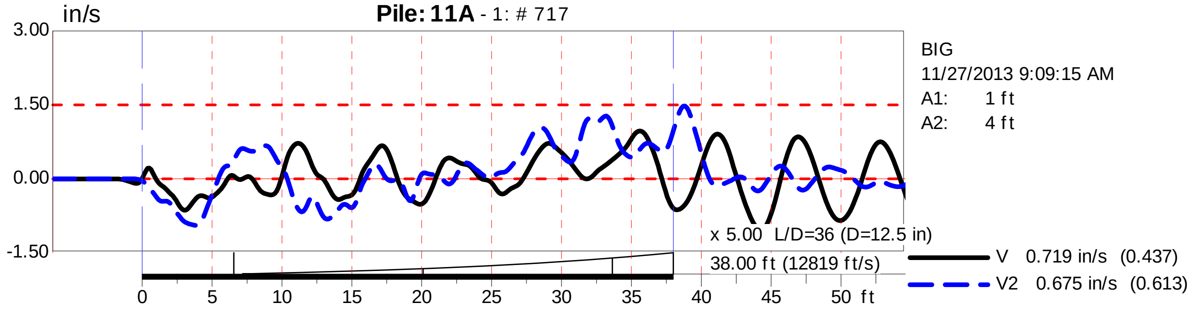

in/s
Pile: 11A - 1: # 722
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:10:08 AM
A1: 1 ft
A2: 4 ft
V 0.267 in/s (0.198)
V2 -0.047 in/s (-0.020)


in/s
Pile: 11A - 1: # 721
1.50
0.75
0.00
-0.75
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:09:31 AM
A1: 1 ft
A2: 4 ft
V 0.269 in/s (0.140)
V2 0.432 in/s (0.416)

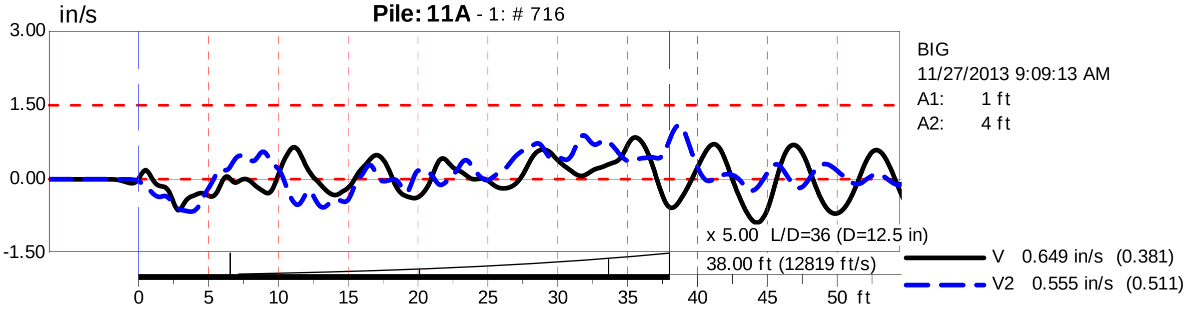

in/s
Pile: 11A - 1: # 720
4.50
2.25
0.00
-2.25
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:09:29 AM
A1: 1 ft
A2: 4 ft
V 0.794 in/s (0.438)
V2 0.920 in/s (0.844)

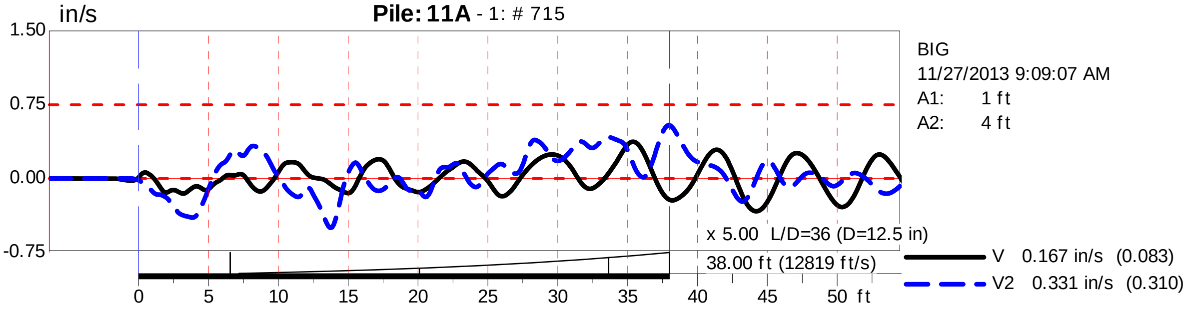

in/s
Pile: 11A - 1: # 719
1.20
0.60
0.00
-0.60
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:09:28 AM
A1: 1 ft
A2: 4 ft
V 0.335 in/s (0.197)
V2 0.272 in/s (0.266)

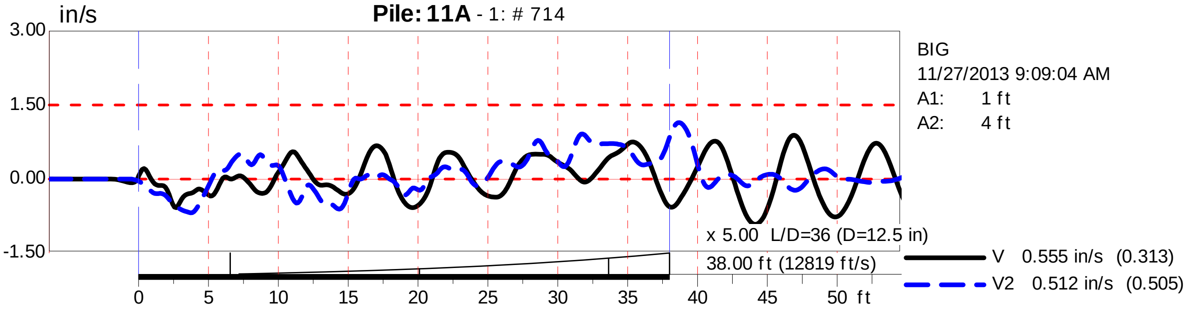

in/s
Pile: 11A - 1: # 718
1.80
0.90
-0.00
-0.90
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:09:17 AM
A1: 1 ft
A2: 4 ft
V 0.508 in/s (0.305)
V2 0.386 in/s (0.357)

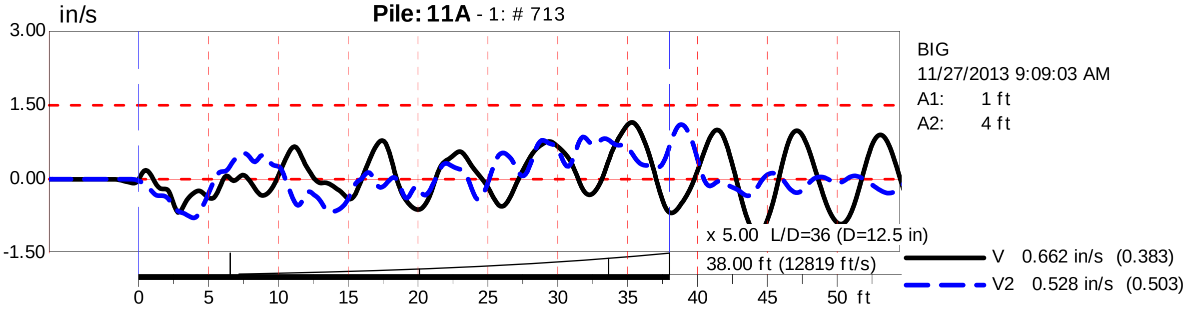

in/s
Pile: 11A - 1: # 717
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
BIG
11/27/2013 9:09:15 AM
A1: 1 ft
A2: 4 ft
V 0.719 in/s (0.437)
V2 0.675 in/s (0.613)

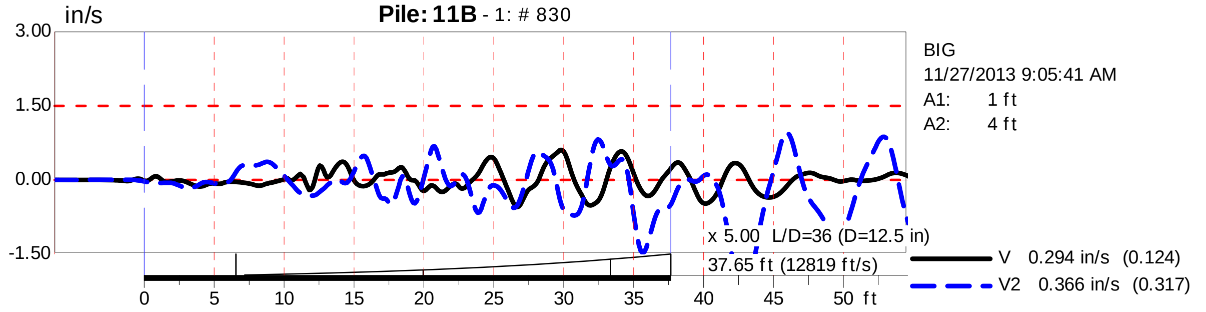
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

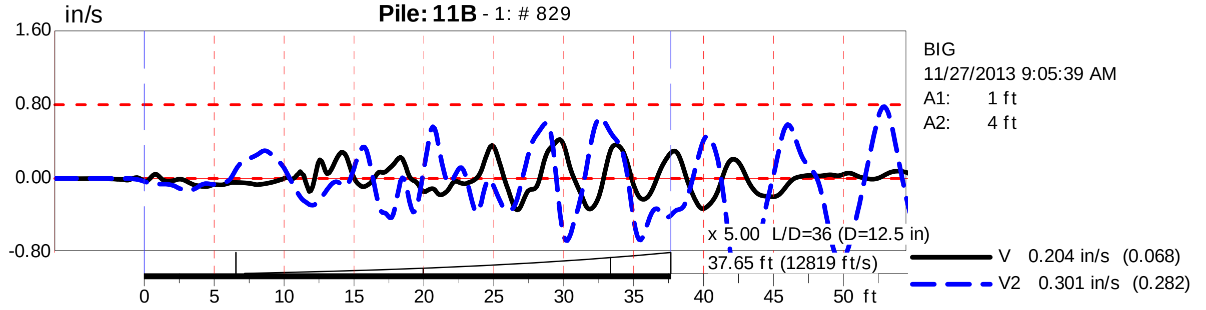


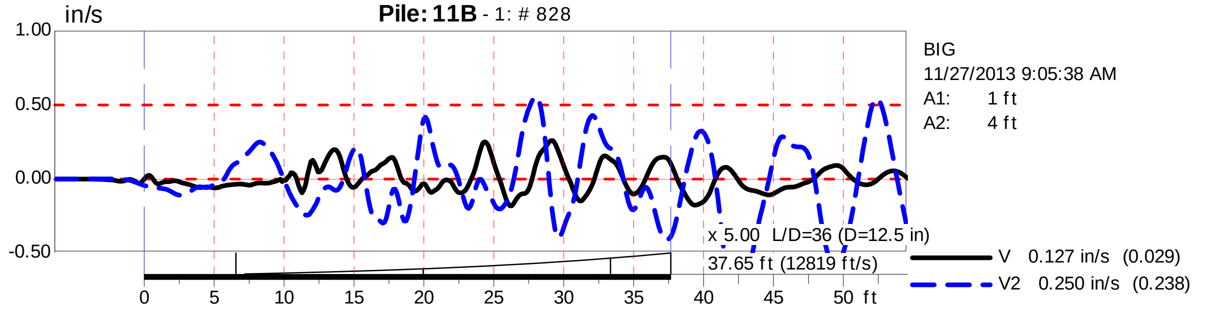


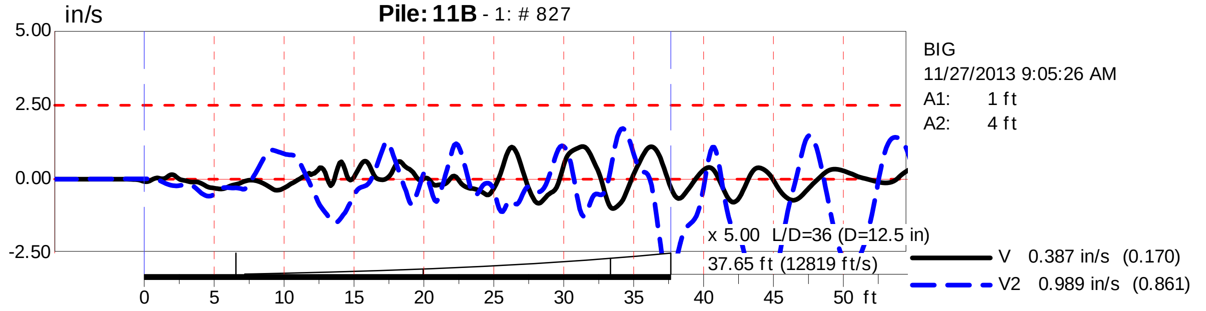


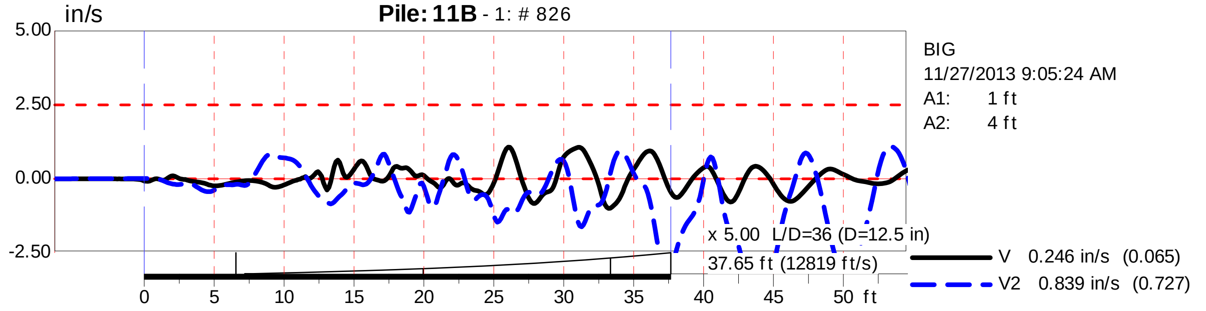


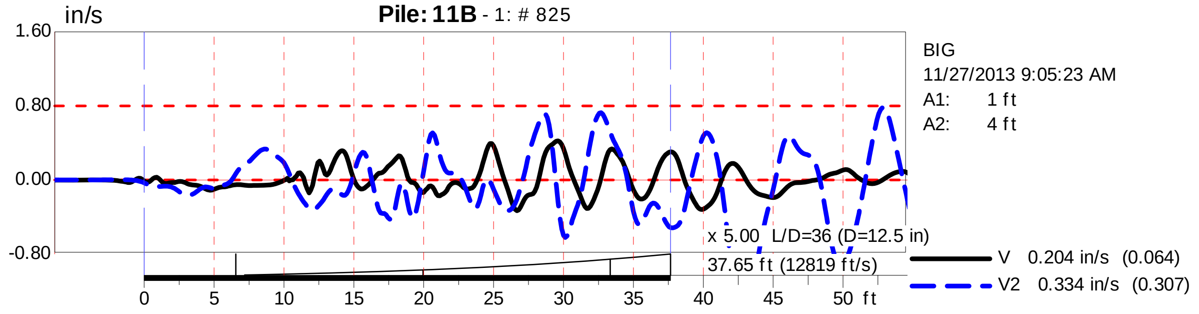

in/s
Pile: 11B - 1: # 830
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:41 AM
A1: 1 ft
A2: 4 ft
V 0.294 in/s (0.124)
V2 0.366 in/s (0.317)

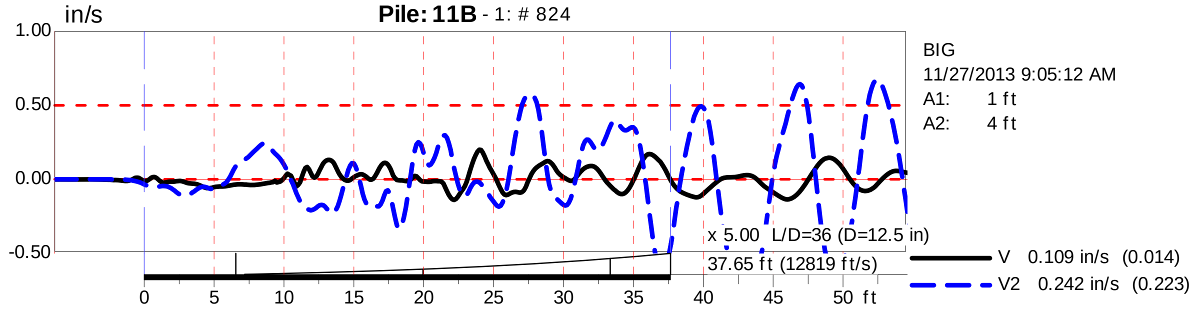

in/s
Pile: 11B - 1: # 829
1.60
0.80
0.00
-0.80
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:39 AM
A1: 1 ft
A2: 4 ft
V 0.204 in/s (0.068)
V2 0.301 in/s (0.282)

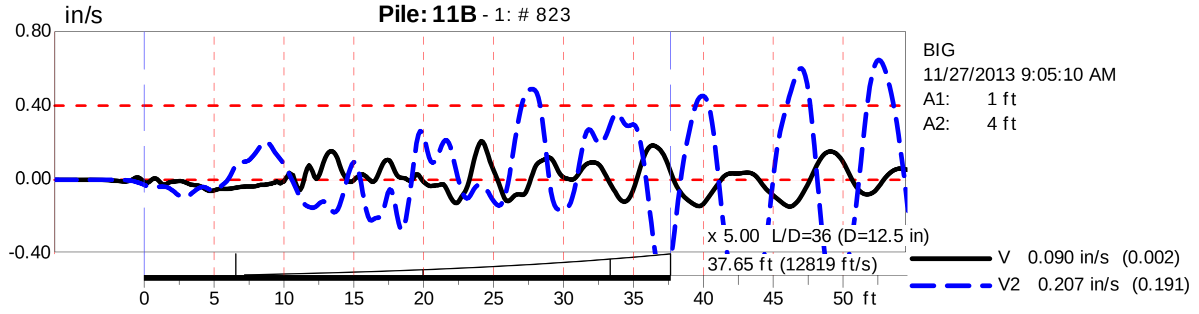

in/s
Pile: 11B - 1: # 828
1.00
0.50
0.00
-0.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:38 AM
A1: 1 ft
A2: 4 ft
V 0.127 in/s (0.029)
V2 0.250 in/s (0.238)

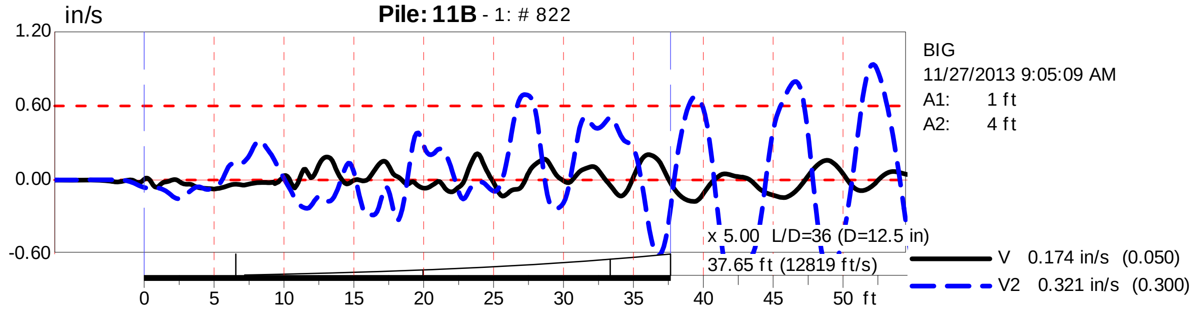

in/s
Pile: 11B - 1: # 827
5.00
2.50
0.00
-2.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:26 AM
A1: 1 ft
A2: 4 ft
V 0.387 in/s (0.170)
V2 0.989 in/s (0.861)

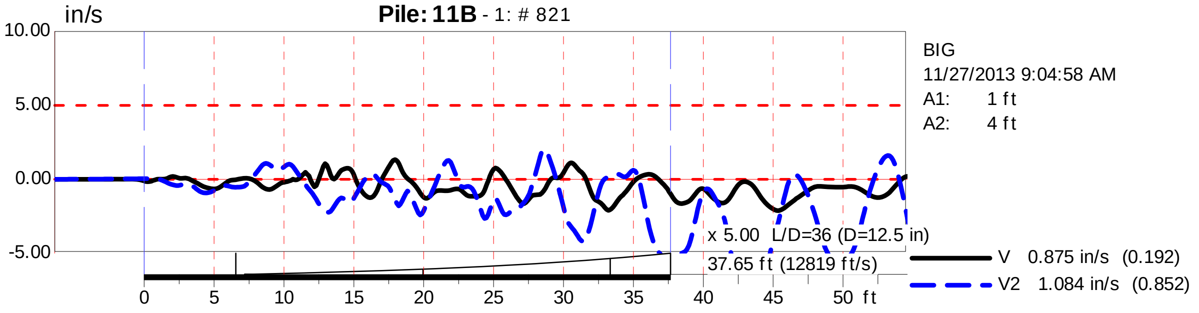

in/s
Pile: 11B - 1: # 826
5.00
2.50
0.00
-2.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:24 AM
A1: 1 ft
A2: 4 ft
V 0.246 in/s (0.065)
V2 0.839 in/s (0.727)

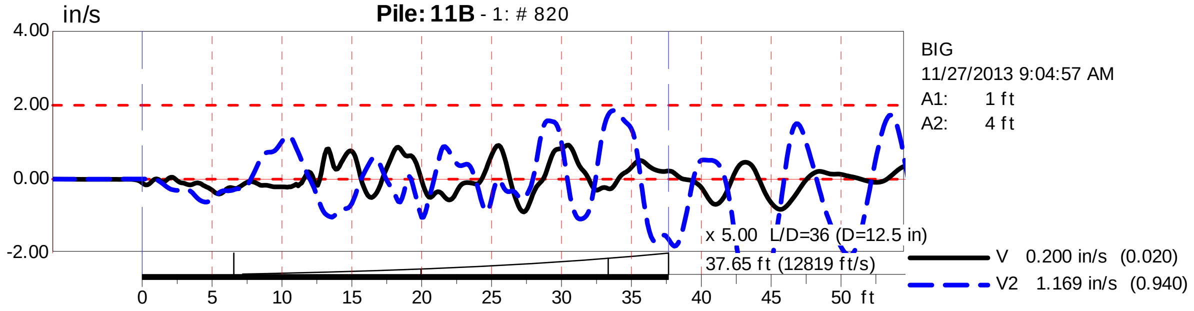

in/s
Pile: 11B - 1: # 825
1.60
0.80
0.00
-0.80
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:23 AM
A1: 1 ft
A2: 4 ft
V 0.204 in/s (0.064)
V2 0.334 in/s (0.307)

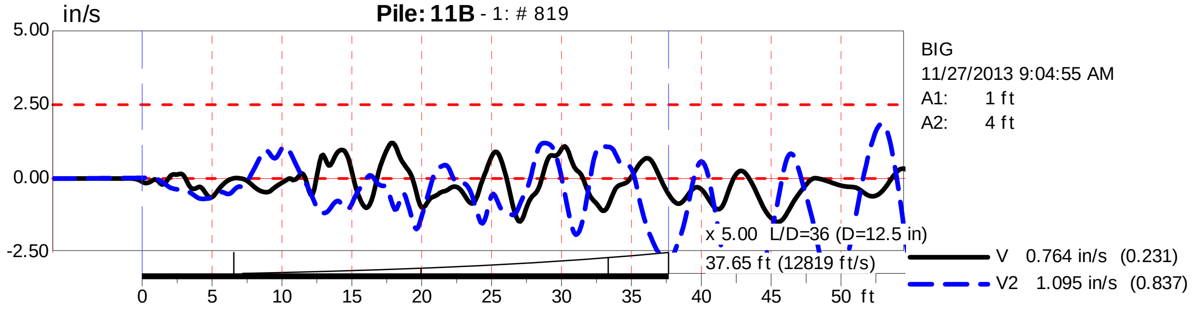

in/s
Pile: 11B - 1: # 824
1.00
0.50
0.00
-0.50
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:12 AM
A1: 1 ft
A2: 4 ft
V 0.109 in/s (0.014)
V2 0.242 in/s (0.223)

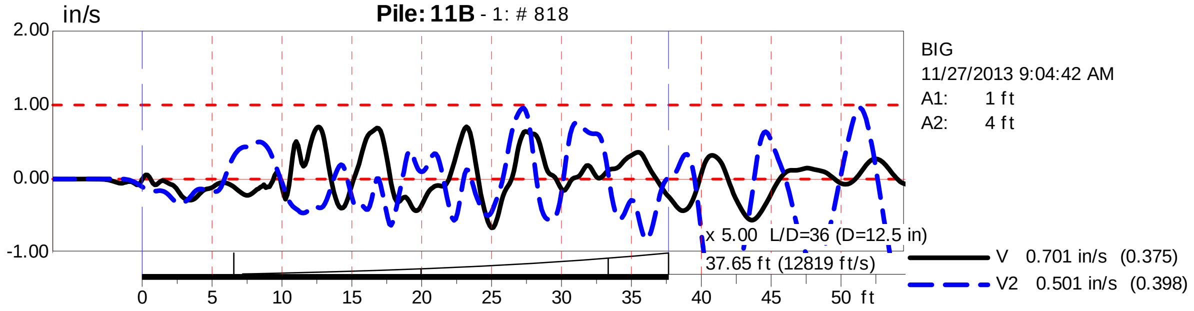

in/s
Pile: 11B - 1: # 823
0.80
0.40
0.00
-0.40
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:10 AM
A1: 1 ft
A2: 4 ft
V 0.090 in/s (0.002)
V2 0.207 in/s (0.191)

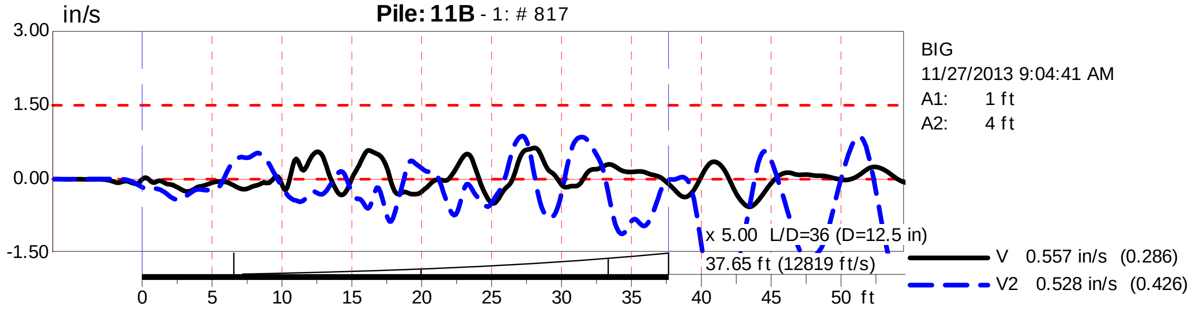

in/s
Pile: 11B - 1: # 822
1.20
0.60
0.00
-0.60
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:05:09 AM
A1: 1 ft
A2: 4 ft
V 0.174 in/s (0.050)
V2 0.321 in/s (0.300)

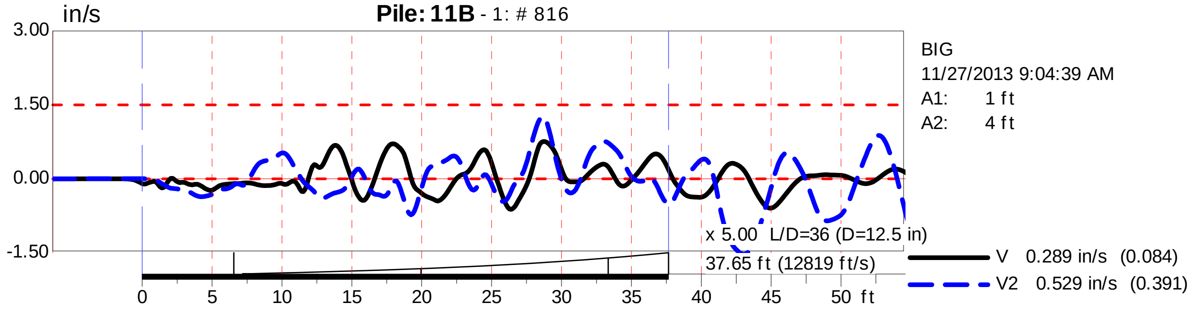

in/s
Pile: 11B - 1: # 821
10.00
5.00
0.00
-5.00
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=36 (D=12.5 in)
37.65 ft (12819 ft/s)
BIG
11/27/2013 9:04:58 AM
A1: 1 ft
A2: 4 ft
V 0.875 in/s (0.192)
V2 1.084 in/s (0.852)


Pile: 11B - 1: # 820

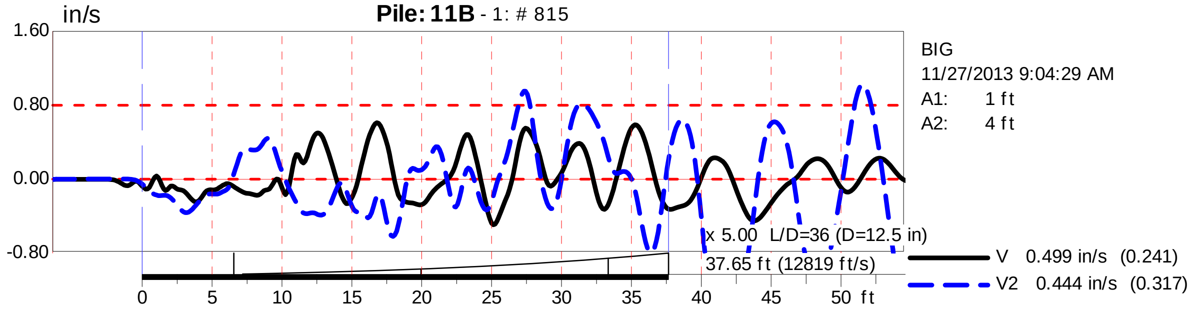

Pile: 11B - 1: # 819


Pile: 11B - 1: # 818

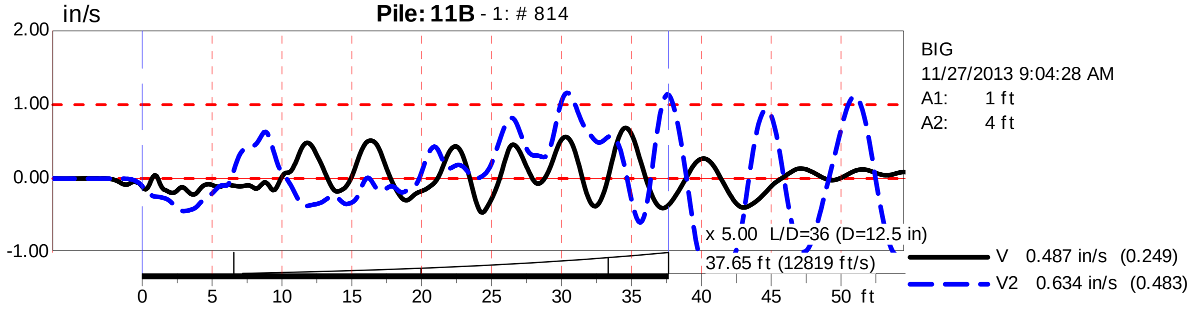

Pile: 11B - 1: # 817


Pile: 11B - 1: # 816

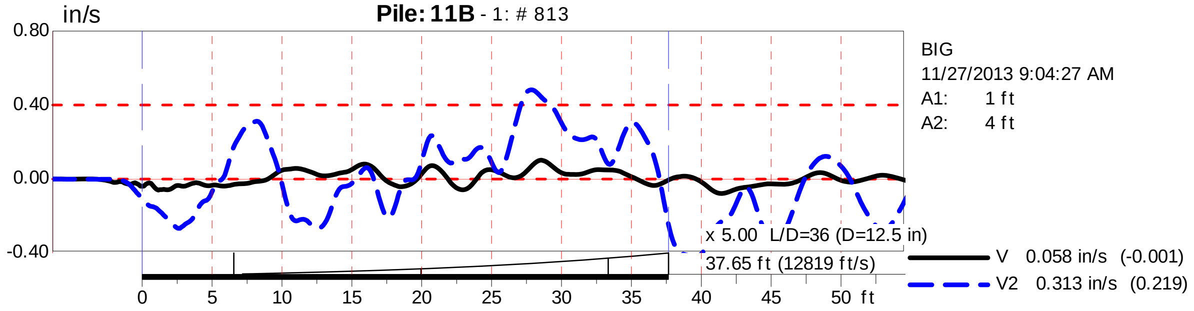
Pile: 11B - 1: # 815

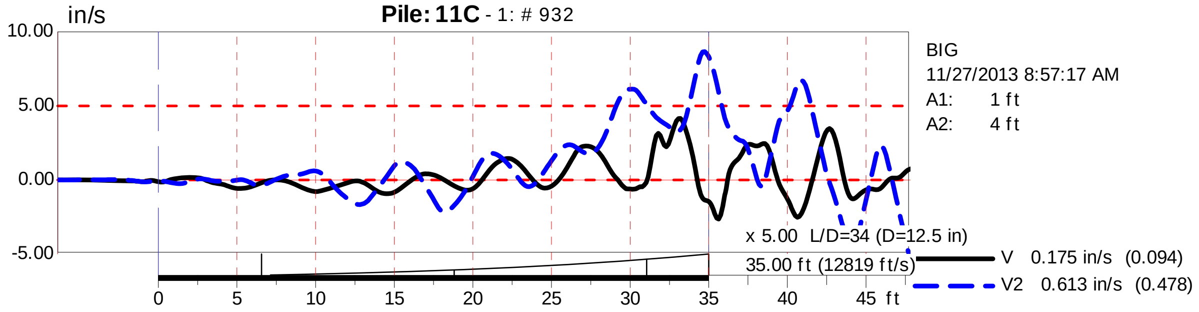


Pile: 11B - 1: # 814



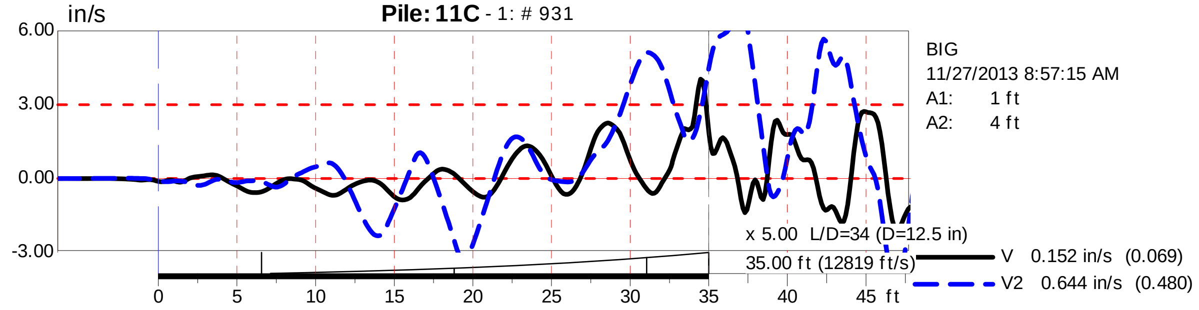
Pile: 11B - 1: # 813




Pile: 11C - 1: # 932

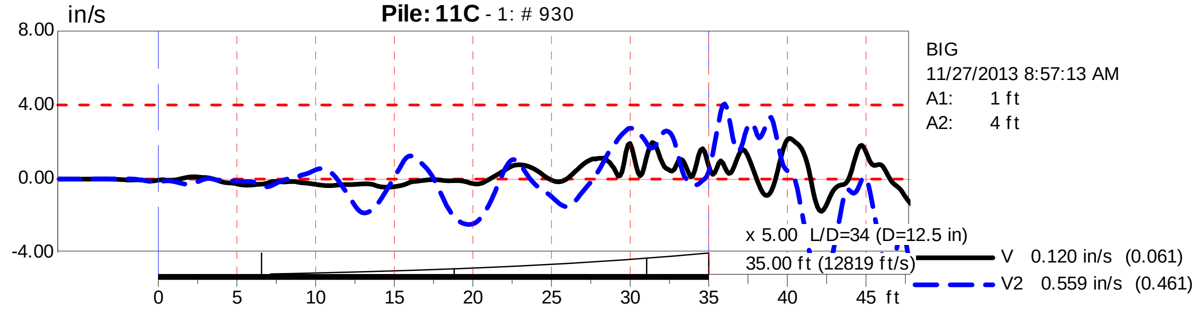
BIG
11/27/2013 8:57:17 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.175 in/s (0.094)
V2 0.613 in/s (0.478)


Pile: 11C - 1: # 931

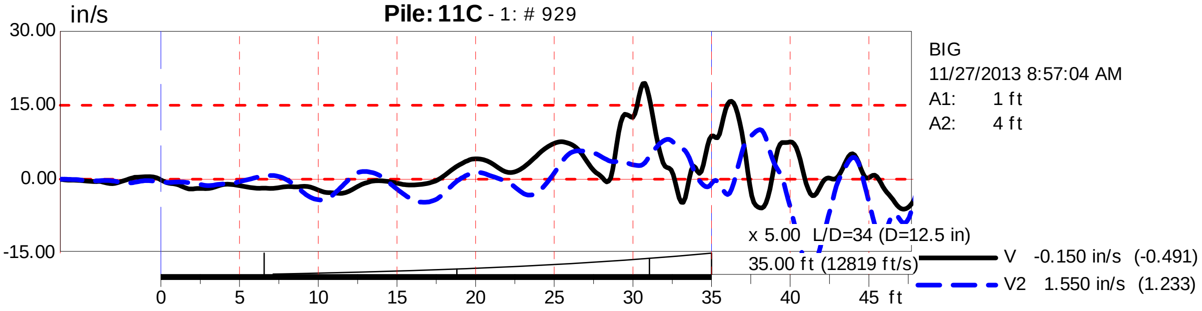
BIG
11/27/2013 8:57:15 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.152 in/s (0.069)
V2 0.644 in/s (0.480)


Pile: 11C - 1: # 930

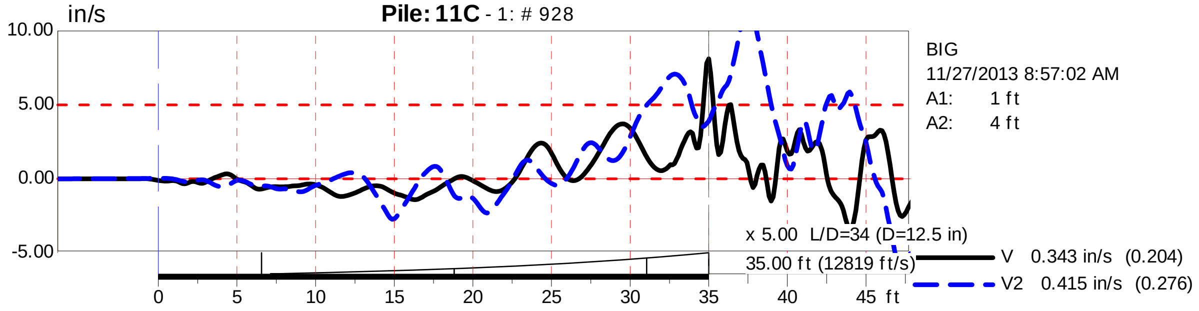
BIG
11/27/2013 8:57:13 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.120 in/s (0.061)
V2 0.559 in/s (0.461)


Pile: 11C - 1: # 929

BIG
11/27/2013 8:57:04 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V -0.150 in/s (-0.491)
V2 1.550 in/s (1.233)


Pile: 11C - 1: # 928

BIG
11/27/2013 8:57:02 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.343 in/s (0.204)
V2 0.415 in/s (0.276)

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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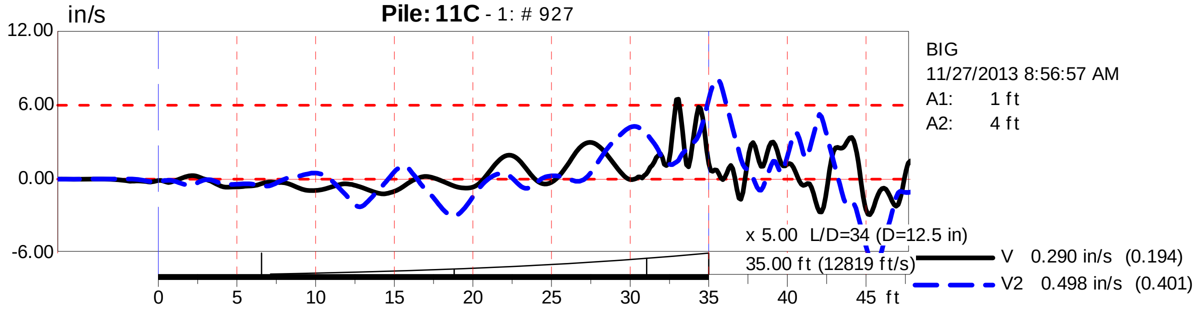
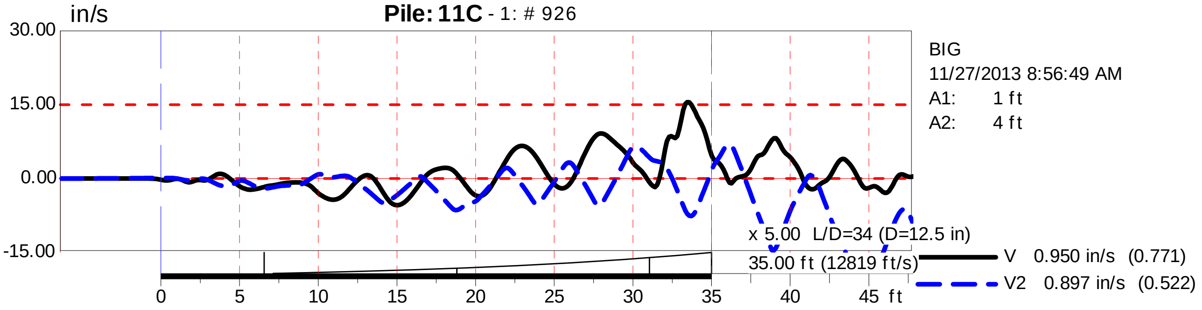

Pile: 11C - 1: # 927

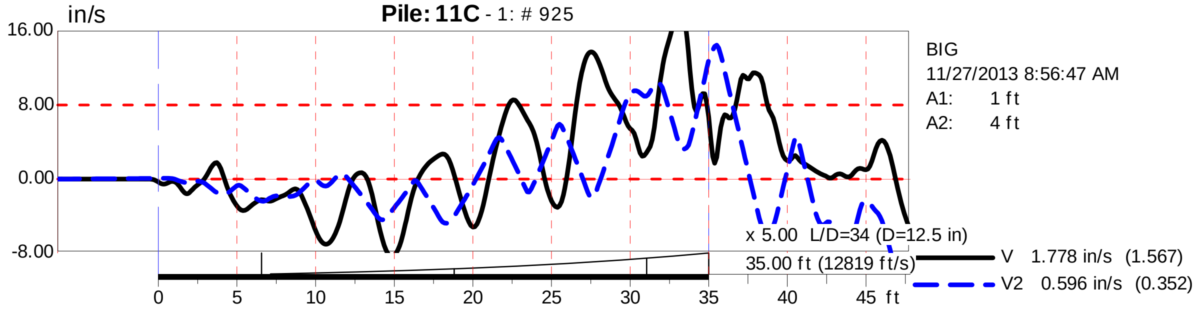
BIG
11/27/2013 8:56:57 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.290 in/s (0.194)
V2 0.498 in/s (0.401)


Pile: 11C - 1: # 926

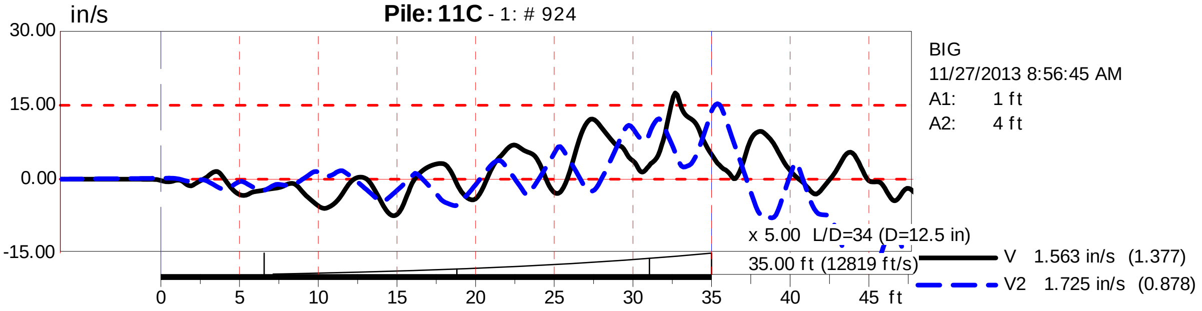
BIG
11/27/2013 8:56:49 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.950 in/s (0.771)
V2 0.897 in/s (0.522)


Pile: 11C - 1: # 925

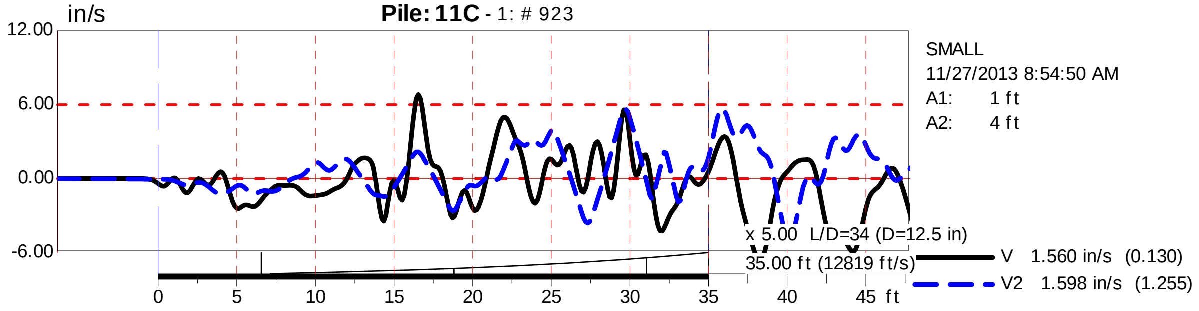
BIG
11/27/2013 8:56:47 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.778 in/s (1.567)
V2 0.596 in/s (0.352)


Pile: 11C - 1: # 924

BIG
11/27/2013 8:56:45 AM
A1: 1 ft
A2: 4 ft

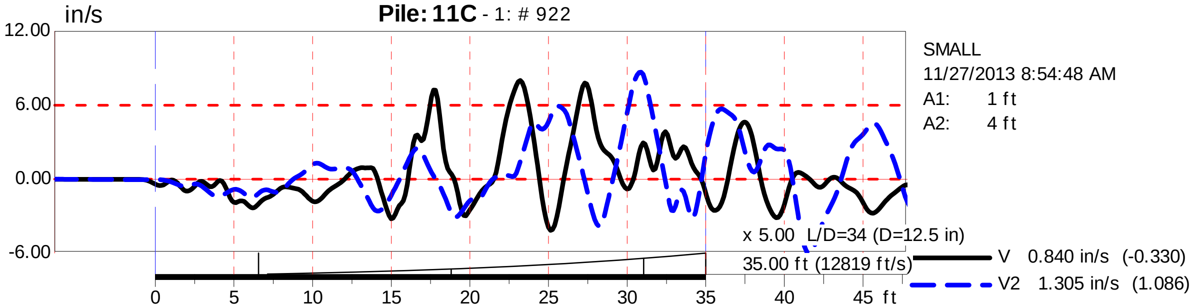
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.563 in/s (1.377)
V2 1.725 in/s (0.878)

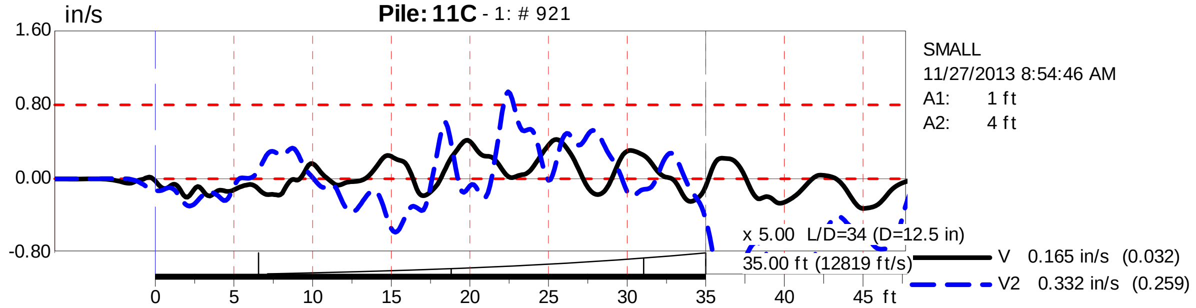

Pile: 11C - 1: # 923

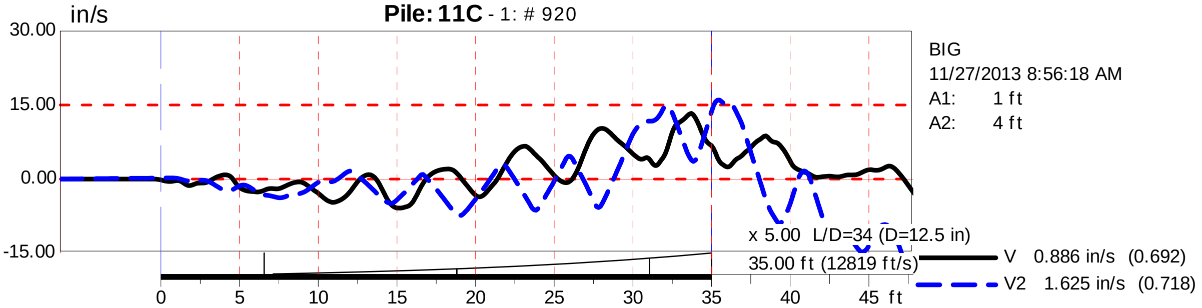
SMALL
11/27/2013 8:54:50 AM
A1: 1 ft
A2: 4 ft

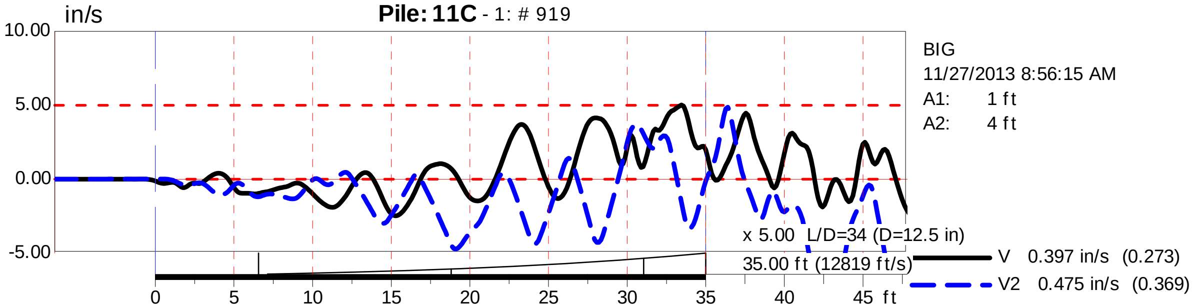
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.560 in/s (0.130)
V2 1.598 in/s (1.255)

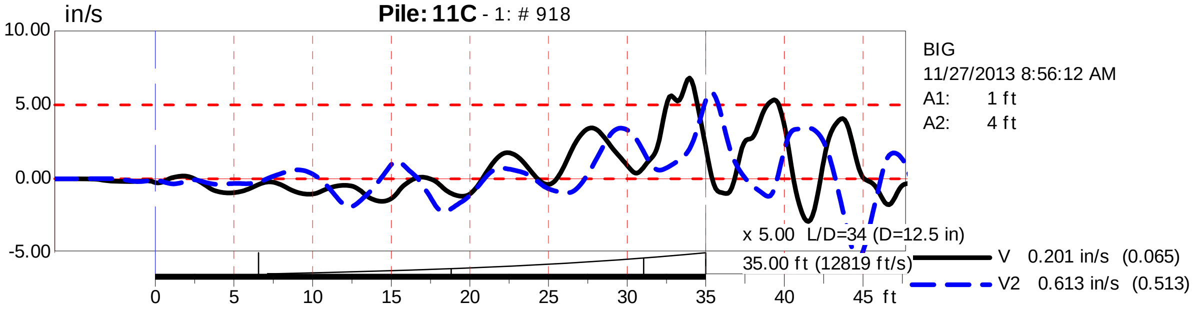
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

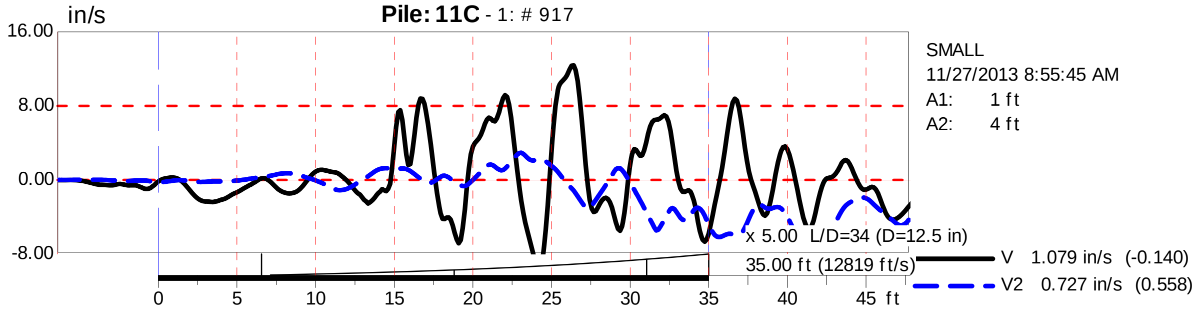


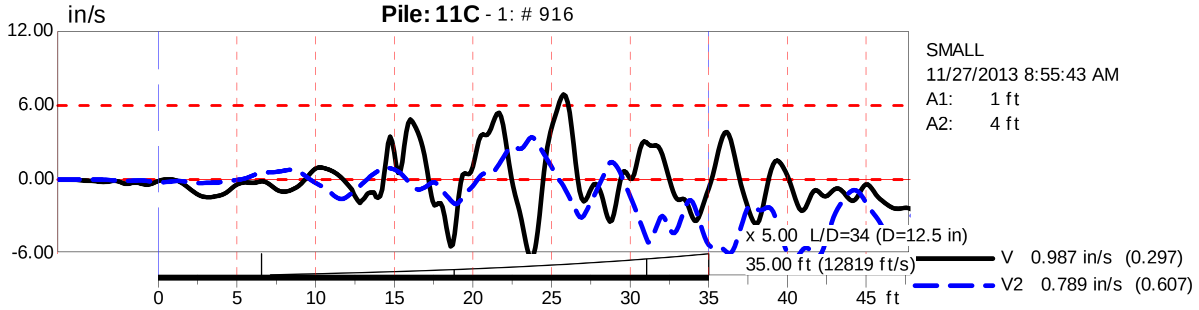


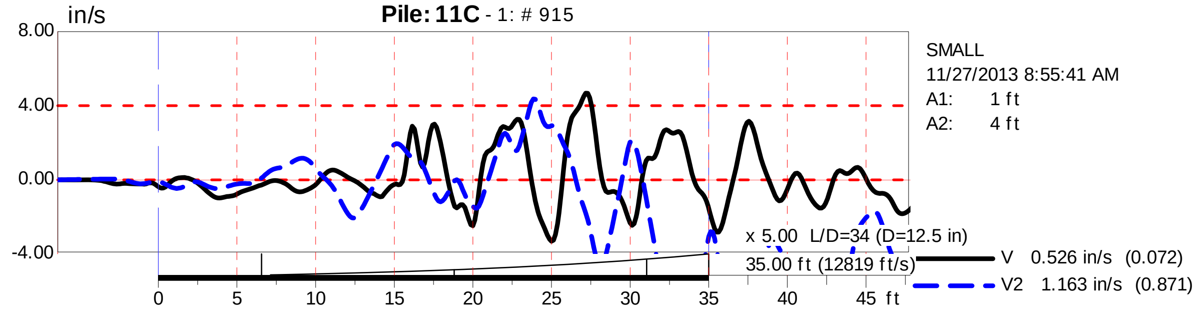


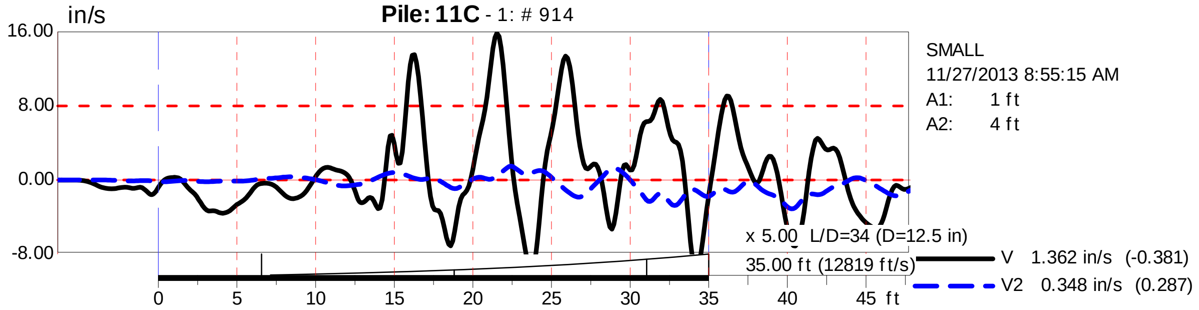


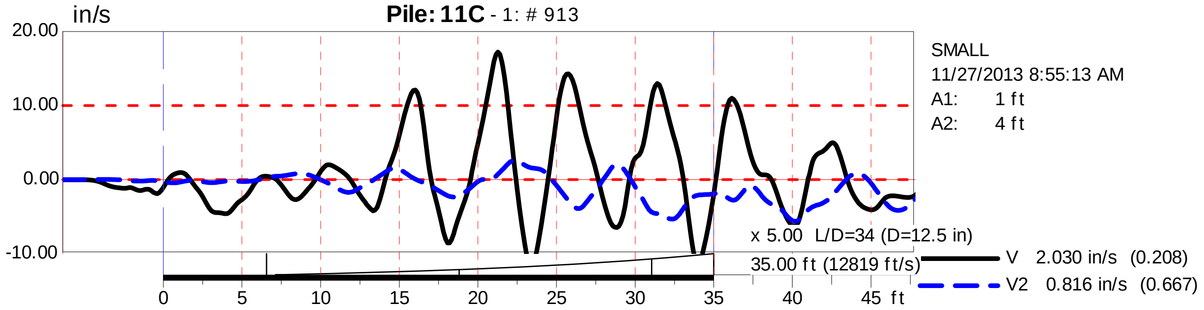


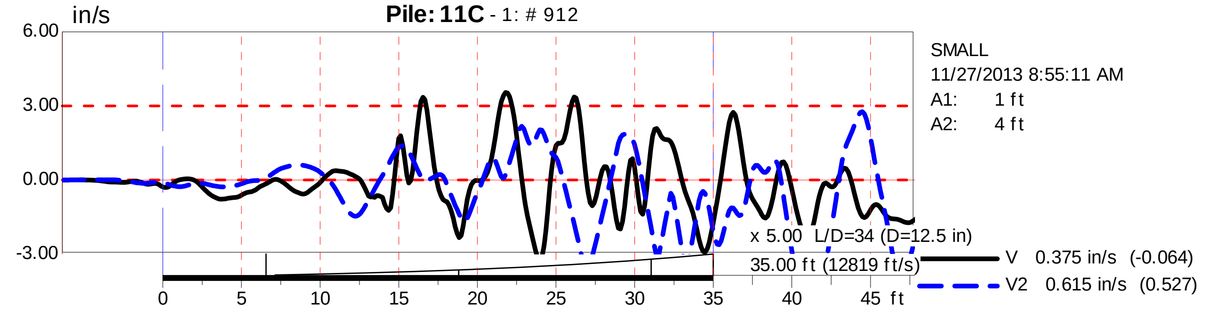

Pile: 11C - 1: # 917

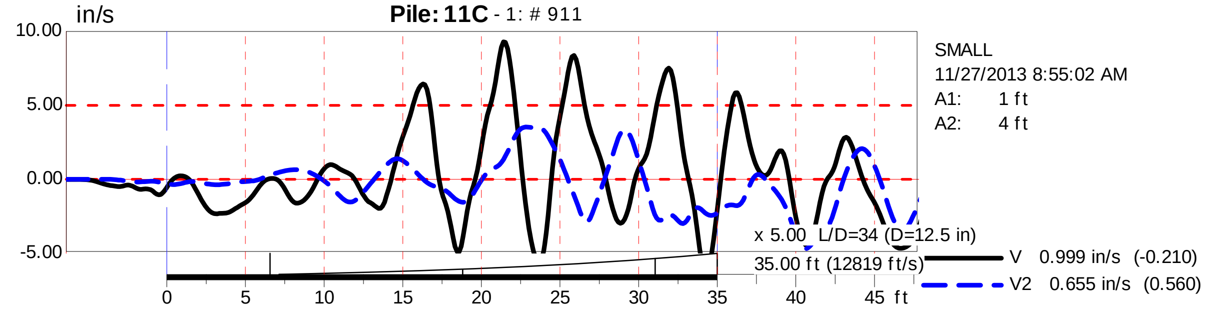

Pile: 11C - 1: # 916

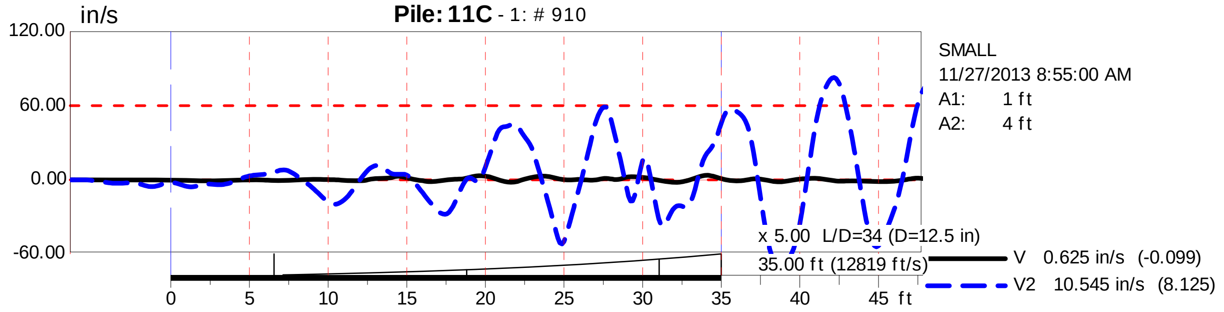

Pile: 11C - 1: # 915

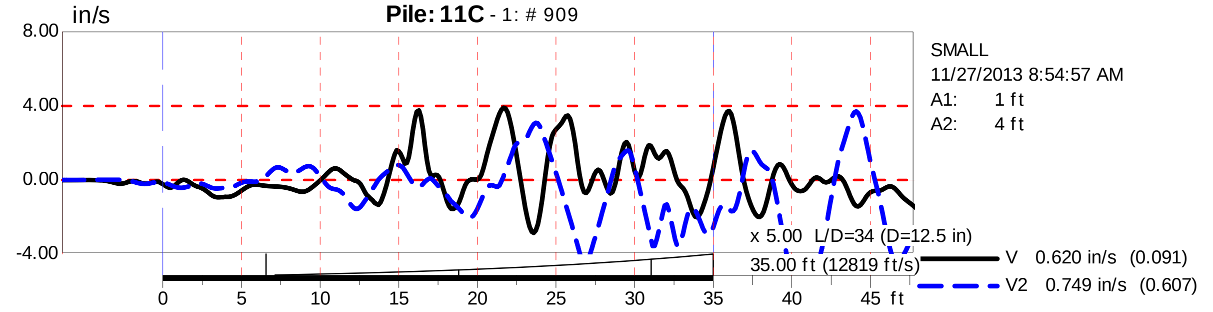

Pile: 11C - 1: # 914


Pile: 11C - 1: # 913

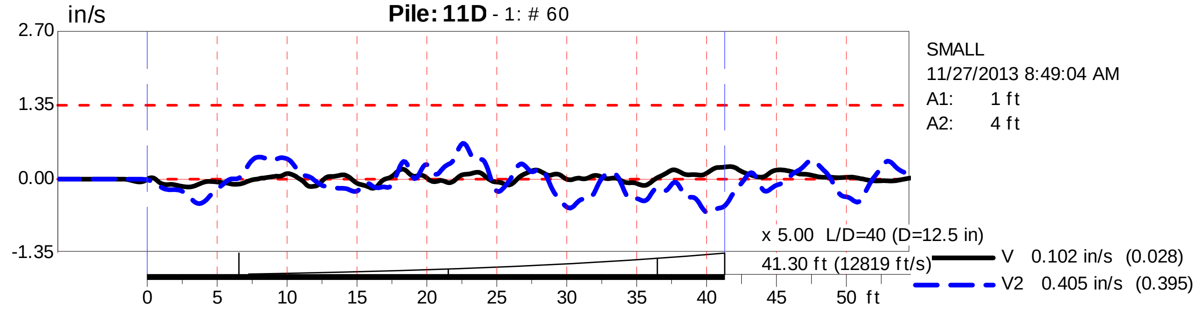

Pile: 11C - 1: # 912


Pile: 11C - 1: # 911


Pile: 11C - 1: # 910

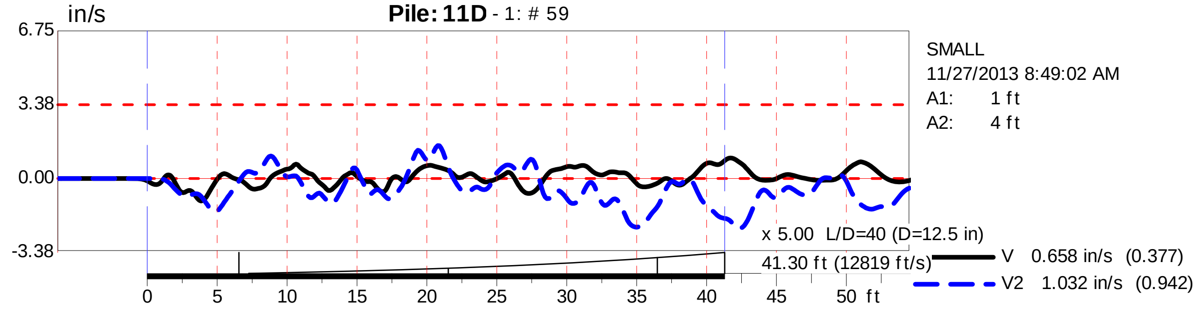

Pile: 11C - 1: # 909

Pile: 11D - 1: # 60



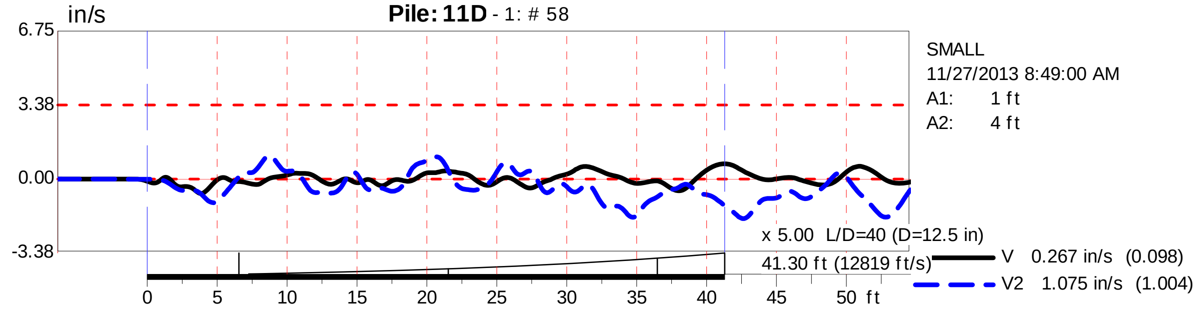
SMALL
11/27/2013 8:49:04 AM
A1: 1 ft
A2: 4 ft

Pile: 11D - 1: # 59



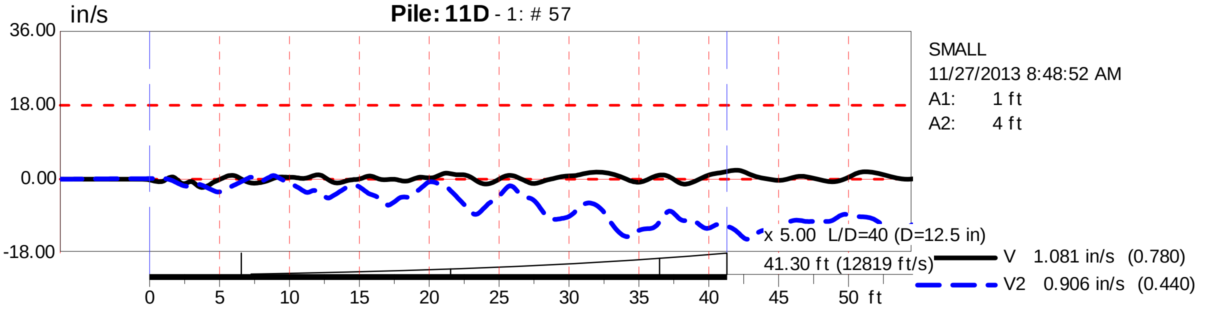
SMALL
11/27/2013 8:49:02 AM
A1: 1 ft
A2: 4 ft

Pile: 11D - 1: # 58



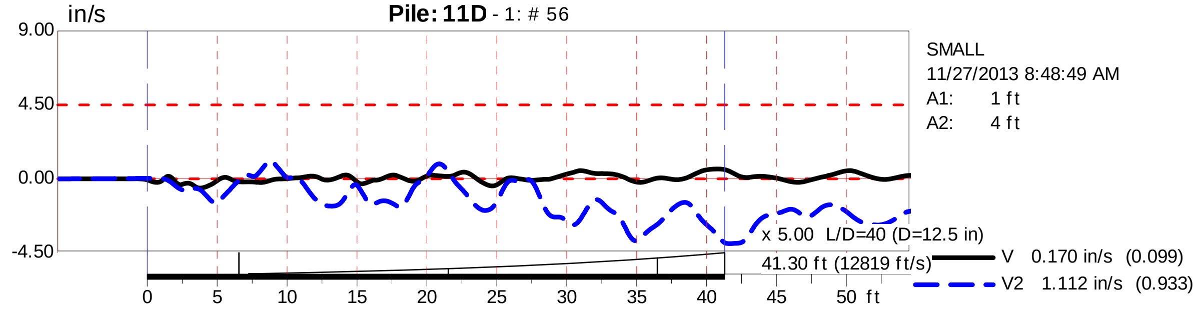
SMALL
11/27/2013 8:49:00 AM
A1: 1 ft
A2: 4 ft

Pile: 11D - 1: # 57



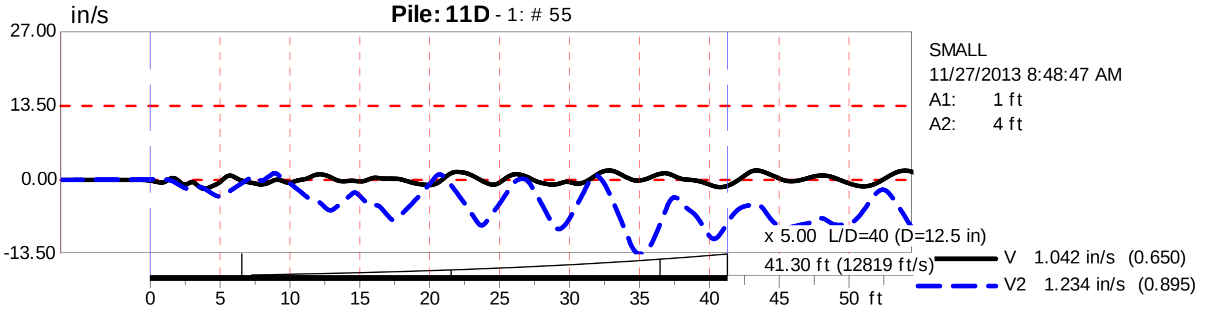
SMALL
11/27/2013 8:48:52 AM
A1: 1 ft
A2: 4 ft

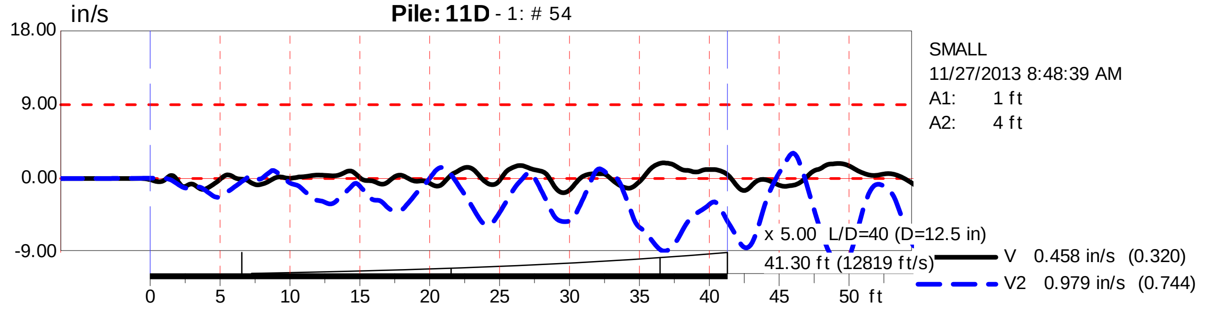
Pile: 11D - 1: # 56

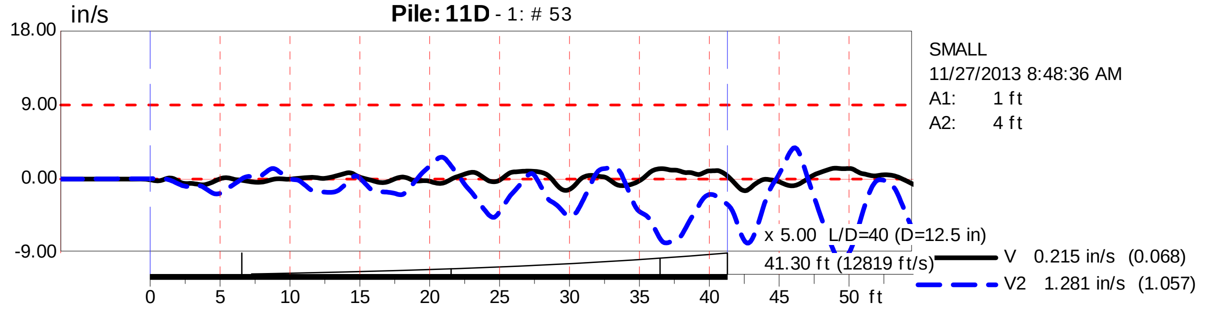


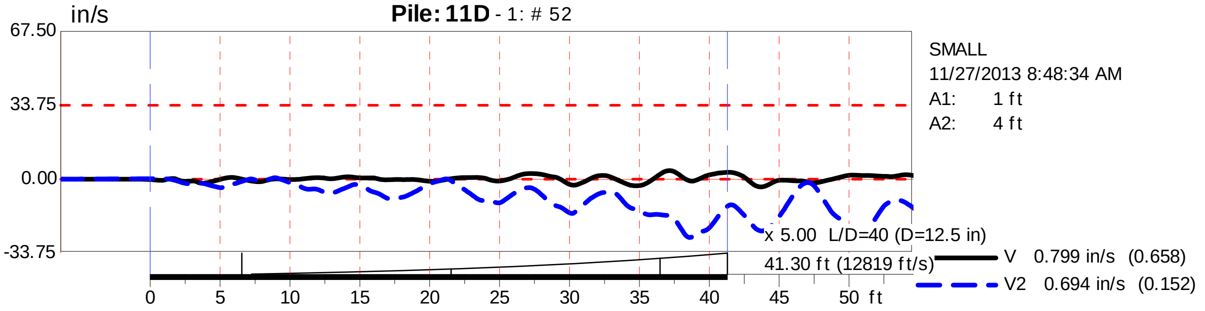
SMALL
11/27/2013 8:48:49 AM
A1: 1 ft
A2: 4 ft

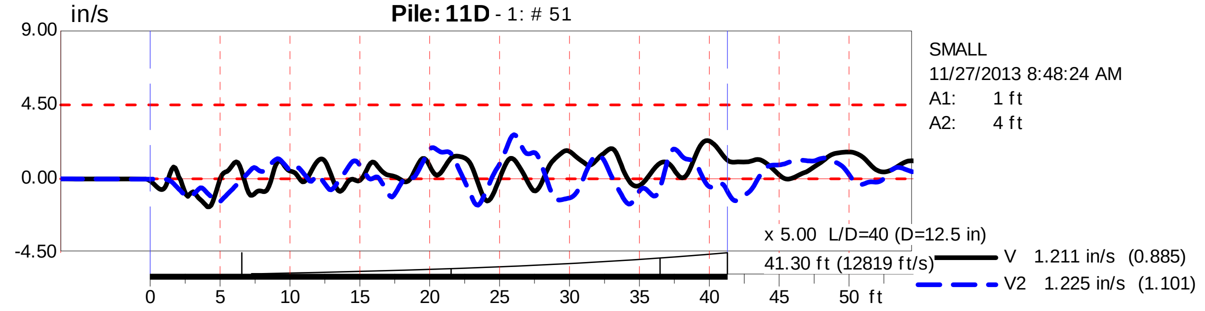
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



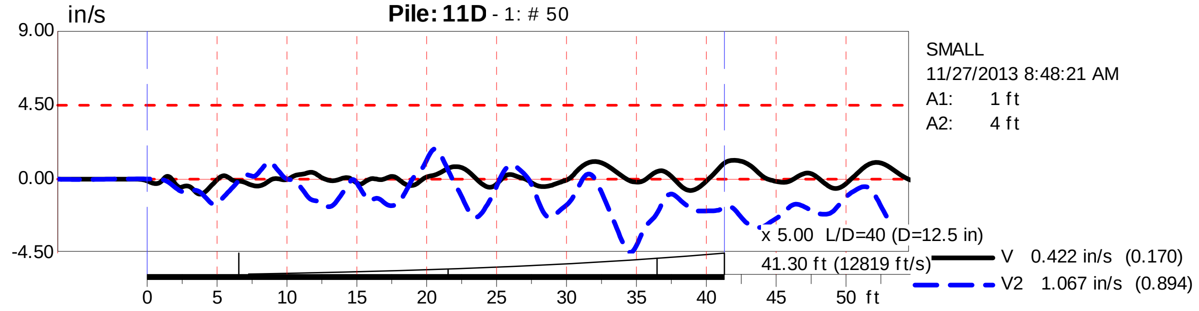




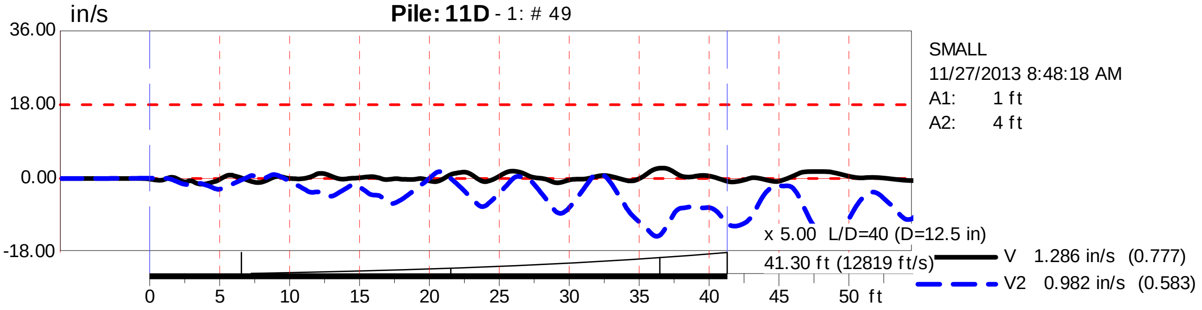




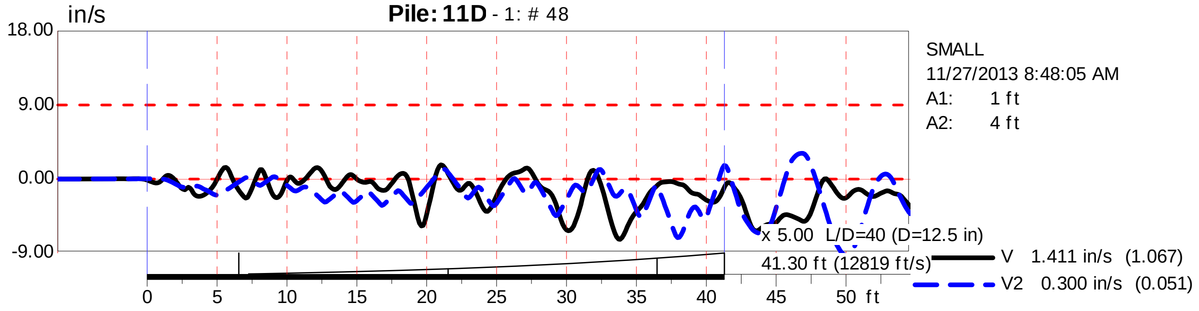
Pile: 11D - 1: # 50



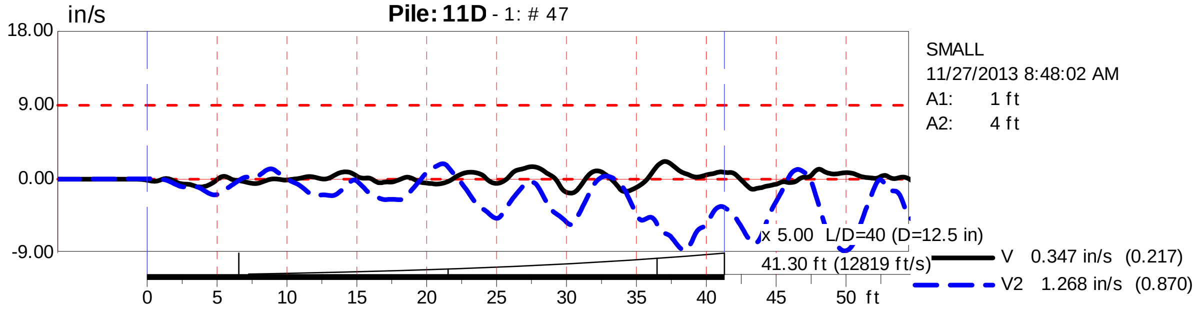
Pile: 11D - 1: # 49



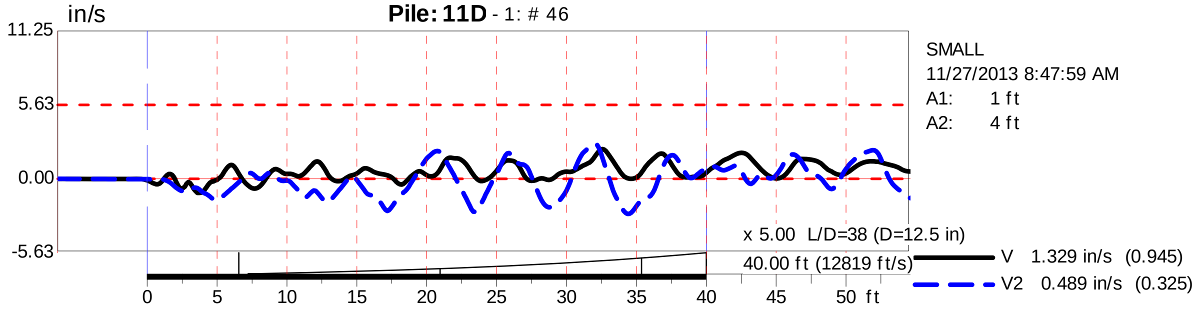
Pile: 11D - 1: # 48

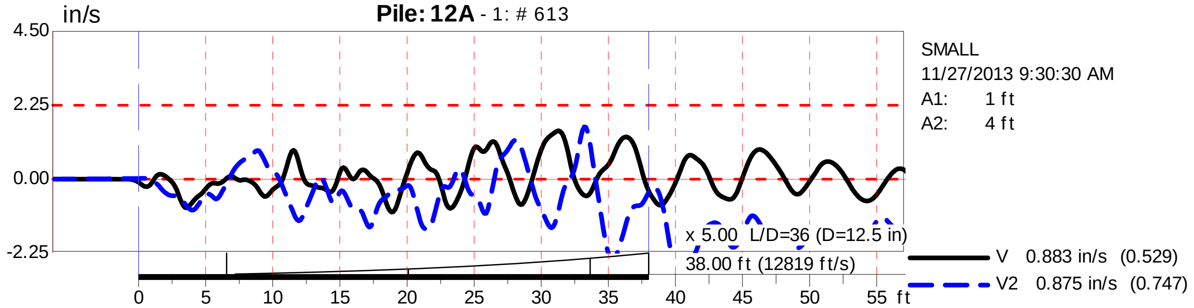


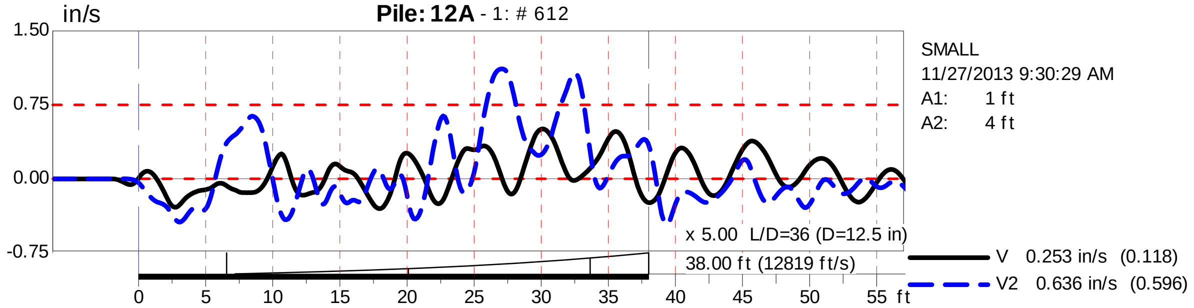
Pile: 11D - 1: # 47

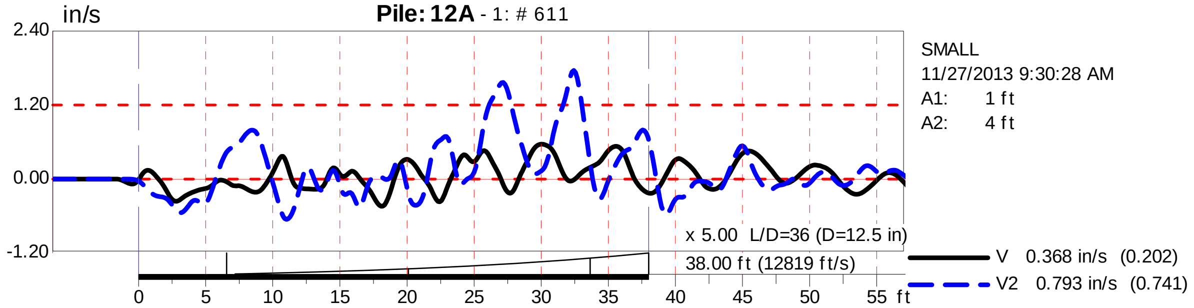


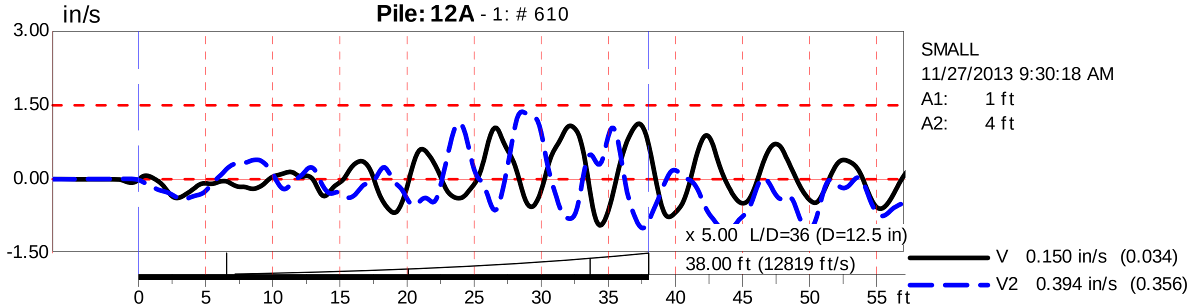
Pile: 11D - 1: # 46

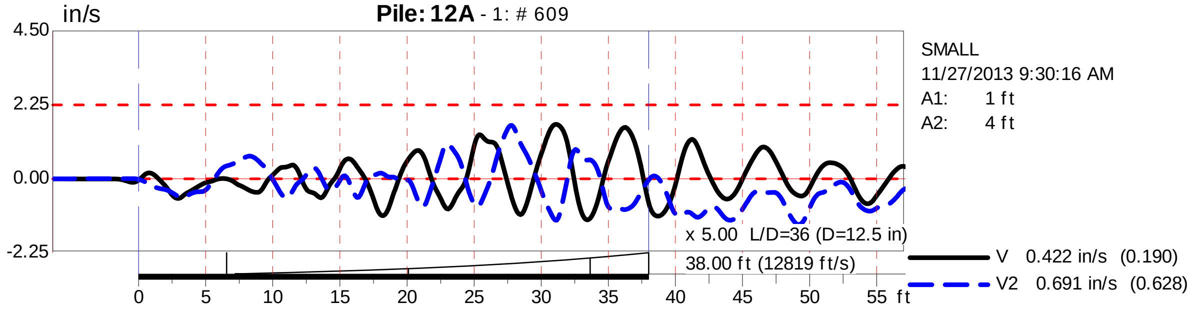


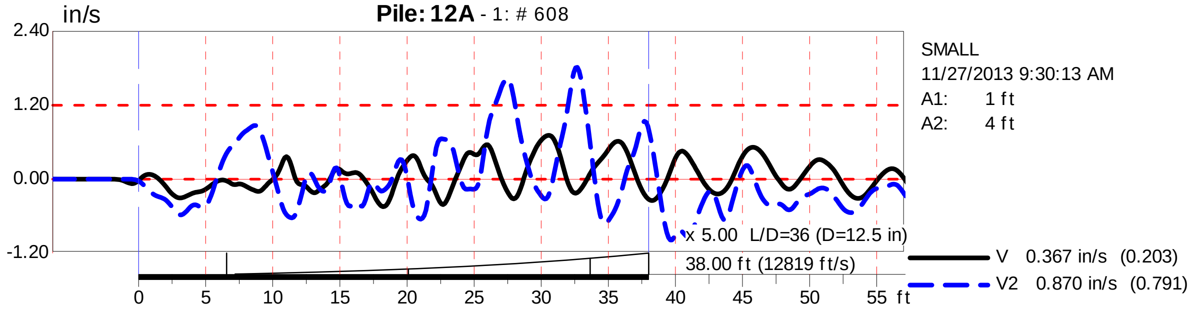

in/s
Pile: 12A - 1: # 613
4.50
2.25
0.00
-2.25
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SMALL
11/27/2013 9:30:30 AM
A1: 1 ft
A2: 4 ft
V 0.883 in/s (0.529)
V2 0.875 in/s (0.747)


in/s
Pile: 12A - 1: # 612
1.50
0.75
0.00
-0.75
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SMALL
11/27/2013 9:30:29 AM
A1: 1 ft
A2: 4 ft
V 0.253 in/s (0.118)
V2 0.636 in/s (0.596)

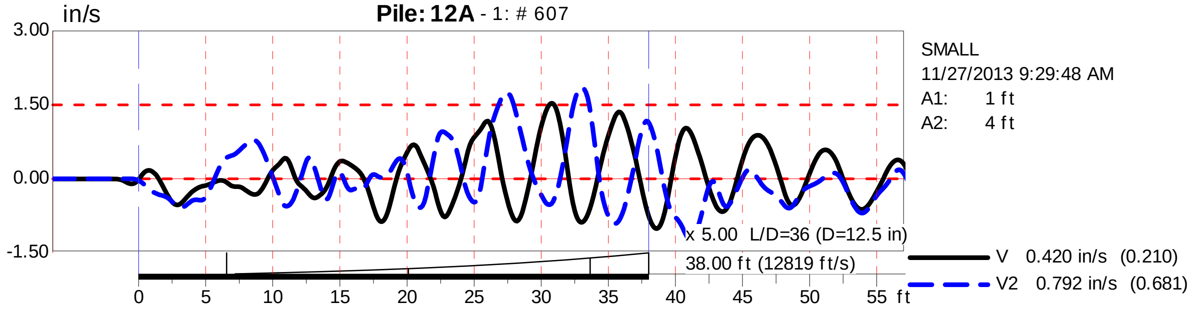

in/s
Pile: 12A - 1: # 611
2.40
1.20
0.00
-1.20
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SMALL
11/27/2013 9:30:28 AM
A1: 1 ft
A2: 4 ft
V 0.368 in/s (0.202)
V2 0.793 in/s (0.741)


in/s
Pile: 12A - 1: # 610
3.00
1.50
0.00
-1.50
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SMALL
11/27/2013 9:30:18 AM
A1: 1 ft
A2: 4 ft
V 0.150 in/s (0.034)
V2 0.394 in/s (0.356)

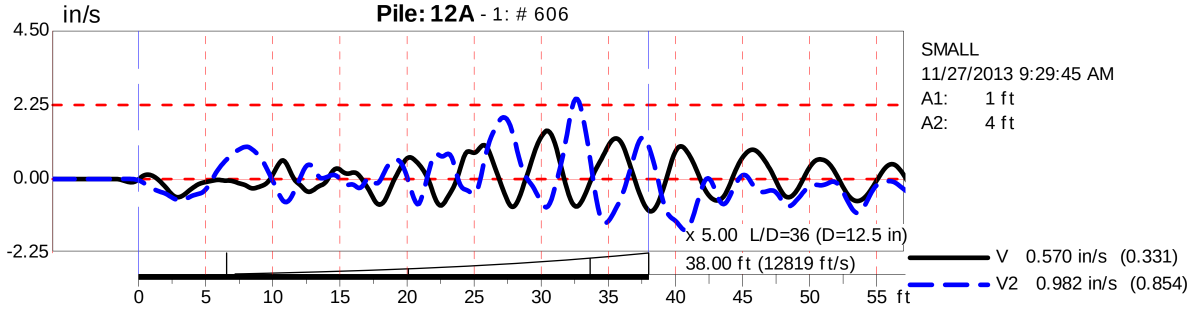

in/s
Pile: 12A - 1: # 609
4.50
2.25
0.00
-2.25
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SMALL
11/27/2013 9:30:16 AM
A1: 1 ft
A2: 4 ft
V 0.422 in/s (0.190)
V2 0.691 in/s (0.628)



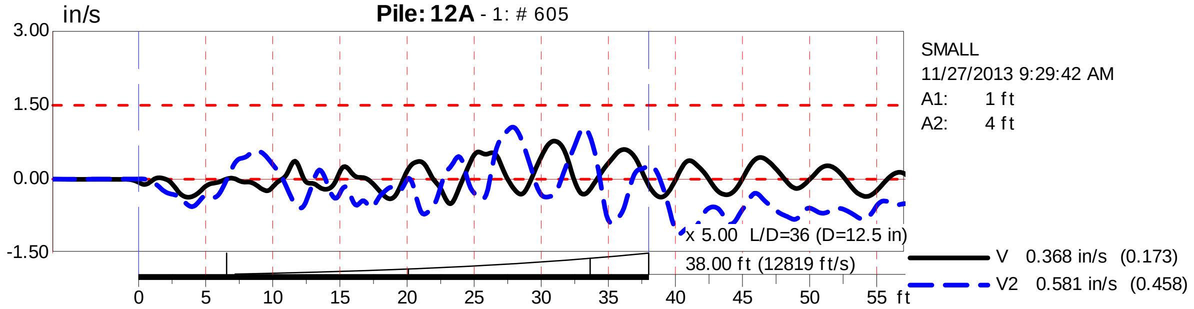
SMALL
11/27/2013 9:30:13 AM
A1: 1 ft
A2: 4 ft



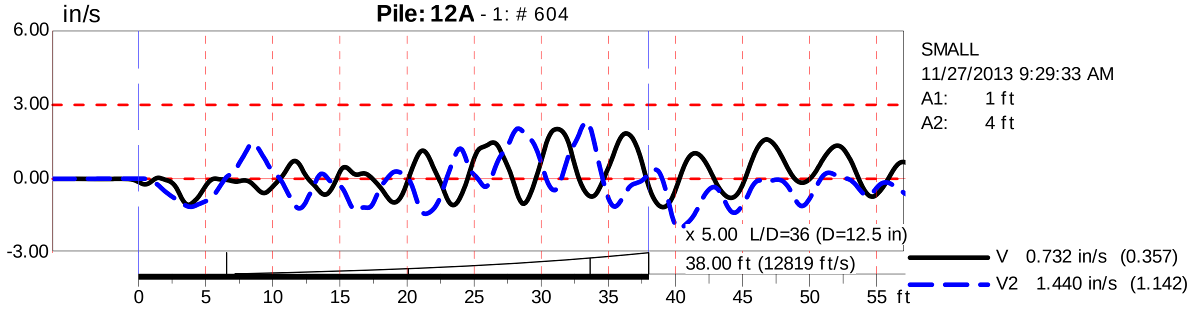
SMALL
11/27/2013 9:29:48 AM
A1: 1 ft
A2: 4 ft



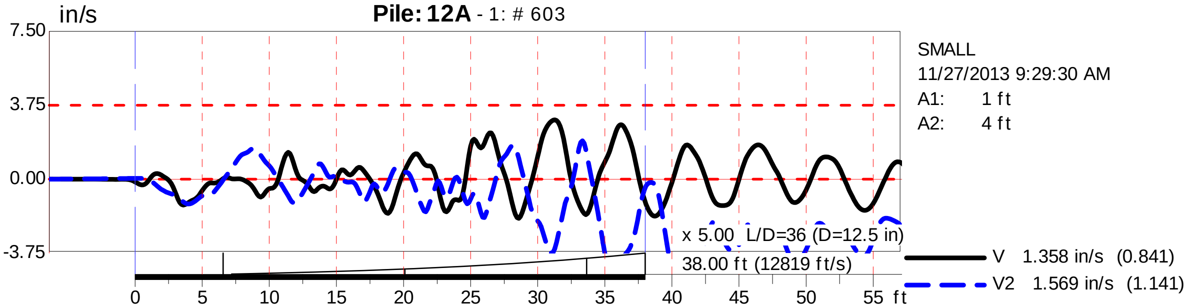
SMALL
11/27/2013 9:29:45 AM
A1: 1 ft
A2: 4 ft

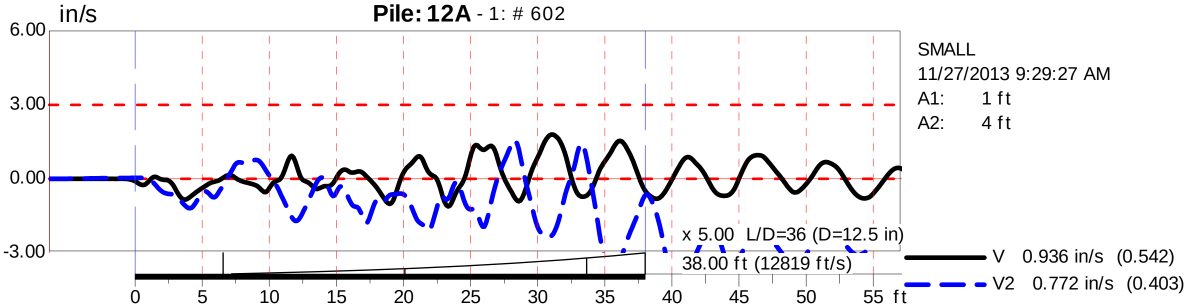


SMALL
11/27/2013 9:29:42 AM
A1: 1 ft
A2: 4 ft



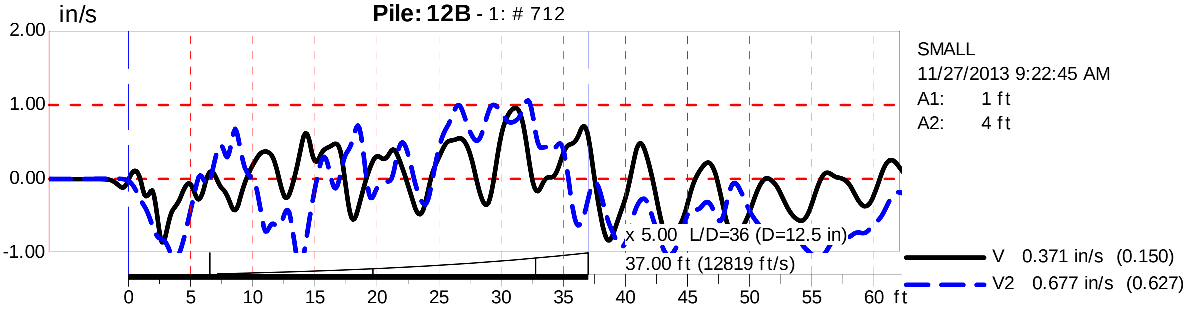
SMALL
11/27/2013 9:29:33 AM
A1: 1 ft
A2: 4 ft


in/s
Pile: 12A - 1: # 603
7.50
3.75
0.00
-3.75
SMALL
11/27/2013 9:29:30 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
V 1.358 in/s (0.841)
V2 1.569 in/s (1.141)


in/s
Pile: 12A - 1: # 602
6.00
3.00
0.00
-3.00
SMALL
11/27/2013 9:29:27 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
V 0.936 in/s (0.542)
V2 0.772 in/s (0.403)

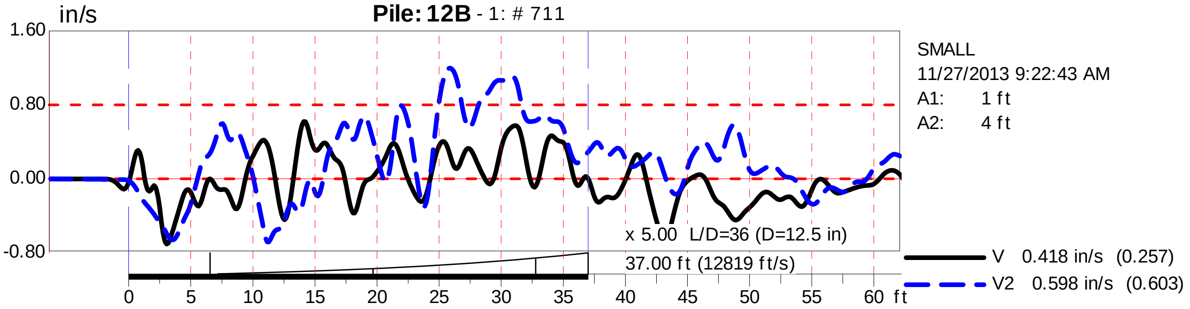
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

Pile: 12B - 1: # 712



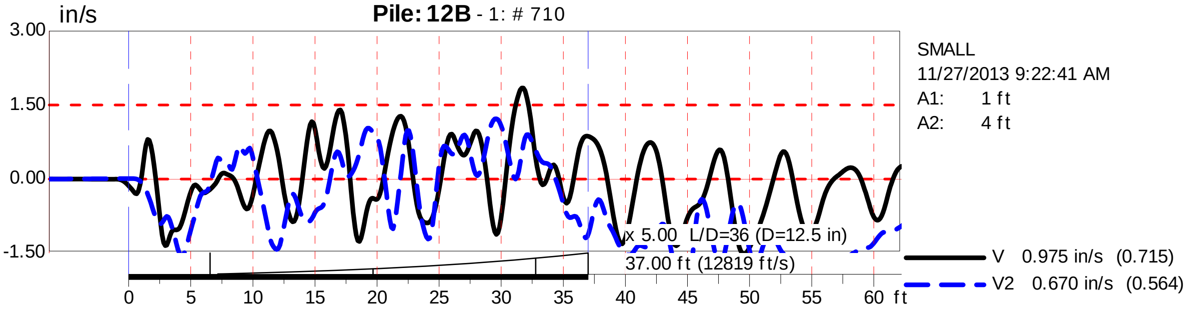
SMALL
11/27/2013 9:22:45 AM
A1: 1 ft
A2: 4 ft
V 0.371 in/s (0.150)
V2 0.677 in/s (0.627)

Pile: 12B - 1: # 711



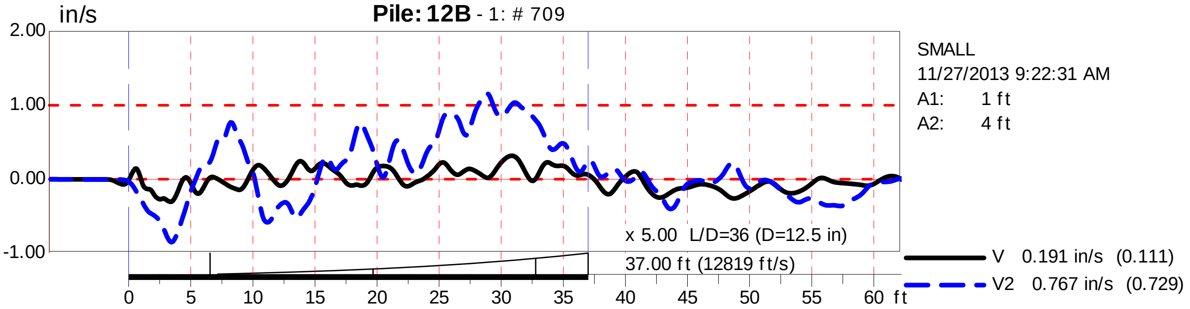
SMALL
11/27/2013 9:22:43 AM
A1: 1 ft
A2: 4 ft
V 0.418 in/s (0.257)
V2 0.598 in/s (0.603)

Pile: 12B - 1: # 710



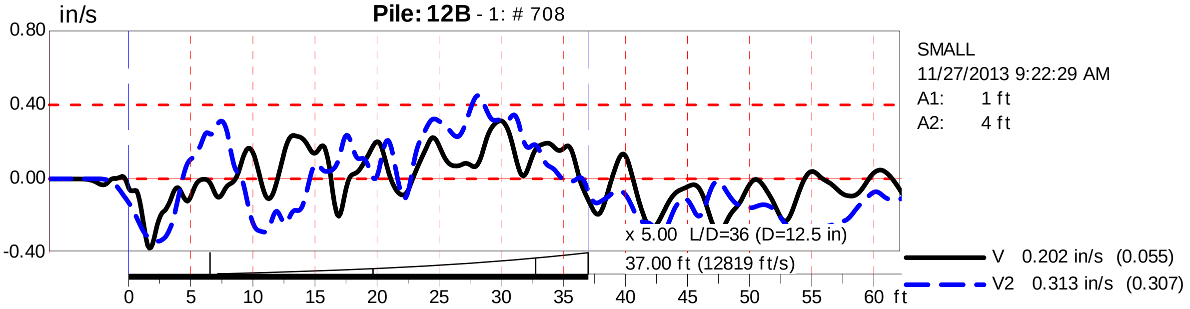
SMALL
11/27/2013 9:22:41 AM
A1: 1 ft
A2: 4 ft
V 0.975 in/s (0.715)
V2 0.670 in/s (0.564)

Pile: 12B - 1: # 709



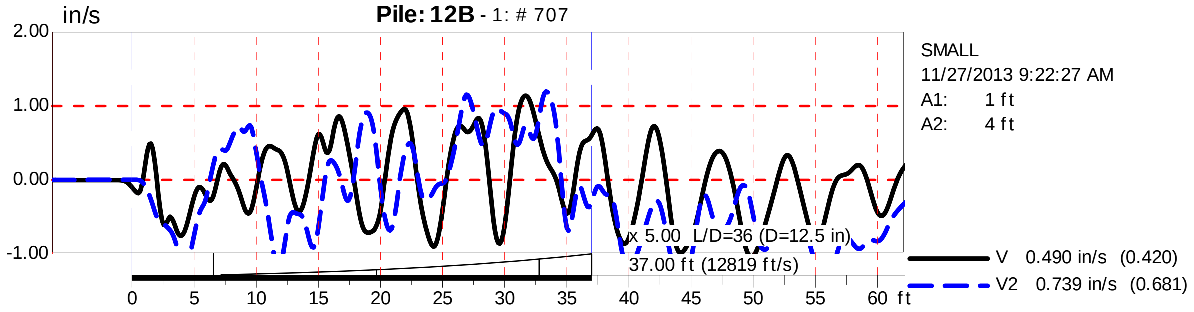
SMALL
11/27/2013 9:22:31 AM
A1: 1 ft
A2: 4 ft
V 0.191 in/s (0.111)
V2 0.767 in/s (0.729)

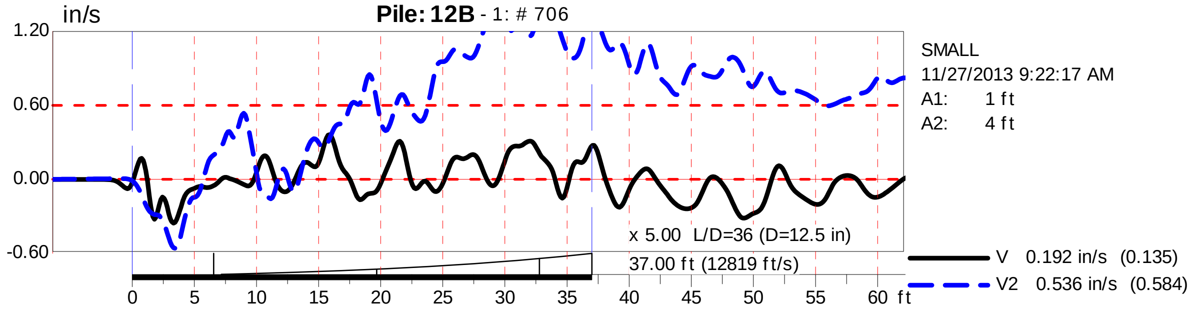
Pile: 12B - 1: # 708

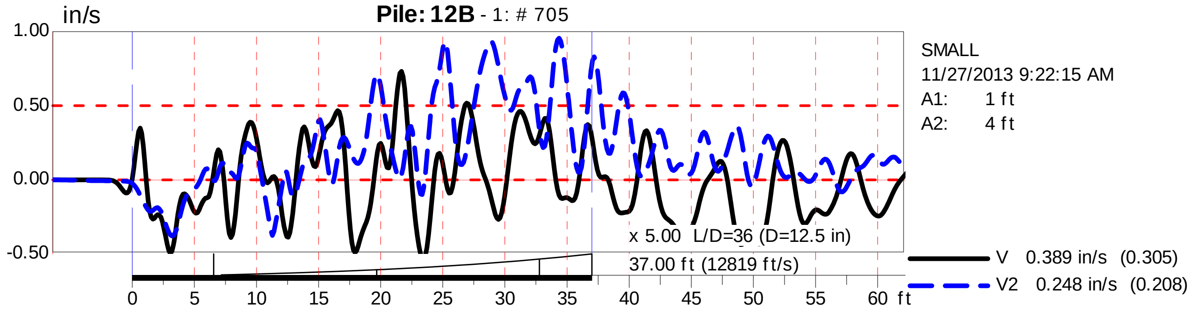


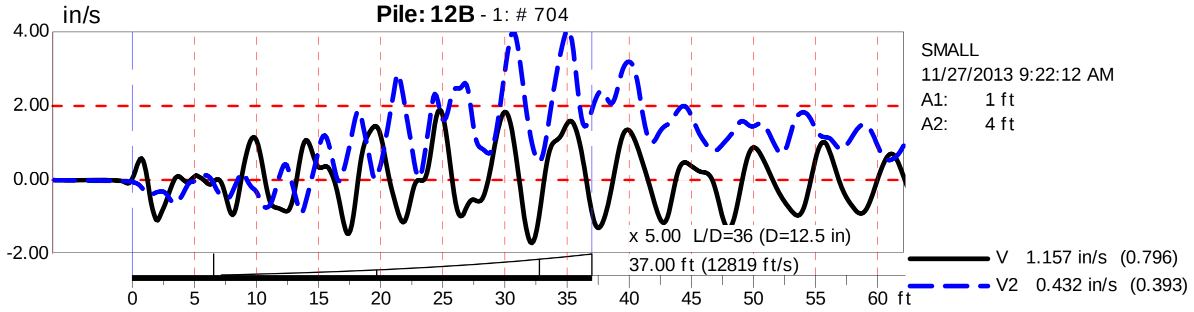
SMALL
11/27/2013 9:22:29 AM
A1: 1 ft
A2: 4 ft
V 0.202 in/s (0.055)
V2 0.313 in/s (0.307)

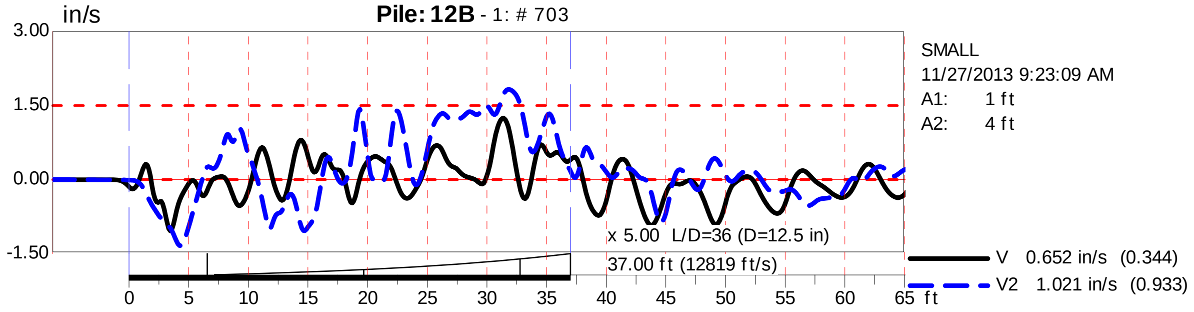
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

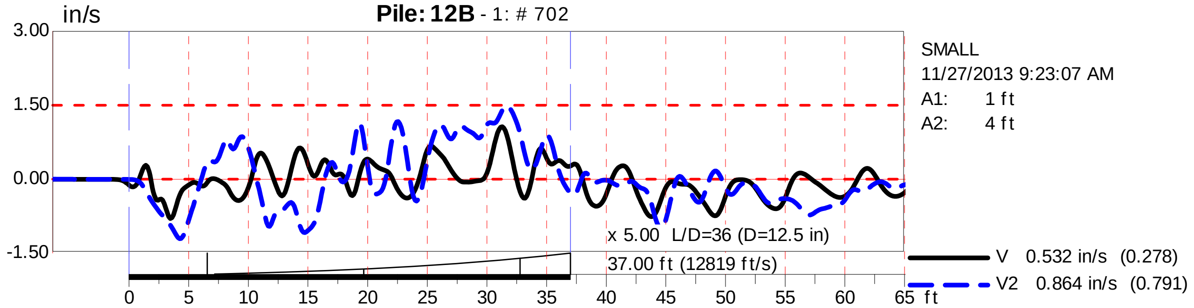


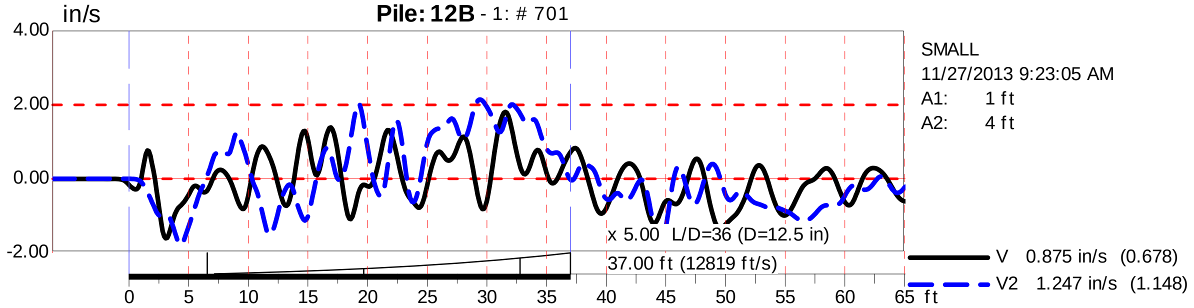


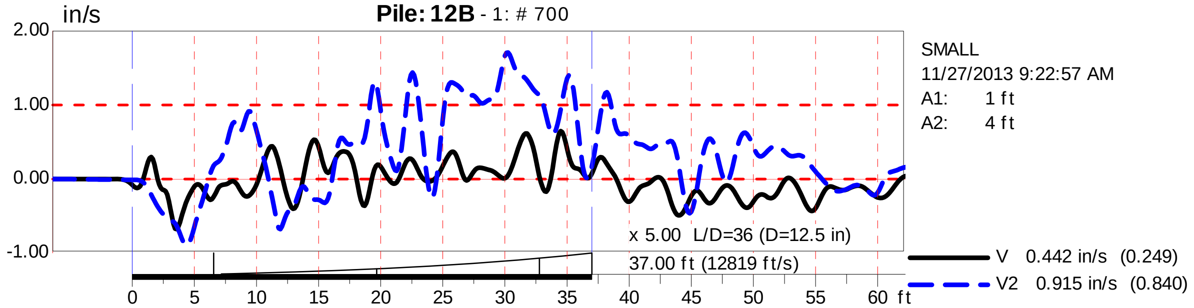


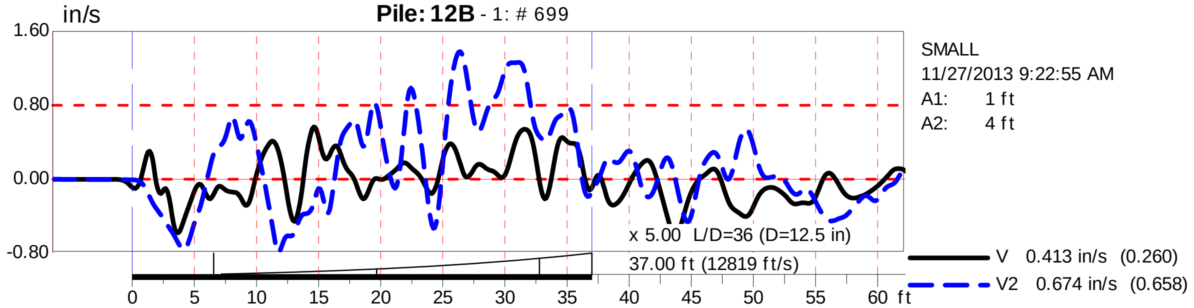


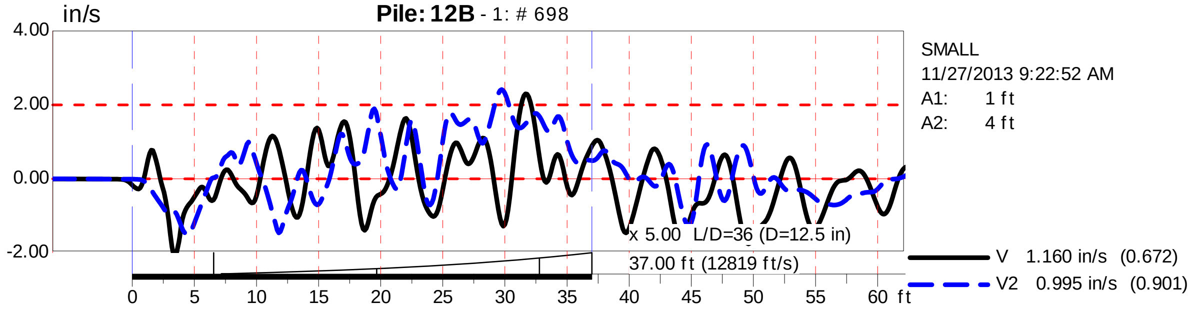


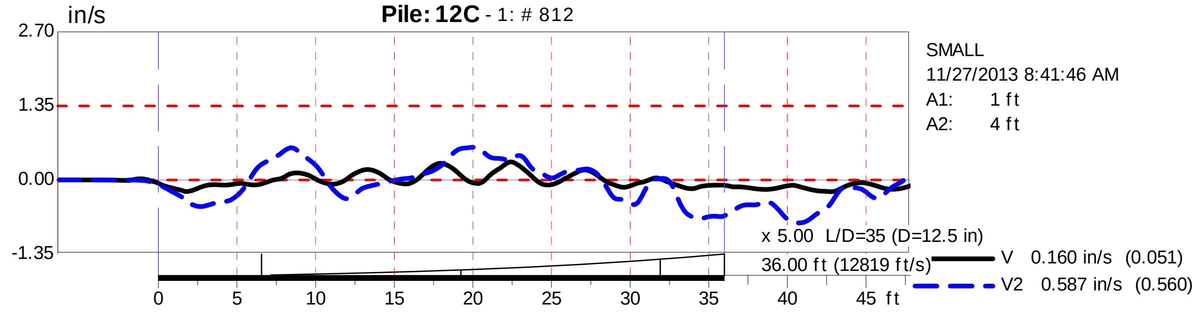

in/s
Pile: 12B - 1: # 702
3.00
1.50
0.00
-1.50
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 ft
SMALL
11/27/2013 9:23:07 AM
A1: 1 ft
A2: 4 ft
V 0.532 in/s (0.278)
V2 0.864 in/s (0.791)

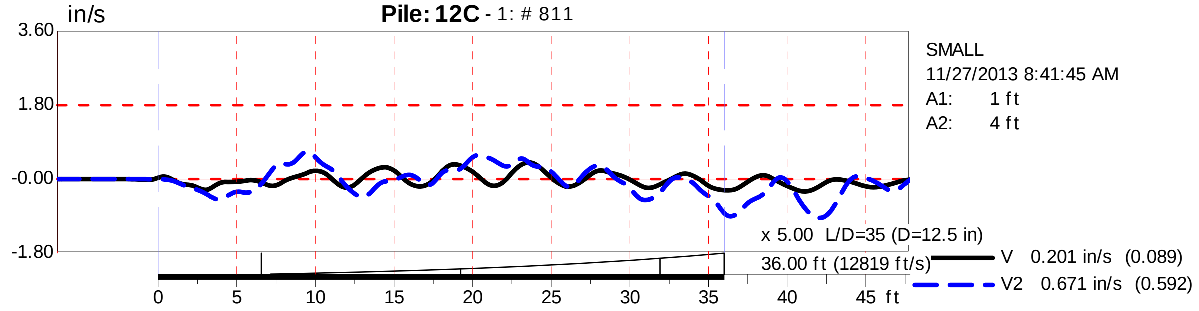

in/s
Pile: 12B - 1: # 701
4.00
2.00
0.00
-2.00
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 ft
SMALL
11/27/2013 9:23:05 AM
A1: 1 ft
A2: 4 ft
V 0.875 in/s (0.678)
V2 1.247 in/s (1.148)

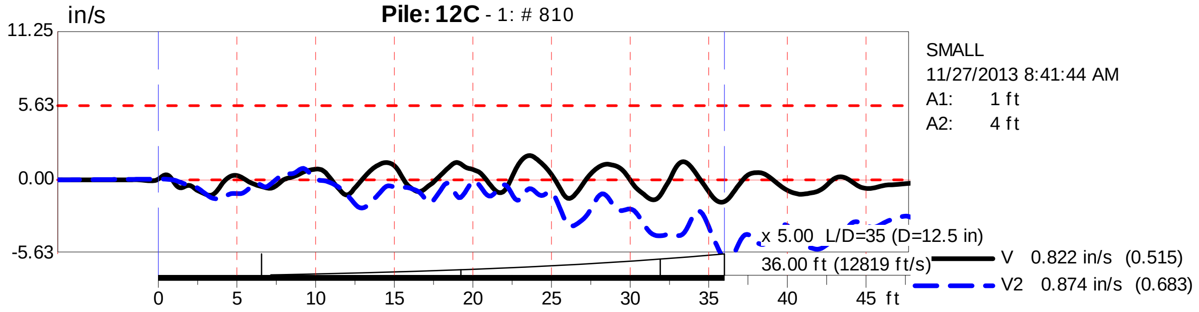

in/s
Pile: 12B - 1: # 700
2.00
1.00
0.00
-1.00
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 ft
SMALL
11/27/2013 9:22:57 AM
A1: 1 ft
A2: 4 ft
V 0.442 in/s (0.249)
V2 0.915 in/s (0.840)

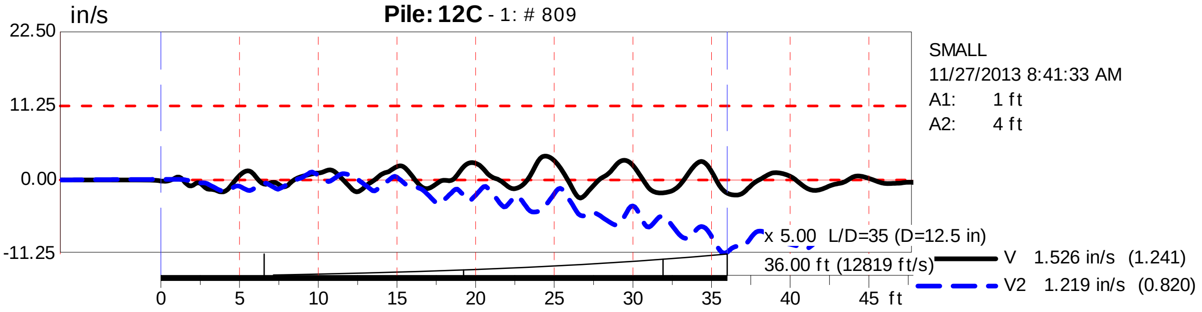

in/s
Pile: 12B - 1: # 699
1.60
0.80
0.00
-0.80
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 ft
SMALL
11/27/2013 9:22:55 AM
A1: 1 ft
A2: 4 ft
V 0.413 in/s (0.260)
V2 0.674 in/s (0.658)

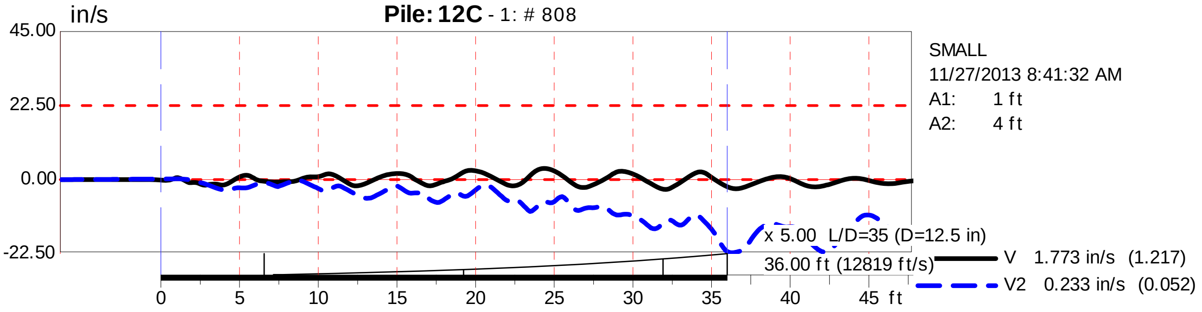

in/s
Pile: 12B - 1: # 698
4.00
2.00
0.00
-2.00
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 ft
SMALL
11/27/2013 9:22:52 AM
A1: 1 ft
A2: 4 ft
V 1.160 in/s (0.672)
V2 0.995 in/s (0.901)


in/s
Pile: 12C - 1: # 812
2.70
1.35
0.00
-1.35
SMALL
11/27/2013 8:41:46 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.160 in/s (0.051)
V2 0.587 in/s (0.560)
0 5 10 15 20 25 30 35 40 45 ft

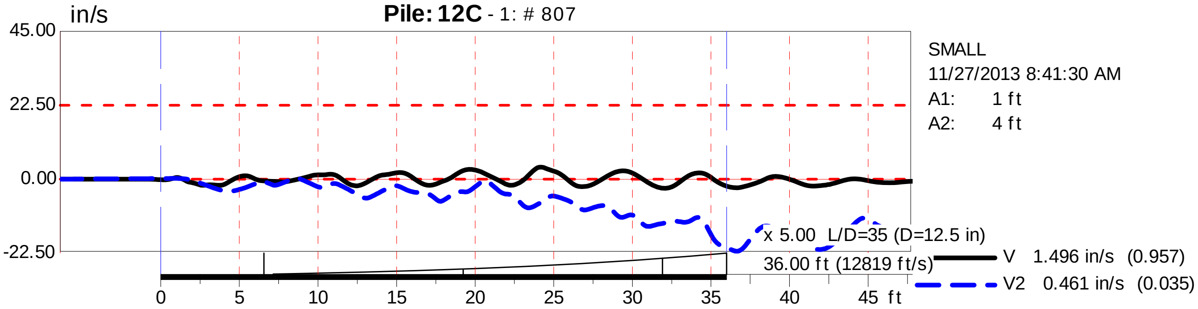

in/s
Pile: 12C - 1: # 811
3.60
1.80
-0.00
-1.80
SMALL
11/27/2013 8:41:45 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.201 in/s (0.089)
V2 0.671 in/s (0.592)
0 5 10 15 20 25 30 35 40 45 ft


in/s
Pile: 12C - 1: # 810
11.25
5.63
0.00
-5.63
SMALL
11/27/2013 8:41:44 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.822 in/s (0.515)
V2 0.874 in/s (0.683)
0 5 10 15 20 25 30 35 40 45 ft


in/s
Pile: 12C - 1: # 809
22.50
11.25
0.00
-11.25
SMALL
11/27/2013 8:41:33 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.526 in/s (1.241)
V2 1.219 in/s (0.820)
0 5 10 15 20 25 30 35 40 45 ft

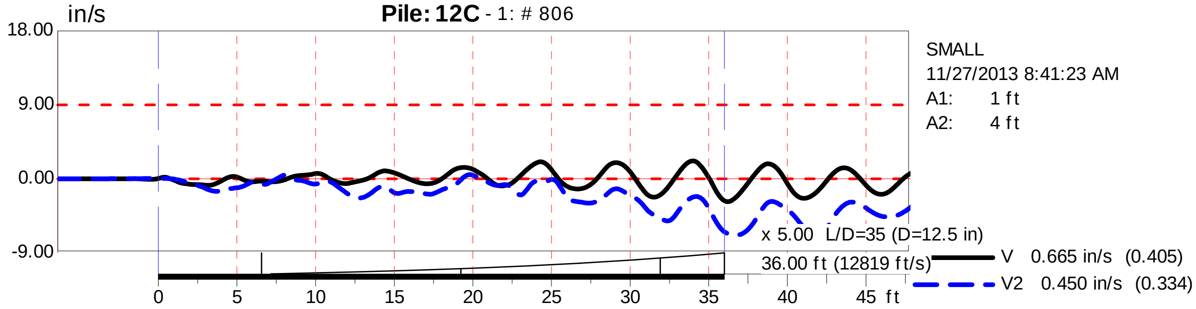

in/s
Pile: 12C - 1: # 808
45.00
22.50
0.00
-22.50
SMALL
11/27/2013 8:41:32 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.773 in/s (1.217)
V2 0.233 in/s (0.052)
0 5 10 15 20 25 30 35 40 45 ft

Pile: 12C - 1: # 807



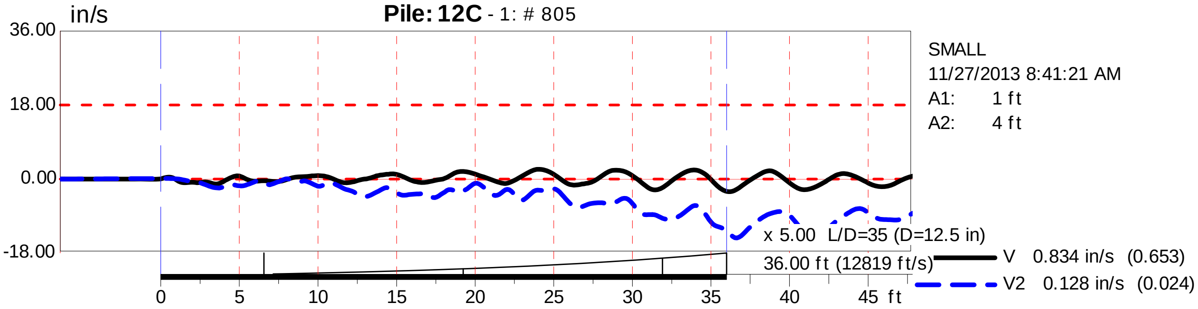
SMALL
11/27/2013 8:41:30 AM
A1: 1 ft
A2: 4 ft

Pile: 12C - 1: # 806



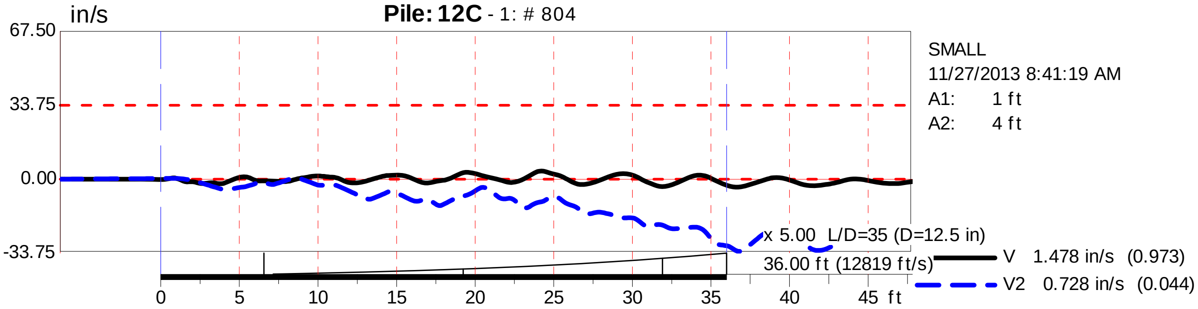
SMALL
11/27/2013 8:41:23 AM
A1: 1 ft
A2: 4 ft

Pile: 12C - 1: # 805



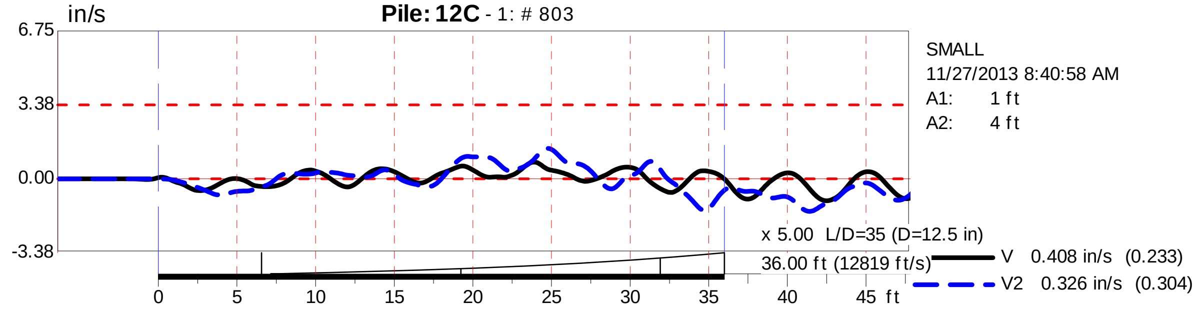
SMALL
11/27/2013 8:41:21 AM
A1: 1 ft
A2: 4 ft

Pile: 12C - 1: # 804

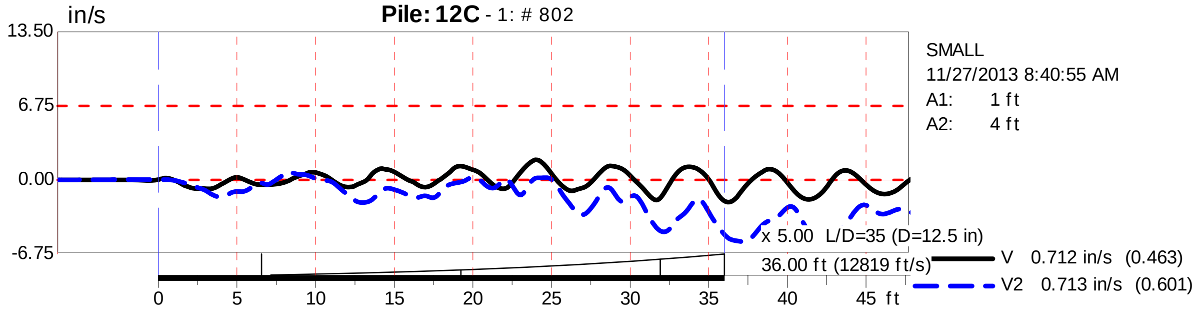


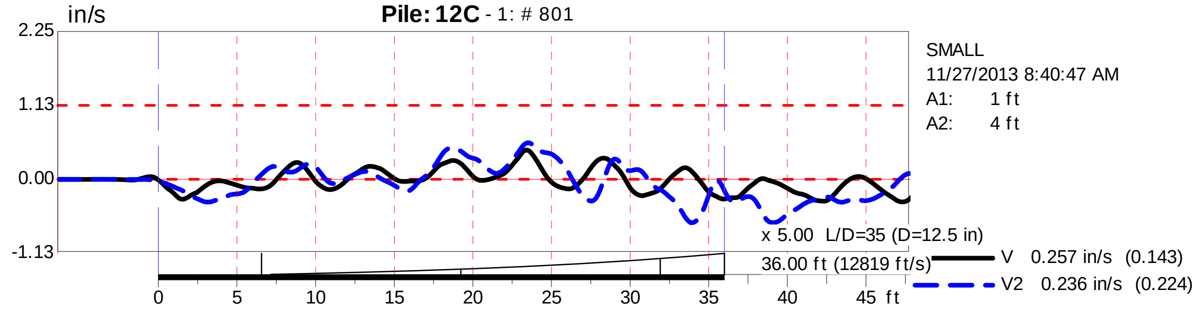
SMALL
11/27/2013 8:41:19 AM
A1: 1 ft
A2: 4 ft

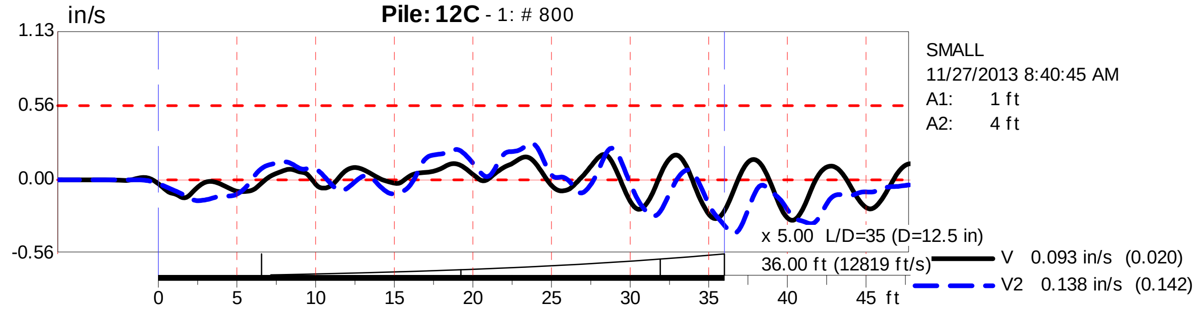
Pile: 12C - 1: # 803

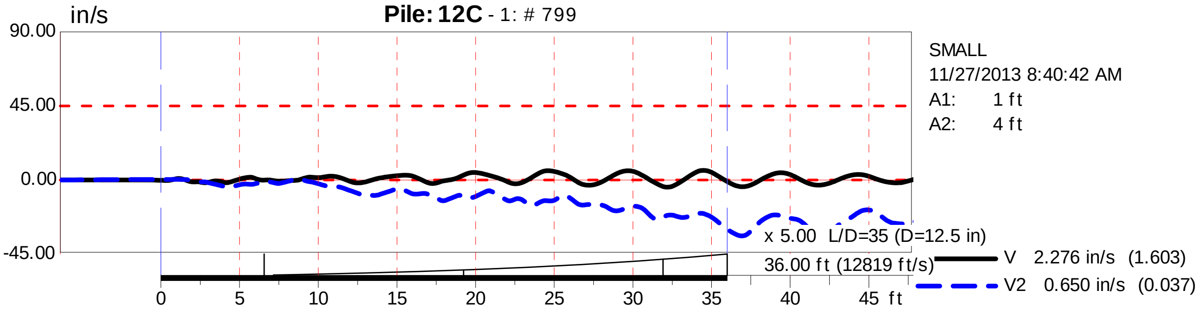


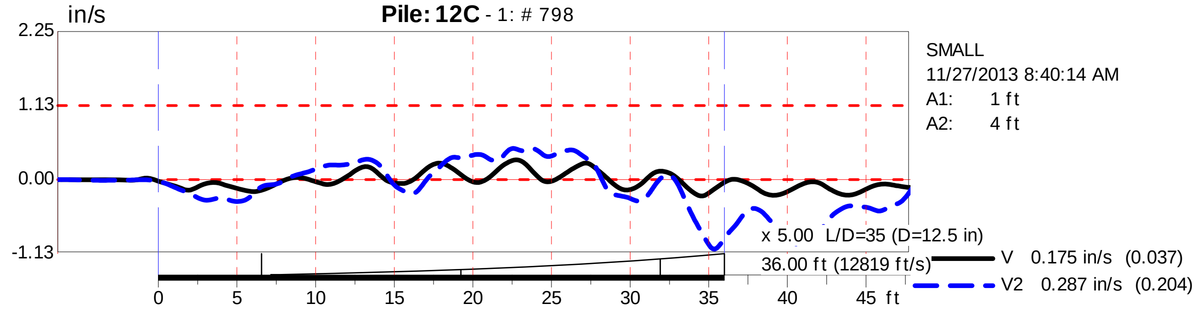
SMALL
11/27/2013 8:40:58 AM
A1: 1 ft
A2: 4 ft

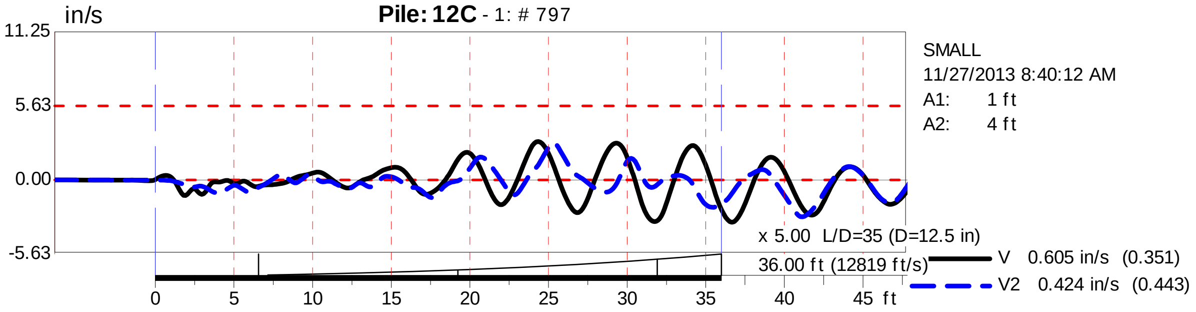

in/s
Pile: 12C - 1: # 802
13.50
6.75
0.00
-6.75
SMALL
11/27/2013 8:40:55 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.712 in/s (0.463)
V2 0.713 in/s (0.601)
0
5
10
15
20
25
30
35
40
45 ft

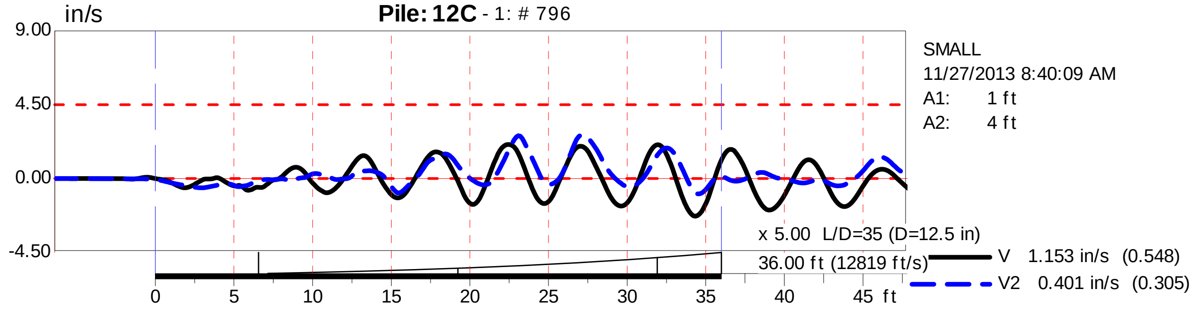

in/s
Pile: 12C - 1: # 801
2.25
1.13
0.00
-1.13
SMALL
11/27/2013 8:40:47 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.257 in/s (0.143)
V2 0.236 in/s (0.224)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 12C - 1: # 800
1.13
0.56
0.00
-0.56
SMALL
11/27/2013 8:40:45 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.093 in/s (0.020)
V2 0.138 in/s (0.142)
0
5
10
15
20
25
30
35
40
45 ft

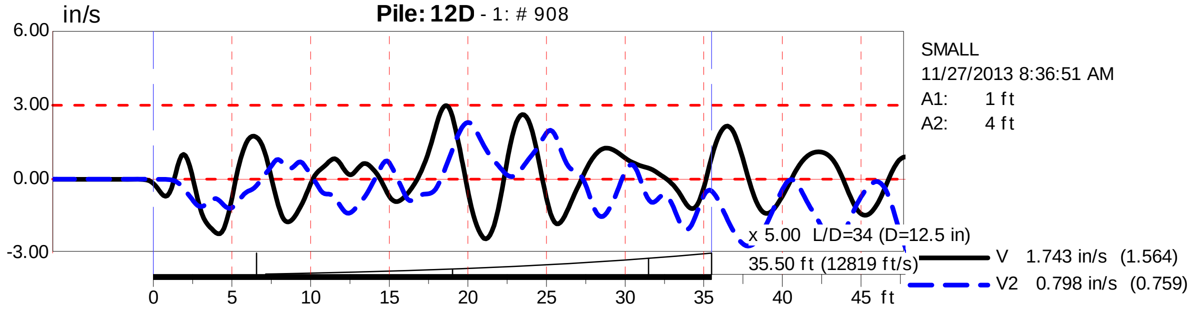

in/s
Pile: 12C - 1: # 799
90.00
45.00
0.00
-45.00
SMALL
11/27/2013 8:40:42 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 2.276 in/s (1.603)
V2 0.650 in/s (0.037)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 12C - 1: # 798
2.25
1.13
0.00
-1.13
SMALL
11/27/2013 8:40:14 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.175 in/s (0.037)
V2 0.287 in/s (0.204)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 12C - 1: # 797
11.25
5.63
0.00
-5.63
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.605 in/s (0.351)
V2 0.424 in/s (0.443)
SMALL
11/27/2013 8:40:12 AM
A1: 1 ft
A2: 4 ft

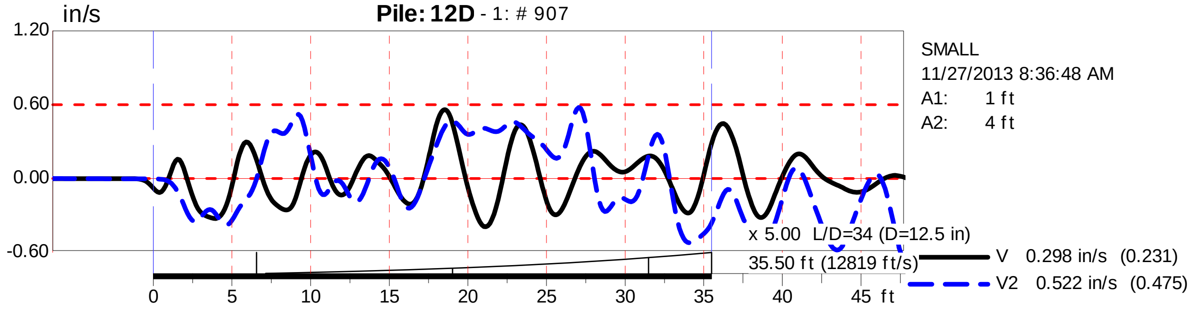

in/s
Pile: 12C - 1: # 796
9.00
4.50
0.00
-4.50
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.153 in/s (0.548)
V2 0.401 in/s (0.305)
SMALL
11/27/2013 8:40:09 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 908



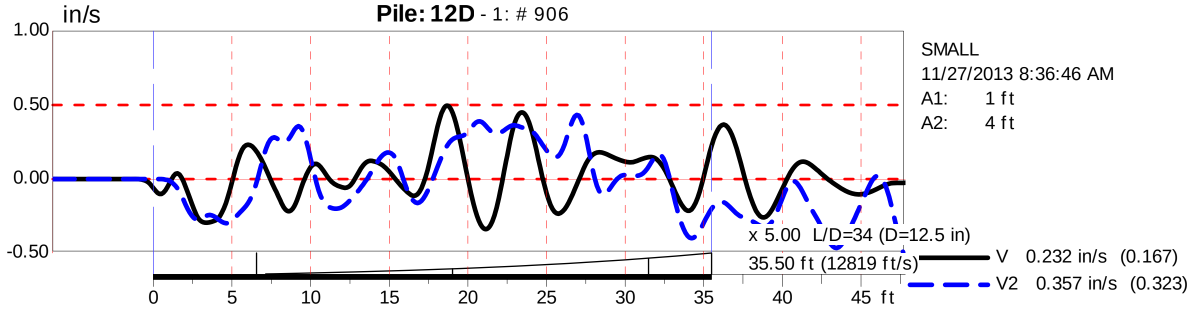
SMALL
11/27/2013 8:36:51 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 907



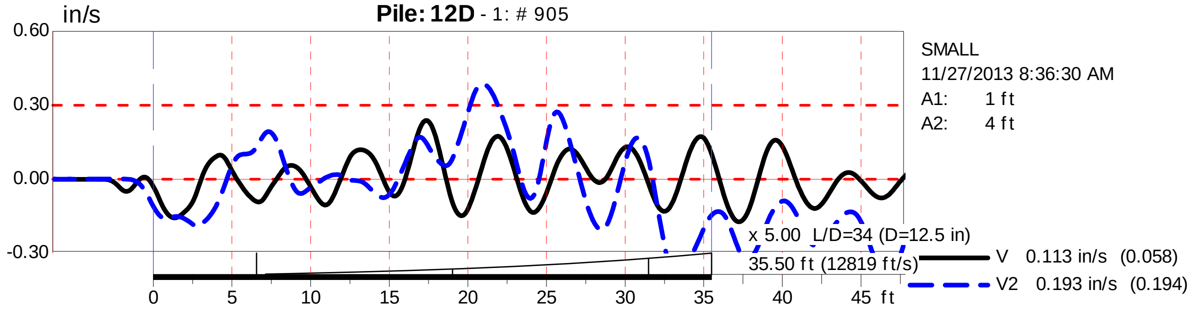
SMALL
11/27/2013 8:36:48 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 906



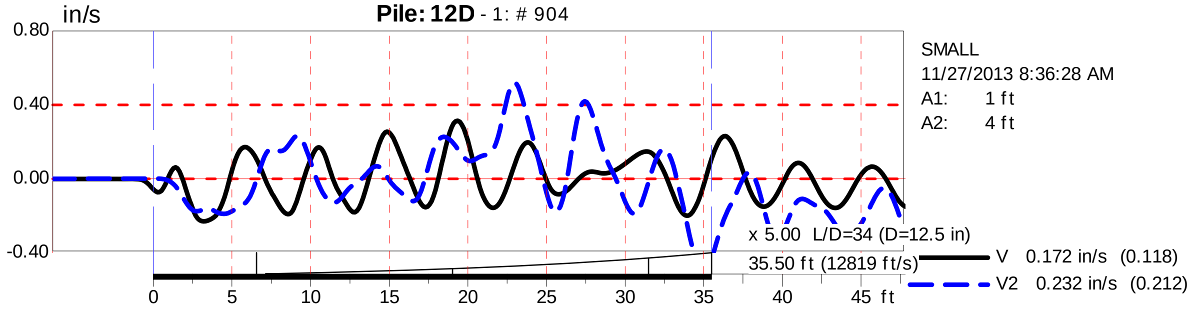
SMALL
11/27/2013 8:36:46 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 905



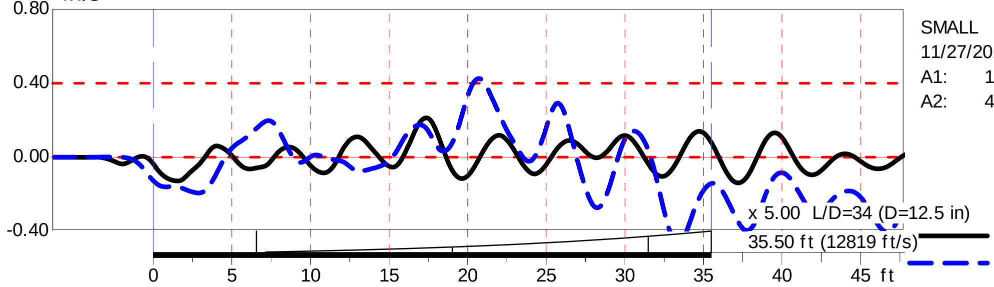
SMALL
11/27/2013 8:36:30 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 904



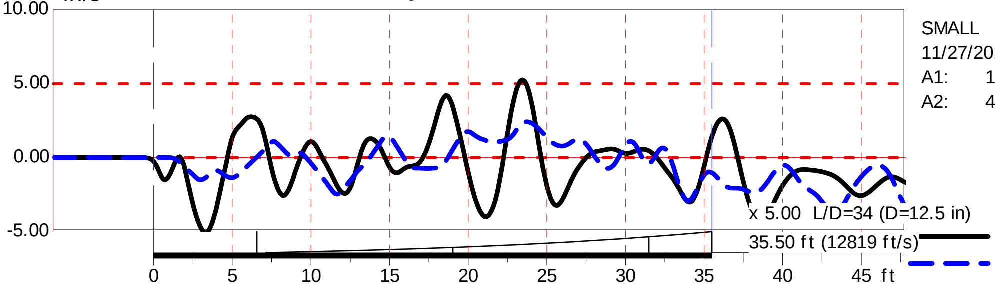
SMALL
11/27/2013 8:36:28 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 903



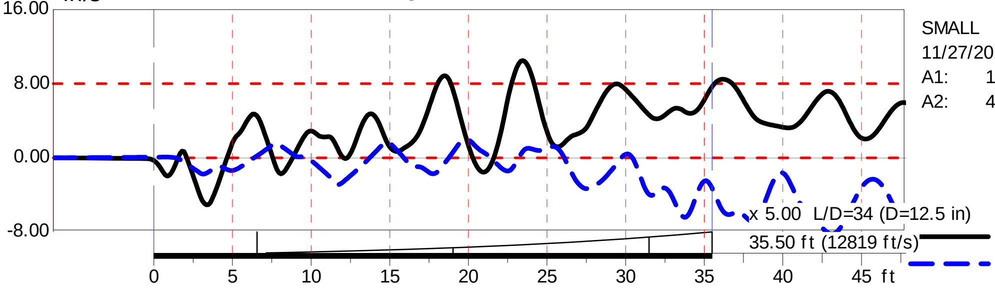
SMALL
11/27/2013 8:36:26 AM
A1: 1 ft
A2: 4 ft
V 0.108 in/s (0.027)
V2 0.198 in/s (0.199)

Pile: 12D - 1: # 902



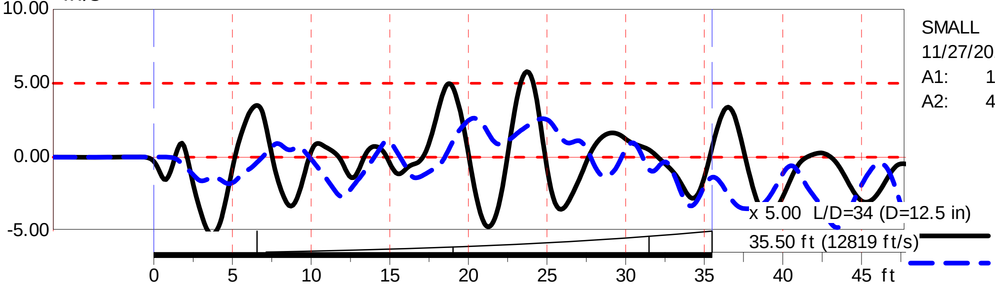
SMALL
11/27/2013 8:36:17 AM
A1: 1 ft
A2: 4 ft
V 2.760 in/s (2.461)
V2 1.086 in/s (1.033)

Pile: 12D - 1: # 901



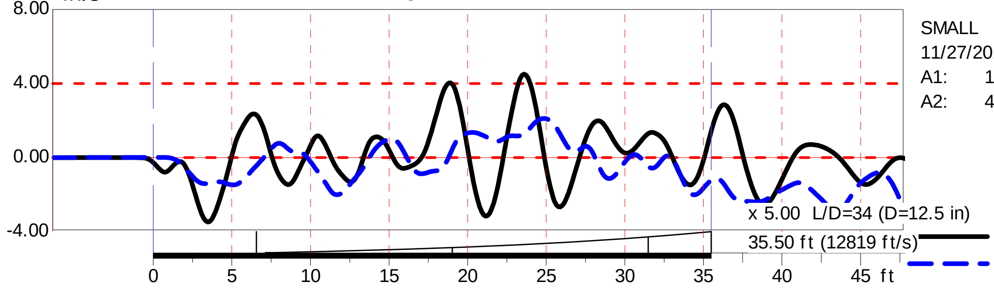
SMALL
11/27/2013 8:36:15 AM
A1: 1 ft
A2: 4 ft
V 4.726 in/s (4.617)
V2 1.577 in/s (1.392)

Pile: 12D - 1: # 900



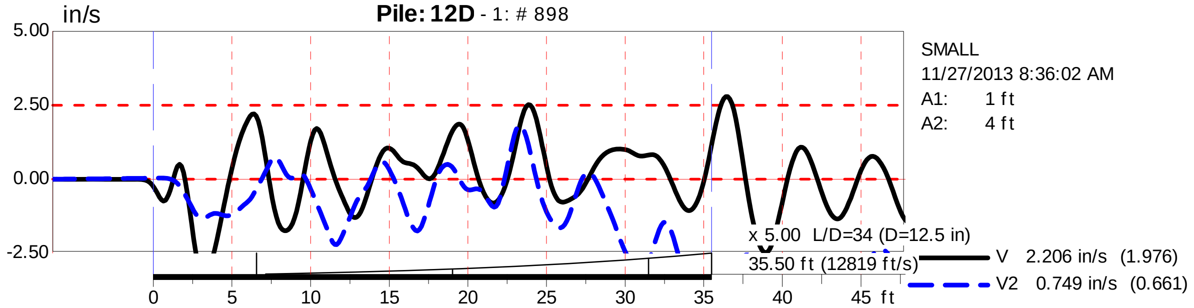
SMALL
11/27/2013 8:36:13 AM
A1: 1 ft
A2: 4 ft
V 3.496 in/s (3.182)
V2 0.930 in/s (0.850)

Pile: 12D - 1: # 899



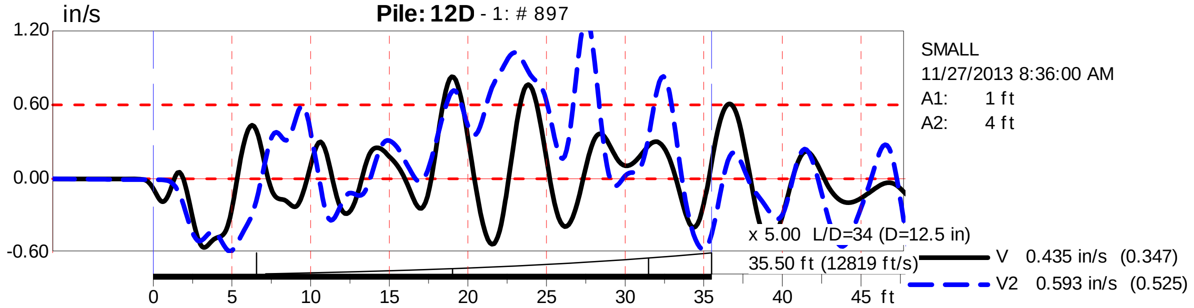
SMALL
11/27/2013 8:36:04 AM
A1: 1 ft
A2: 4 ft
V 2.366 in/s (2.141)
V2 0.777 in/s (0.722)

Pile: 12D - 1: # 898



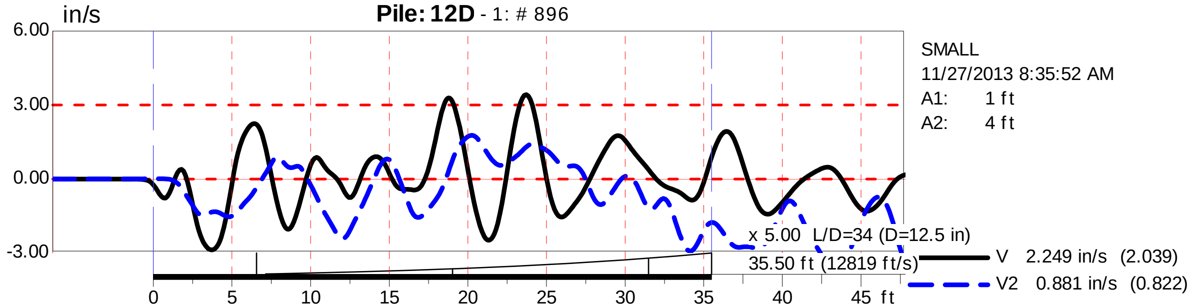
SMALL
11/27/2013 8:36:02 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 897



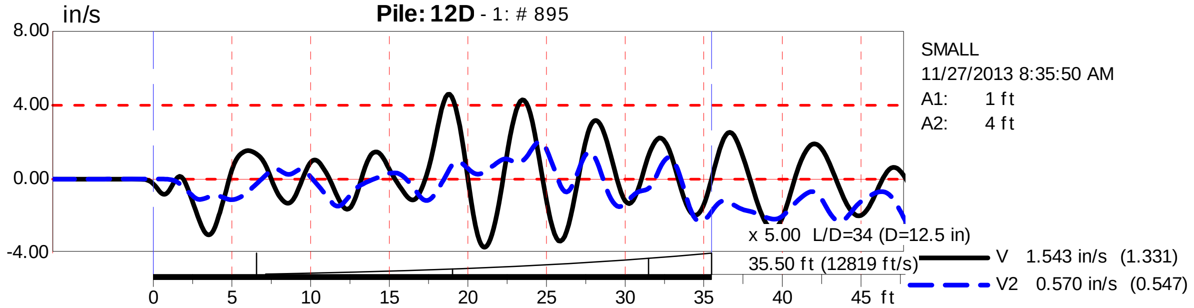
SMALL
11/27/2013 8:36:00 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 896



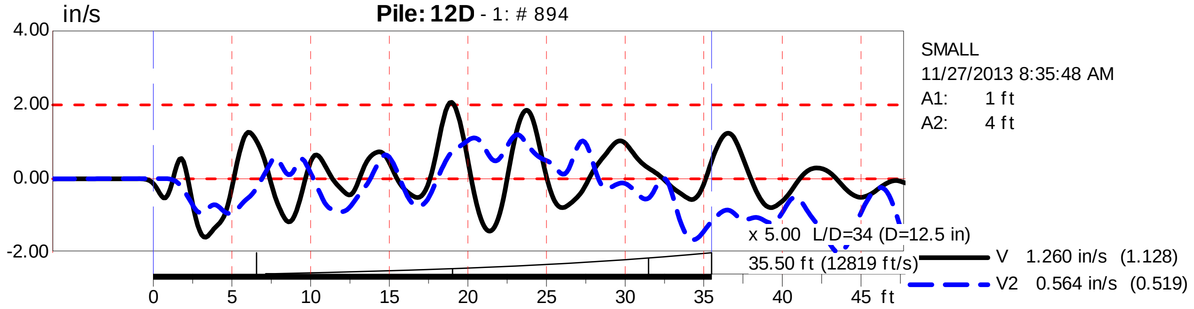
SMALL
11/27/2013 8:35:52 AM
A1: 1 ft
A2: 4 ft

Pile: 12D - 1: # 895

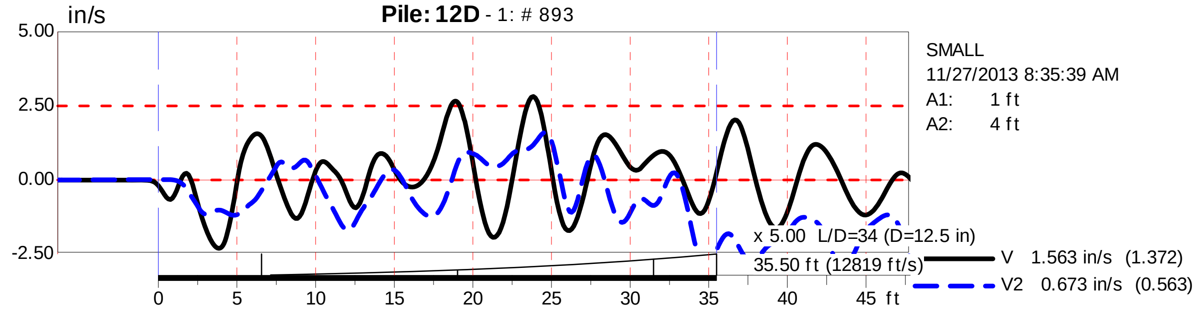


SMALL
11/27/2013 8:35:50 AM
A1: 1 ft
A2: 4 ft

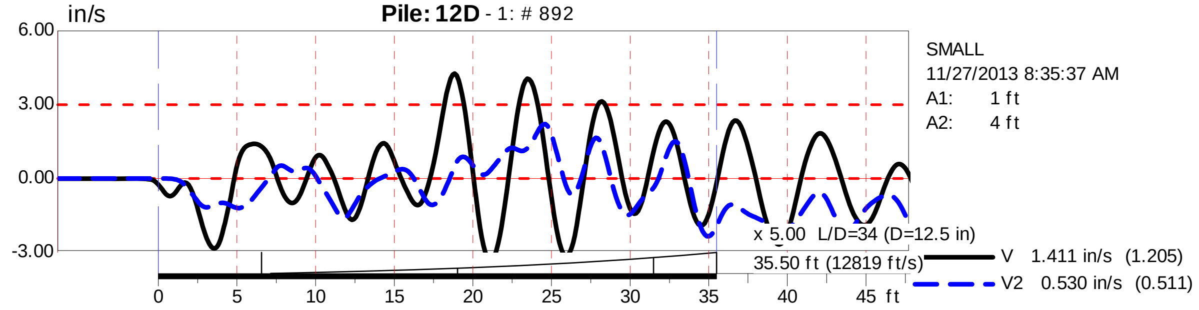
Pile: 12D - 1: # 894



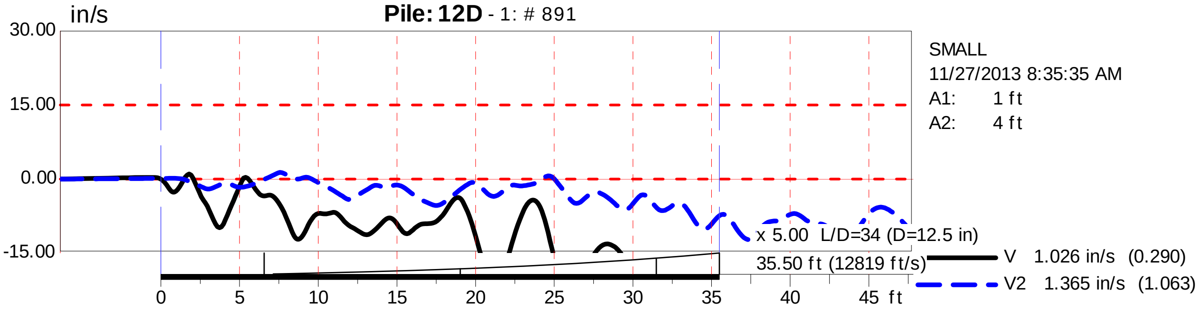
SMALL
11/27/2013 8:35:48 AM
A1: 1 ft
A2: 4 ft



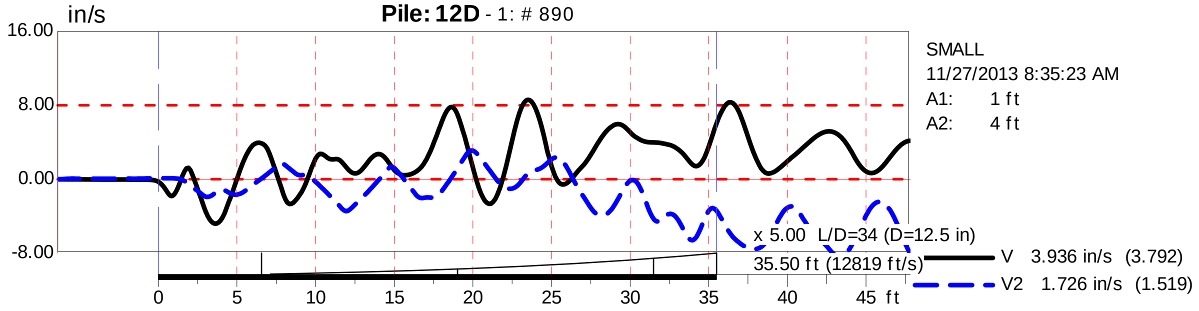
Pile: 12D - 1: # 893



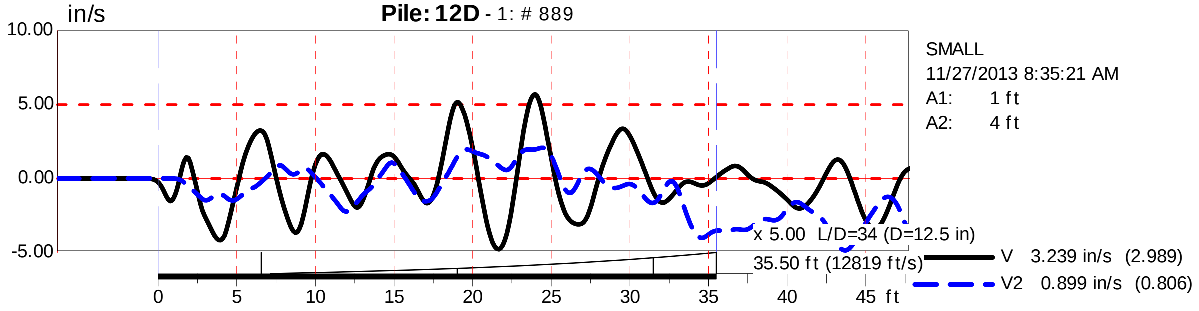
Pile: 12D - 1: # 892



Pile: 12D - 1: # 891



Pile: 12D - 1: # 890

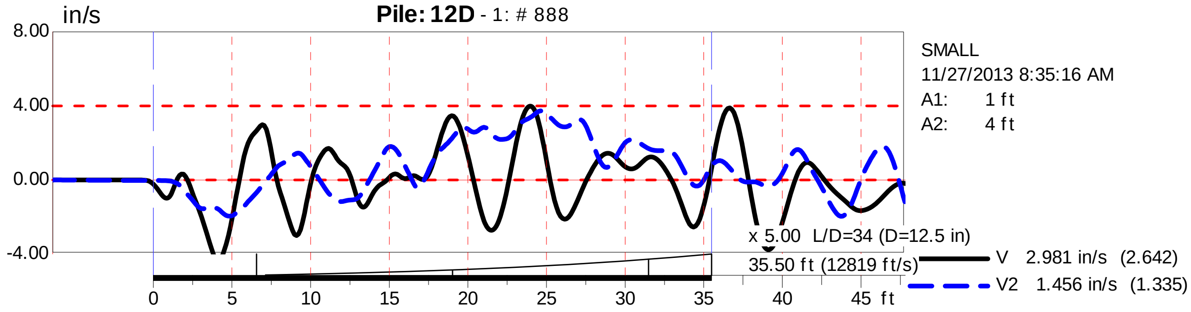


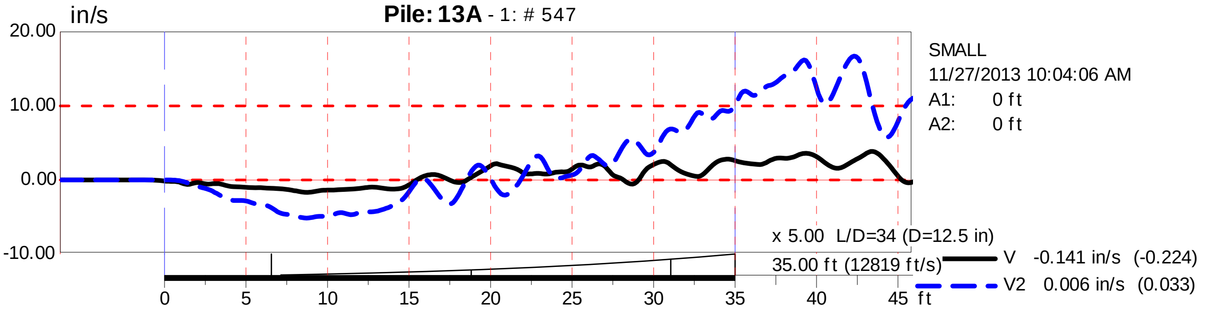
Pile: 12D - 1: # 889

Pile Dynamics, Inc. 12/29/2013

PIT Raw data

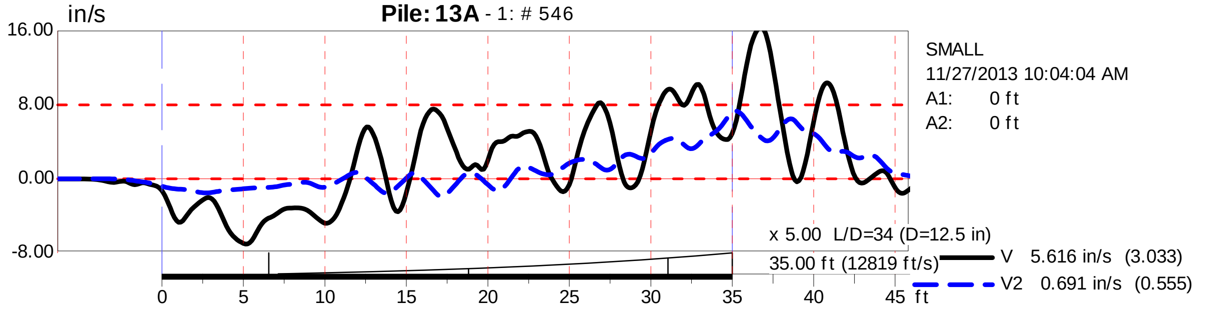
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO





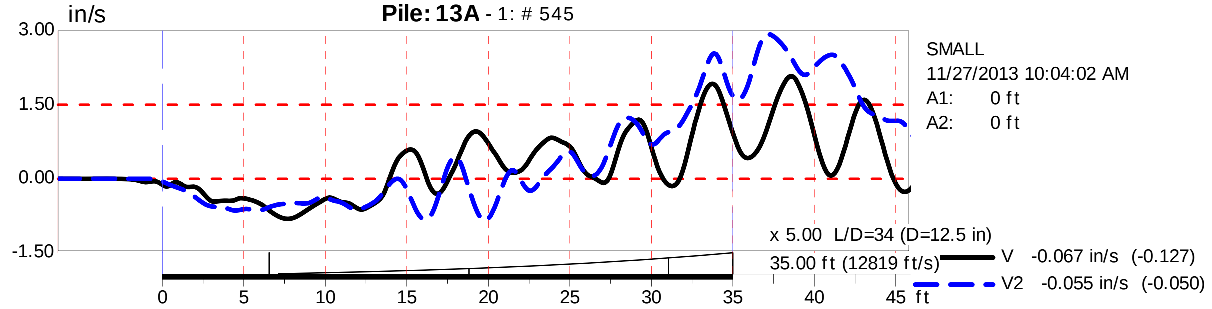
Pile: 13A - 1: # 547

SMALL
11/27/2013 10:04:06 AM
A1: 0 ft
A2: 0 ft



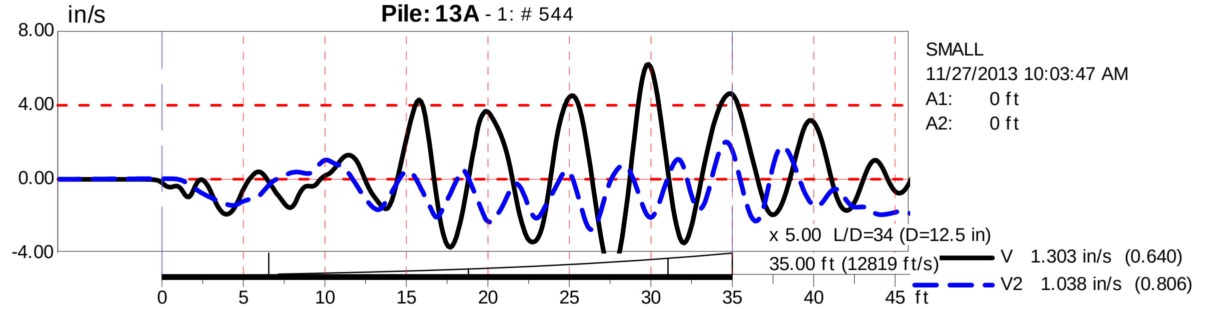
Pile: 13A - 1: # 546

SMALL
11/27/2013 10:04:04 AM
A1: 0 ft
A2: 0 ft



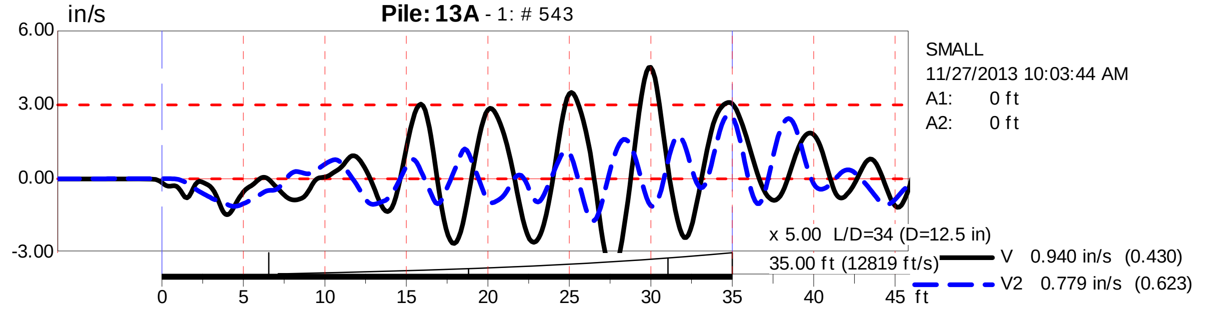
Pile: 13A - 1: # 545

SMALL
11/27/2013 10:04:02 AM
A1: 0 ft
A2: 0 ft



Pile: 13A - 1: # 544

SMALL
11/27/2013 10:03:47 AM
A1: 0 ft
A2: 0 ft

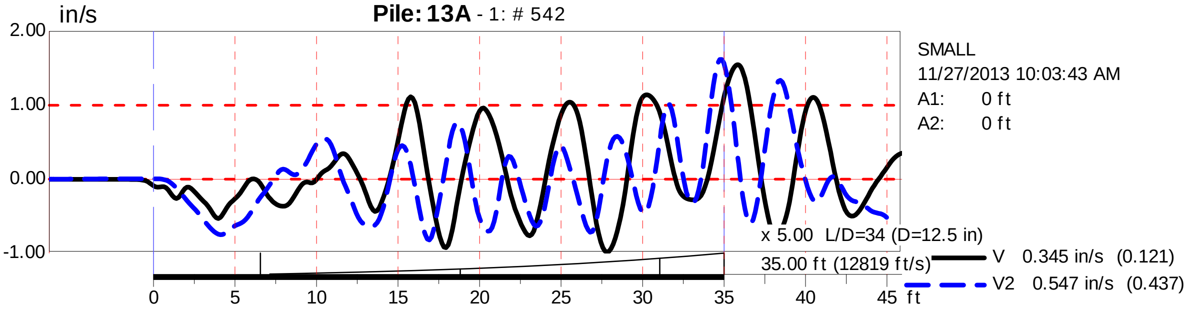


Pile: 13A - 1: # 543

SMALL
11/27/2013 10:03:44 AM
A1: 0 ft
A2: 0 ft

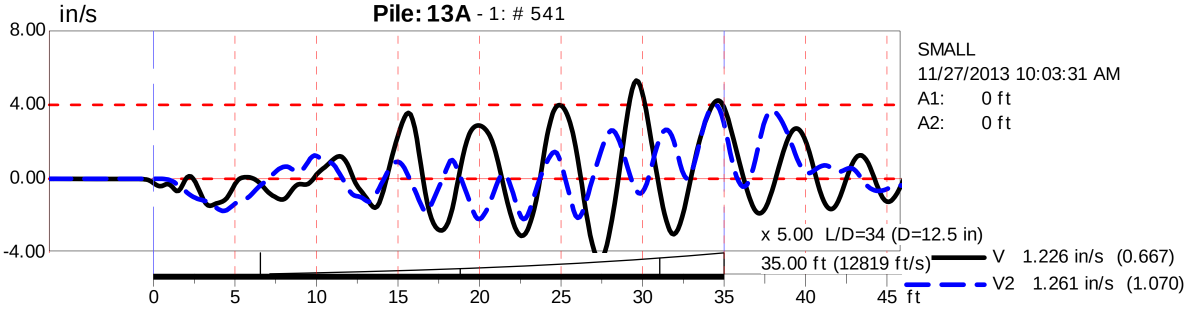
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

Pile: 13A - 1: # 542



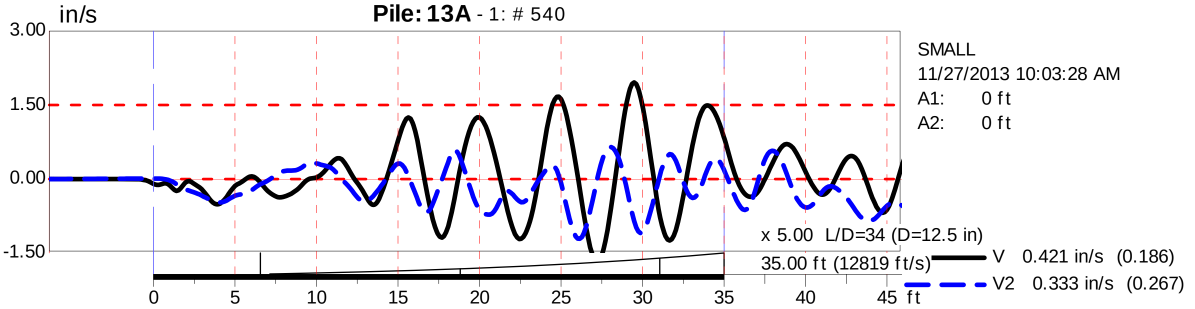
SMALL
11/27/2013 10:03:43 AM
A1: 0 ft
A2: 0 ft

Pile: 13A - 1: # 541



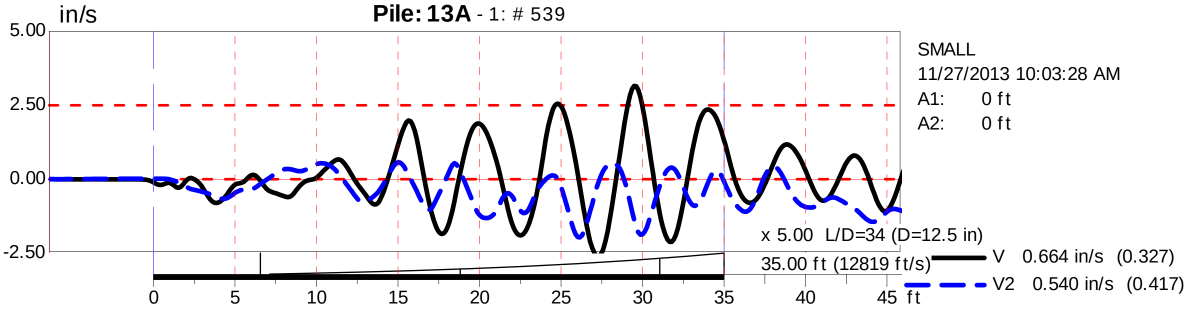
SMALL
11/27/2013 10:03:31 AM
A1: 0 ft
A2: 0 ft

Pile: 13A - 1: # 540



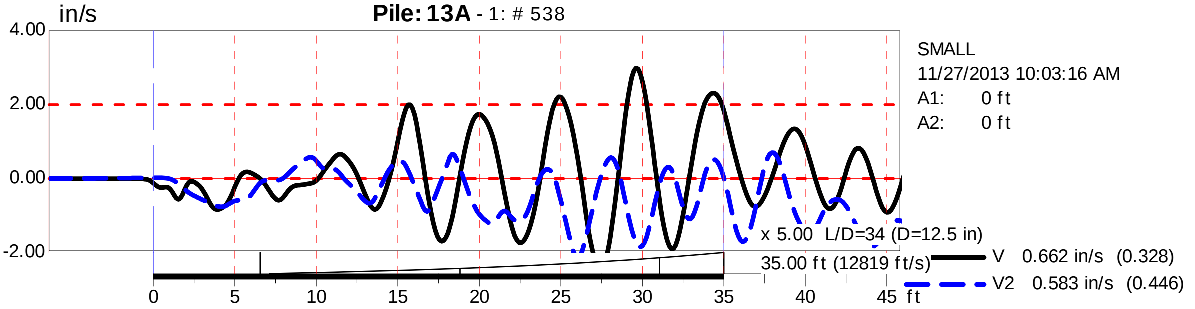
SMALL
11/27/2013 10:03:28 AM
A1: 0 ft
A2: 0 ft

Pile: 13A - 1: # 539

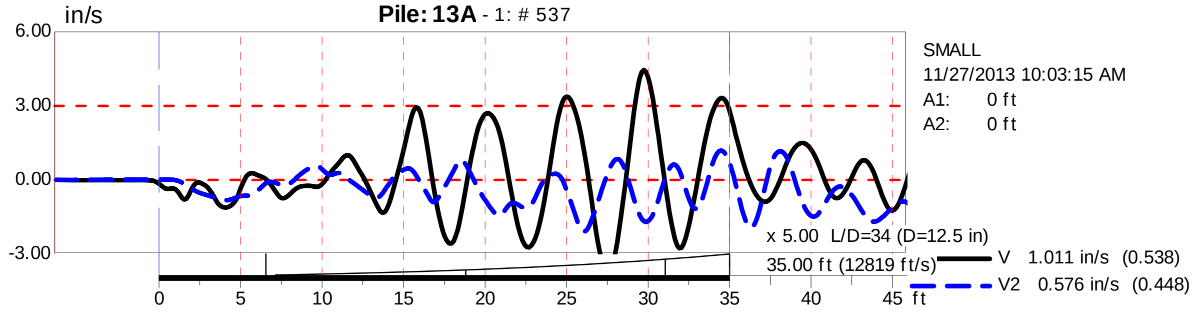


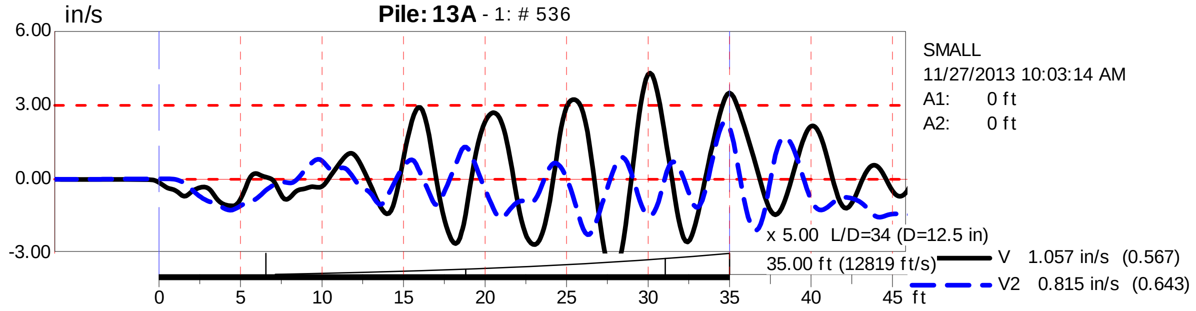
SMALL
11/27/2013 10:03:28 AM
A1: 0 ft
A2: 0 ft

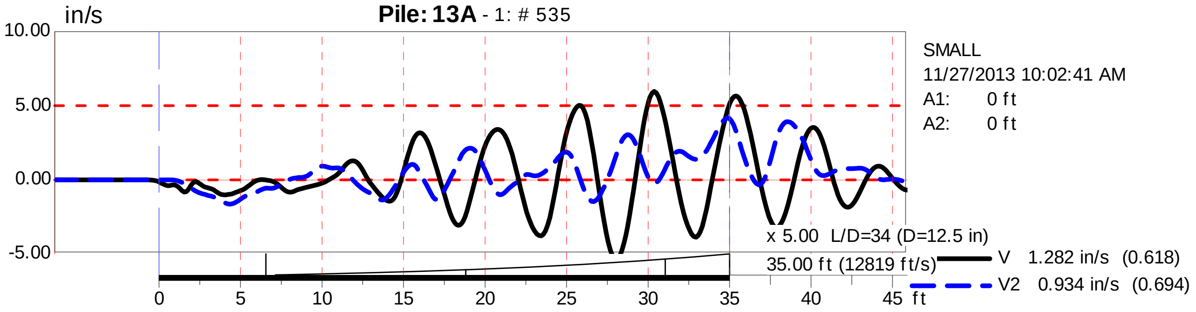
Pile: 13A - 1: # 538

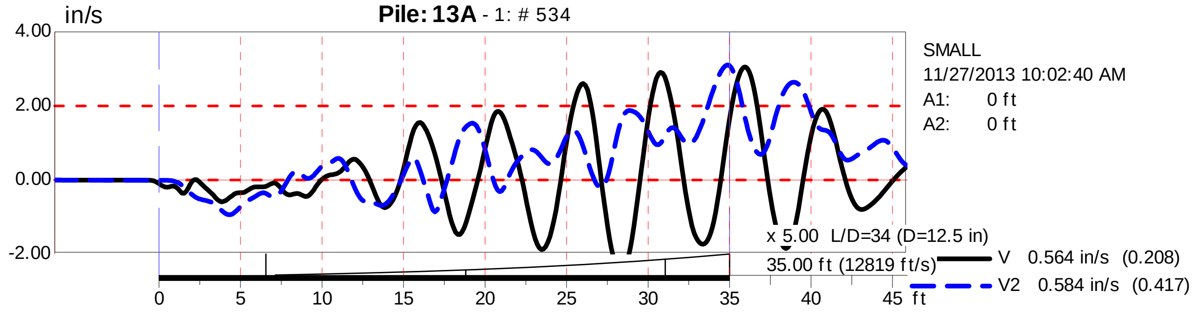


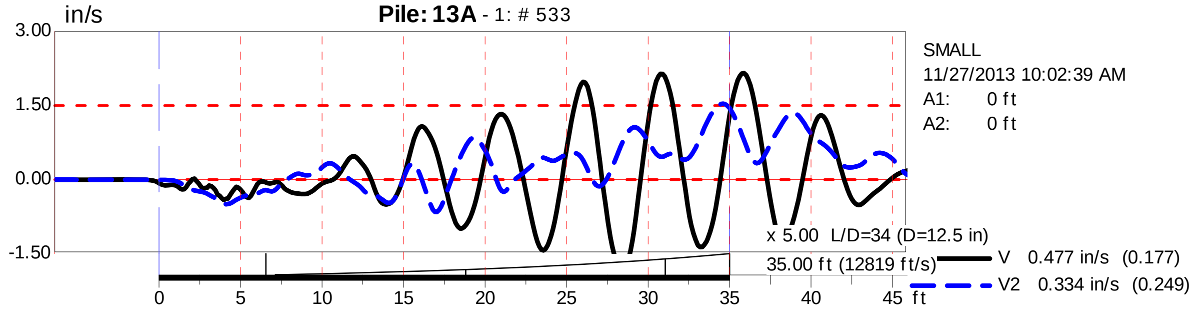
SMALL
11/27/2013 10:03:16 AM
A1: 0 ft
A2: 0 ft

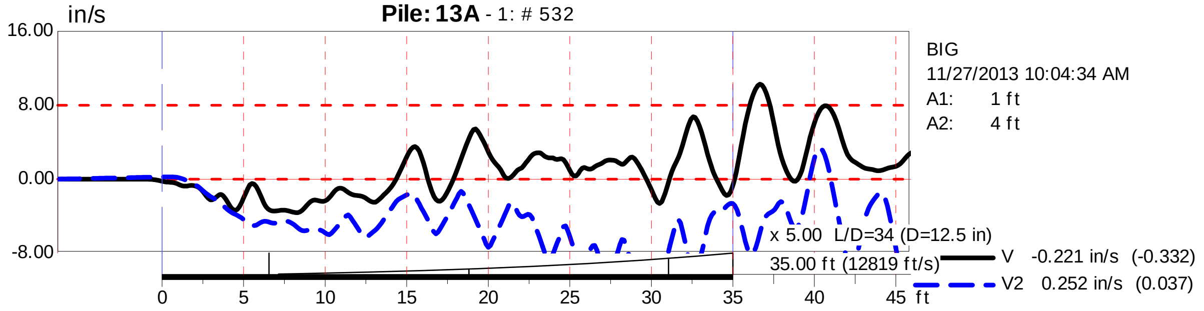

in/s
Pile: 13A - 1: # 537
6.00
3.00
0.00
-3.00
SMALL
11/27/2013 10:03:15 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.011 in/s (0.538)
V2 0.576 in/s (0.448)
0
5
10
15
20
25
30
35
40
45 ft

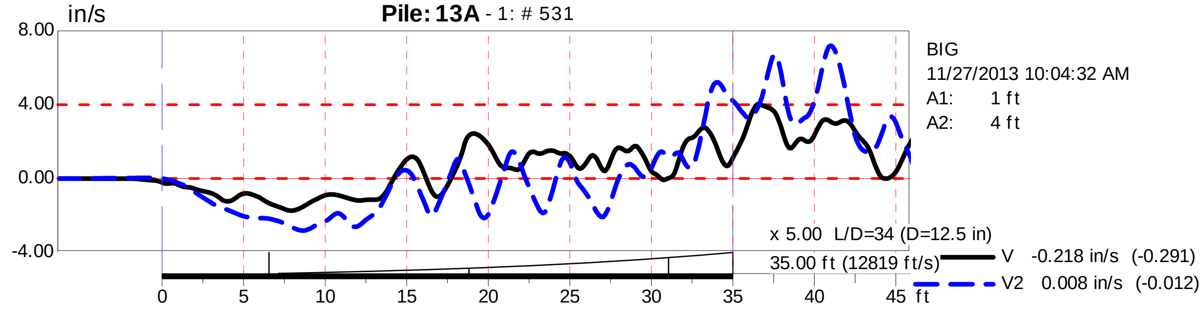

in/s
Pile: 13A - 1: # 536
6.00
3.00
0.00
-3.00
SMALL
11/27/2013 10:03:14 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.057 in/s (0.567)
V2 0.815 in/s (0.643)
0
5
10
15
20
25
30
35
40
45 ft

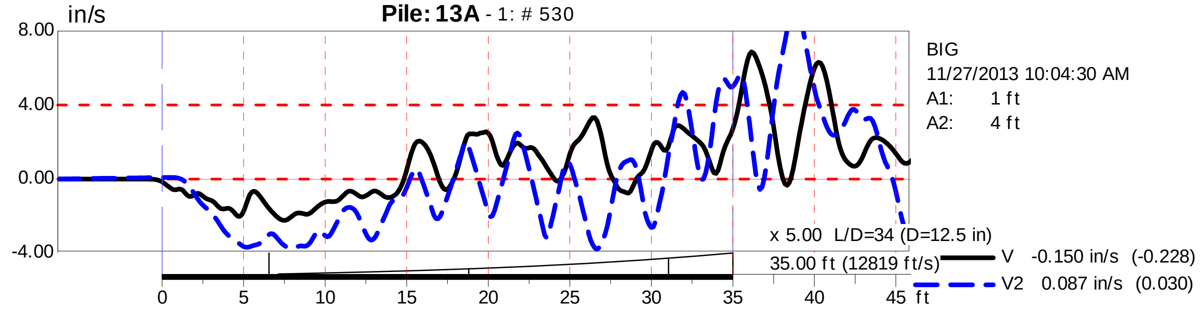

in/s
Pile: 13A - 1: # 535
10.00
5.00
0.00
-5.00
SMALL
11/27/2013 10:02:41 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.282 in/s (0.618)
V2 0.934 in/s (0.694)
0
5
10
15
20
25
30
35
40
45 ft

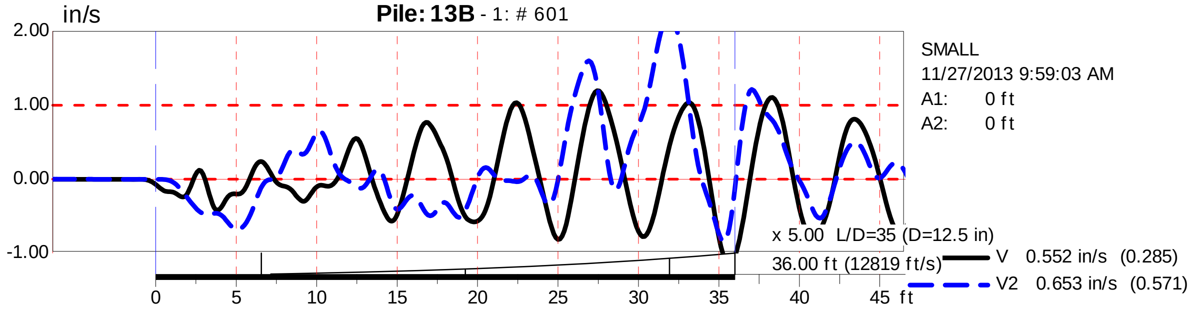

in/s
Pile: 13A - 1: # 534
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:02:40 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.564 in/s (0.208)
V2 0.584 in/s (0.417)
0
5
10
15
20
25
30
35
40
45 ft

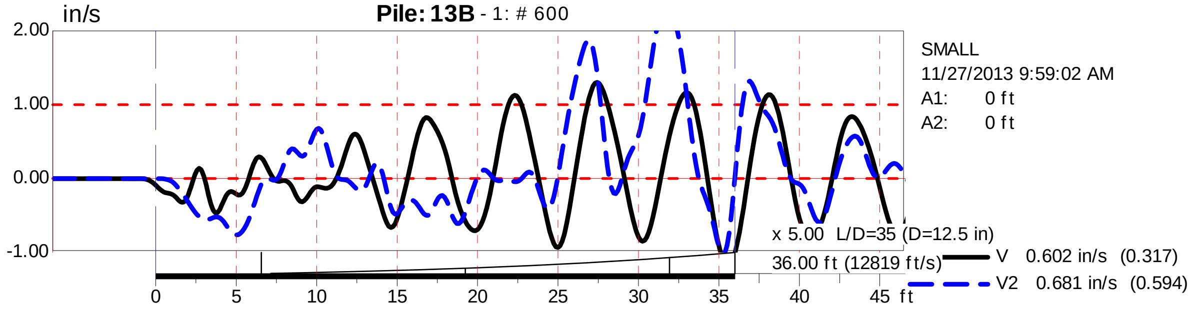

in/s
Pile: 13A - 1: # 533
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 10:02:39 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.477 in/s (0.177)
V2 0.334 in/s (0.249)
0
5
10
15
20
25
30
35
40
45 ft

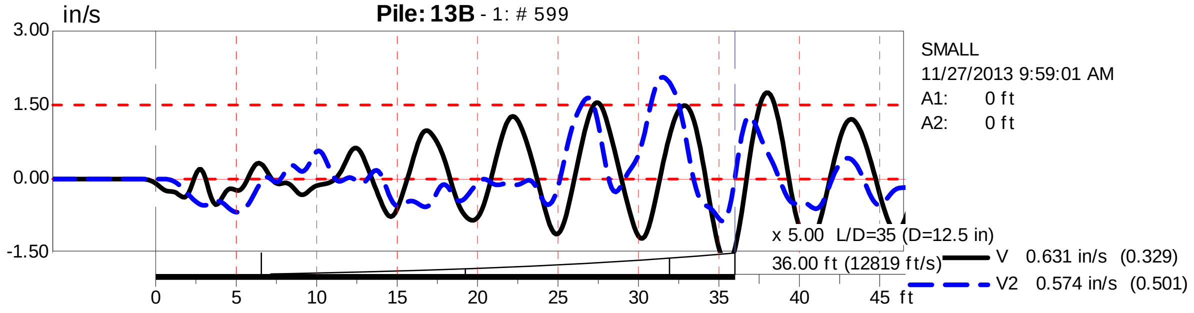

in/s
Pile: 13A - 1: # 532
16.00
8.00
0.00
-8.00
BIG
11/27/2013 10:04:34 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V -0.221 in/s (-0.332)
V2 0.252 in/s (0.037)
0
5
10
15
20
25
30
35
40
45 ft

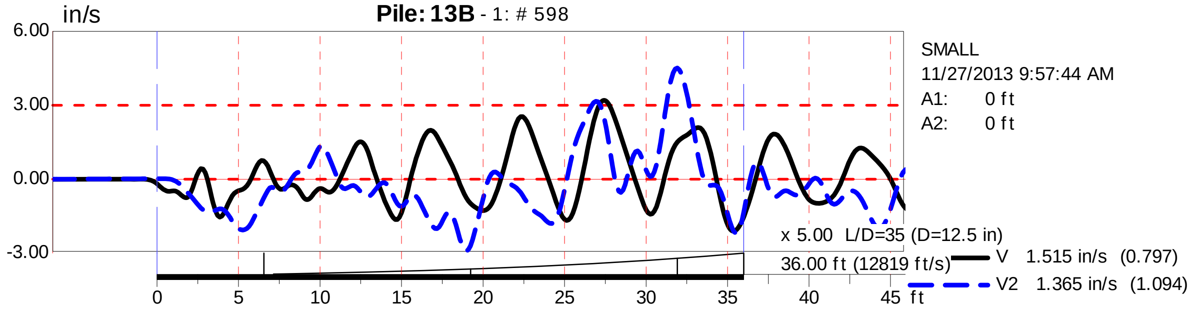

in/s
Pile: 13A - 1: # 531
8.00
4.00
0.00
-4.00
BIG
11/27/2013 10:04:32 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V -0.218 in/s (-0.291)
V2 0.008 in/s (-0.012)
0
5
10
15
20
25
30
35
40
45 ft

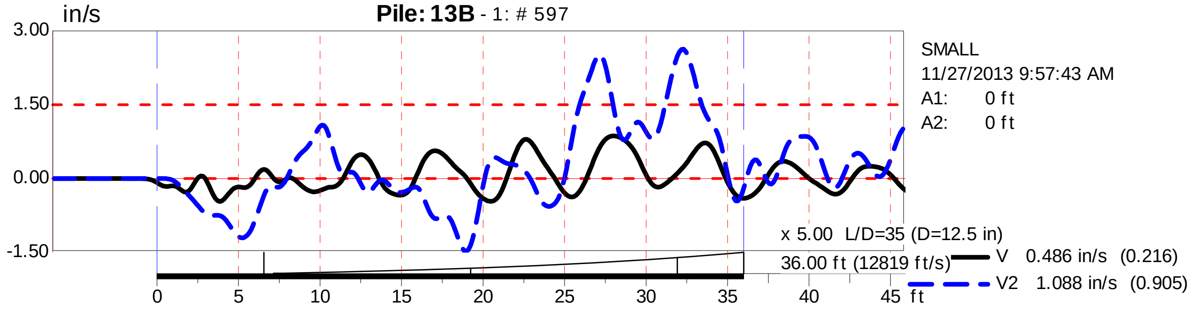

in/s
Pile: 13A - 1: # 530
8.00
4.00
0.00
-4.00
BIG
11/27/2013 10:04:30 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V -0.150 in/s (-0.228)
V2 0.087 in/s (0.030)
0
5
10
15
20
25
30
35
40
45 ft

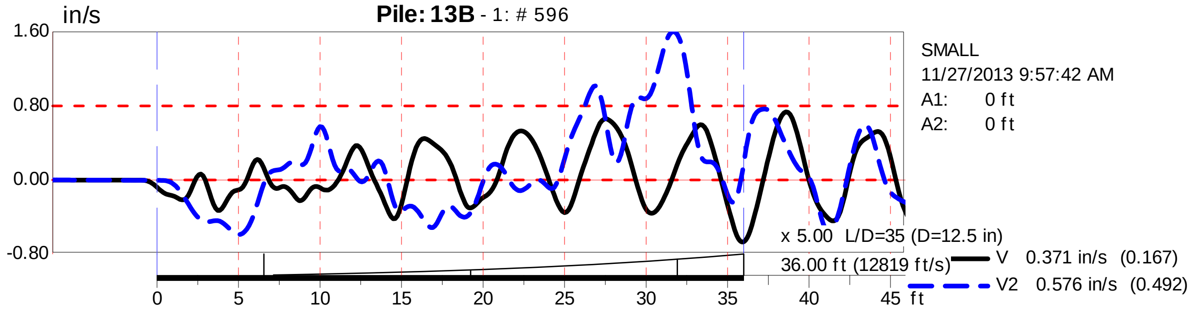

in/s
Pile: 13B - 1: # 601
2.00
1.00
0.00
-1.00
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 9:59:03 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.552 in/s (0.285)
V2 0.653 in/s (0.571)

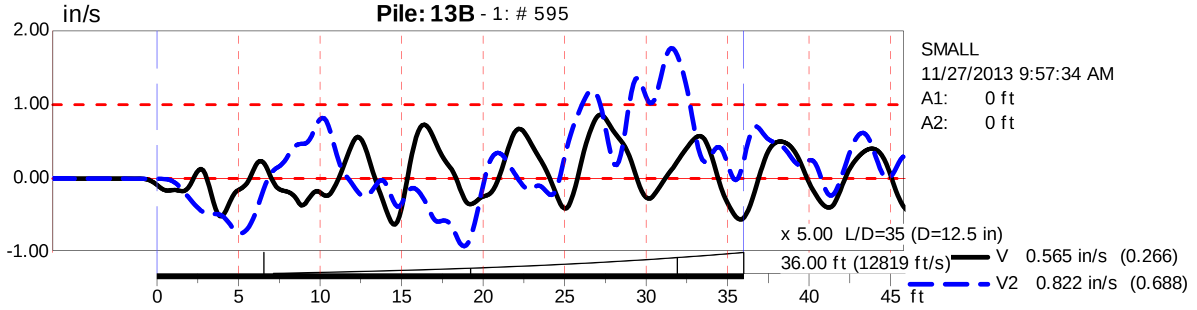

in/s
Pile: 13B - 1: # 600
2.00
1.00
0.00
-1.00
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 9:59:02 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.602 in/s (0.317)
V2 0.681 in/s (0.594)

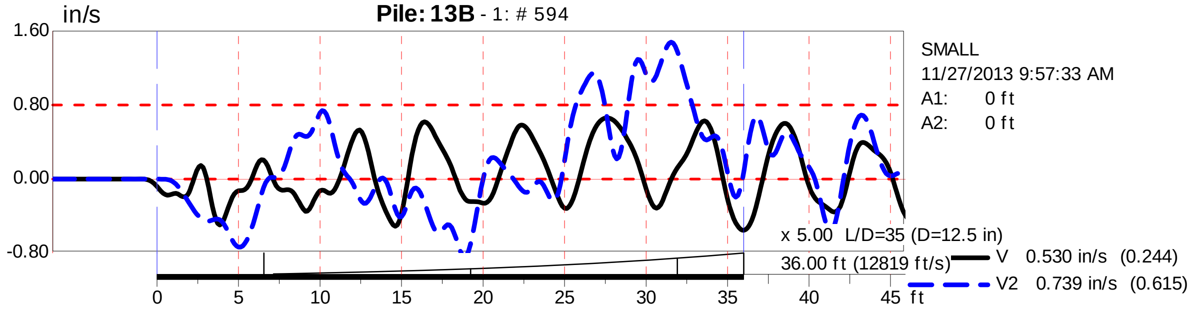

in/s
Pile: 13B - 1: # 599
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 9:59:01 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.631 in/s (0.329)
V2 0.574 in/s (0.501)

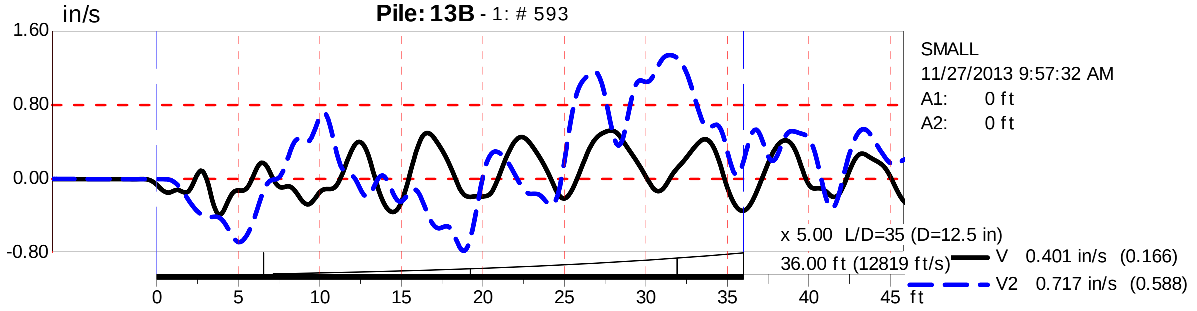

in/s
Pile: 13B - 1: # 598
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 9:57:44 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.515 in/s (0.797)
V2 1.365 in/s (1.094)

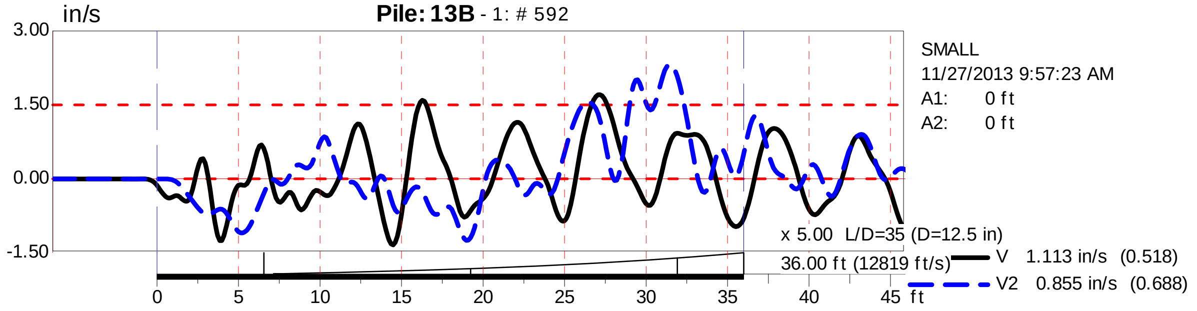

in/s
Pile: 13B - 1: # 597
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 9:57:43 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.486 in/s (0.216)
V2 1.088 in/s (0.905)

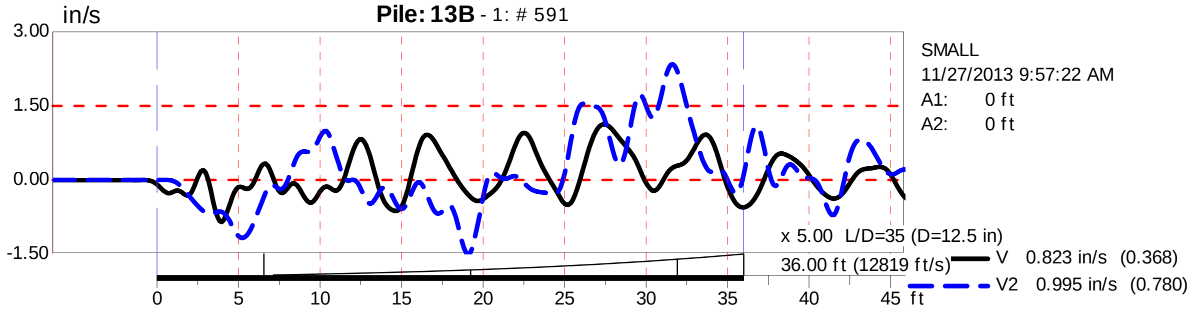

in/s
Pile: 13B - 1: # 596
1.60
0.80
0.00
-0.80
0
5
10
15
20
25
30
35
40
45
ft
SMALL
11/27/2013 9:57:42 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.371 in/s (0.167)
V2 0.576 in/s (0.492)

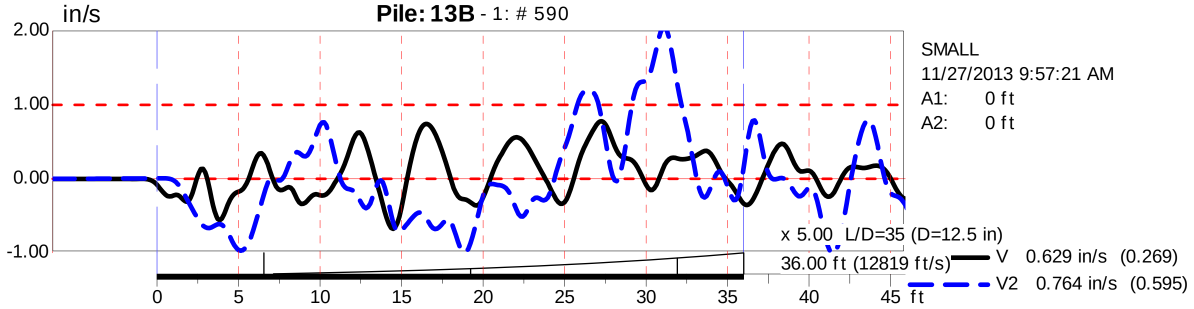

in/s
Pile: 13B - 1: # 595
2.00
1.00
0.00
-1.00
0
5
10
15
20
25
30
35
40
45
ft
SMALL
11/27/2013 9:57:34 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.565 in/s (0.266)
V2 0.822 in/s (0.688)

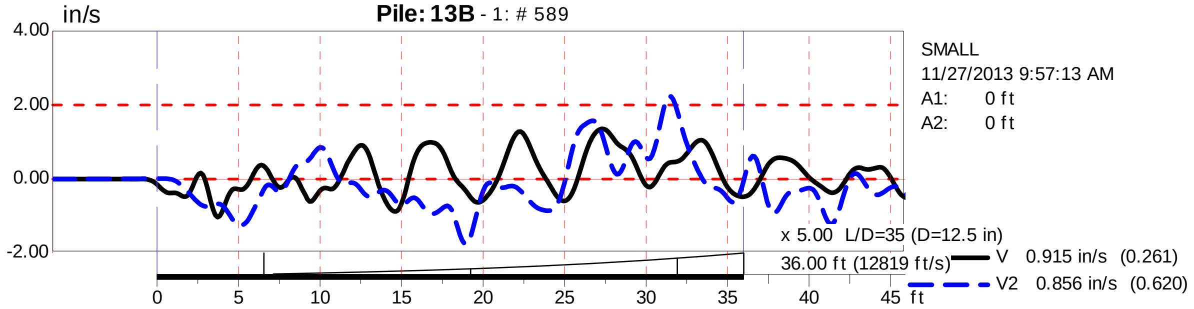

in/s
Pile: 13B - 1: # 594
1.60
0.80
0.00
-0.80
0
5
10
15
20
25
30
35
40
45
ft
SMALL
11/27/2013 9:57:33 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.530 in/s (0.244)
V2 0.739 in/s (0.615)

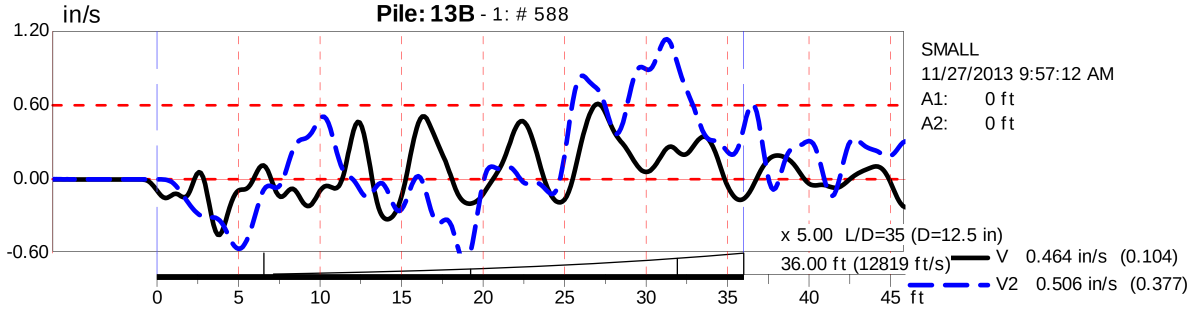

in/s
Pile: 13B - 1: # 593
1.60
0.80
0.00
-0.80
0
5
10
15
20
25
30
35
40
45
ft
SMALL
11/27/2013 9:57:32 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.401 in/s (0.166)
V2 0.717 in/s (0.588)

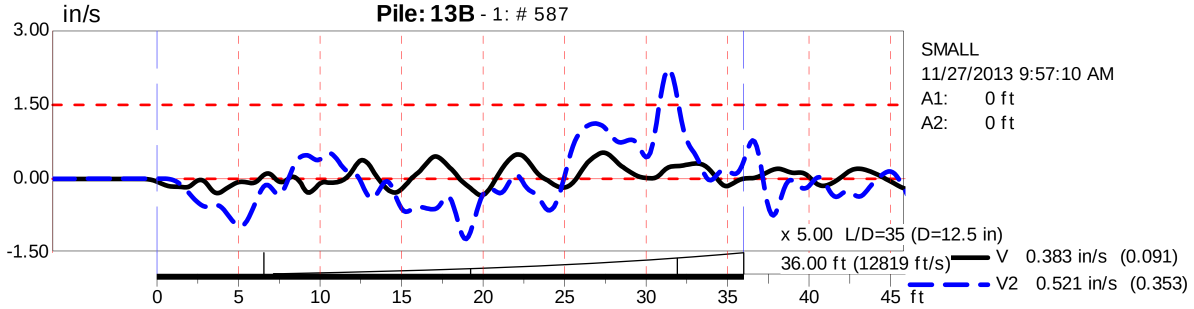

in/s
Pile: 13B - 1: # 592
3.00
1.50
0.00
-1.50
0
5
10
15
20
25
30
35
40
45
ft
SMALL
11/27/2013 9:57:23 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.113 in/s (0.518)
V2 0.855 in/s (0.688)


in/s
Pile: 13B - 1: # 591
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 9:57:22 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.823 in/s (0.368)
V2 0.995 in/s (0.780)
0
5
10
15
20
25
30
35
40
45 ft

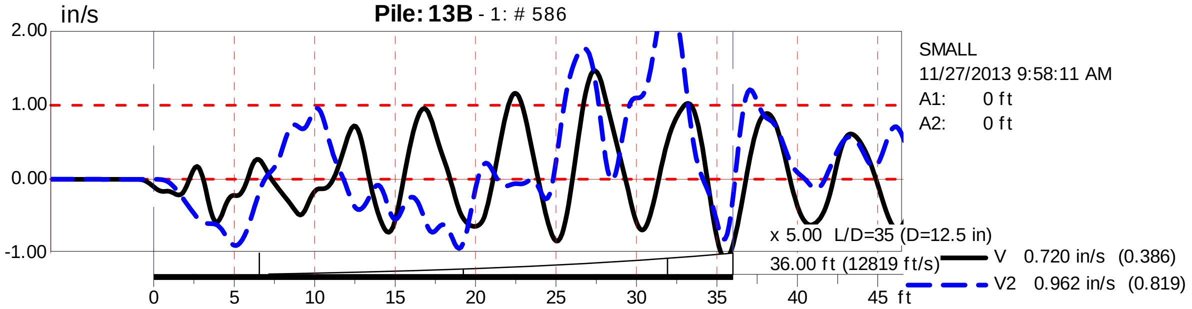

in/s
Pile: 13B - 1: # 590
2.00
1.00
0.00
-1.00
SMALL
11/27/2013 9:57:21 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.629 in/s (0.269)
V2 0.764 in/s (0.595)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 13B - 1: # 589
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 9:57:13 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.915 in/s (0.261)
V2 0.856 in/s (0.620)
0
5
10
15
20
25
30
35
40
45 ft

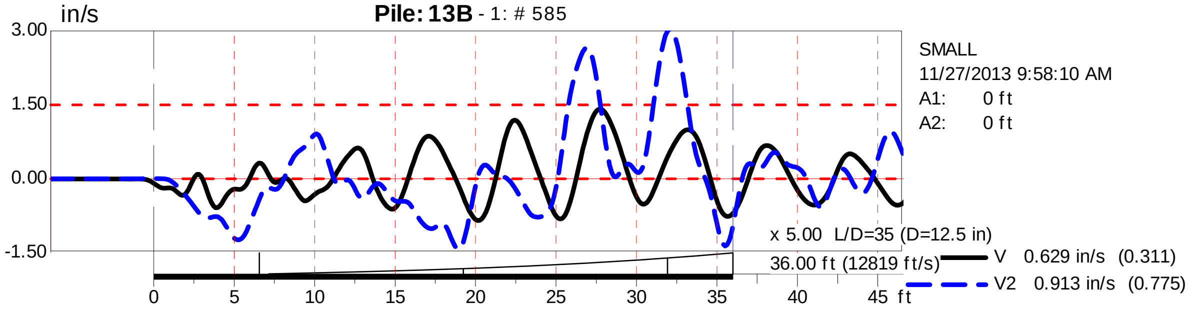

in/s
Pile: 13B - 1: # 588
1.20
0.60
0.00
-0.60
SMALL
11/27/2013 9:57:12 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.464 in/s (0.104)
V2 0.506 in/s (0.377)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 13B - 1: # 587
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 9:57:10 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.383 in/s (0.091)
V2 0.521 in/s (0.353)
0
5
10
15
20
25
30
35
40
45 ft

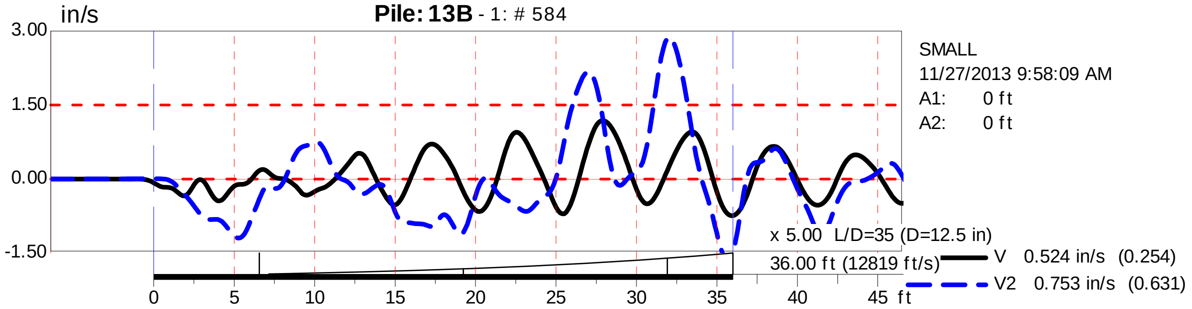
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO


Pile: 13B - 1: # 586

SMALL
11/27/2013 9:58:11 AM
A1: 0 ft
A2: 0 ft

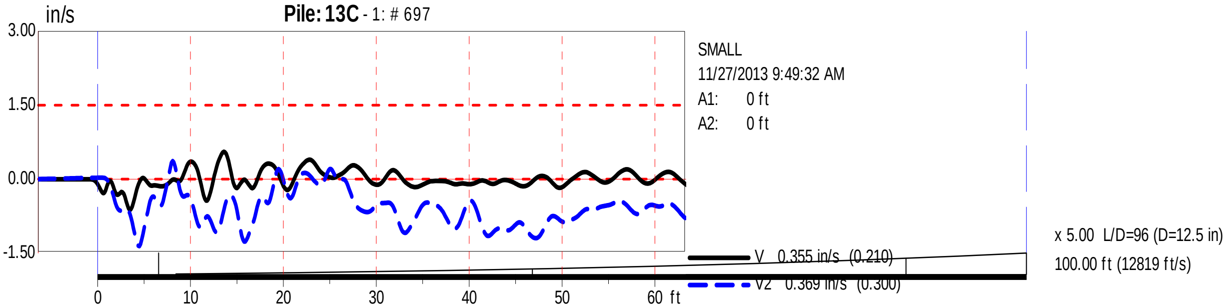

Pile: 13B - 1: # 585

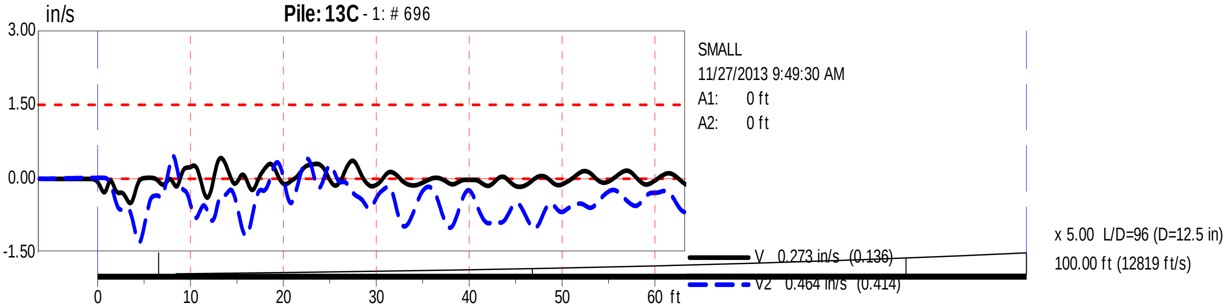
SMALL
11/27/2013 9:58:10 AM
A1: 0 ft
A2: 0 ft

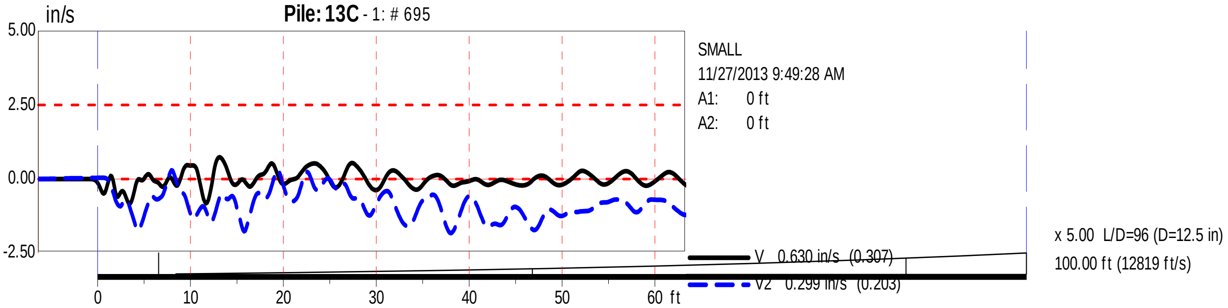

Pile: 13B - 1: # 584

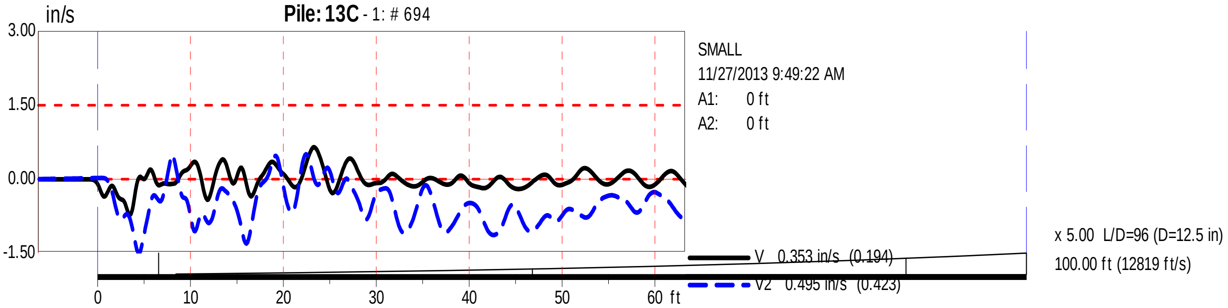
SMALL
11/27/2013 9:58:09 AM
A1: 0 ft
A2: 0 ft

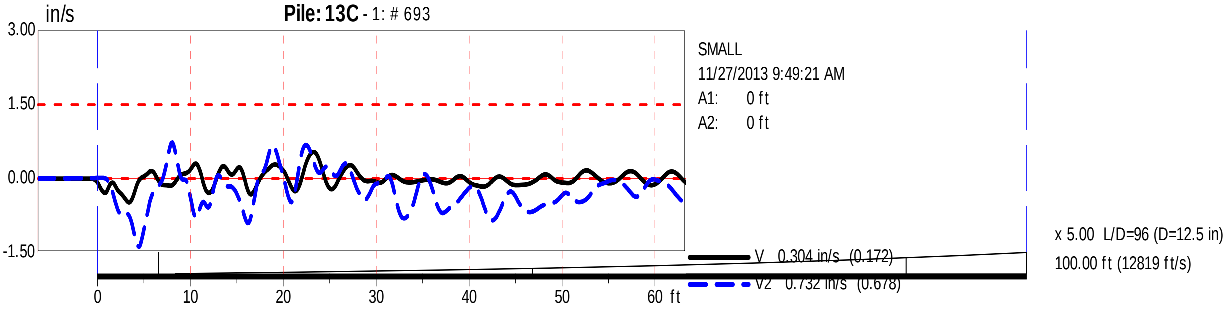
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



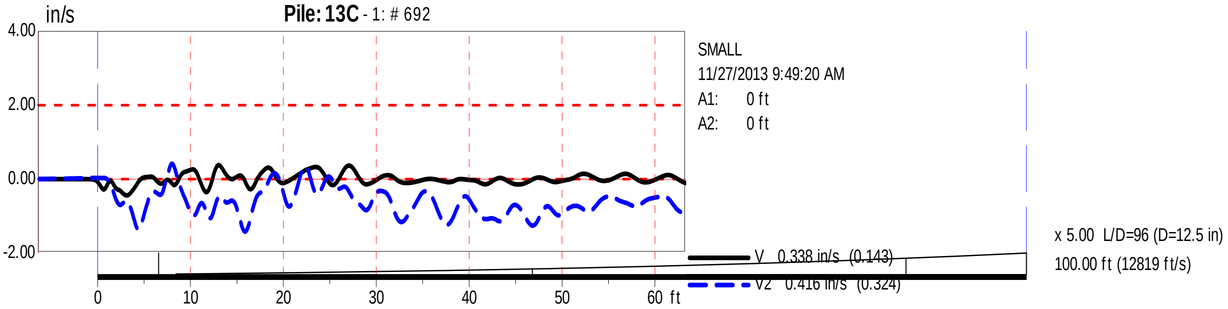


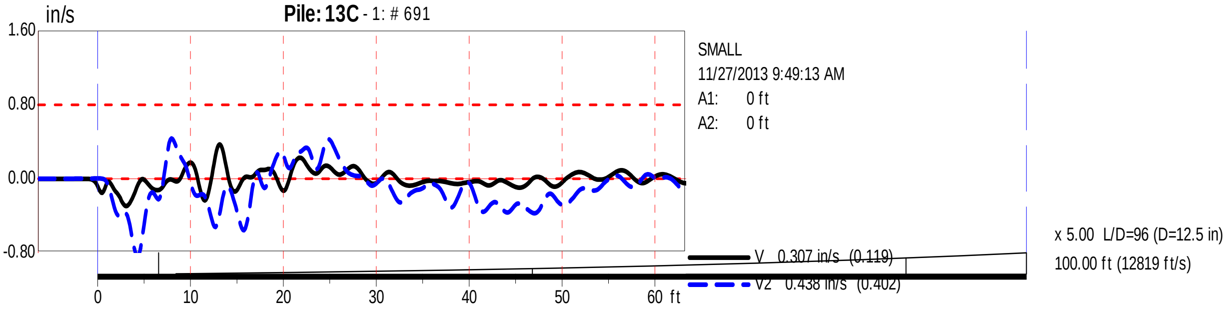


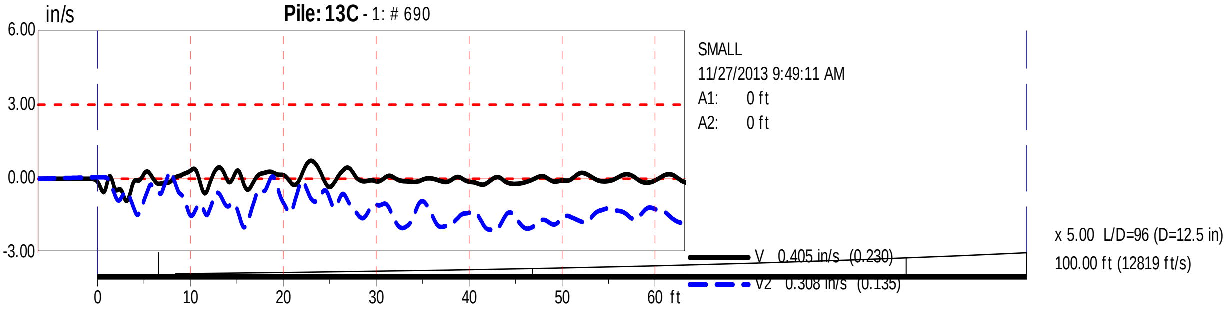


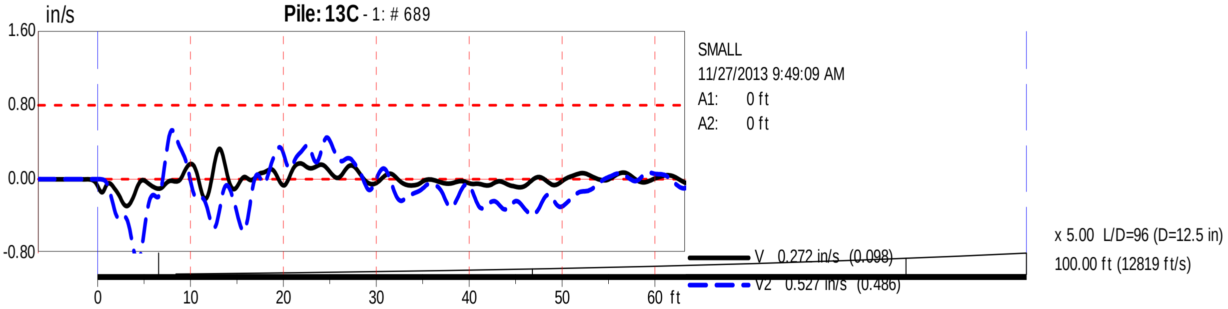


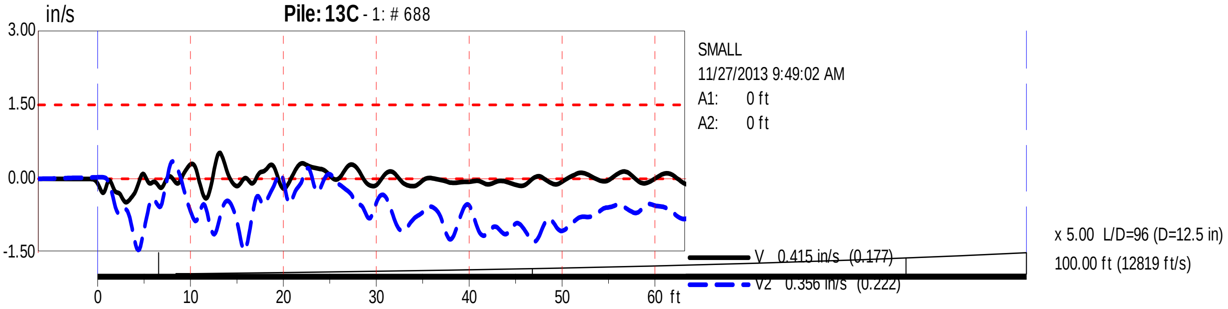
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

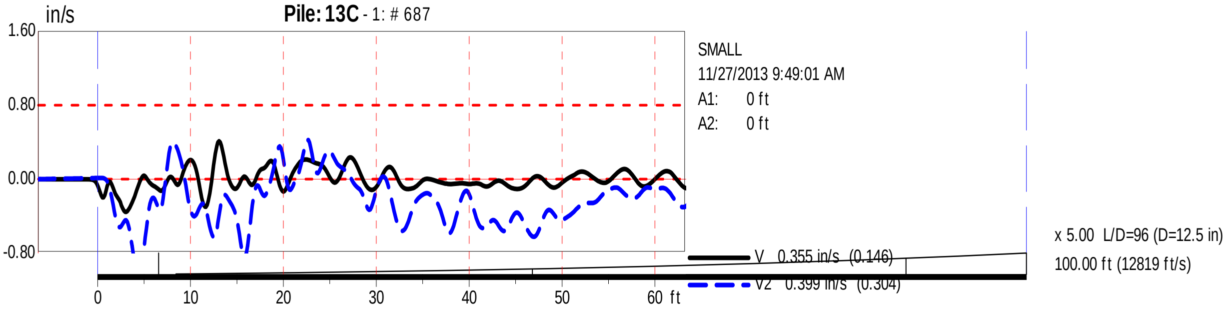




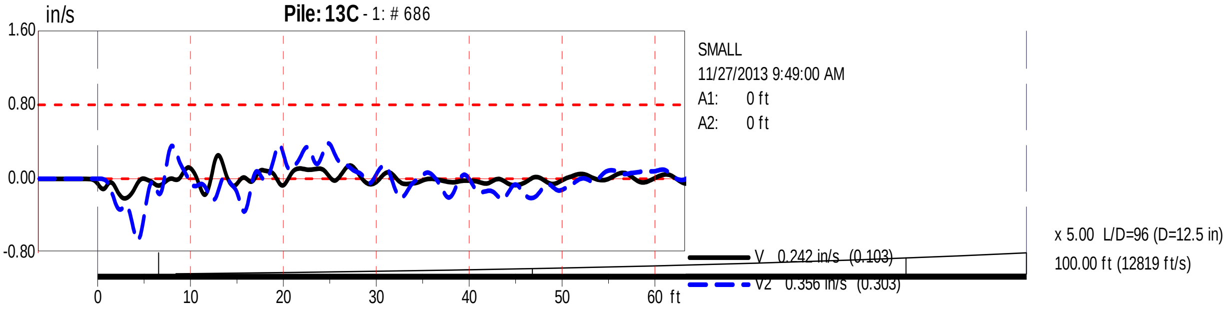




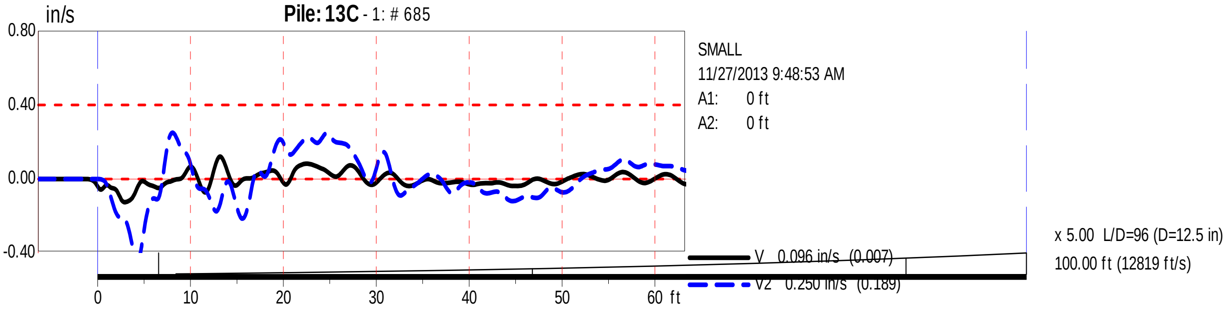




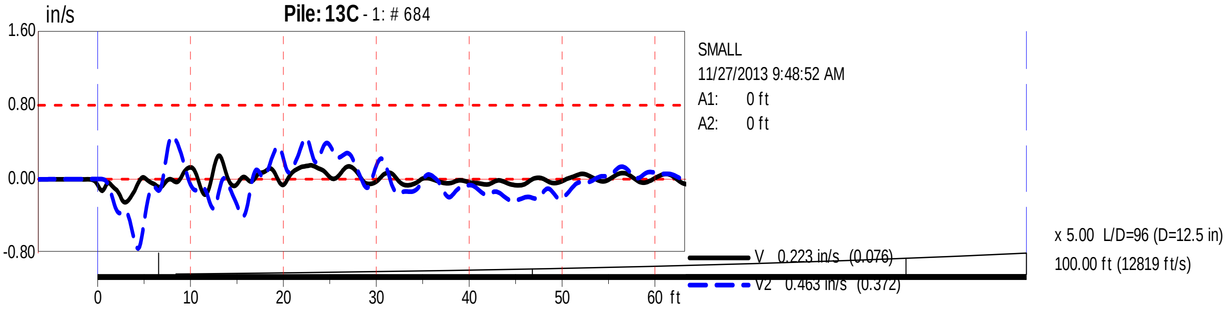
Pile: 13C - 1: # 687



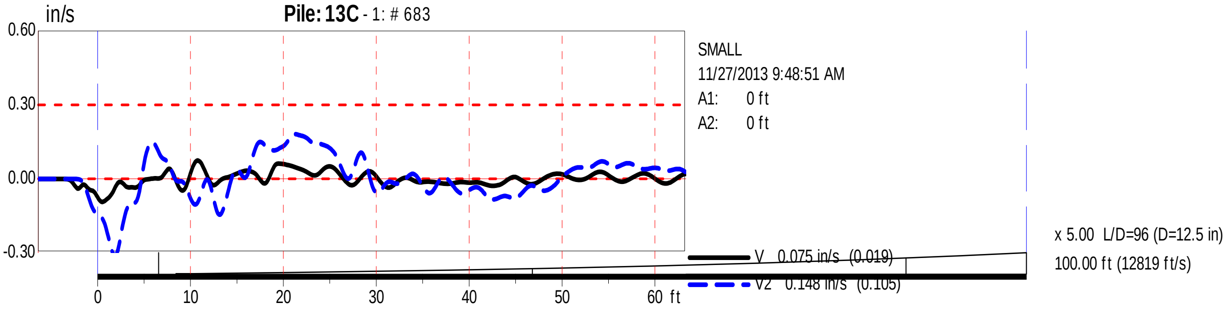
Pile: 13C - 1: # 686



Pile: 13C - 1: # 685

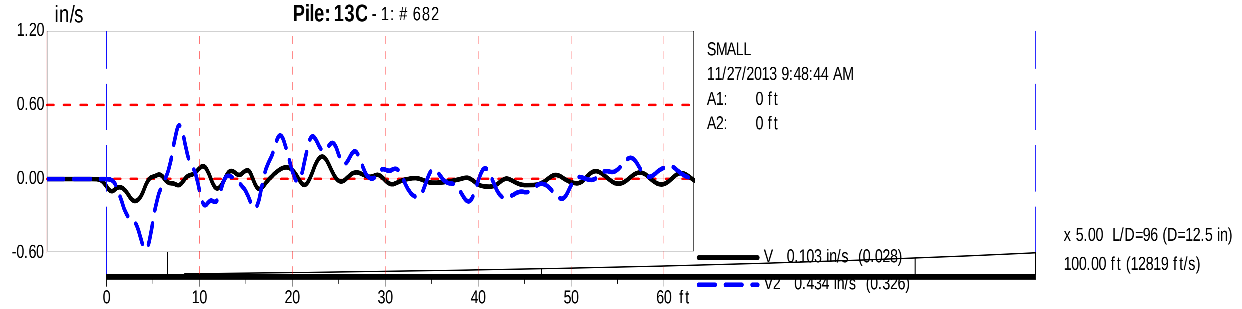


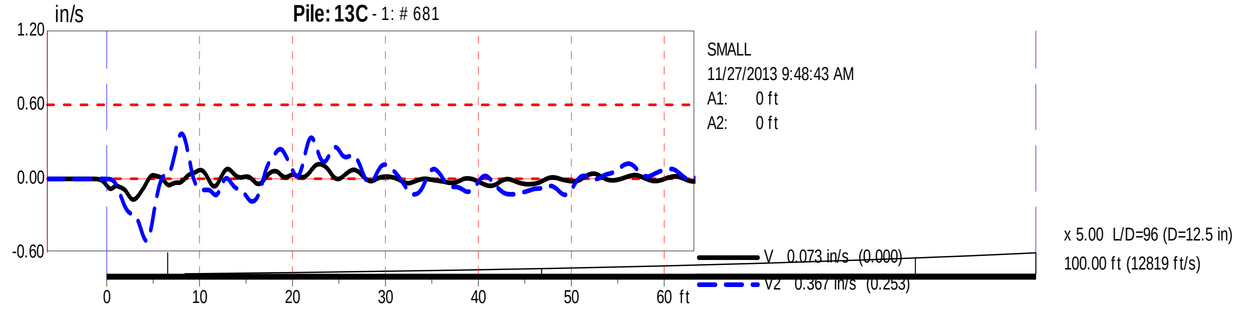
Pile: 13C - 1: # 684

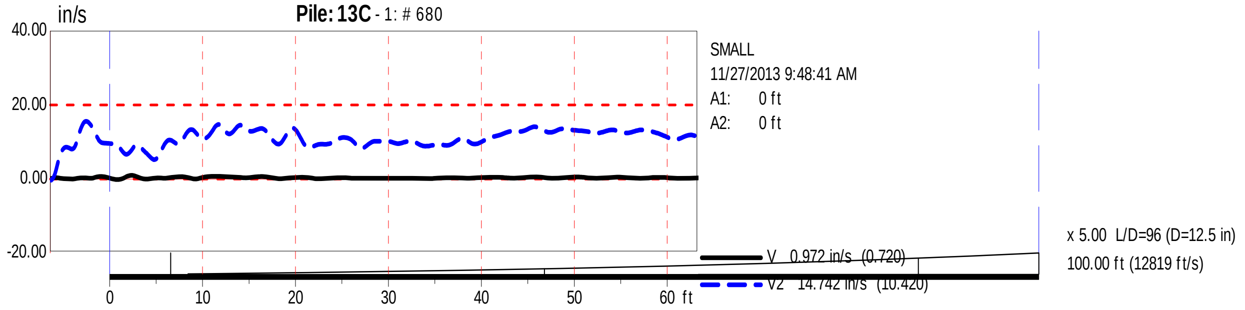


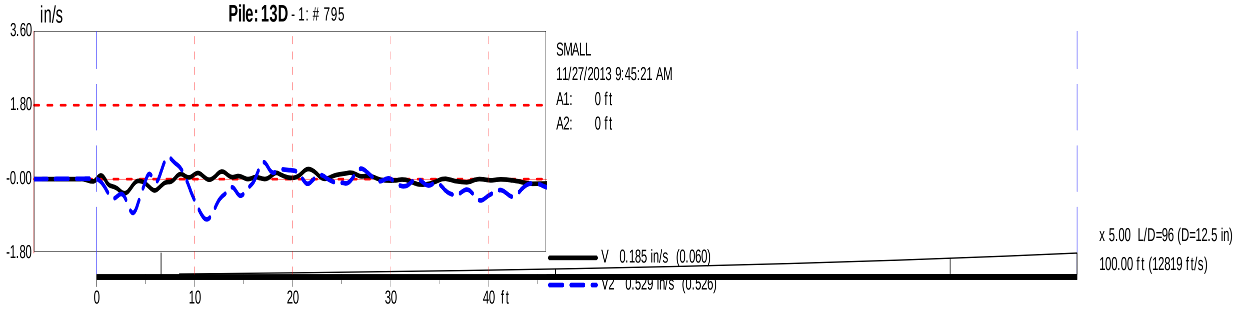
Pile: 13C - 1: # 683

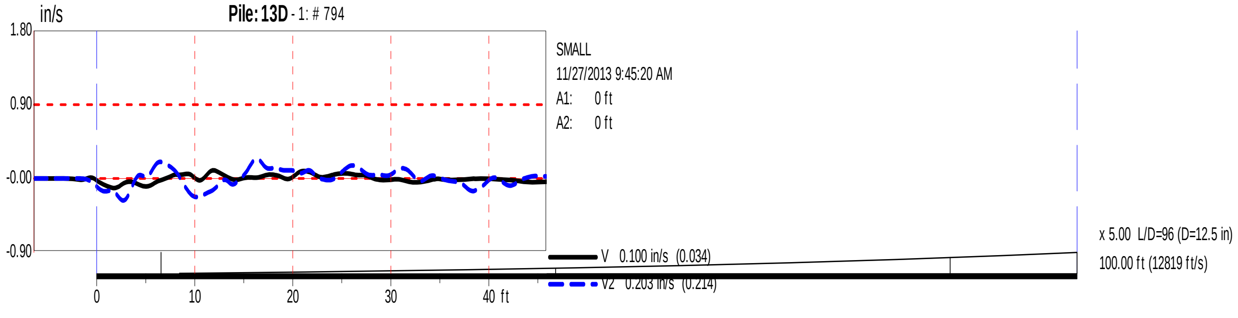
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

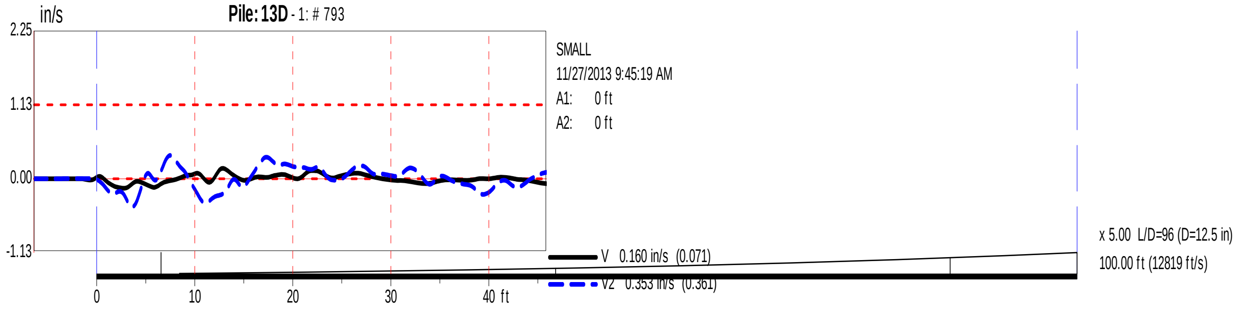


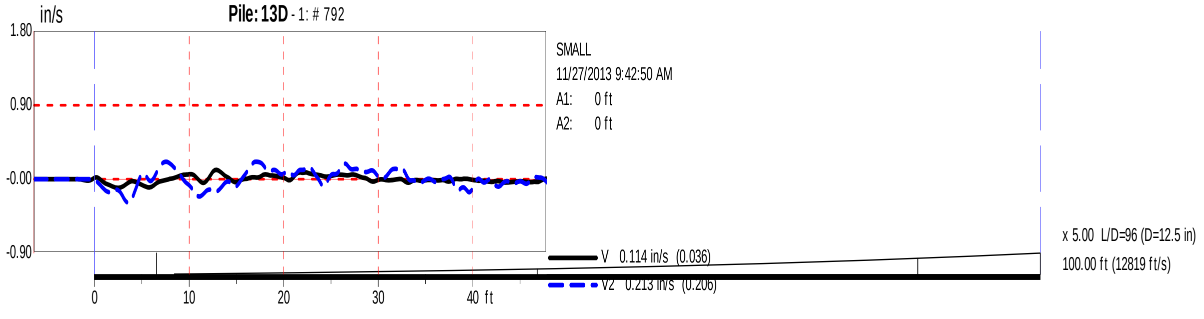


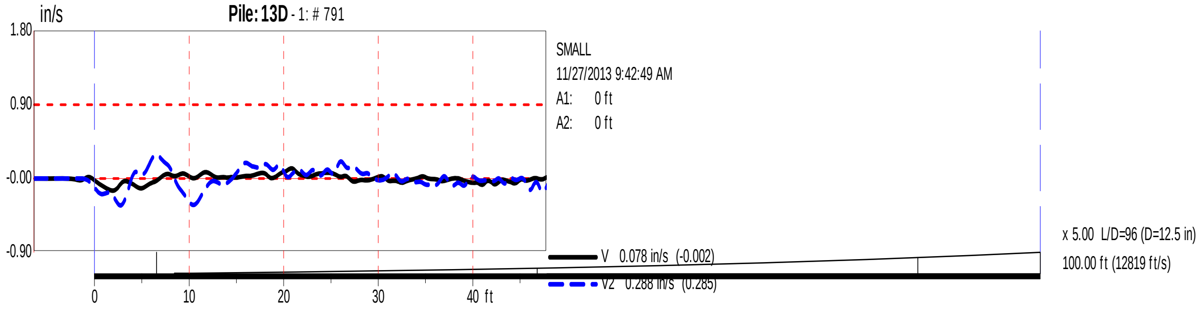



in/s
Pile: 13D - 1: # 795
3.60
1.80
-0.00
-1.80
0
10
20
30
40 ft
SMALL
11/27/2013 9:45:21 AM
A1: 0 ft
A2: 0 ft
V 0.185 in/s (0.060)
V2 0.529 in/s (0.526)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

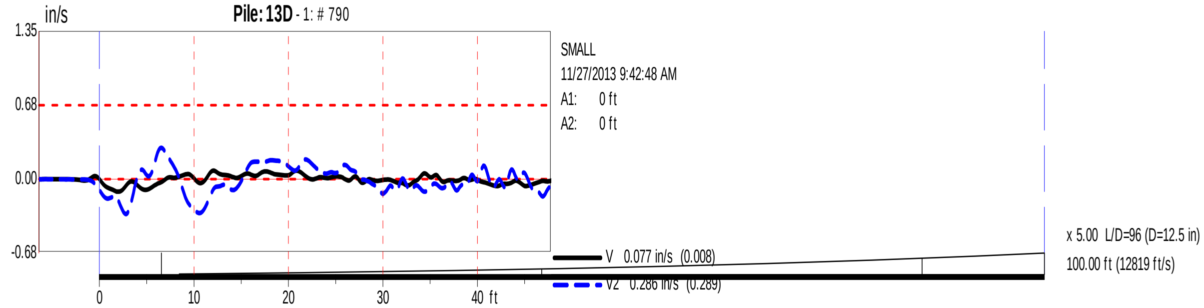

in/s
Pile: 13D - 1: # 794
1.80
0.90
-0.00
-0.90
0
10
20
30
40 ft
SMALL
11/27/2013 9:45:20 AM
A1: 0 ft
A2: 0 ft
V 0.100 in/s (0.034)
V2 0.203 in/s (0.214)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

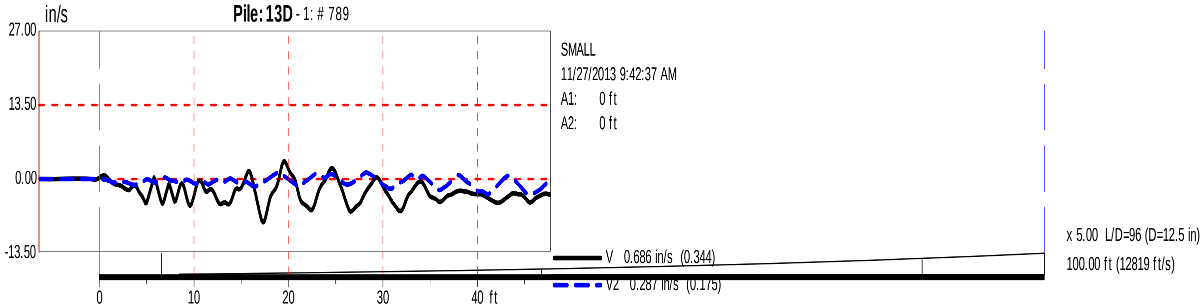

in/s
Pile: 13D - 1: # 793
2.25
1.13
0.00
-1.13
0
10
20
30
40 ft
SMALL
11/27/2013 9:45:19 AM
A1: 0 ft
A2: 0 ft
V 0.160 in/s (0.071)
V2 0.353 in/s (0.361)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

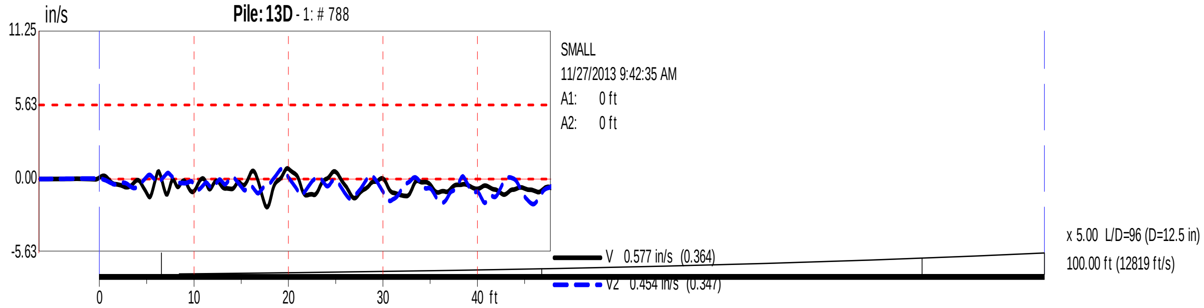

in/s
Pile: 13D - 1: # 792
1.80
0.90
-0.00
-0.90
0
10
20
30
40 ft
SMALL
11/27/2013 9:42:50 AM
A1: 0 ft
A2: 0 ft
V 0.114 in/s (0.036)
V2 0.213 in/s (0.206)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

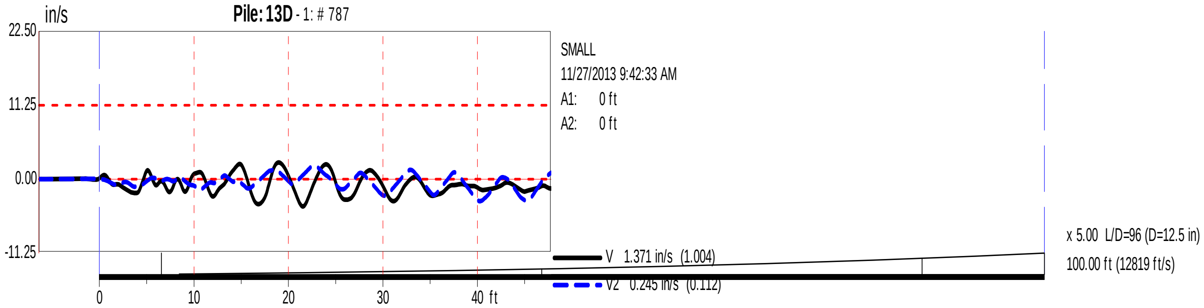

in/s
Pile: 13D - 1: # 791
1.80
0.90
-0.00
-0.90
0
10
20
30
40 ft
SMALL
11/27/2013 9:42:49 AM
A1: 0 ft
A2: 0 ft
V 0.078 in/s (-0.002)
V2 0.288 in/s (0.285)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

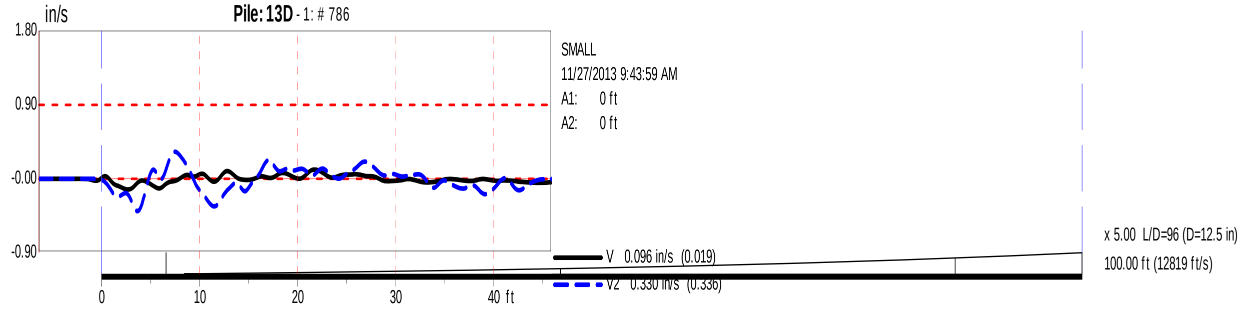
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



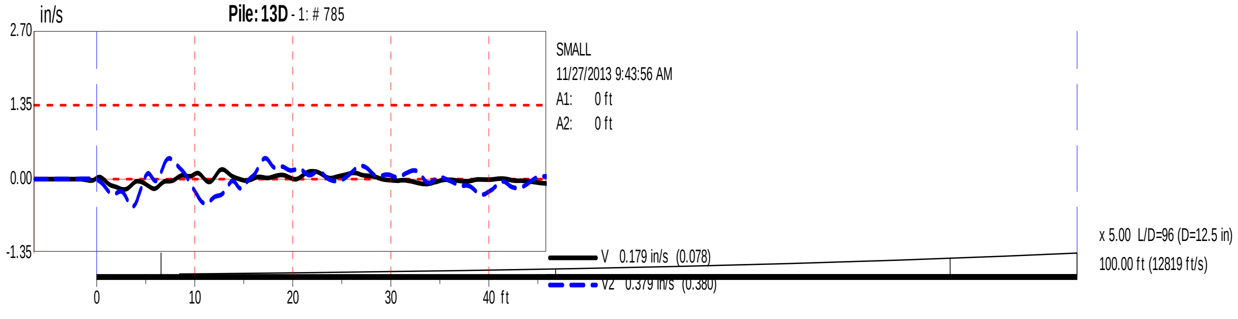


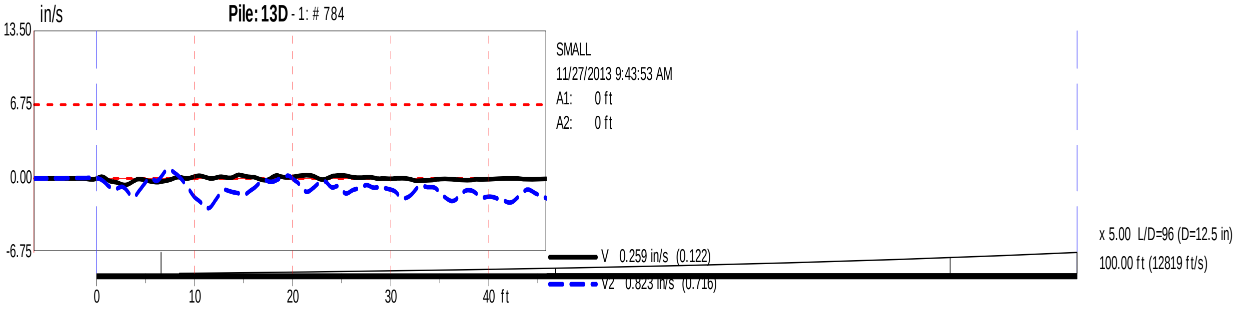


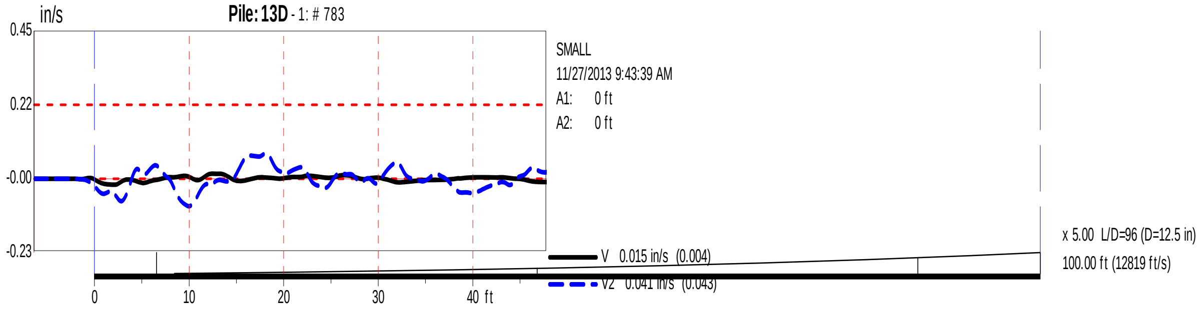


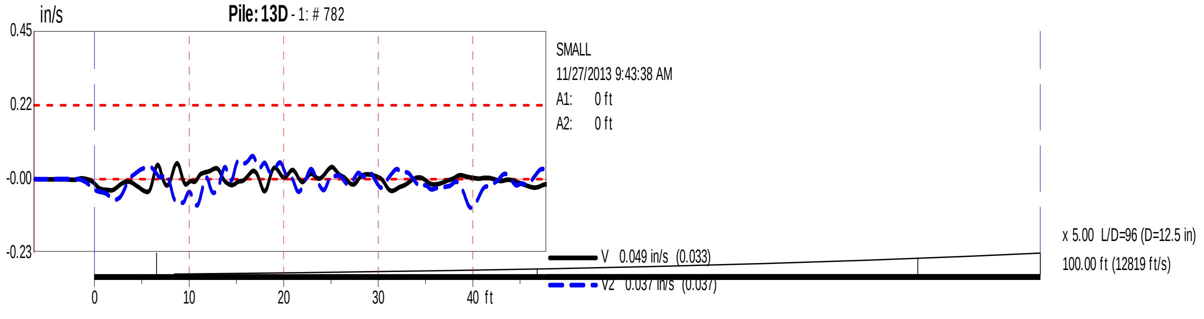


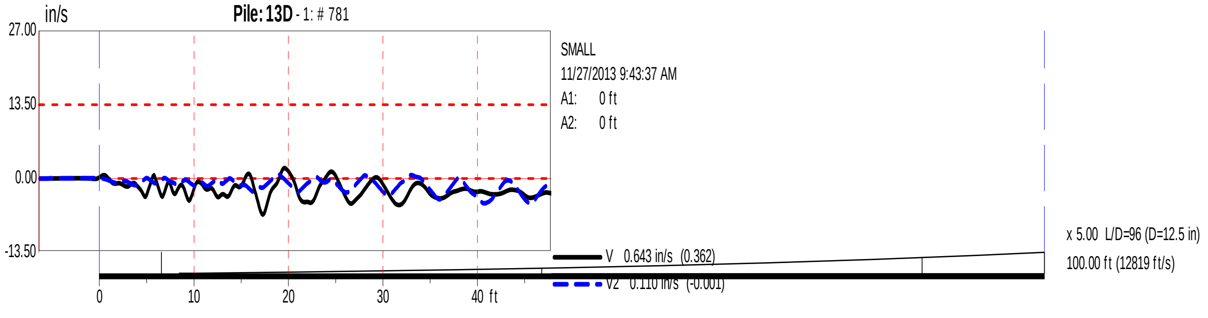
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

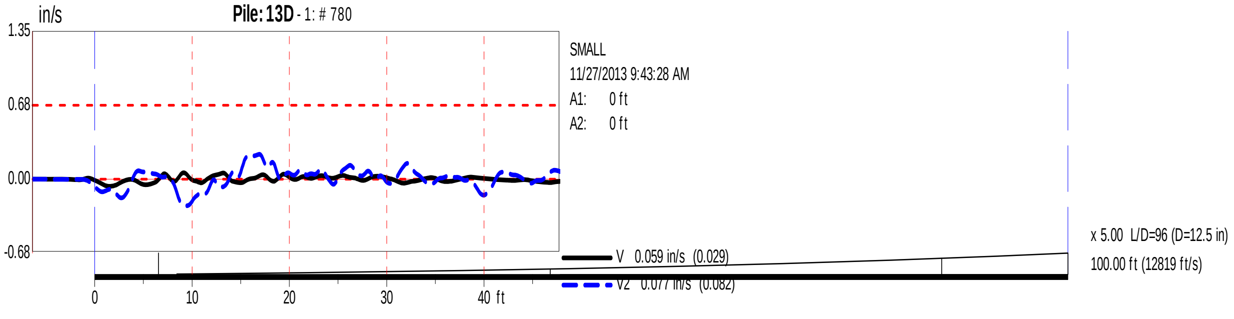


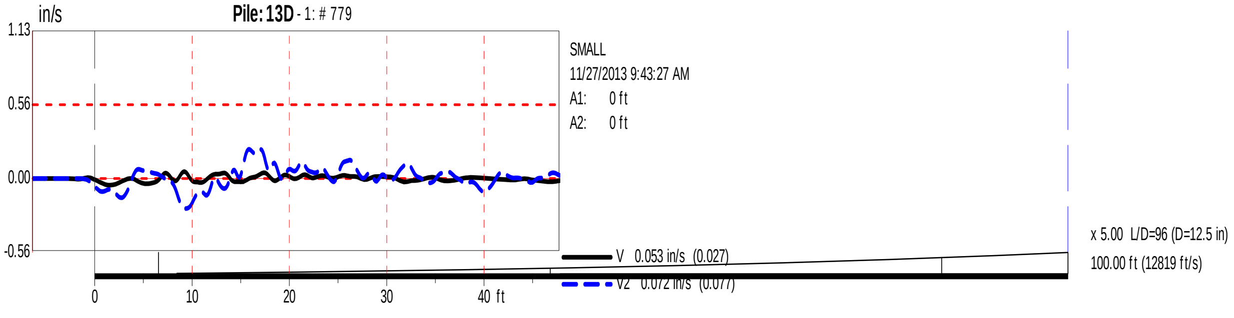


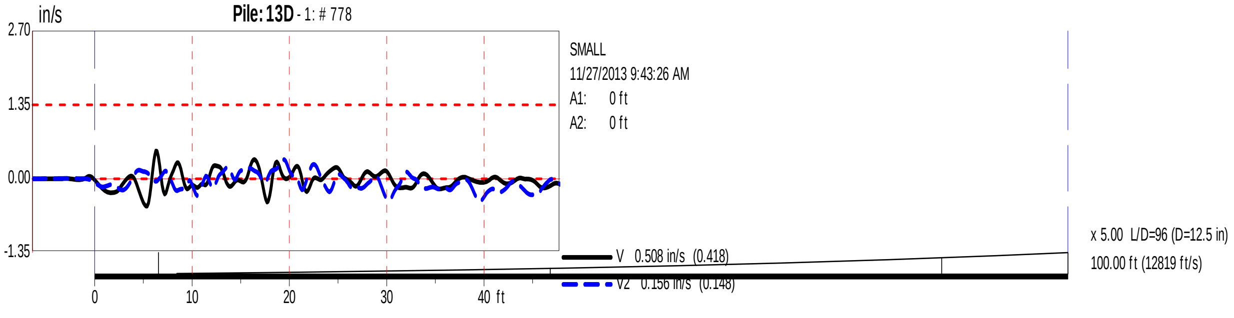


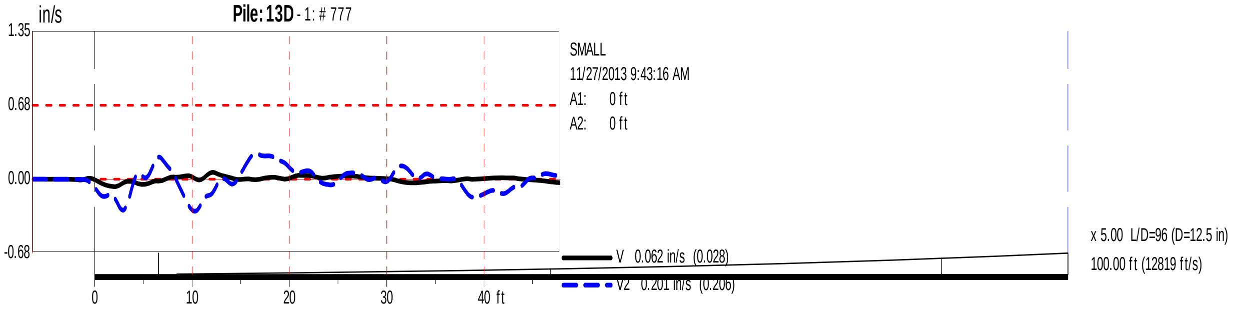


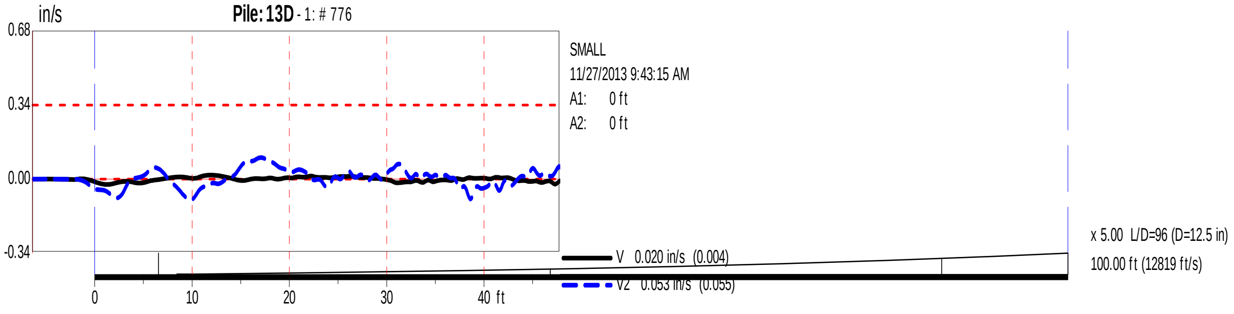


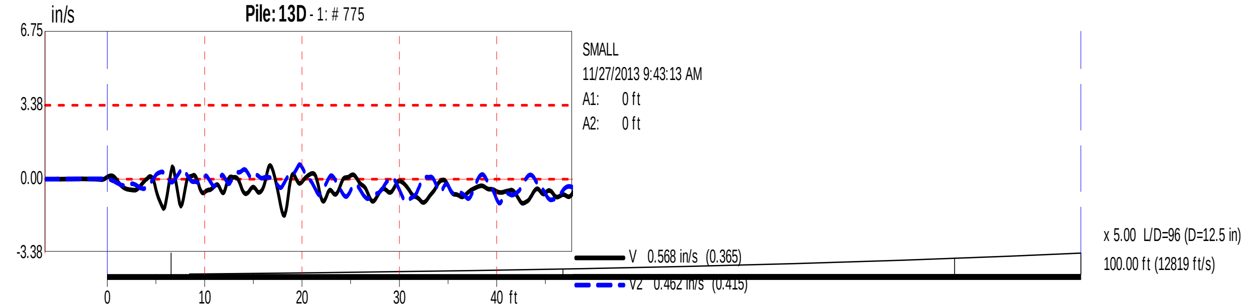

in/s
Pile: 13D - 1: # 780
1.35
0.68
0.00
-0.68
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:28 AM
A1: 0 ft
A2: 0 ft
V 0.059 in/s (0.029)
V2 0.077 in/s (0.082)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

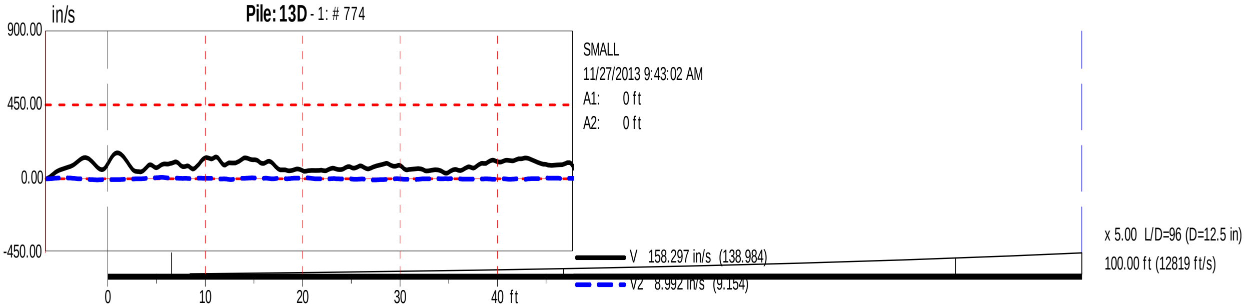

in/s
Pile: 13D - 1: # 779
1.13
0.56
0.00
-0.56
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:27 AM
A1: 0 ft
A2: 0 ft
V 0.053 in/s (0.027)
V2 0.072 in/s (0.077)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

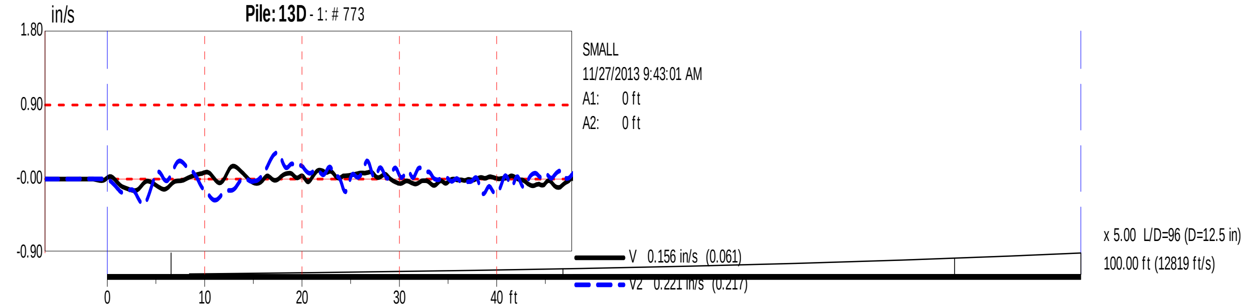

in/s
Pile: 13D - 1: # 778
2.70
1.35
0.00
-1.35
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:26 AM
A1: 0 ft
A2: 0 ft
V 0.508 in/s (0.418)
V2 0.156 in/s (0.148)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

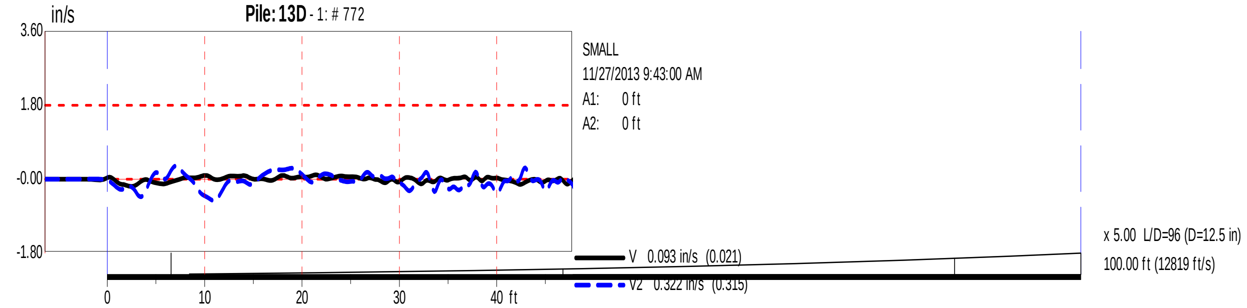

in/s
Pile: 13D - 1: # 777
1.35
0.68
0.00
-0.68
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:16 AM
A1: 0 ft
A2: 0 ft
V 0.062 in/s (0.028)
V2 0.201 in/s (0.206)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

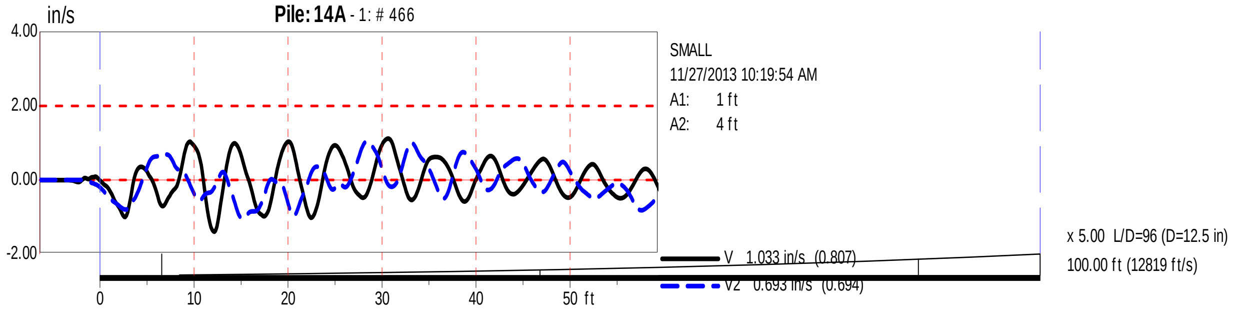

in/s
Pile: 13D - 1: # 776
0.68
0.34
0.00
-0.34
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:15 AM
A1: 0 ft
A2: 0 ft
V 0.020 in/s (0.004)
V2 0.053 in/s (0.055)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

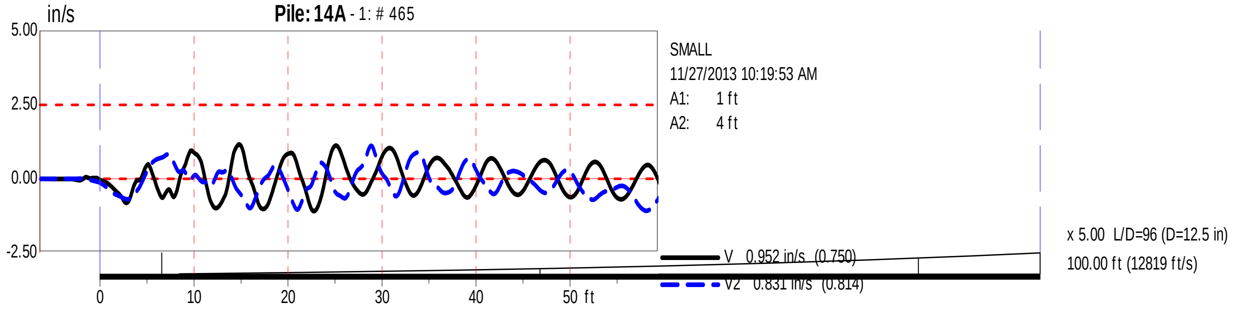

in/s
Pile: 13D - 1: # 775
6.75
3.38
0.00
-3.38
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:13 AM
A1: 0 ft
A2: 0 ft
V 0.568 in/s (0.365)
V2 0.462 in/s (0.415)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

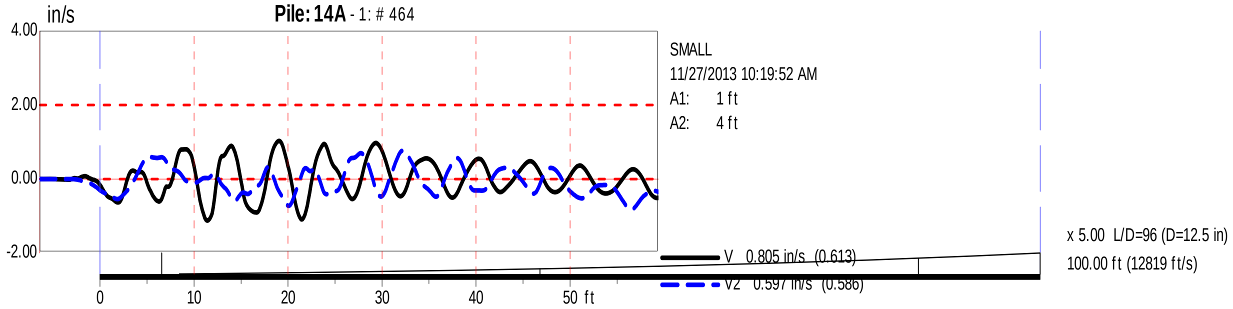

in/s
Pile: 13D - 1: # 774
900.00
450.00
0.00
-450.00
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:02 AM
A1: 0 ft
A2: 0 ft
V 158.297 in/s (138.984)
V2 8.992 in/s (9.154)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

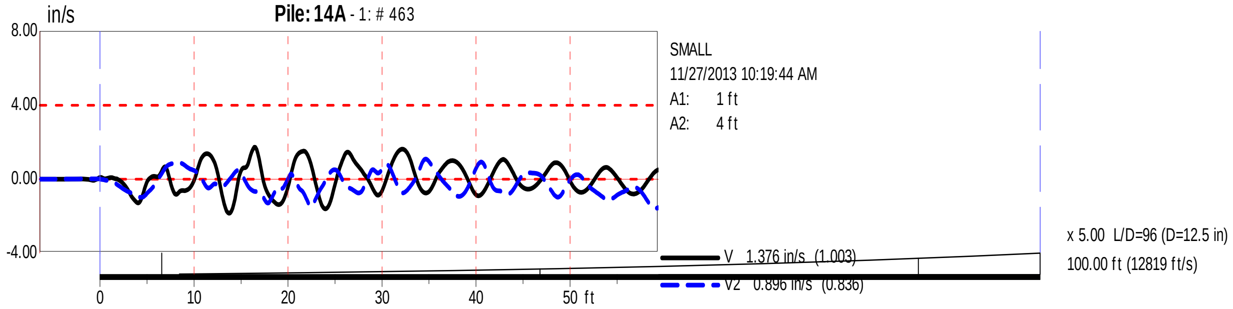

in/s
Pile: 13D - 1: # 773
1.80
0.90
-0.00
-0.90
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:01 AM
A1: 0 ft
A2: 0 ft
V 0.156 in/s (0.061)
V2 0.221 in/s (0.217)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

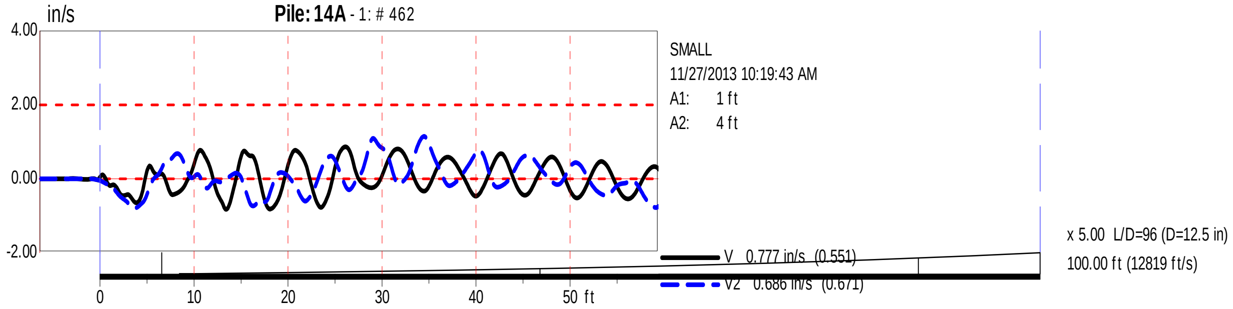

in/s
Pile: 13D - 1: # 772
3.60
1.80
-0.00
-1.80
0
10
20
30
40 ft
SMALL
11/27/2013 9:43:00 AM
A1: 0 ft
A2: 0 ft
V 0.093 in/s (0.021)
V2 0.322 in/s (0.315)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

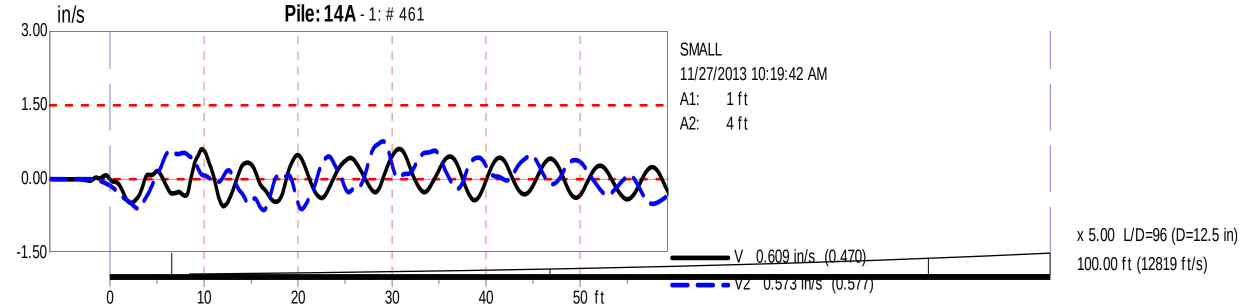

in/s
Pile: 14A - 1: # 466
4.00
2.00
0.00
-2.00
0
10
20
30
40
50 ft
SMALL
11/27/2013 10:19:54 AM
A1: 1 ft
A2: 4 ft
V 1.033 in/s (0.807)
V2 0.693 in/s (0.694)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

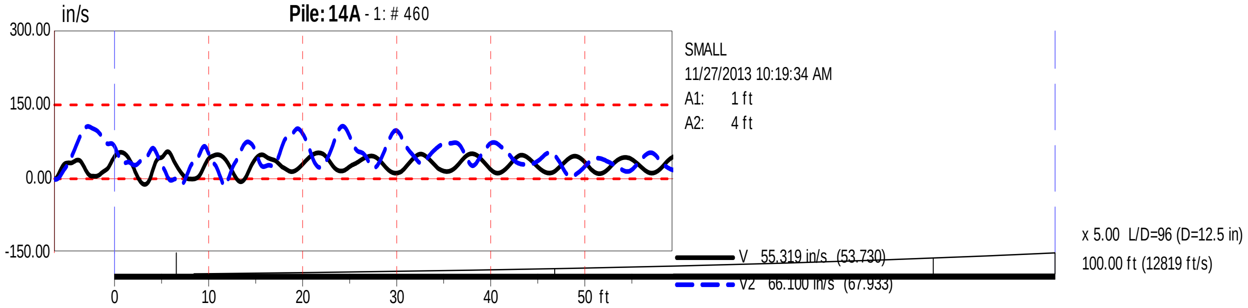

in/s
Pile: 14A - 1: # 465
5.00
2.50
0.00
-2.50
0
10
20
30
40
50 ft
SMALL
11/27/2013 10:19:53 AM
A1: 1 ft
A2: 4 ft
V 0.952 in/s (0.750)
V2 0.831 in/s (0.814)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

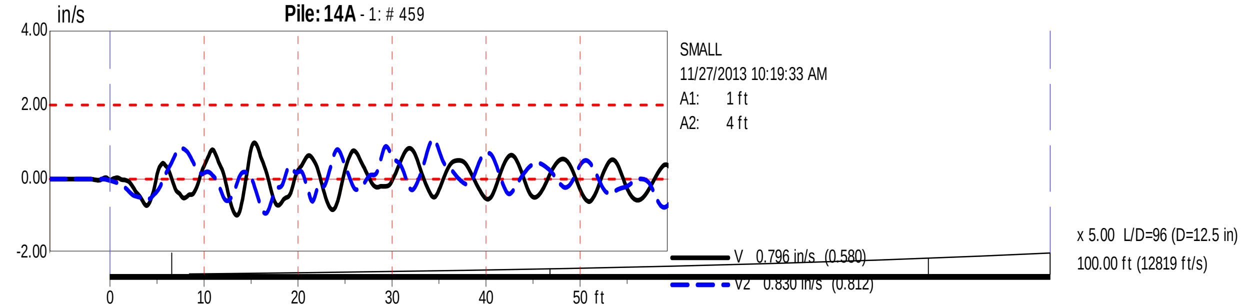

in/s
Pile: 14A - 1: # 464
4.00
2.00
0.00
-2.00
0
10
20
30
40
50 ft
SMALL
11/27/2013 10:19:52 AM
A1: 1 ft
A2: 4 ft
V 0.805 in/s (0.613)
V2 0.597 in/s (0.586)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

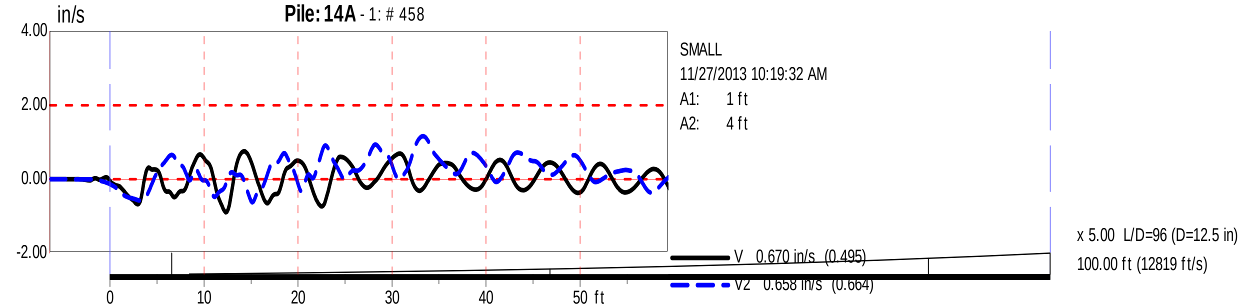

in/s
Pile: 14A - 1: # 463
8.00
4.00
0.00
-4.00
0
10
20
30
40
50 ft
SMALL
11/27/2013 10:19:44 AM
A1: 1 ft
A2: 4 ft
V 1.376 in/s (1.003)
V2 0.896 in/s (0.836)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)

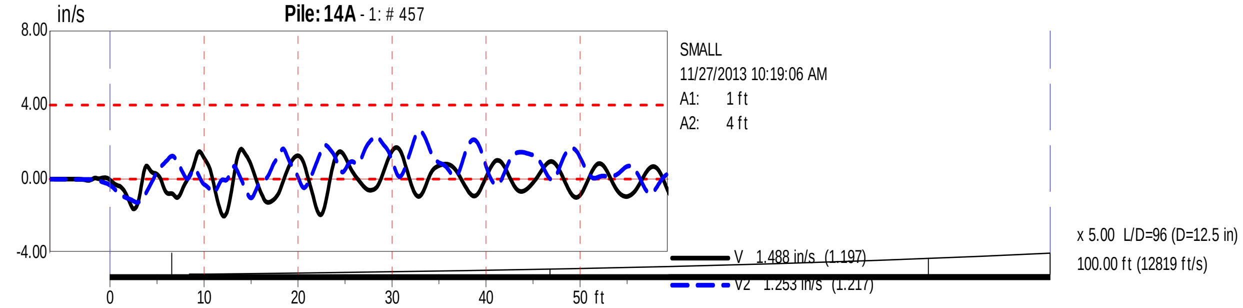

in/s
Pile: 14A - 1: # 462
4.00
2.00
0.00
-2.00
0
10
20
30
40
50 ft
SMALL
11/27/2013 10:19:43 AM
A1: 1 ft
A2: 4 ft
V 0.777 in/s (0.551)
V2 0.686 in/s (0.671)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)


in/s
Pile: 14A - 1: # 461
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 10:19:42 AM
A1: 1 ft
A2: 4 ft
V 0.609 in/s (0.470)
V2 0.573 in/s (0.577)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50 ft


in/s
Pile: 14A - 1: # 460
300.00
150.00
0.00
-150.00
SMALL
11/27/2013 10:19:34 AM
A1: 1 ft
A2: 4 ft
V 55.319 in/s (53.730)
V2 66.100 in/s (67.933)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50 ft


in/s
Pile: 14A - 1: # 459
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:19:33 AM
A1: 1 ft
A2: 4 ft
V 0.796 in/s (0.580)
V2 0.830 in/s (0.812)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50 ft

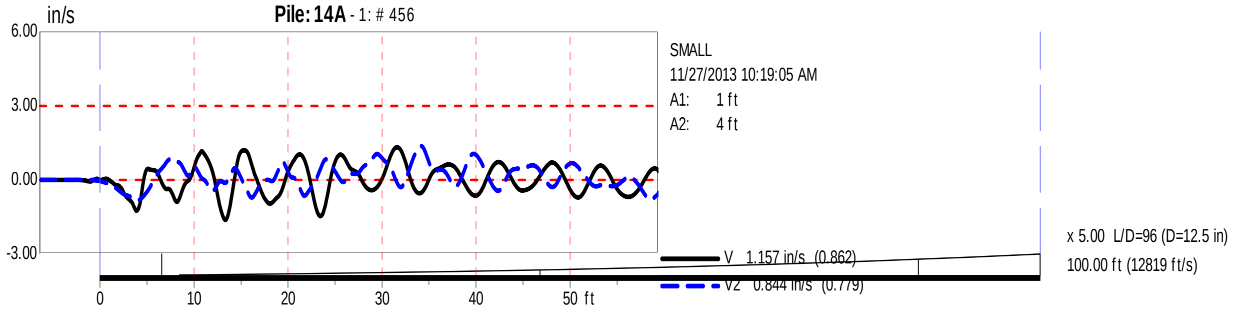

in/s
Pile: 14A - 1: # 458
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:19:32 AM
A1: 1 ft
A2: 4 ft
V 0.670 in/s (0.495)
V2 0.658 in/s (0.664)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50 ft

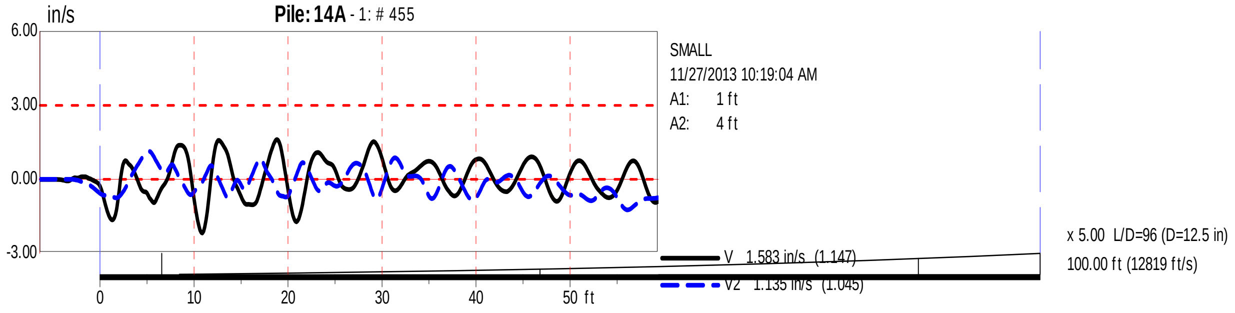

in/s
Pile: 14A - 1: # 457
8.00
4.00
0.00
-4.00
SMALL
11/27/2013 10:19:06 AM
A1: 1 ft
A2: 4 ft
V 1.488 in/s (1.197)
V2 1.253 in/s (1.217)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30
40
50 ft

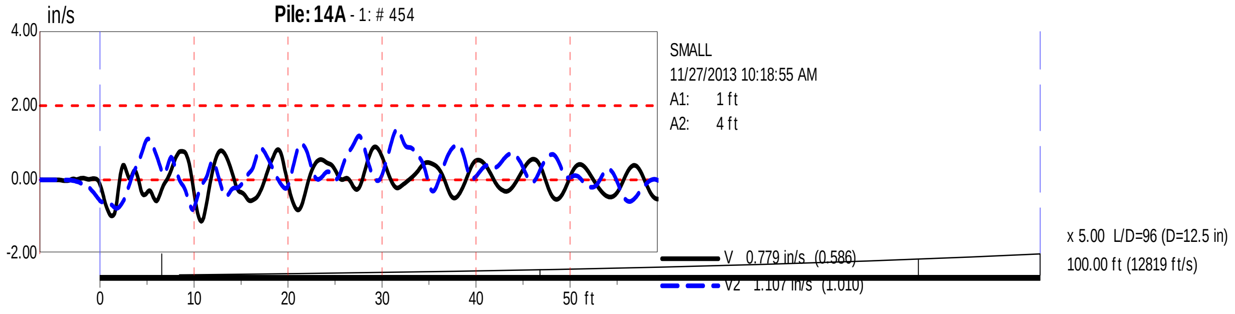
Pile Dynamics, Inc. 12/29/2013

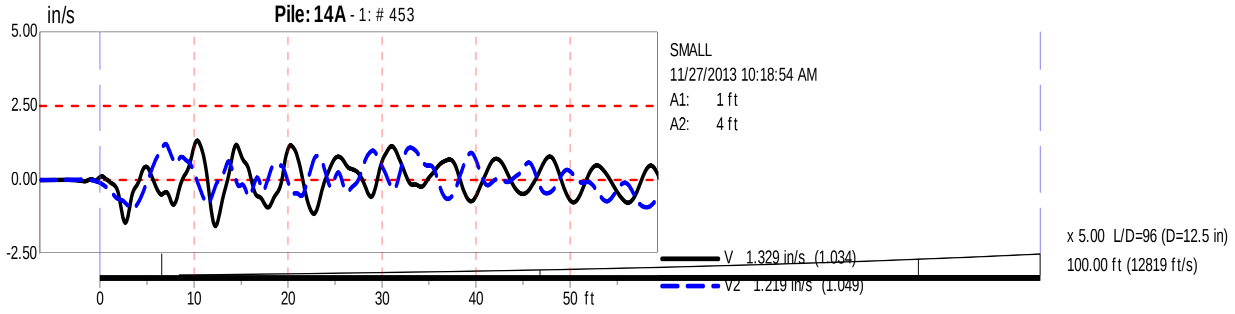
PIT Raw data

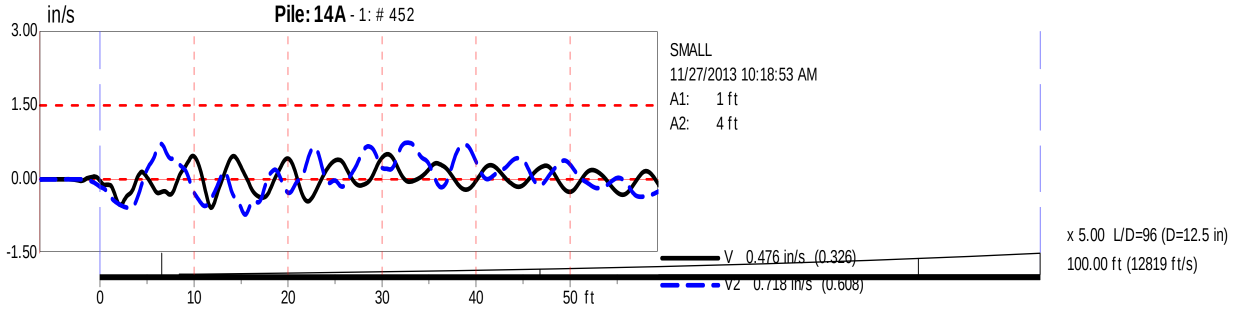
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO







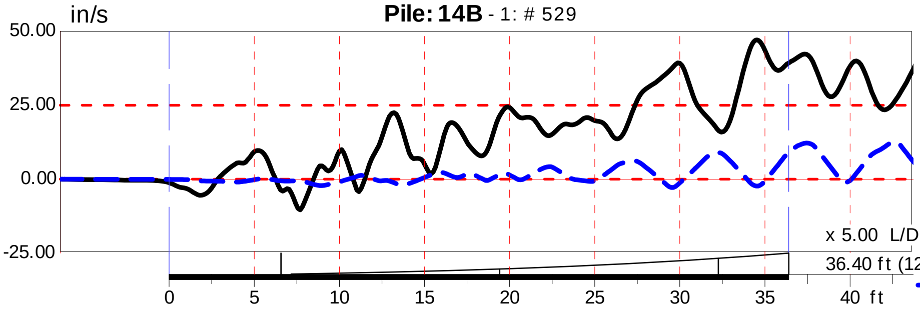




Pile Dynamics, Inc.
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT

12/29/2013
PIT-W 2009-2.DEMO

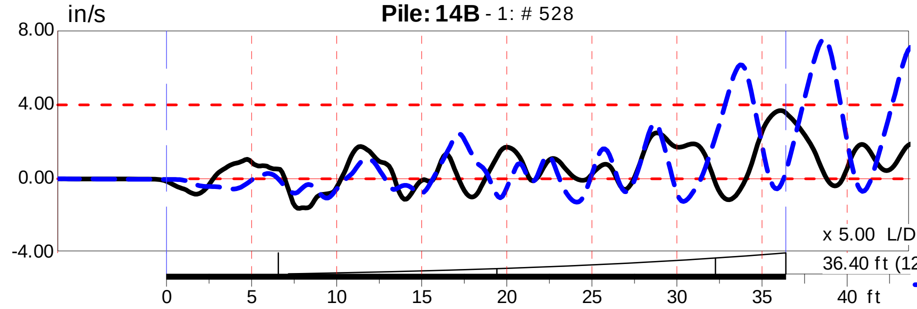
Pile: 14B - 1: # 529



SMALL
11/27/2013 10:14:39 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 19.629 in/s (12.937)
V2 1.327 in/s (1.251)

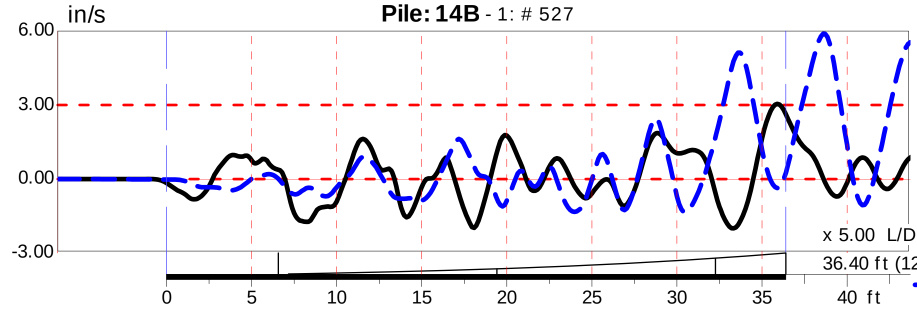
Pile: 14B - 1: # 528



SMALL
11/27/2013 10:14:35 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 1.747 in/s (1.179)
V2 1.092 in/s (0.950)

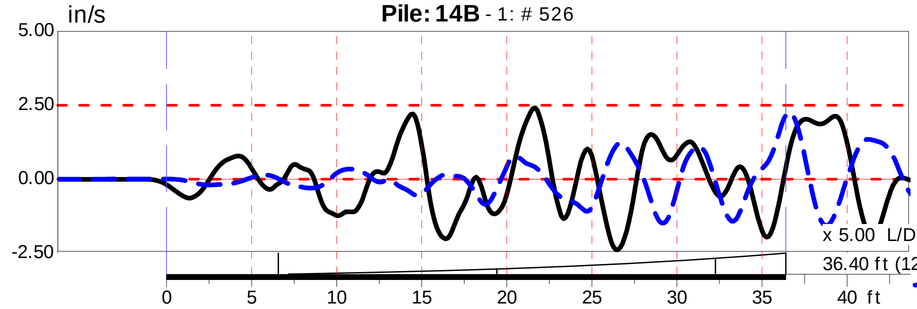
Pile: 14B - 1: # 527



SMALL
11/27/2013 10:14:34 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 1.630 in/s (1.039)
V2 0.908 in/s (0.792)

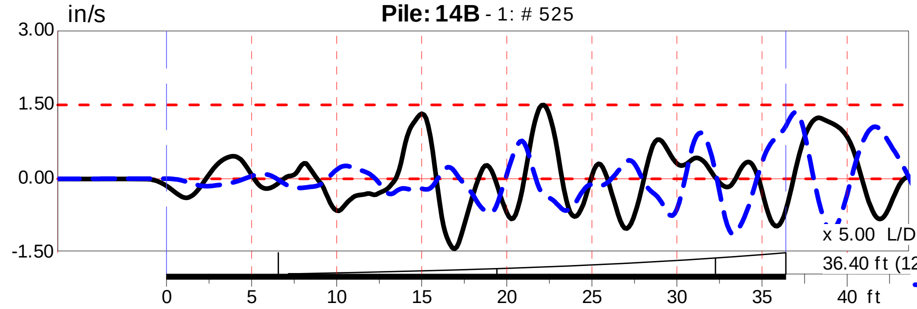
Pile: 14B - 1: # 526



SMALL
11/27/2013 10:14:18 AM
A1: 1 ft
A2: 4 ft

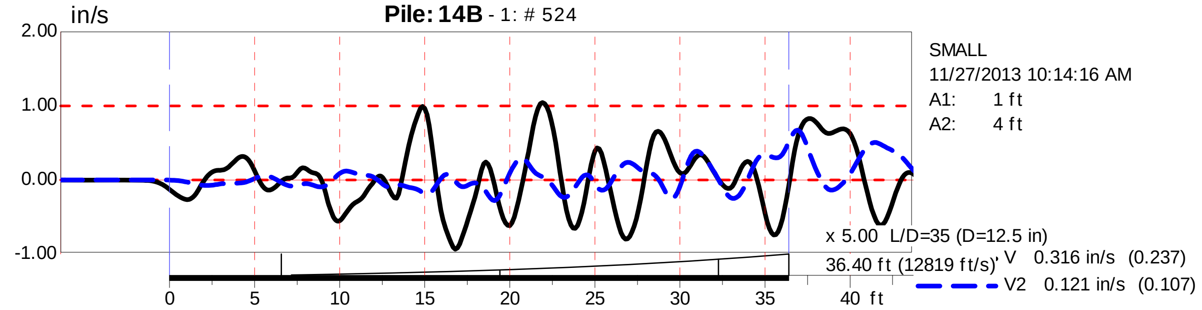
x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 0.783 in/s (0.650)
V2 0.341 in/s (0.280)

Pile: 14B - 1: # 525

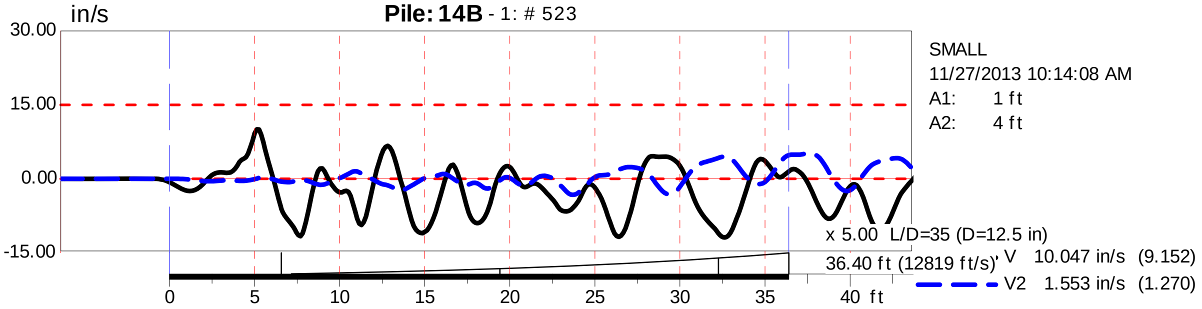


SMALL
11/27/2013 10:14:17 AM
A1: 1 ft
A2: 4 ft

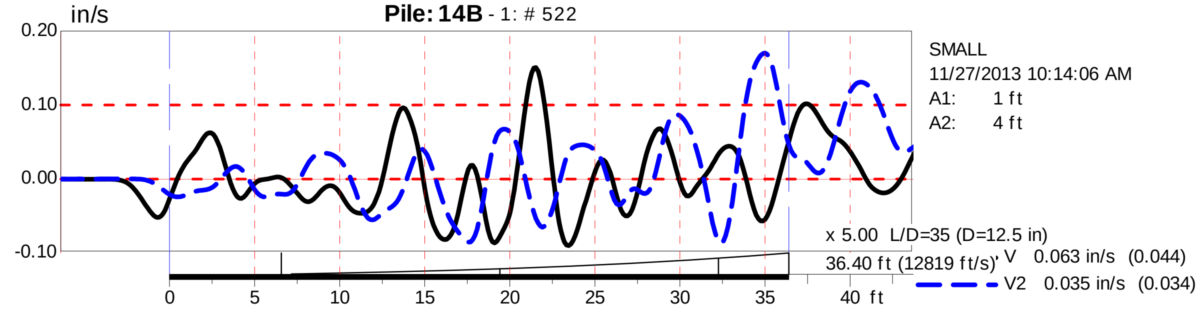
x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 0.459 in/s (0.367)
V2 0.263 in/s (0.218)


Pile: 14B - 1: # 524

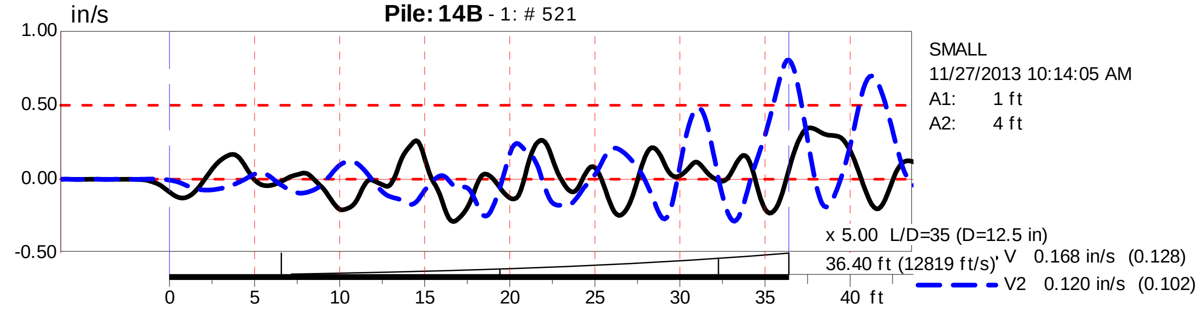
SMALL
11/27/2013 10:14:16 AM
A1: 1 ft
A2: 4 ft


Pile: 14B - 1: # 523

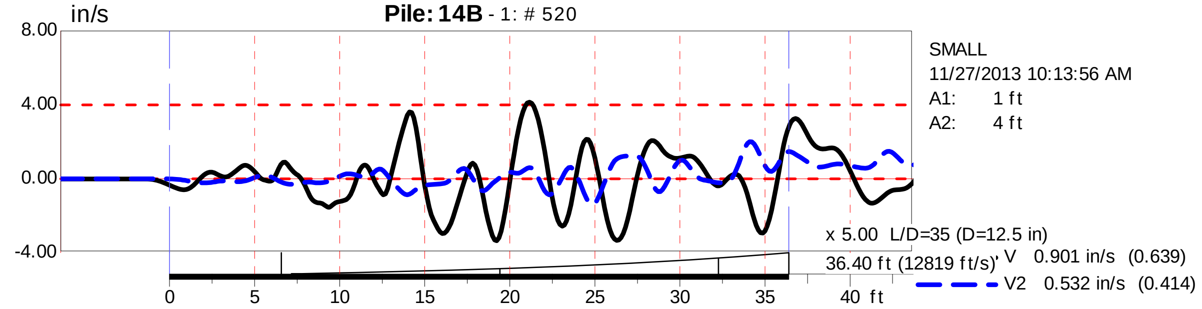
SMALL
11/27/2013 10:14:08 AM
A1: 1 ft
A2: 4 ft


Pile: 14B - 1: # 522

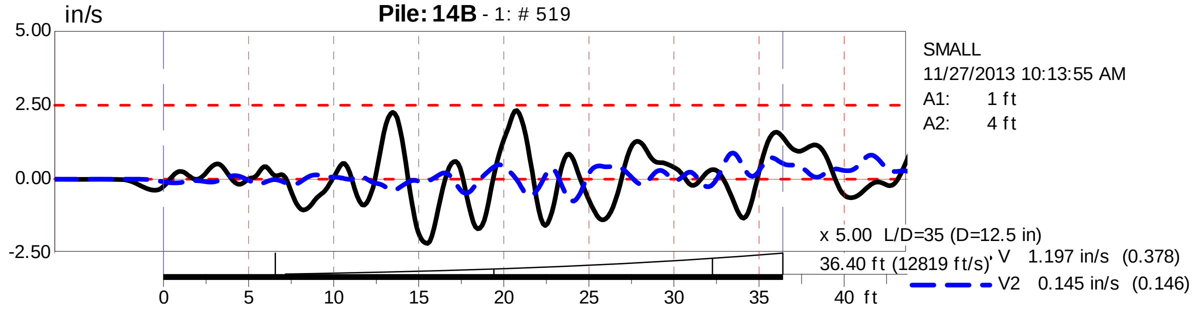
SMALL
11/27/2013 10:14:06 AM
A1: 1 ft
A2: 4 ft


Pile: 14B - 1: # 521

SMALL
11/27/2013 10:14:05 AM
A1: 1 ft
A2: 4 ft

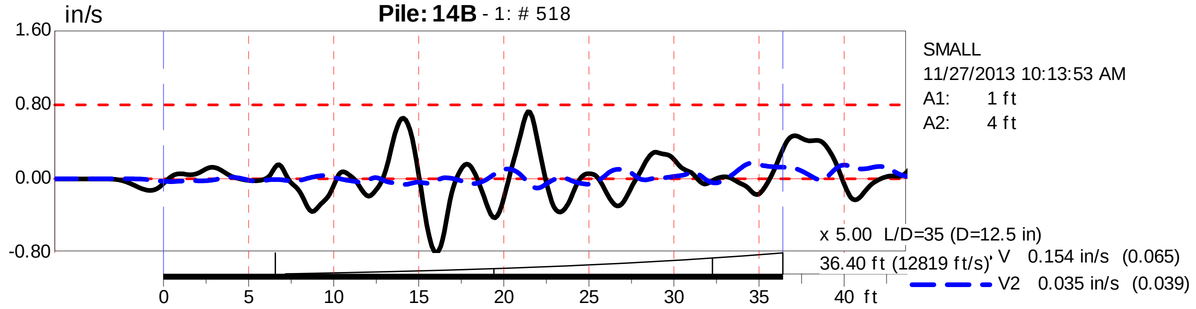

Pile: 14B - 1: # 520

SMALL
11/27/2013 10:13:56 AM
A1: 1 ft
A2: 4 ft


Pile: 14B - 1: # 519

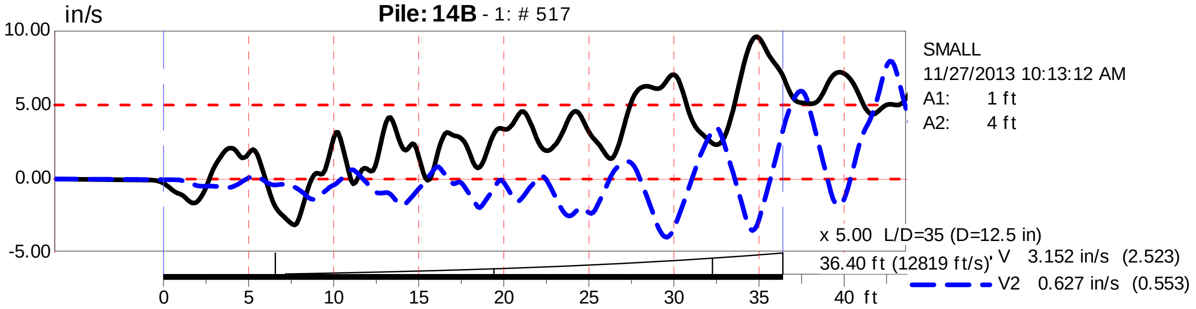
SMALL
11/27/2013 10:13:55 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 1.197 in/s (0.378)
V2 0.145 in/s (0.146)


Pile: 14B - 1: # 518

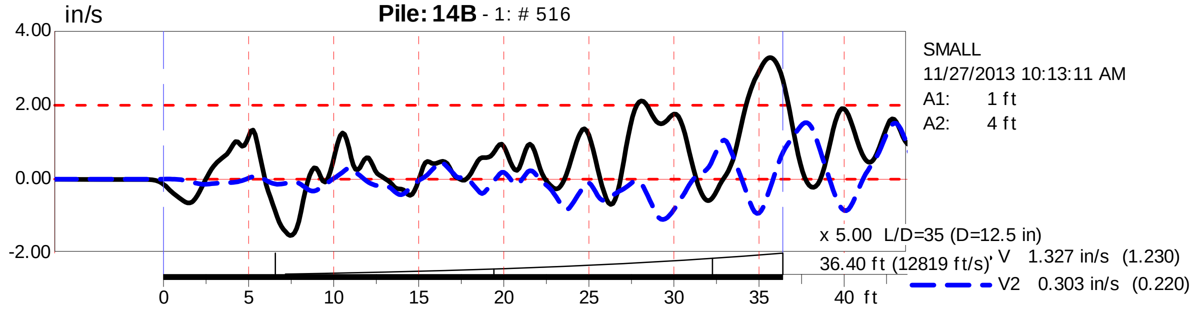
SMALL
11/27/2013 10:13:53 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 0.154 in/s (0.065)
V2 0.035 in/s (0.039)


Pile: 14B - 1: # 517

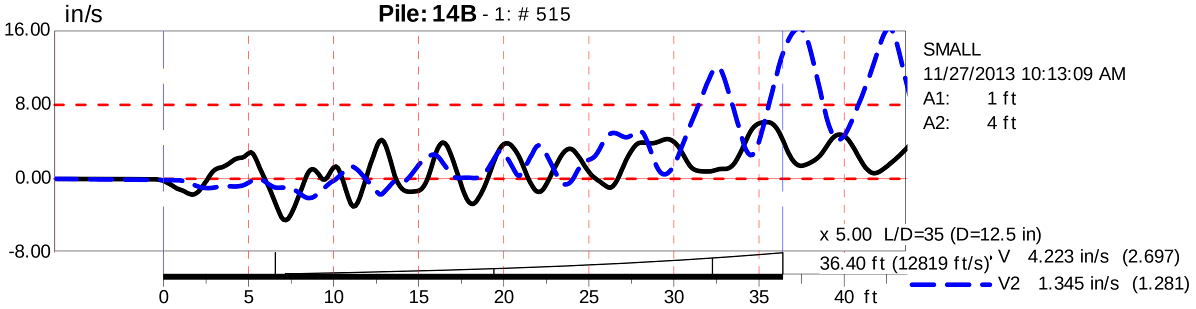
SMALL
11/27/2013 10:13:12 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 3.152 in/s (2.523)
V2 0.627 in/s (0.553)


Pile: 14B - 1: # 516

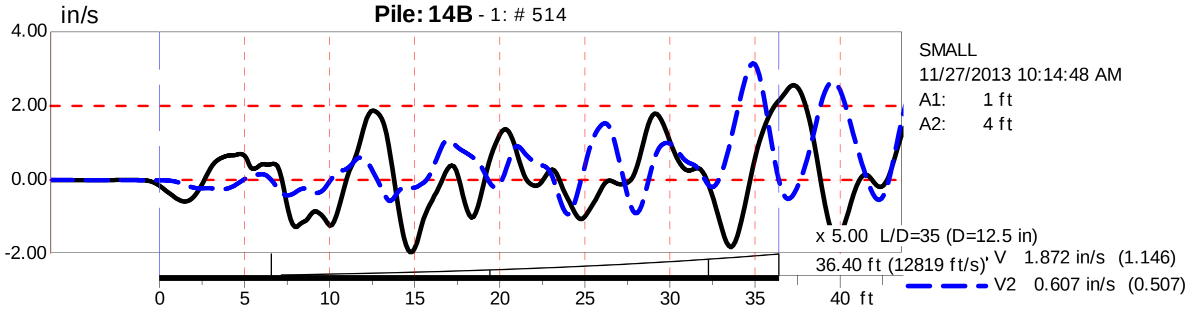
SMALL
11/27/2013 10:13:11 AM
A1: 1 ft
A2: 4 ft

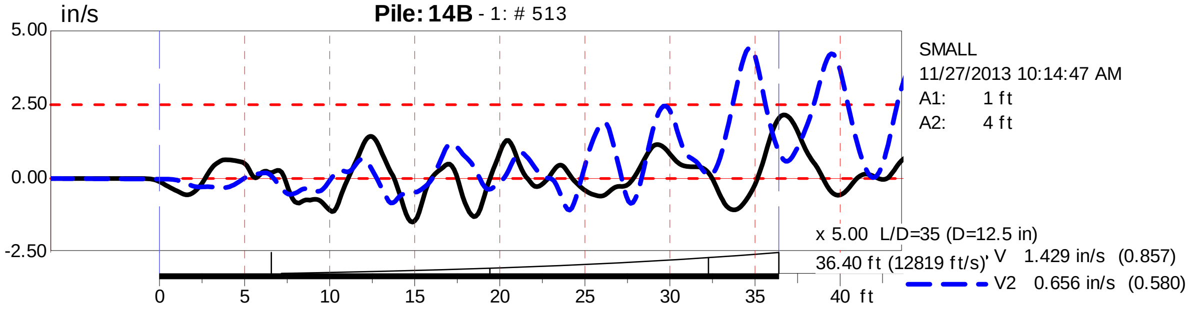
x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 1.327 in/s (1.230)
V2 0.303 in/s (0.220)

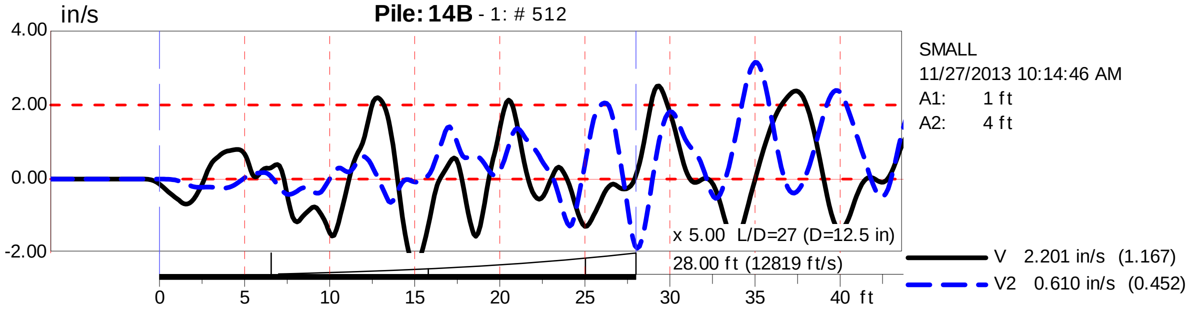

Pile: 14B - 1: # 515

SMALL
11/27/2013 10:13:09 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 4.223 in/s (2.697)
V2 1.345 in/s (1.281)


in/s
Pile: 14B - 1: # 514
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:14:48 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 1.872 in/s (1.146)
V2 0.607 in/s (0.507)
0
5
10
15
20
25
30
35
40 ft


in/s
Pile: 14B - 1: # 513
5.00
2.50
0.00
-2.50
SMALL
11/27/2013 10:14:47 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=35 (D=12.5 in)
36.40 ft (12819 ft/s)
V 1.429 in/s (0.857)
V2 0.656 in/s (0.580)
0
5
10
15
20
25
30
35
40 ft


in/s
Pile: 14B - 1: # 512
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:14:46 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=27 (D=12.5 in)
28.00 ft (12819 ft/s)
V 2.201 in/s (1.167)
V2 0.610 in/s (0.452)
0
5
10
15
20
25
30
35
40 ft

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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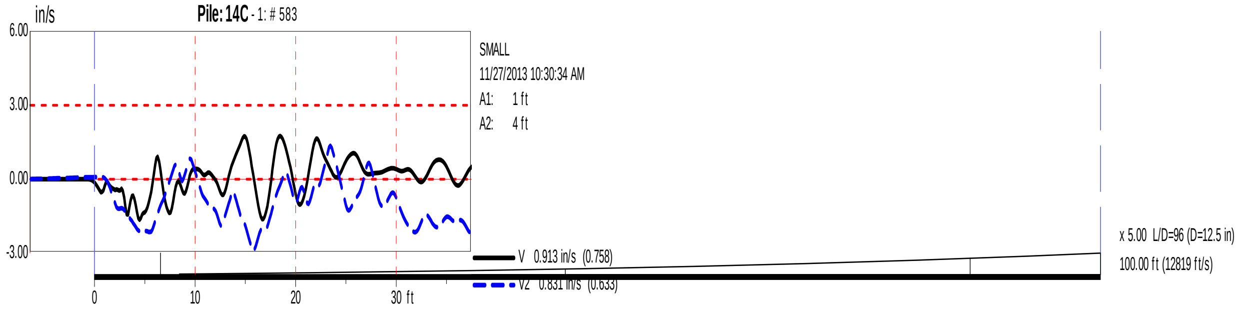
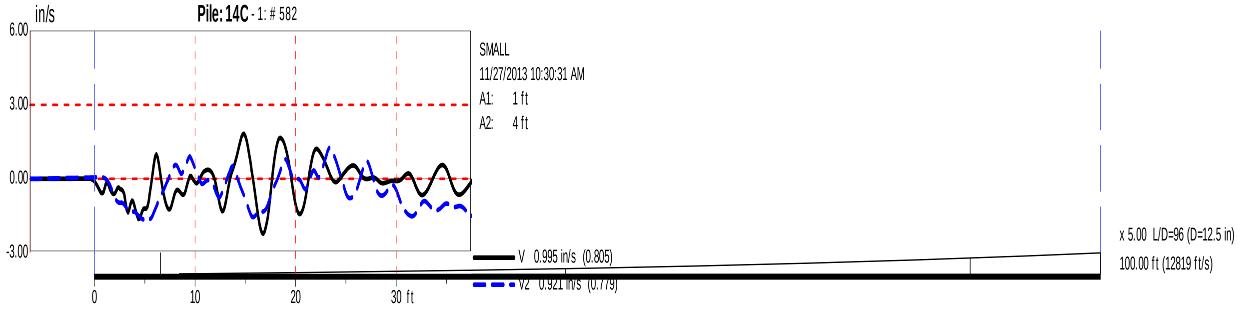
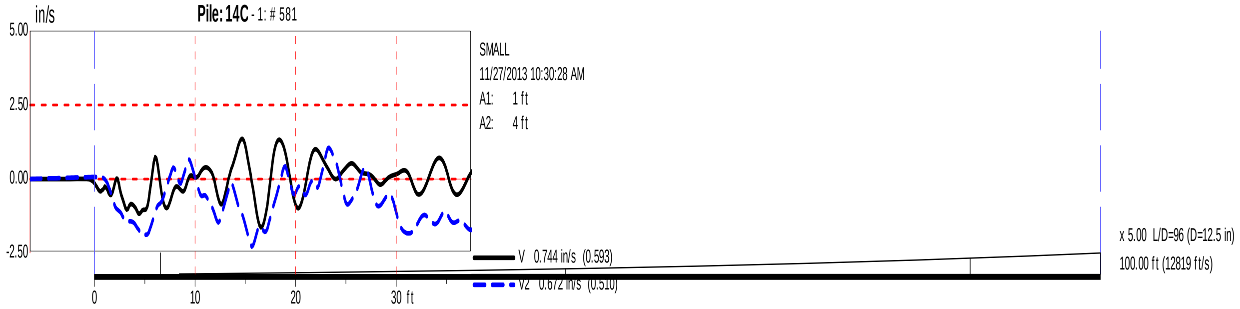
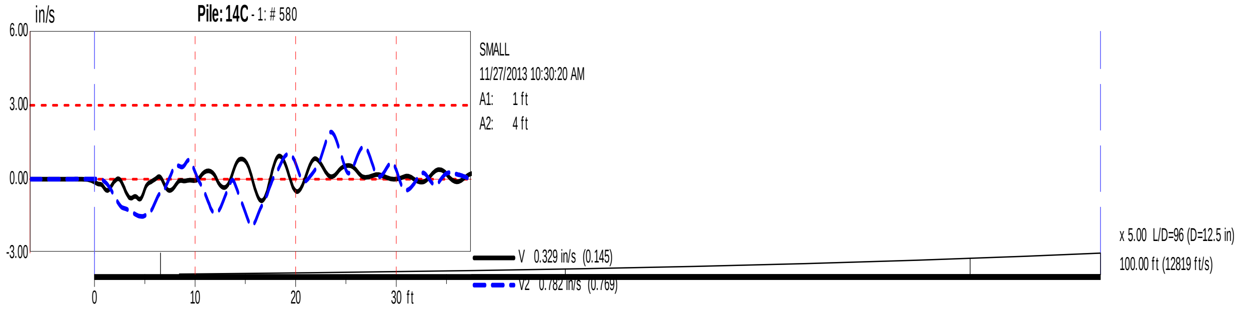
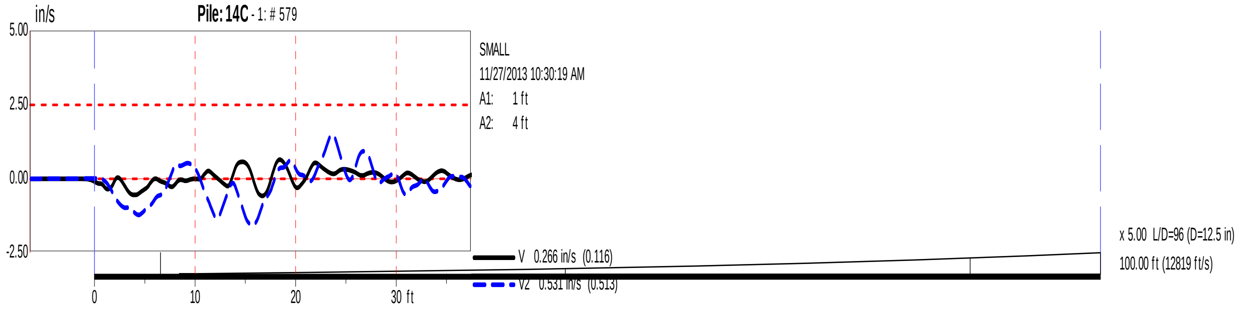
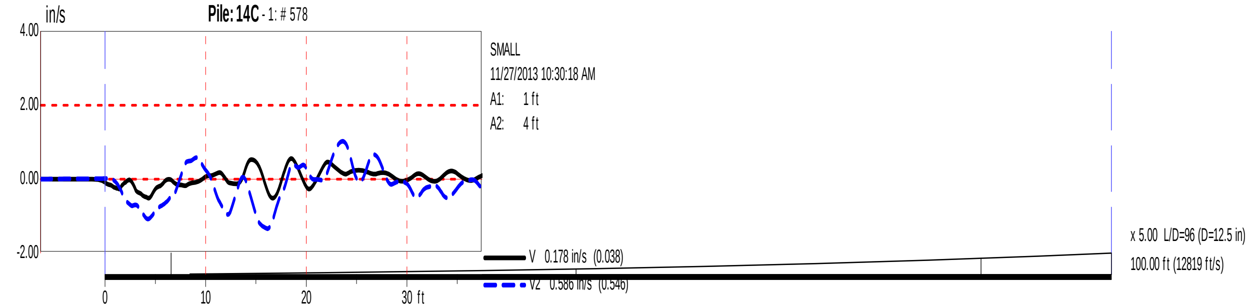

Pile: 14C - 1: # 583

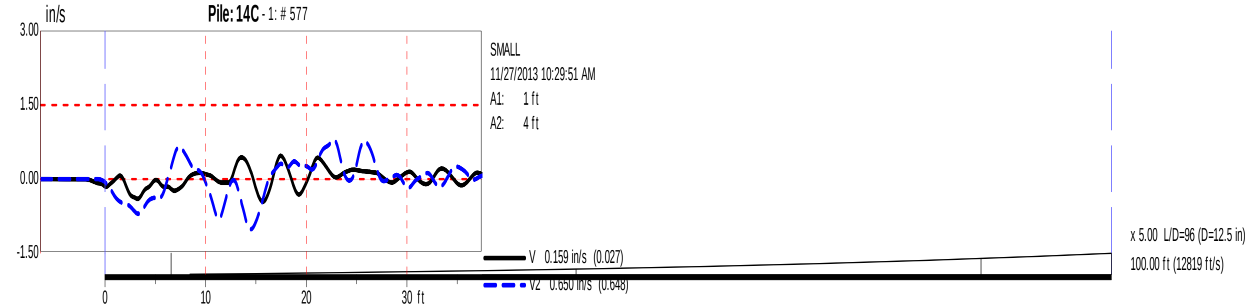

Pile: 14C - 1: # 582

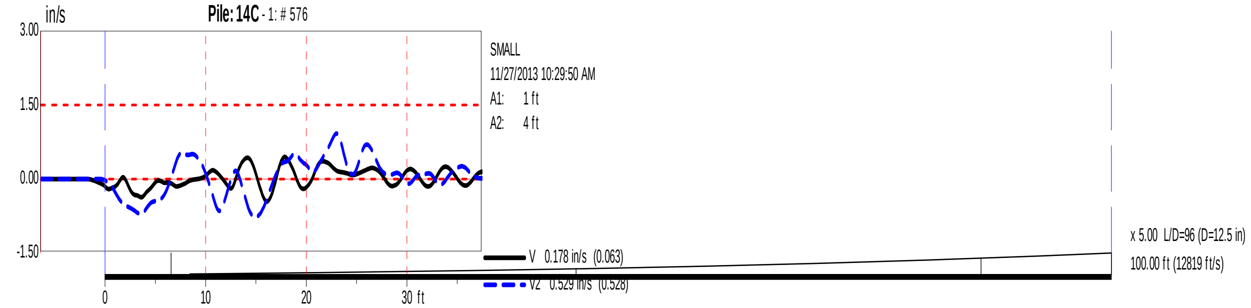

Pile: 14C - 1: # 581

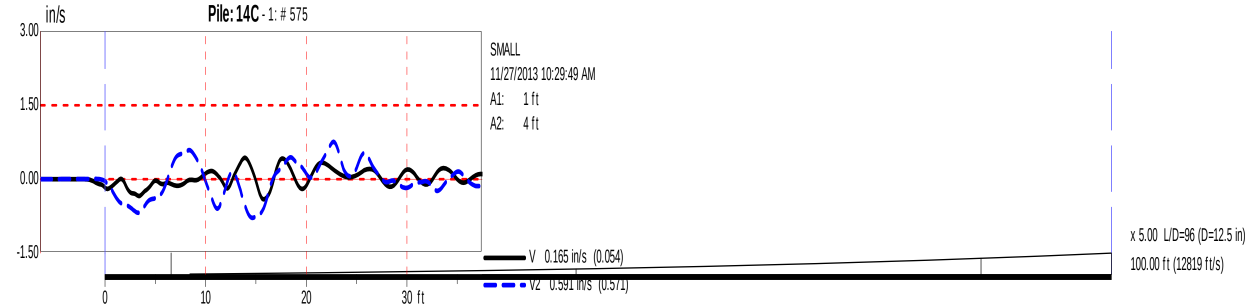

Pile: 14C - 1: # 580

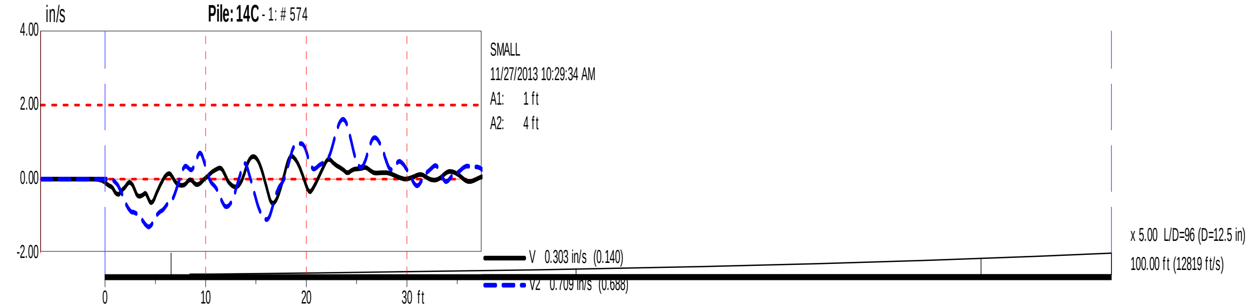

Pile: 14C - 1: # 579


in/s
Pile: 14C - 1: # 578
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:30:18 AM
A1: 1 ft
A2: 4 ft
V 0.178 in/s (0.038)
V2 0.586 in/s (0.546)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30 ft


in/s
Pile: 14C - 1: # 577
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 10:29:51 AM
A1: 1 ft
A2: 4 ft
V 0.159 in/s (0.027)
V2 0.650 in/s (0.648)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30 ft


in/s
Pile: 14C - 1: # 576
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 10:29:50 AM
A1: 1 ft
A2: 4 ft
V 0.178 in/s (0.063)
V2 0.529 in/s (0.528)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30 ft


in/s
Pile: 14C - 1: # 575
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 10:29:49 AM
A1: 1 ft
A2: 4 ft
V 0.165 in/s (0.054)
V2 0.591 in/s (0.571)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30 ft


in/s
Pile: 14C - 1: # 574
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 10:29:34 AM
A1: 1 ft
A2: 4 ft
V 0.303 in/s (0.140)
V2 0.709 in/s (0.688)
x 5.00 L/D=96 (D=12.5 in)
100.00 ft (12819 ft/s)
0
10
20
30 ft

Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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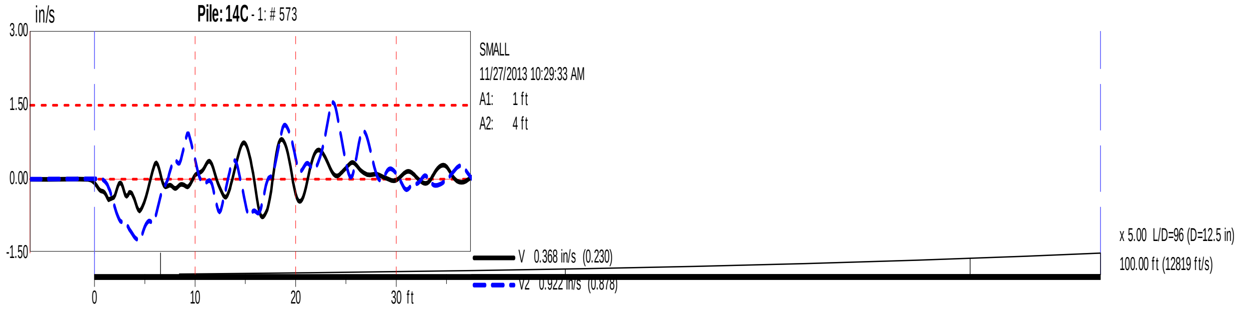
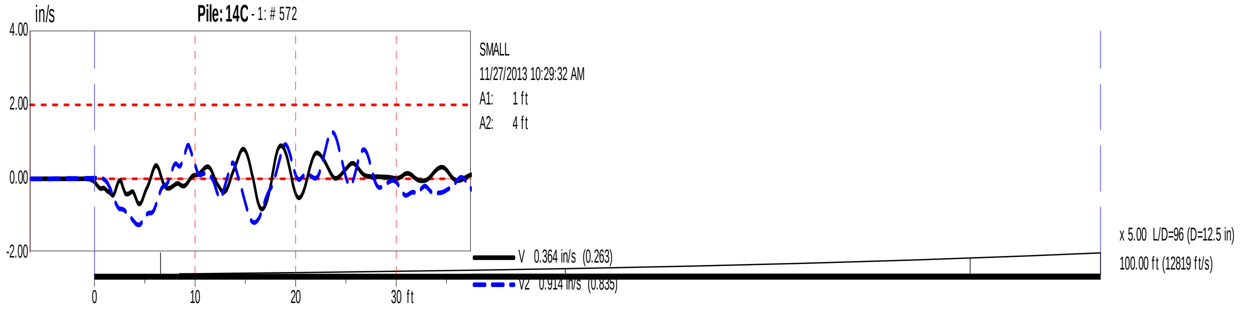
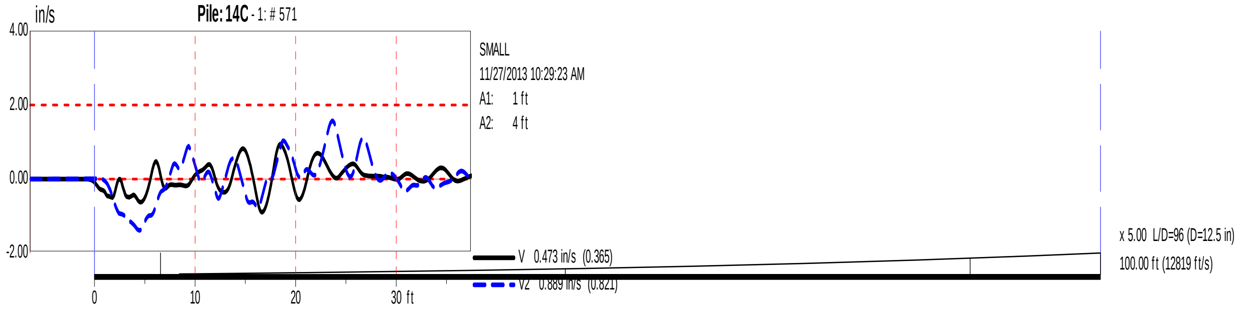
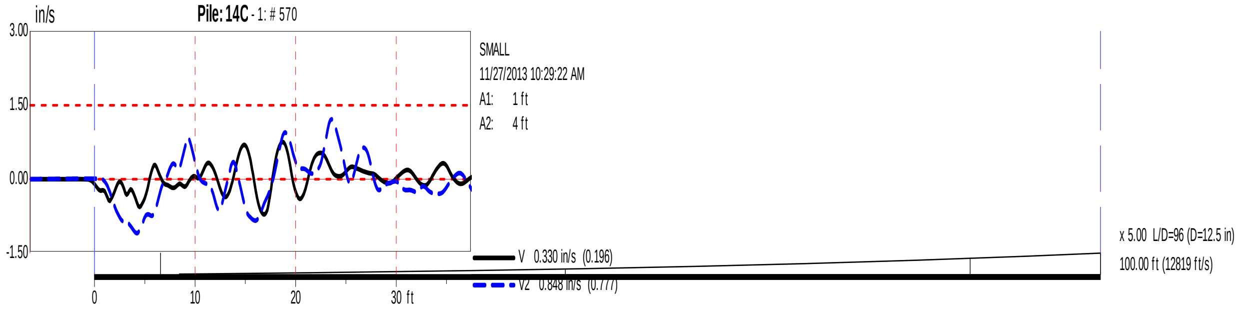
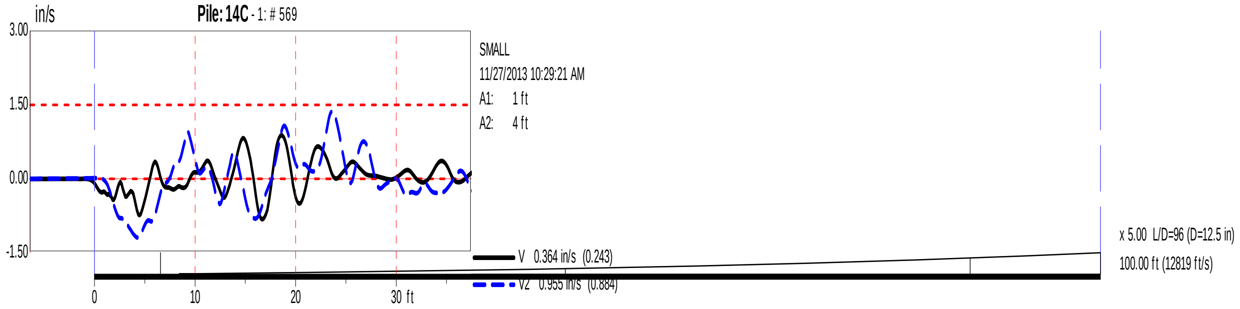


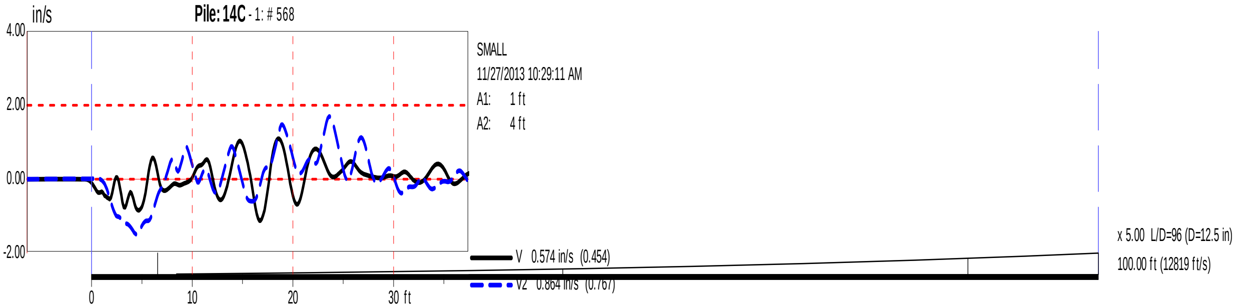


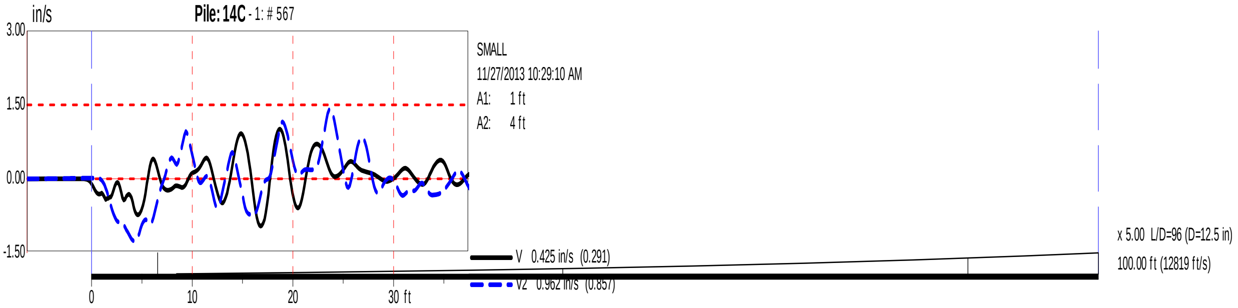


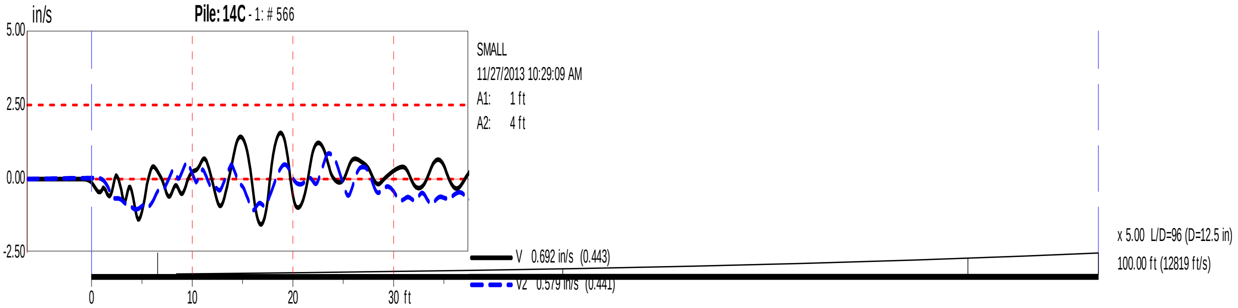


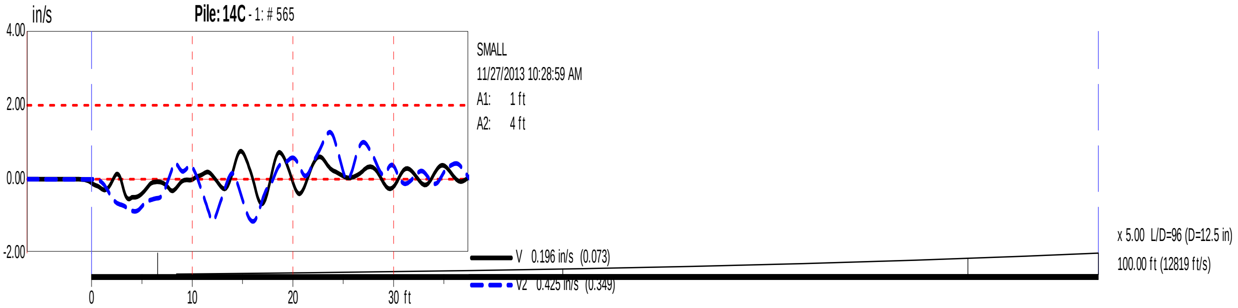


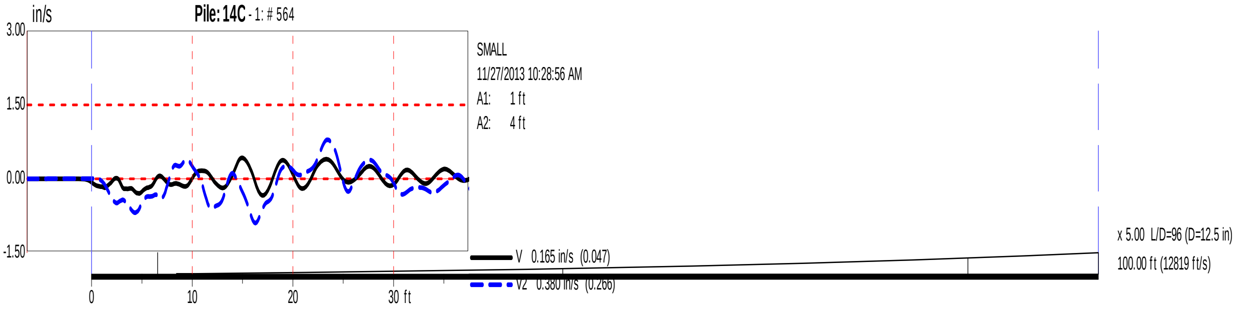
Pile Dynamics, Inc. 12/29/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO











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PIT Raw data

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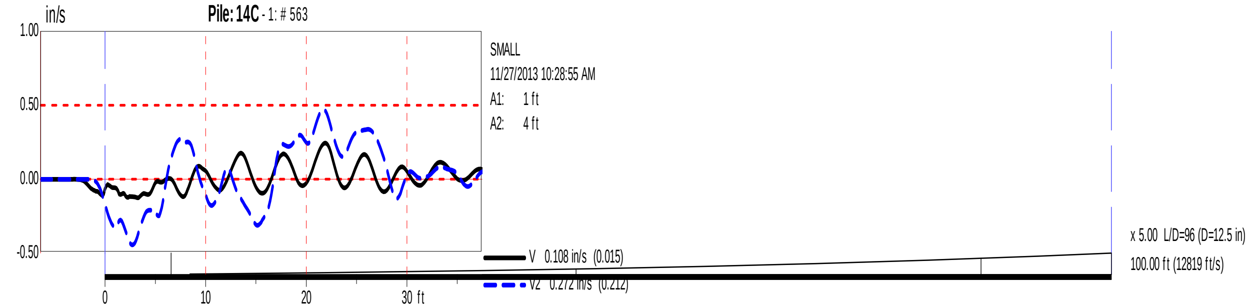
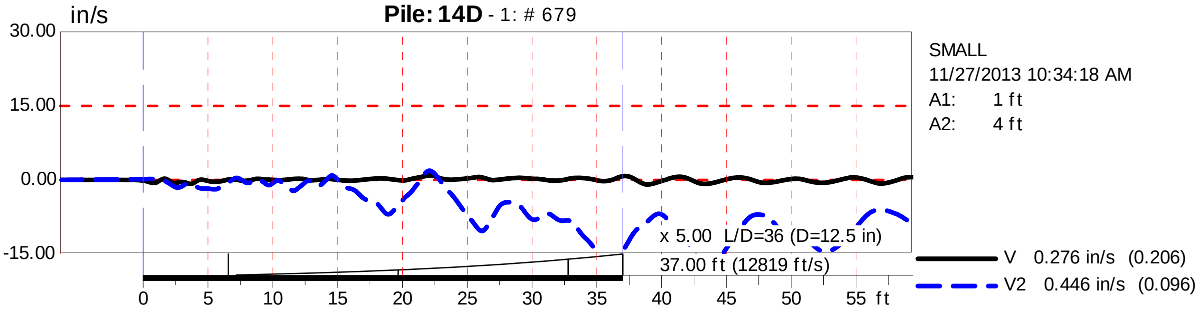
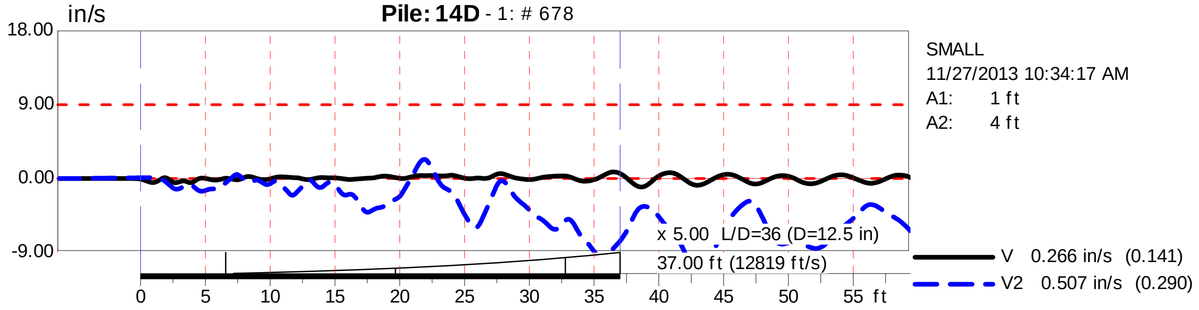
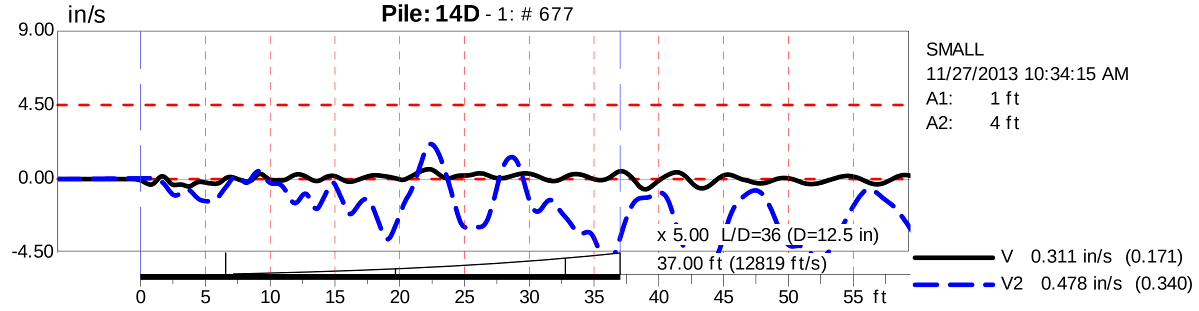




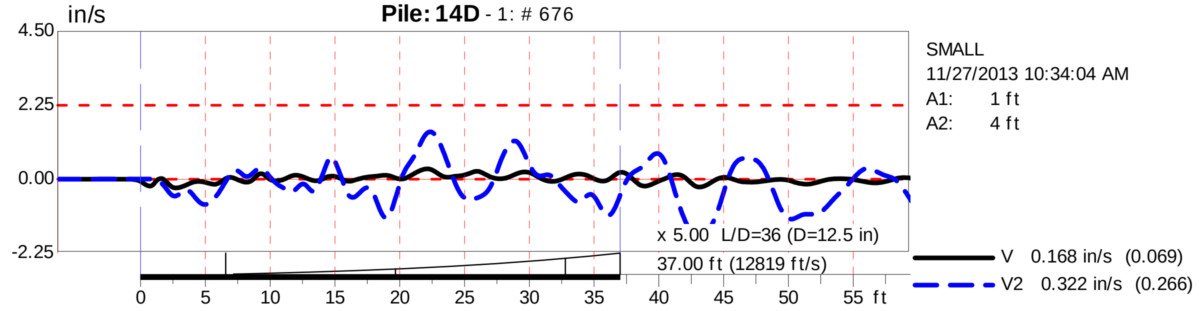
Pile: 14D - 1: # 679



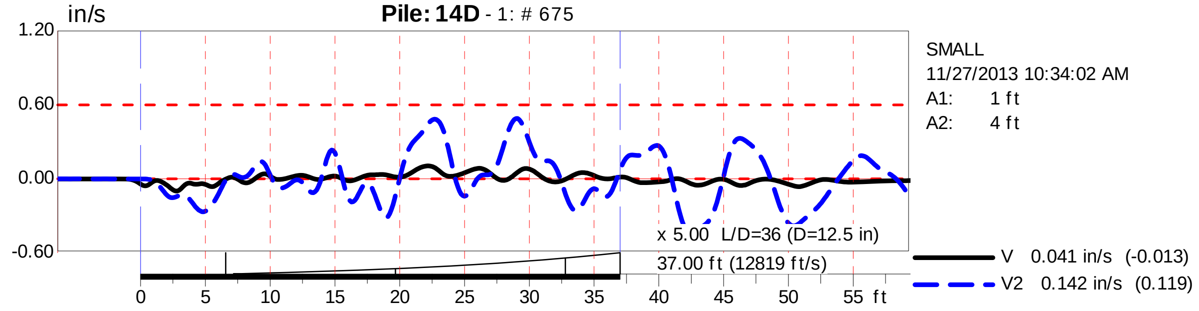
Pile: 14D - 1: # 678



Pile: 14D - 1: # 677

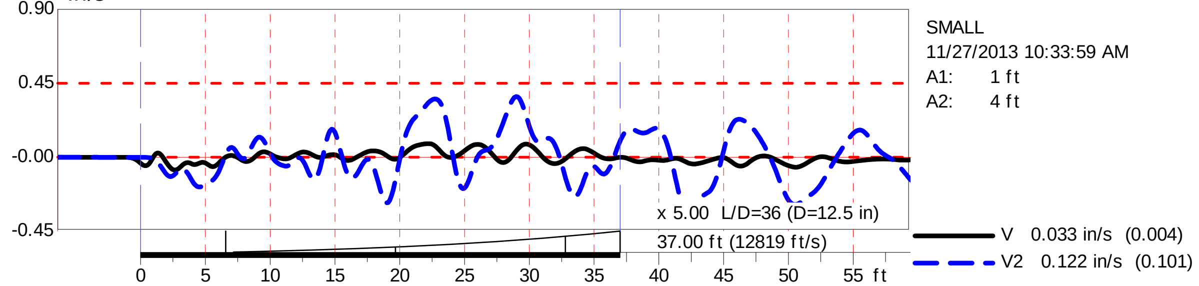


Pile: 14D - 1: # 676

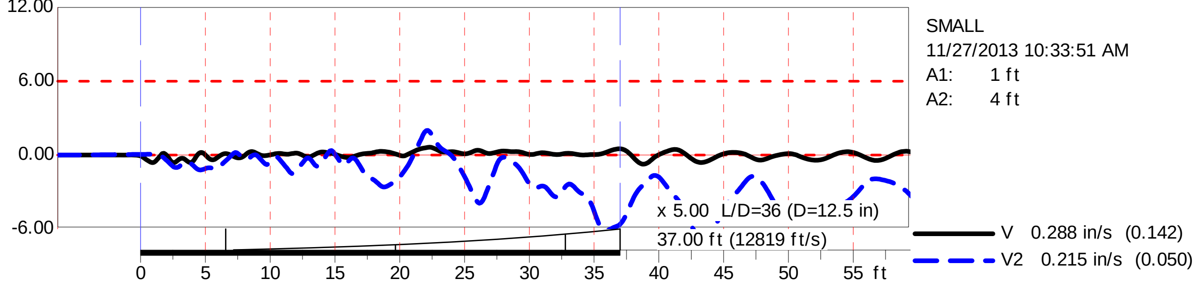


Pile: 14D - 1: # 675

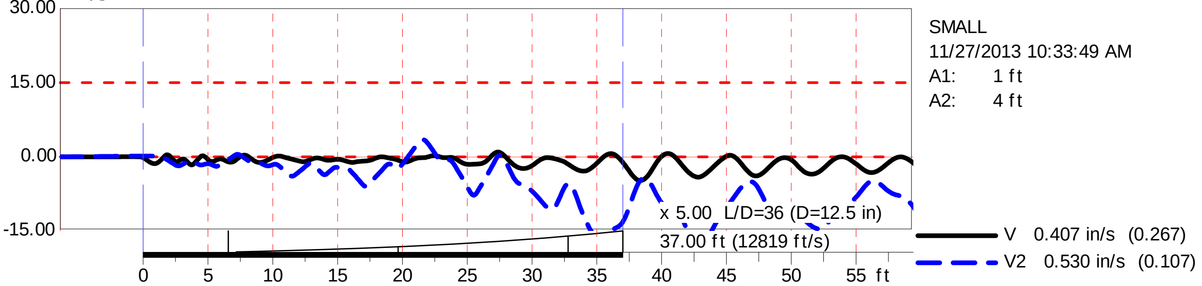
Pile: 14D - 1: # 674



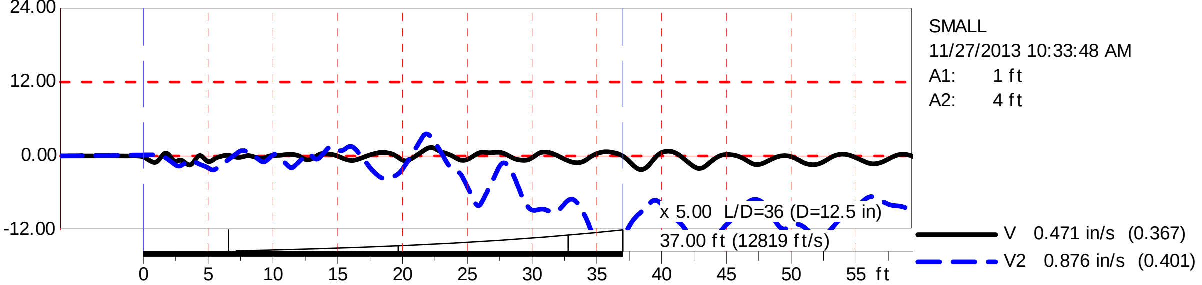
Pile: 14D - 1: # 673



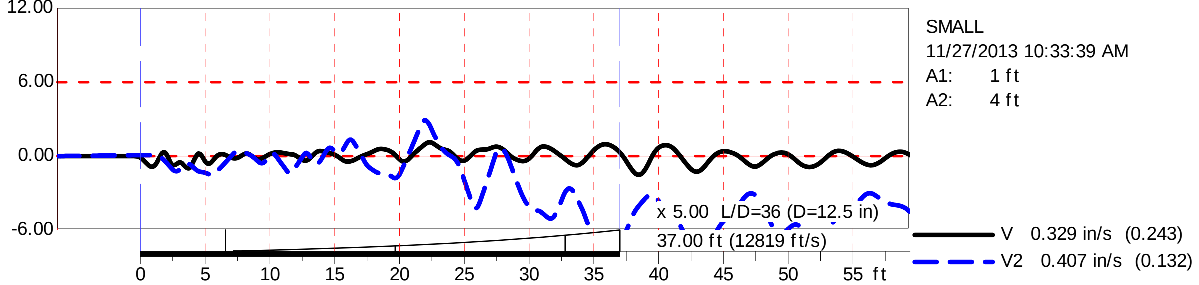
Pile: 14D - 1: # 672



Pile: 14D - 1: # 671



Pile: 14D - 1: # 670



Pile Dynamics, Inc. 12/29/2013
PIT Raw data
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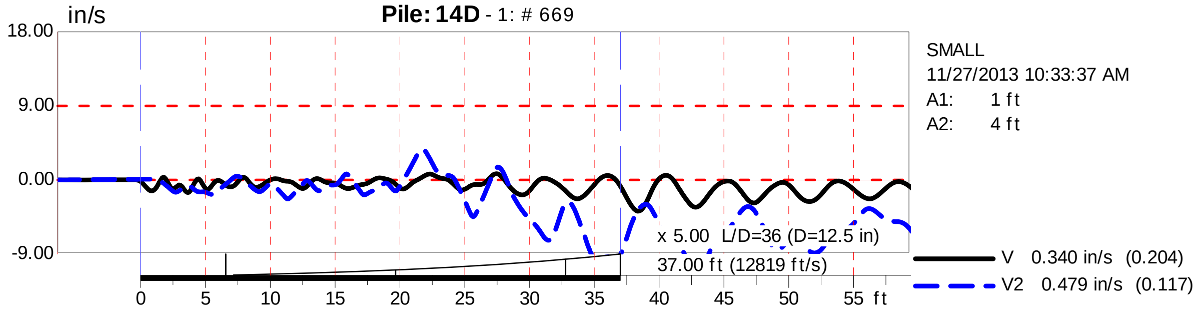
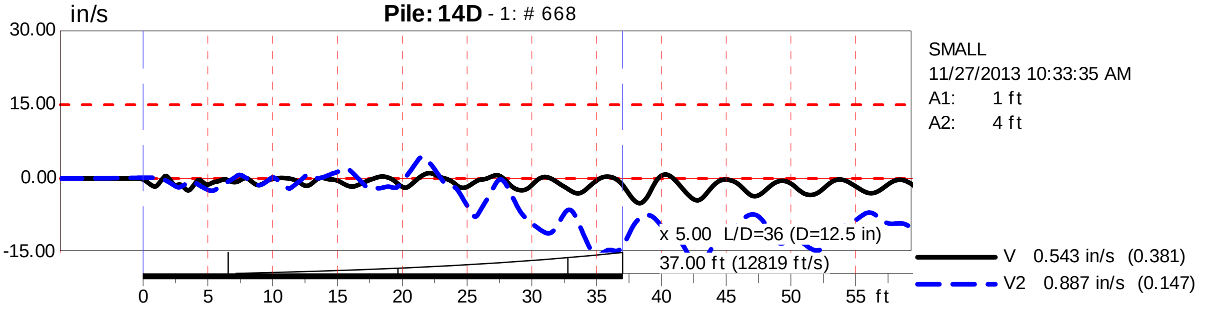

Pile: 14D - 1: # 669

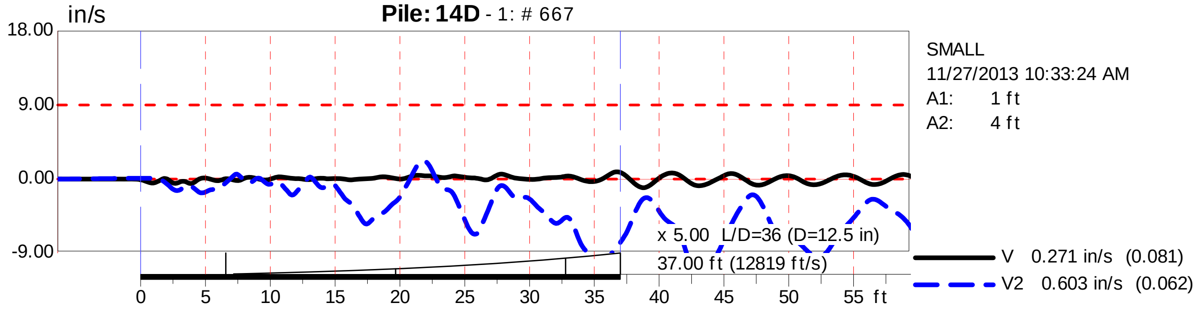
SMALL
11/27/2013 10:33:37 AM
A1: 1 ft
A2: 4 ft

V 0.340 in/s (0.204)
V2 0.479 in/s (0.117)


Pile: 14D - 1: # 668

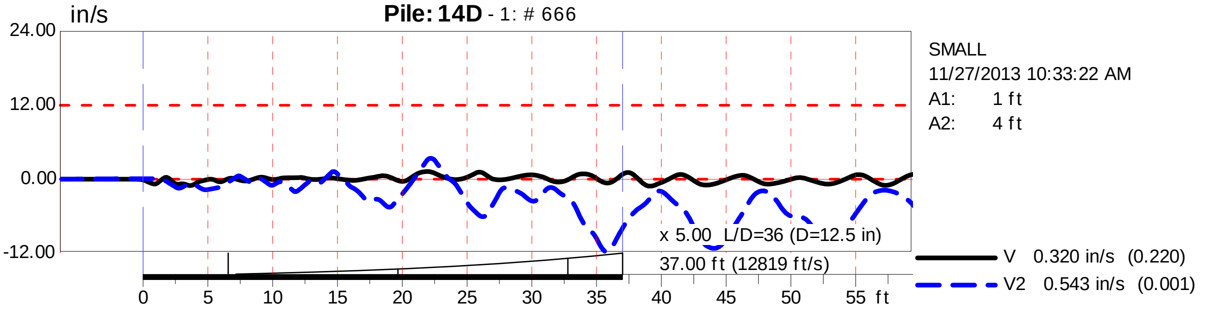
SMALL
11/27/2013 10:33:35 AM
A1: 1 ft
A2: 4 ft

V 0.543 in/s (0.381)
V2 0.887 in/s (0.147)


Pile: 14D - 1: # 667

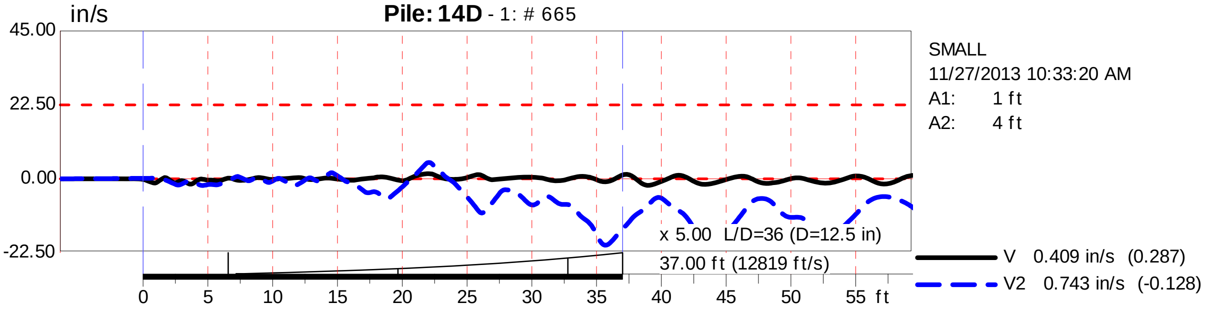
SMALL
11/27/2013 10:33:24 AM
A1: 1 ft
A2: 4 ft

V 0.271 in/s (0.081)
V2 0.603 in/s (0.062)


Pile: 14D - 1: # 666

SMALL
11/27/2013 10:33:22 AM
A1: 1 ft
A2: 4 ft

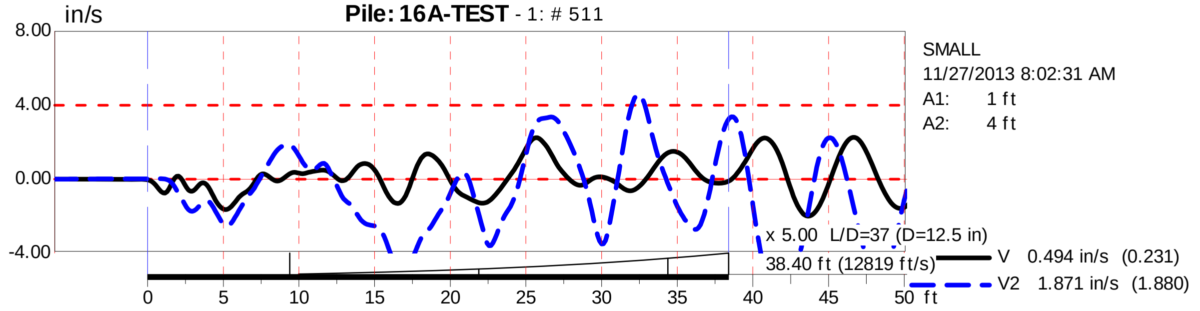
V 0.320 in/s (0.220)
V2 0.543 in/s (0.001)


Pile: 14D - 1: # 665

SMALL
11/27/2013 10:33:20 AM
A1: 1 ft
A2: 4 ft

V 0.409 in/s (0.287)
V2 0.743 in/s (-0.128)

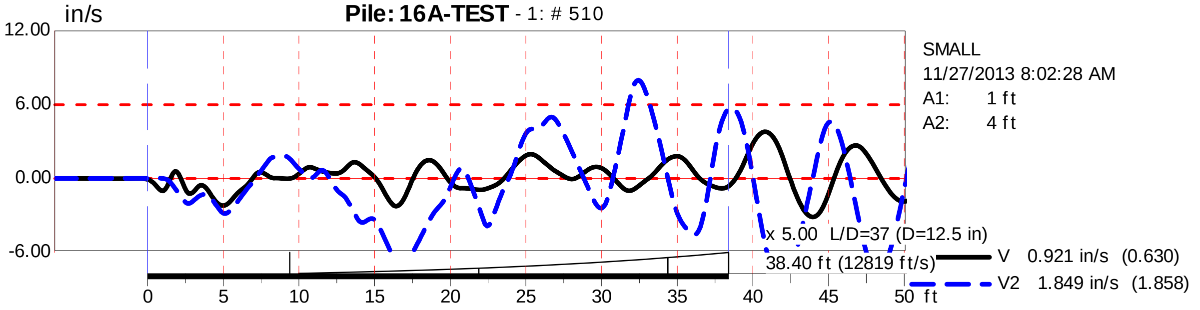
Pile: 16A-TEST - 1: # 511



SMALL
11/27/2013 8:02:31 AM
A1: 1 ft
A2: 4 ft

V 0.494 in/s (0.231)
V2 1.871 in/s (1.880)

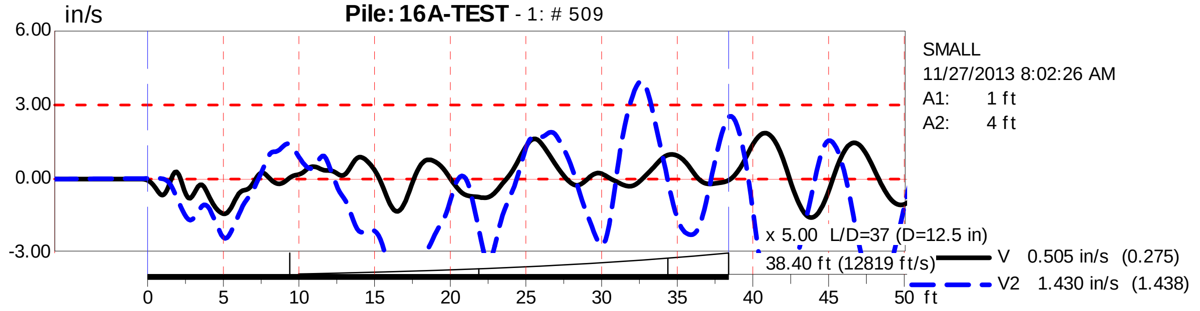
Pile: 16A-TEST - 1: # 510



SMALL
11/27/2013 8:02:28 AM
A1: 1 ft
A2: 4 ft

V 0.921 in/s (0.630)
V2 1.849 in/s (1.858)

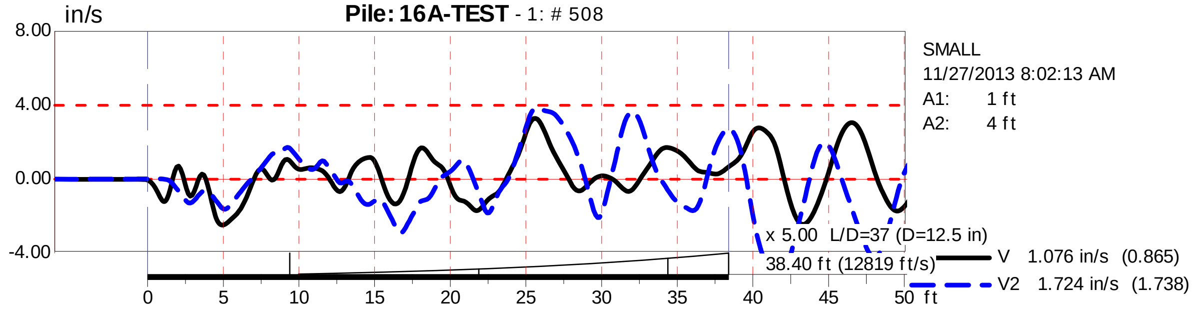
Pile: 16A-TEST - 1: # 509



SMALL
11/27/2013 8:02:26 AM
A1: 1 ft
A2: 4 ft

V 0.505 in/s (0.275)
V2 1.430 in/s (1.438)

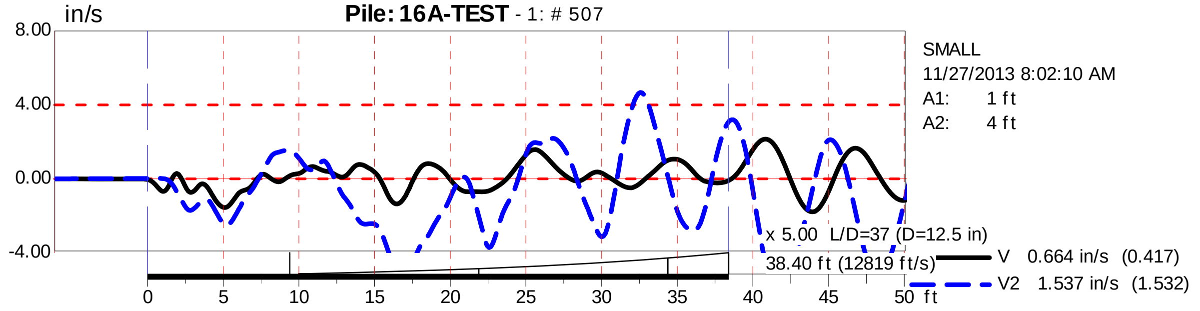
Pile: 16A-TEST - 1: # 508



SMALL
11/27/2013 8:02:13 AM
A1: 1 ft
A2: 4 ft

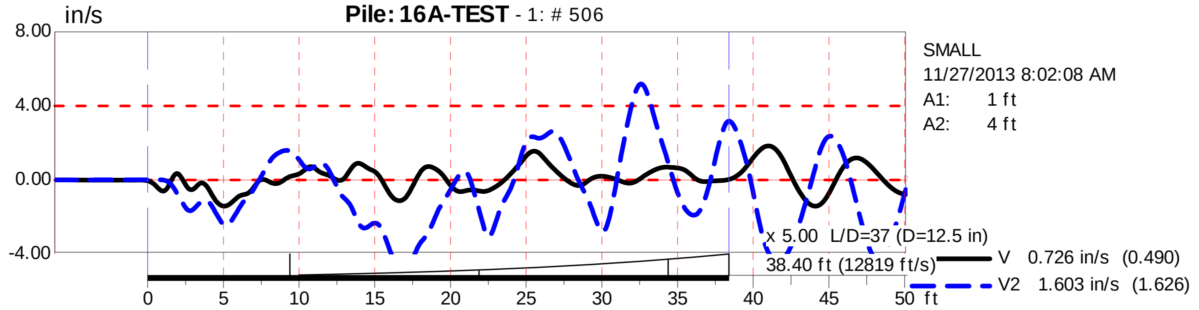
V 1.076 in/s (0.865)
V2 1.724 in/s (1.738)

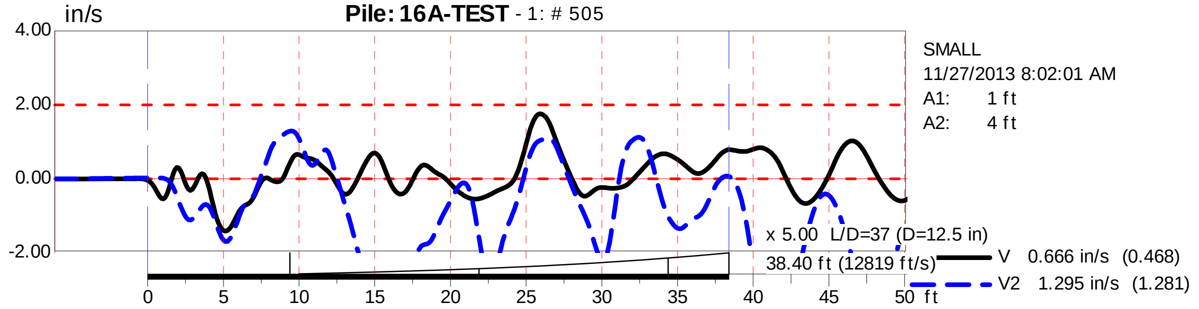
Pile: 16A-TEST - 1: # 507

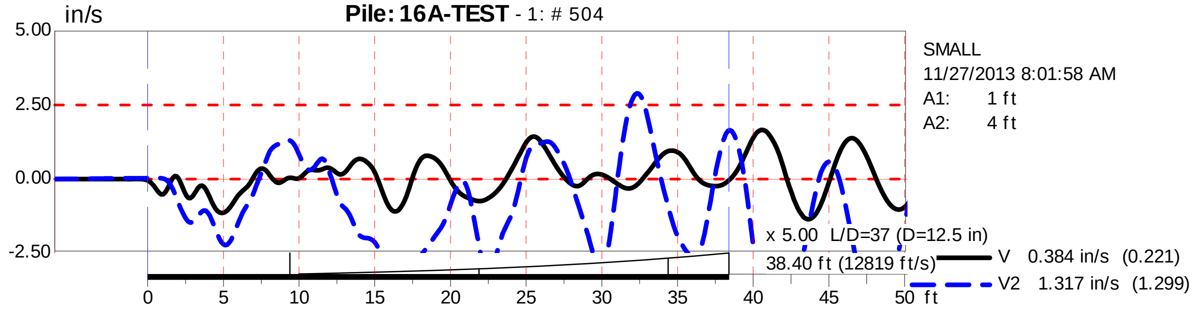


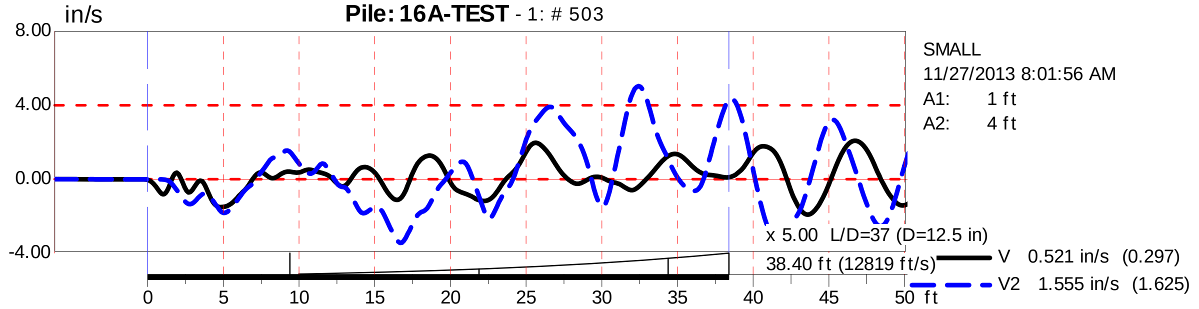
SMALL
11/27/2013 8:02:10 AM
A1: 1 ft
A2: 4 ft

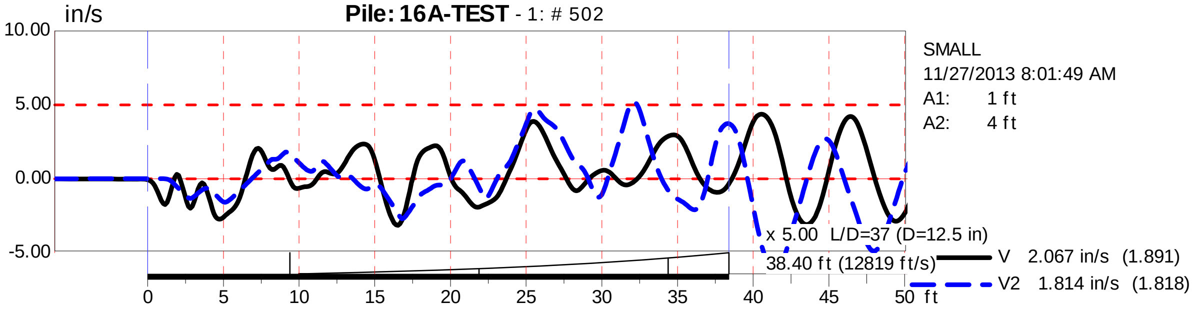
V 0.664 in/s (0.417)
V2 1.537 in/s (1.532)

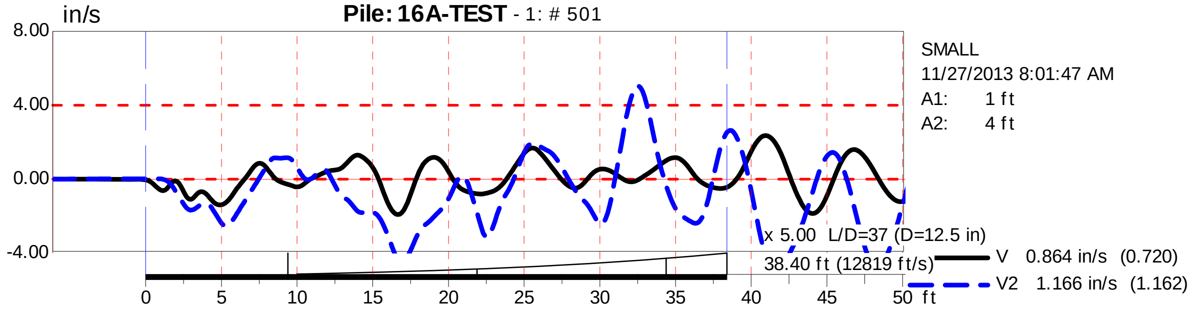

in/s
Pile: 16A-TEST - 1: # 506
8.00
4.00
0.00
-4.00
SMALL
11/27/2013 8:02:08 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
V 0.726 in/s (0.490)
V2 1.603 in/s (1.626)
0
5
10
15
20
25
30
35
40
45
50 ft

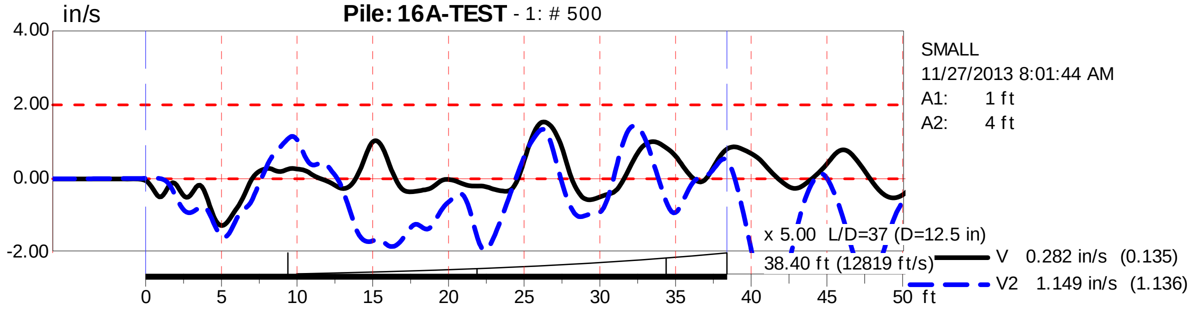

in/s
Pile: 16A-TEST - 1: # 505
4.00
2.00
0.00
-2.00
SMALL
11/27/2013 8:02:01 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
V 0.666 in/s (0.468)
V2 1.295 in/s (1.281)
0
5
10
15
20
25
30
35
40
45
50 ft

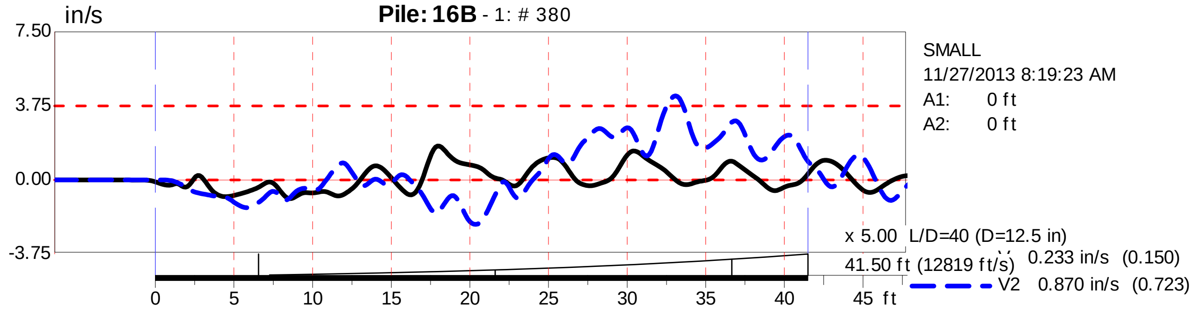

in/s
Pile: 16A-TEST - 1: # 504
5.00
2.50
0.00
-2.50
SMALL
11/27/2013 8:01:58 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
V 0.384 in/s (0.221)
V2 1.317 in/s (1.299)
0
5
10
15
20
25
30
35
40
45
50 ft


in/s
Pile: 16A-TEST - 1: # 503
8.00
4.00
0.00
-4.00
SMALL
11/27/2013 8:01:56 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
V 0.521 in/s (0.297)
V2 1.555 in/s (1.625)
0
5
10
15
20
25
30
35
40
45
50 ft


in/s
Pile: 16A-TEST - 1: # 502
10.00
5.00
0.00
-5.00
SMALL
11/27/2013 8:01:49 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
V 2.067 in/s (1.891)
V2 1.814 in/s (1.818)
0
5
10
15
20
25
30
35
40
45
50 ft


in/s
Pile: 16A-TEST - 1: # 501
8.00
4.00
0.00
-4.00
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
SMALL
11/27/2013 8:01:47 AM
A1: 1 ft
A2: 4 ft
V 0.864 in/s (0.720)
V2 1.166 in/s (1.162)

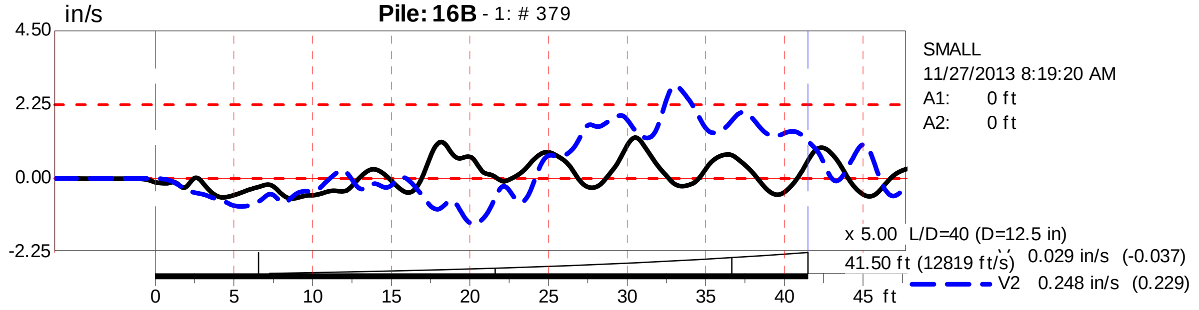

in/s
Pile: 16A-TEST - 1: # 500
4.00
2.00
0.00
-2.00
0
5
10
15
20
25
30
35
40
45
50 ft
x 5.00 L/D=37 (D=12.5 in)
38.40 ft (12819 ft/s)
SMALL
11/27/2013 8:01:44 AM
A1: 1 ft
A2: 4 ft
V 0.282 in/s (0.135)
V2 1.149 in/s (1.136)



Pile: 16B - 1: # 380

SMALL
11/27/2013 8:19:23 AM
A1: 0 ft
A2: 0 ft

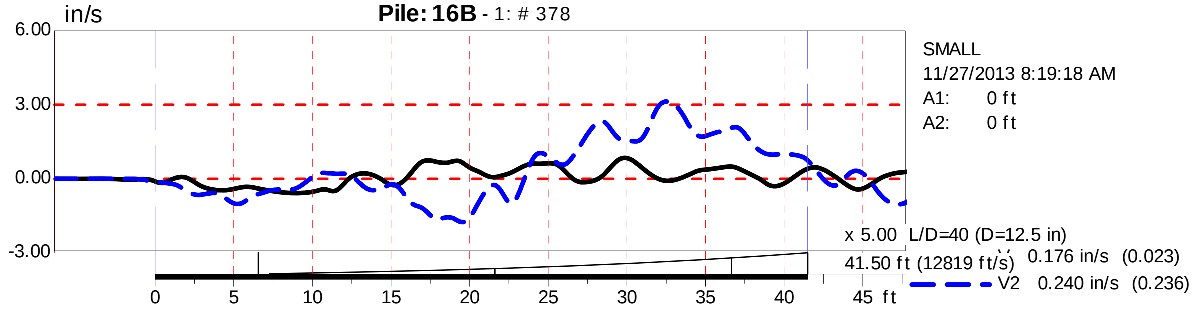
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s) 0.233 in/s (0.150)
V2 0.870 in/s (0.723)



Pile: 16B - 1: # 379

SMALL
11/27/2013 8:19:20 AM
A1: 0 ft
A2: 0 ft

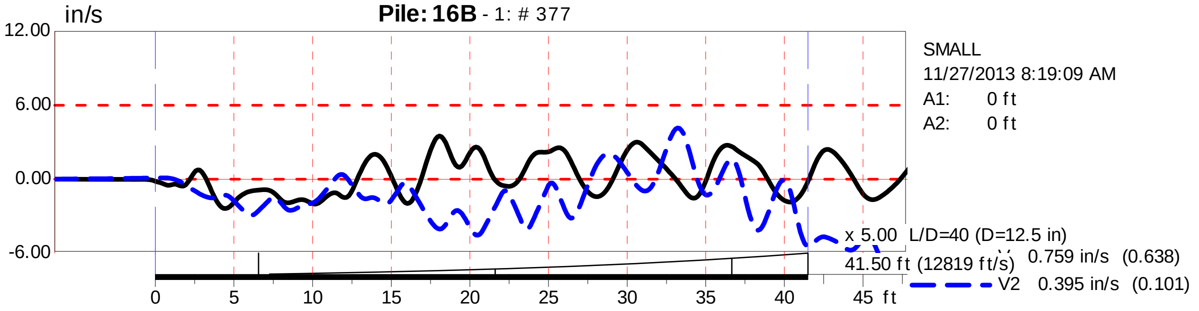
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s) 0.029 in/s (-0.037)
V2 0.248 in/s (0.229)



Pile: 16B - 1: # 378

SMALL
11/27/2013 8:19:18 AM
A1: 0 ft
A2: 0 ft

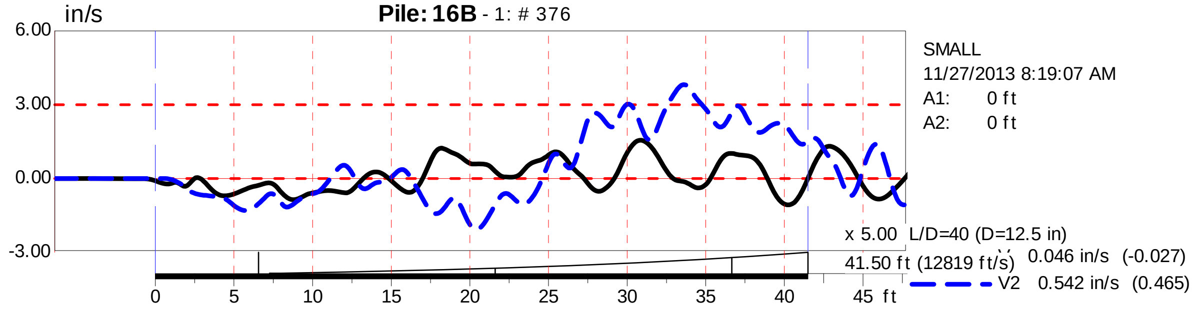
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s) 0.176 in/s (0.023)
V2 0.240 in/s (0.236)



Pile: 16B - 1: # 377

SMALL
11/27/2013 8:19:09 AM
A1: 0 ft
A2: 0 ft

x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s) 0.759 in/s (0.638)
V2 0.395 in/s (0.101)

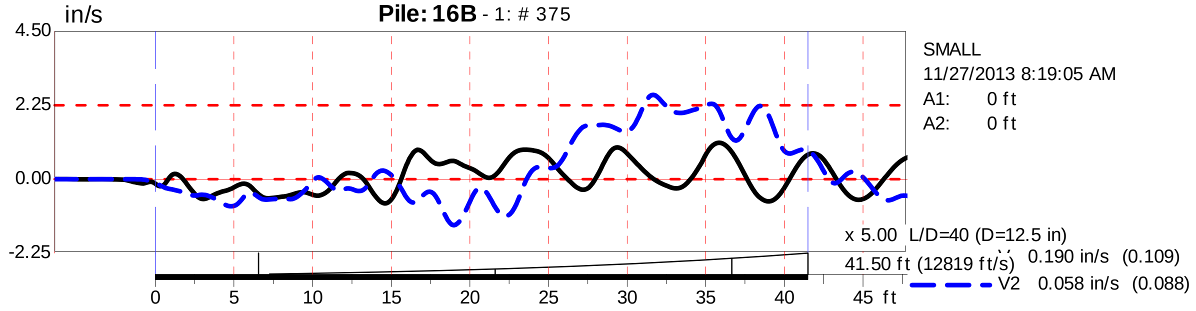


Pile: 16B - 1: # 376

SMALL
11/27/2013 8:19:07 AM
A1: 0 ft
A2: 0 ft

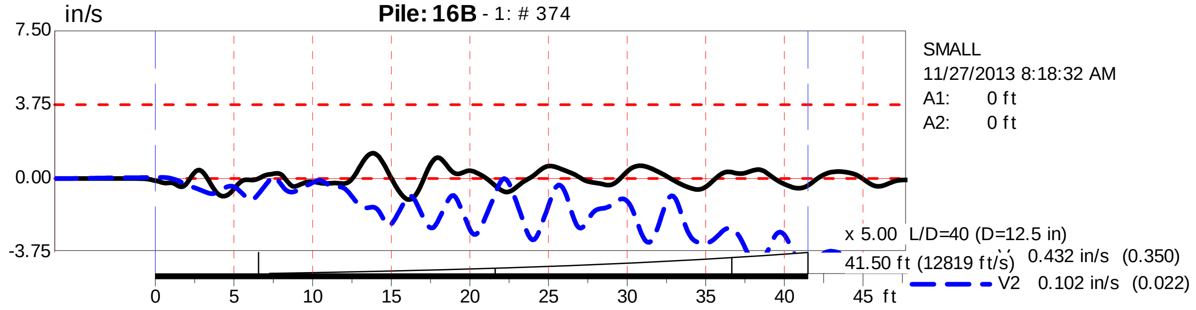
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s) 0.046 in/s (-0.027)
V2 0.542 in/s (0.465)

Pile: 16B - 1: # 375



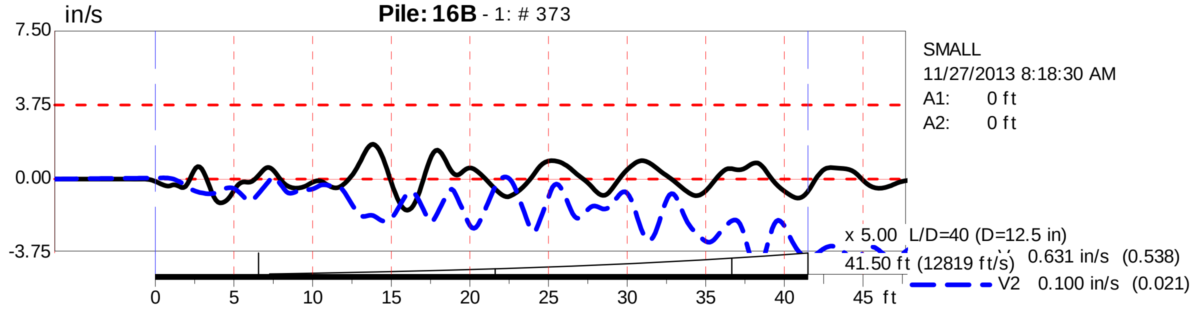
SMALL
11/27/2013 8:19:05 AM
A1: 0 ft
A2: 0 ft

Pile: 16B - 1: # 374



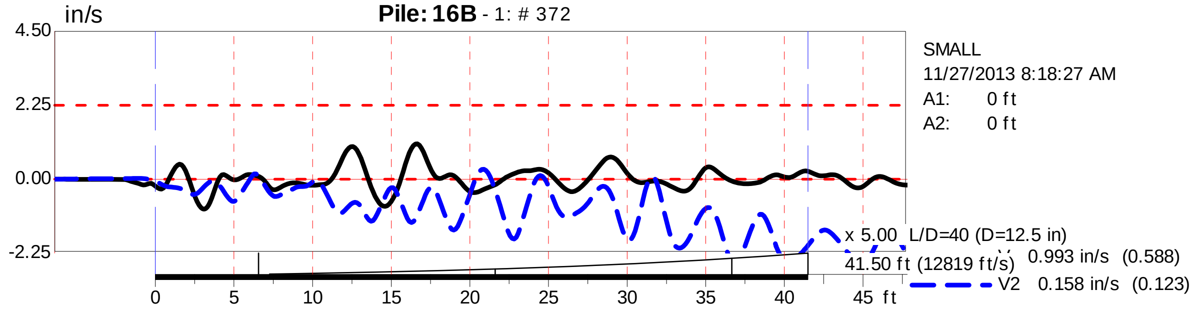
SMALL
11/27/2013 8:18:32 AM
A1: 0 ft
A2: 0 ft

Pile: 16B - 1: # 373



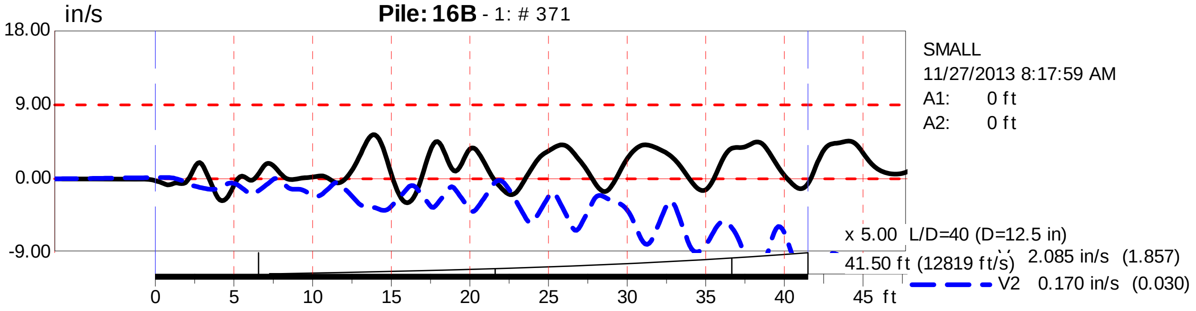
SMALL
11/27/2013 8:18:30 AM
A1: 0 ft
A2: 0 ft

Pile: 16B - 1: # 372



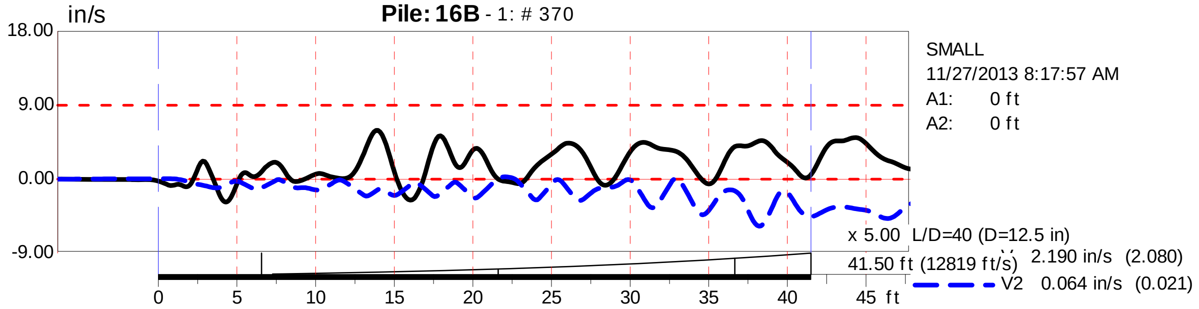
SMALL
11/27/2013 8:18:27 AM
A1: 0 ft
A2: 0 ft

Pile: 16B - 1: # 371



SMALL
11/27/2013 8:17:59 AM
A1: 0 ft
A2: 0 ft

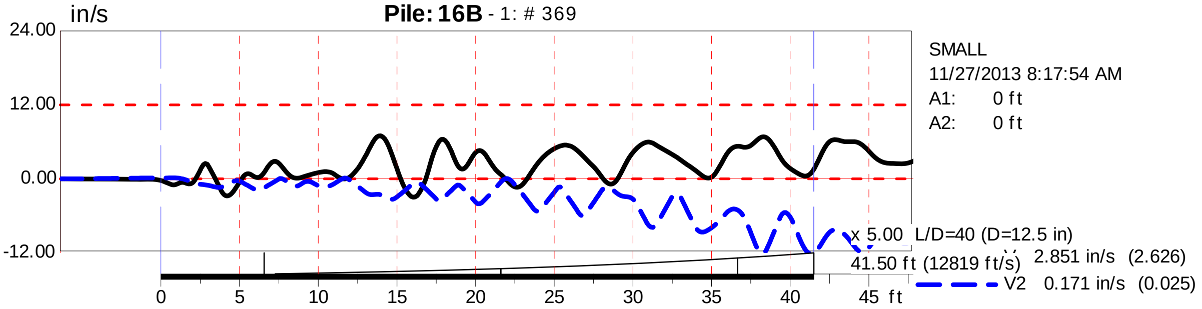
Pile: 16B - 1: # 370



SMALL
11/27/2013 8:17:57 AM
A1: 0 ft
A2: 0 ft

L/D=40 (D=12.5 in)
2.190 in/s (2.080)
V2 0.064 in/s (0.021)

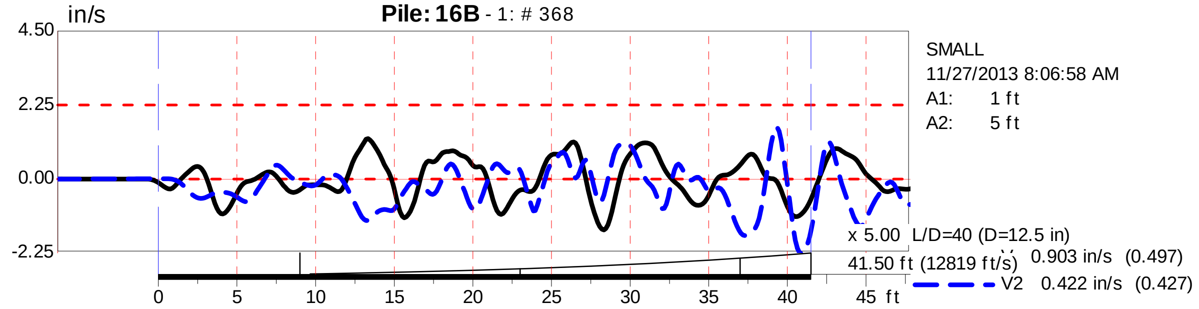
Pile: 16B - 1: # 369



SMALL
11/27/2013 8:17:54 AM
A1: 0 ft
A2: 0 ft

L/D=40 (D=12.5 in)
2.851 in/s (2.626)
V2 0.171 in/s (0.025)

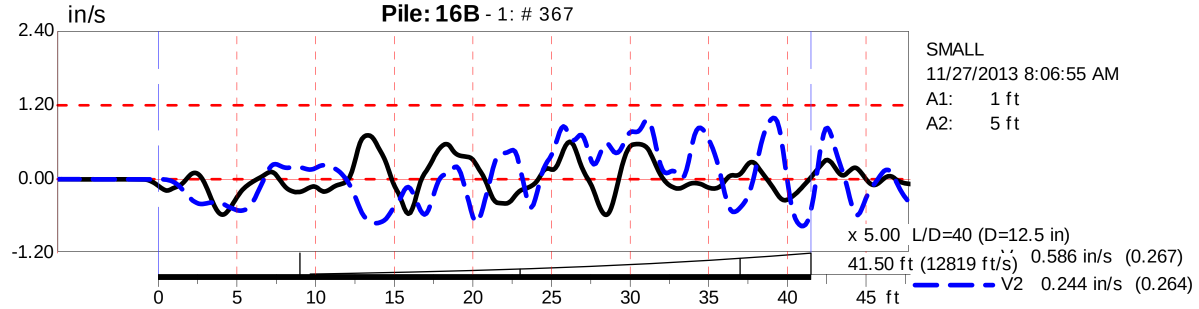
Pile: 16B - 1: # 368



SMALL
11/27/2013 8:06:58 AM
A1: 1 ft
A2: 5 ft

L/D=40 (D=12.5 in)
0.903 in/s (0.497)
V2 0.422 in/s (0.427)

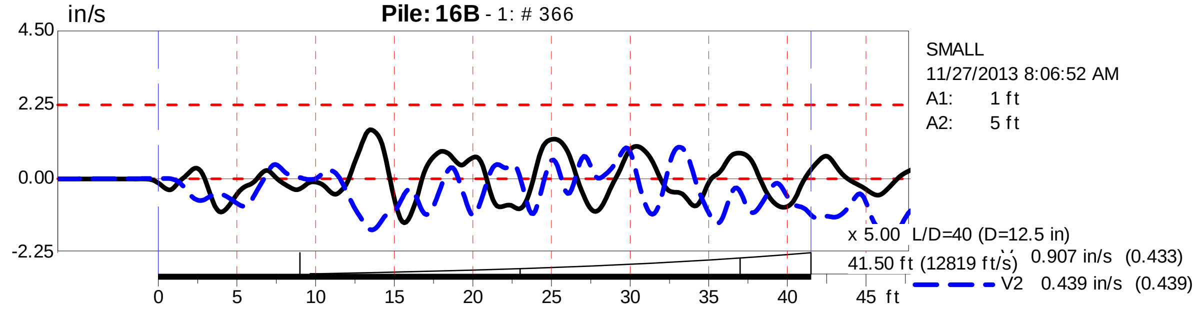
Pile: 16B - 1: # 367



SMALL
11/27/2013 8:06:55 AM
A1: 1 ft
A2: 5 ft

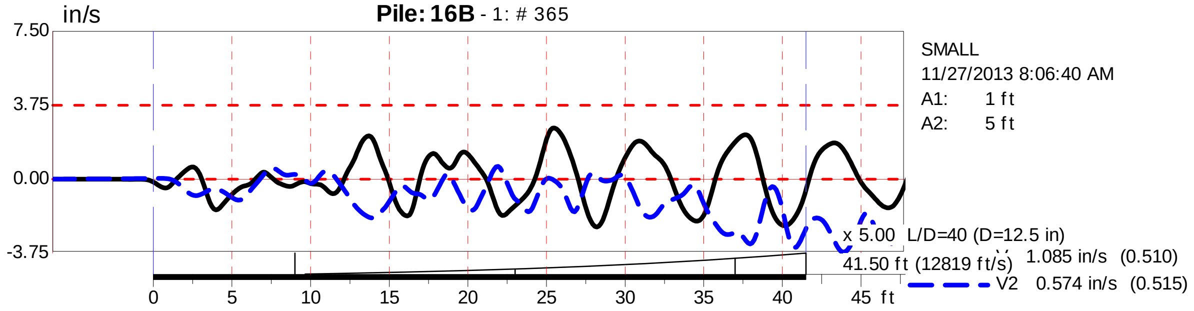
L/D=40 (D=12.5 in)
0.586 in/s (0.267)
V2 0.244 in/s (0.264)

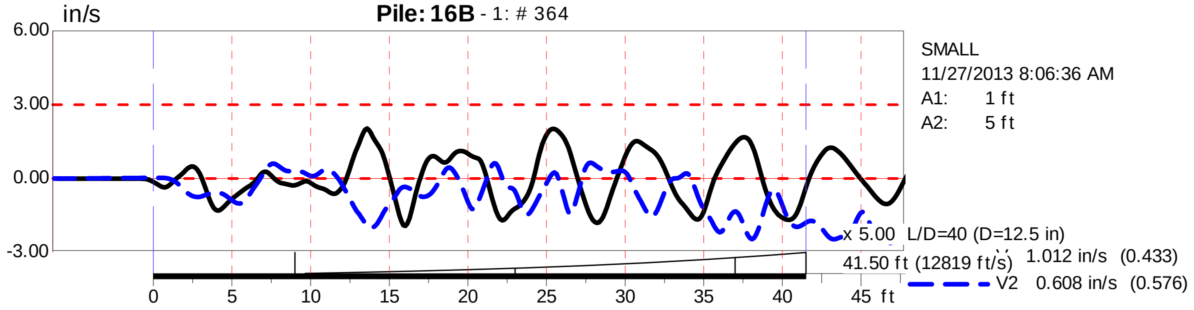
Pile: 16B - 1: # 366

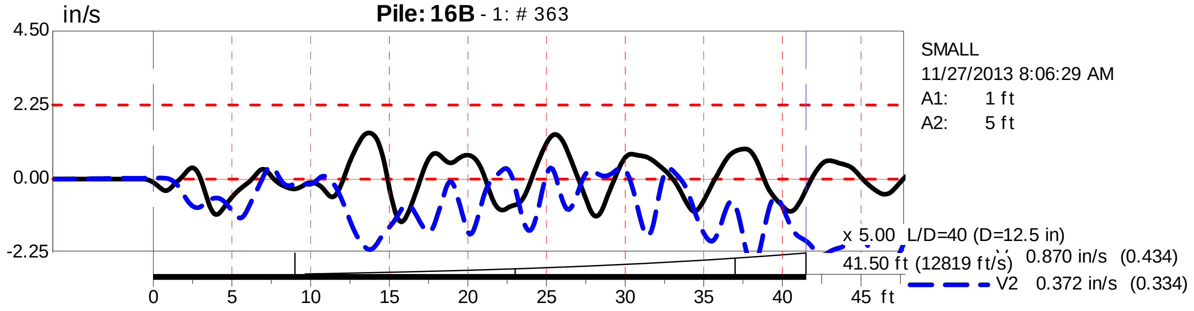


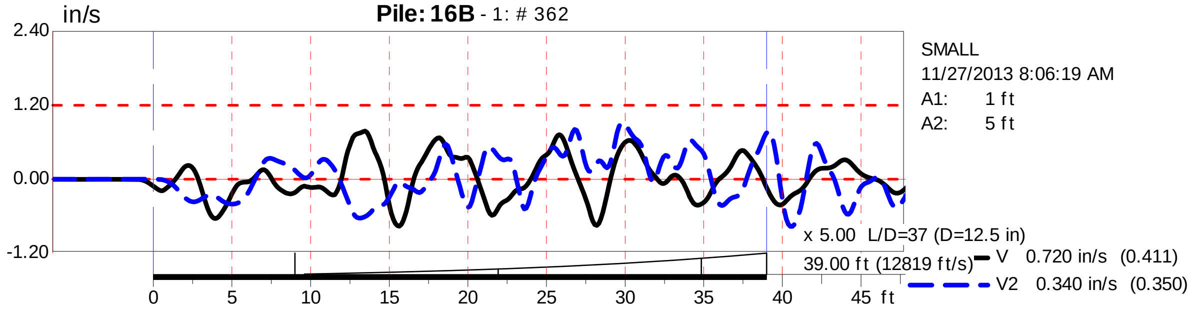
SMALL
11/27/2013 8:06:52 AM
A1: 1 ft
A2: 5 ft

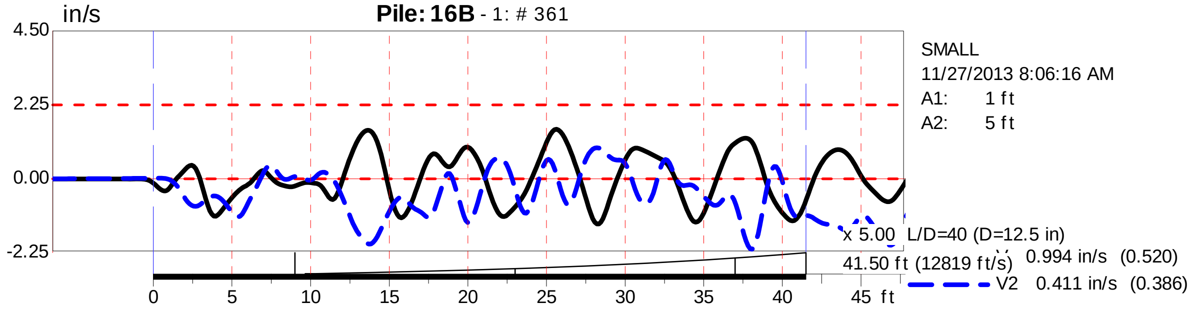
L/D=40 (D=12.5 in)
0.907 in/s (0.433)
V2 0.439 in/s (0.439)


in/s
Pile: 16B - 1: # 365
7.50
3.75
0.00
-3.75
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 8:06:40 AM
A1: 1 ft
A2: 5 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
V 1.085 in/s (0.510)
V2 0.574 in/s (0.515)

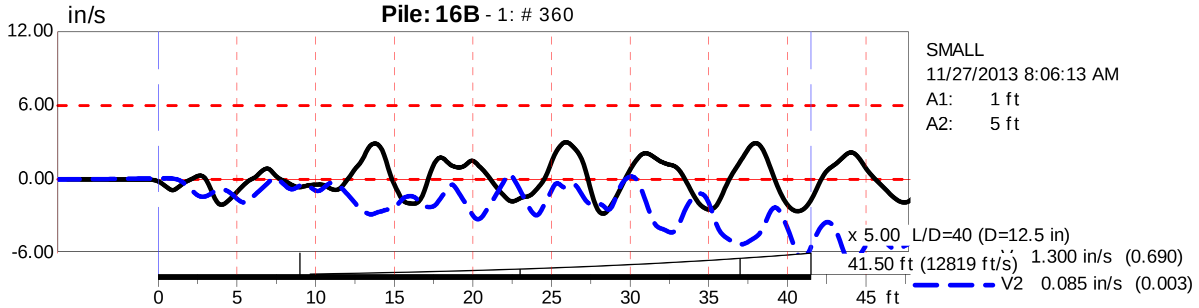

in/s
Pile: 16B - 1: # 364
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 8:06:36 AM
A1: 1 ft
A2: 5 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
V 1.012 in/s (0.433)
V2 0.608 in/s (0.576)


in/s
Pile: 16B - 1: # 363
4.50
2.25
0.00
-2.25
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 8:06:29 AM
A1: 1 ft
A2: 5 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
V 0.870 in/s (0.434)
V2 0.372 in/s (0.334)


in/s
Pile: 16B - 1: # 362
2.40
1.20
0.00
-1.20
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 8:06:19 AM
A1: 1 ft
A2: 5 ft
x 5.00 L/D=37 (D=12.5 in)
39.00 ft (12819 ft/s)
V 0.720 in/s (0.411)
V2 0.340 in/s (0.350)


in/s
Pile: 16B - 1: # 361
4.50
2.25
0.00
-2.25
0
5
10
15
20
25
30
35
40
45 ft
SMALL
11/27/2013 8:06:16 AM
A1: 1 ft
A2: 5 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
V 0.994 in/s (0.520)
V2 0.411 in/s (0.386)

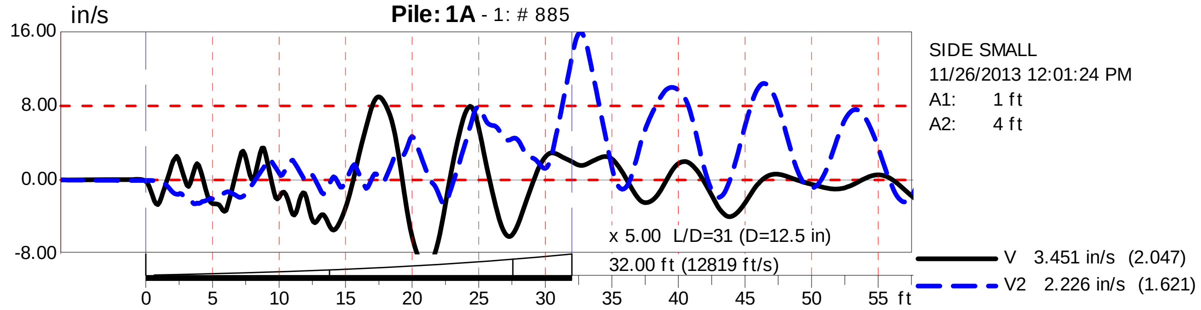
Pile: 16B - 1: # 360

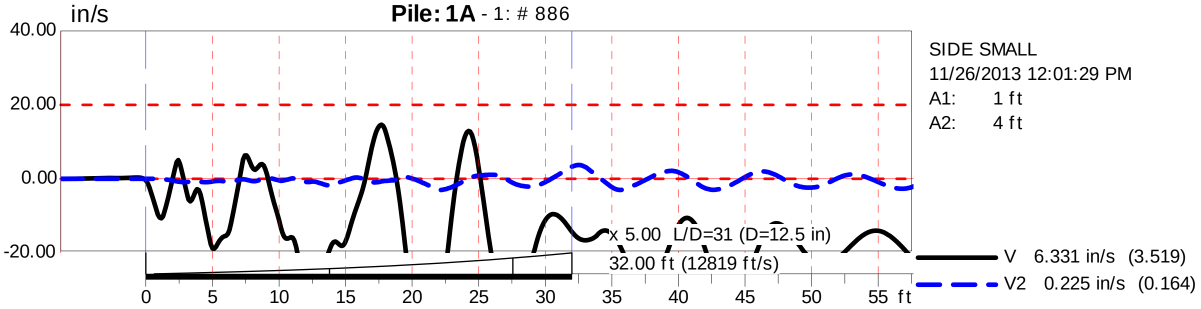


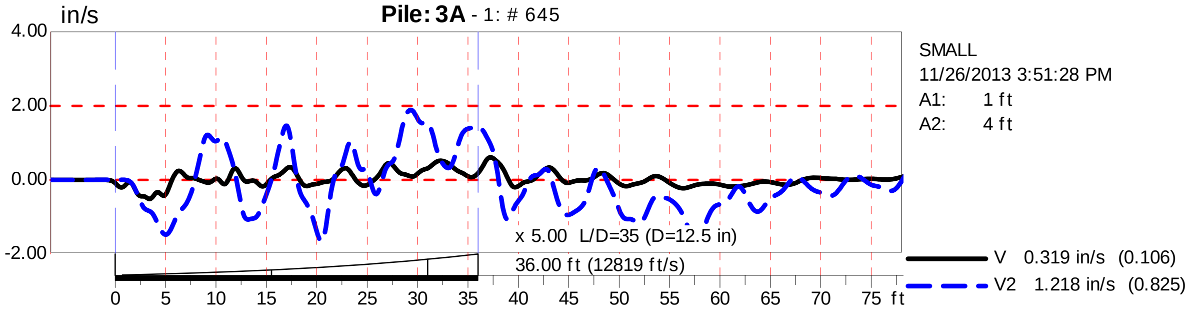
SMALL
11/27/2013 8:06:13 AM
A1: 1 ft
A2: 5 ft

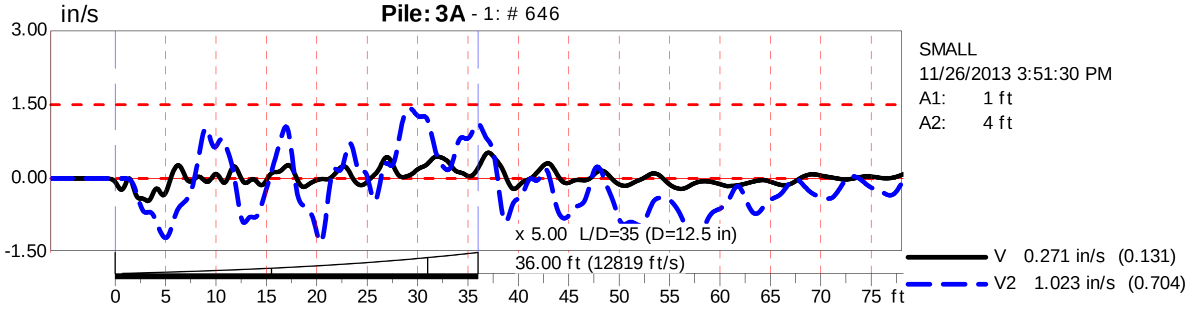
Attachment D

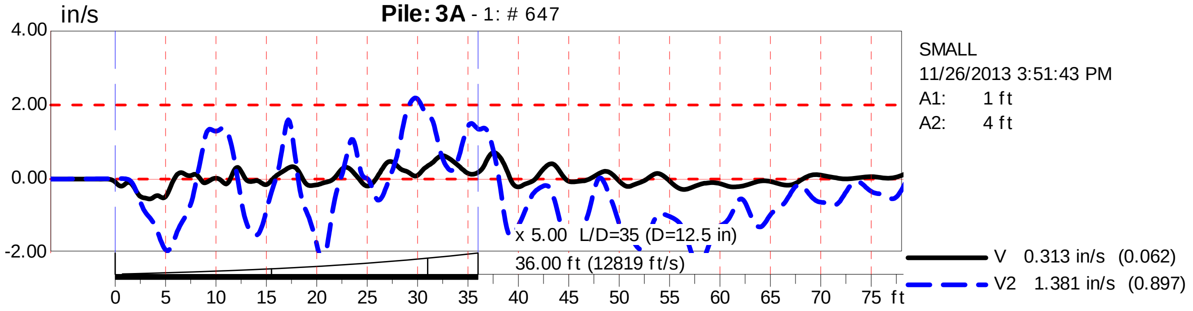
Reliable Data Collected


in/s
Pile: 1A - 1: # 885
16.00
8.00
0.00
-8.00
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:01:24 PM
A1: 1 ft
A2: 4 ft
V 3.451 in/s (2.047)
V2 2.226 in/s (1.621)

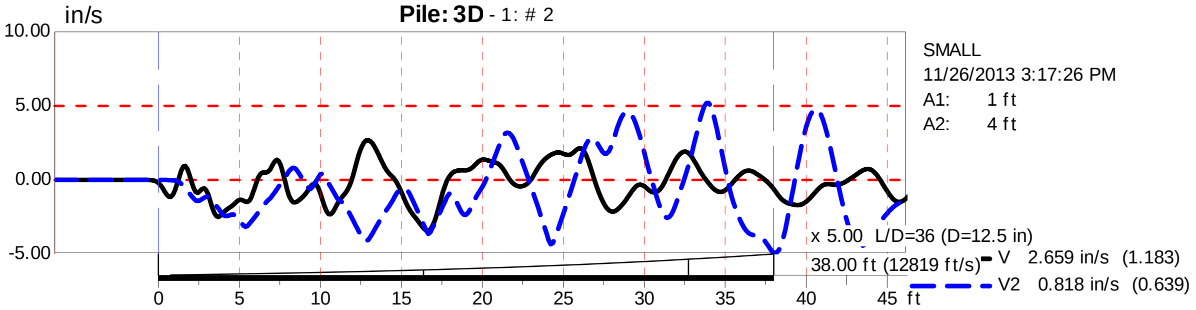

in/s
Pile: 1A - 1: # 886
40.00
20.00
0.00
-20.00
x 5.00 L/D=31 (D=12.5 in)
32.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SIDE SMALL
11/26/2013 12:01:29 PM
A1: 1 ft
A2: 4 ft
V 6.331 in/s (3.519)
V2 0.225 in/s (0.164)

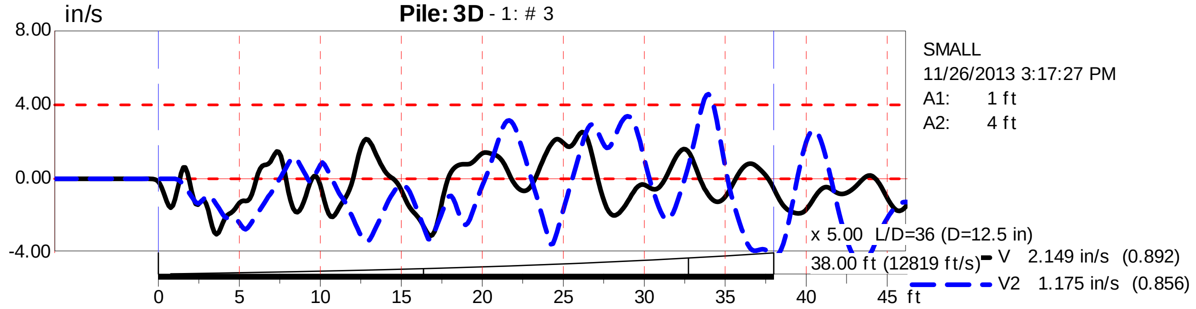

in/s
Pile: 3A - 1: # 645
4.00
2.00
0.00
-2.00
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75 ft
SMALL
11/26/2013 3:51:28 PM
A1: 1 ft
A2: 4 ft
V 0.319 in/s (0.106)
V2 1.218 in/s (0.825)

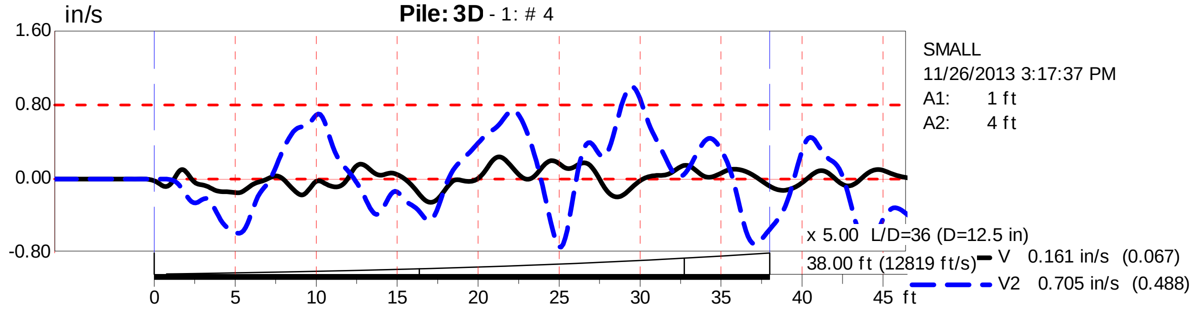

in/s
Pile: 3A - 1: # 646
3.00
1.50
0.00
-1.50
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75 ft
SMALL
11/26/2013 3:51:30 PM
A1: 1 ft
A2: 4 ft
V 0.271 in/s (0.131)
V2 1.023 in/s (0.704)

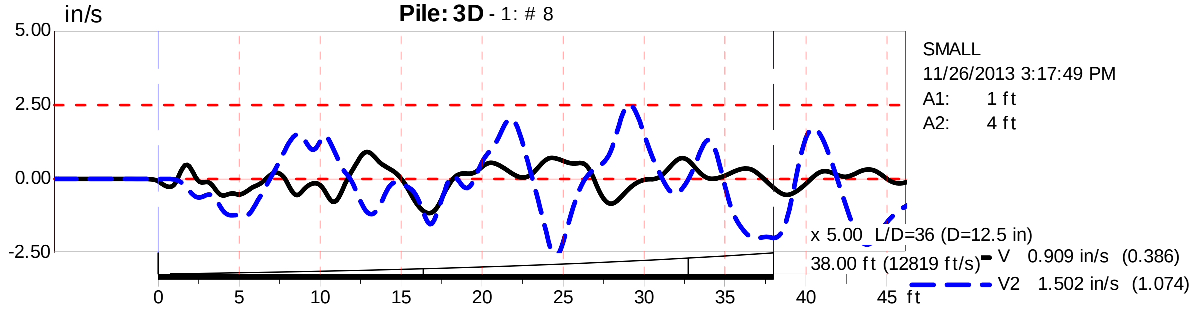

in/s
Pile: 3A - 1: # 647
4.00
2.00
0.00
-2.00
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75 ft
SMALL
11/26/2013 3:51:43 PM
A1: 1 ft
A2: 4 ft
V 0.313 in/s (0.062)
V2 1.381 in/s (0.897)

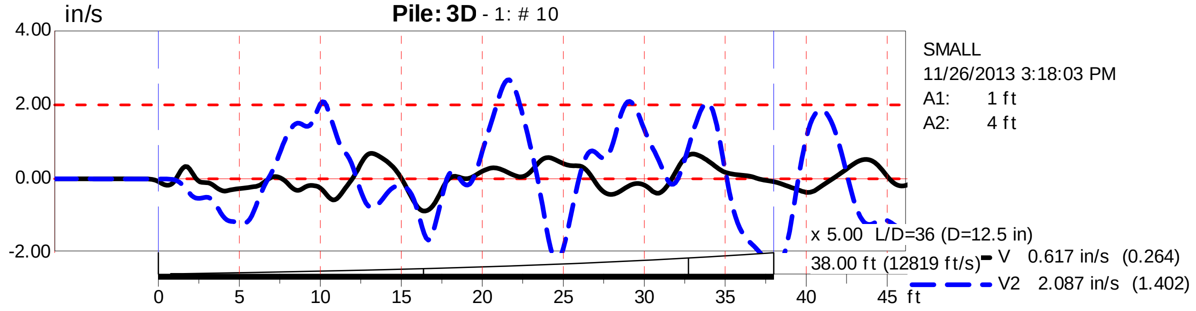
Pile Dynamics, Inc. 12/24/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



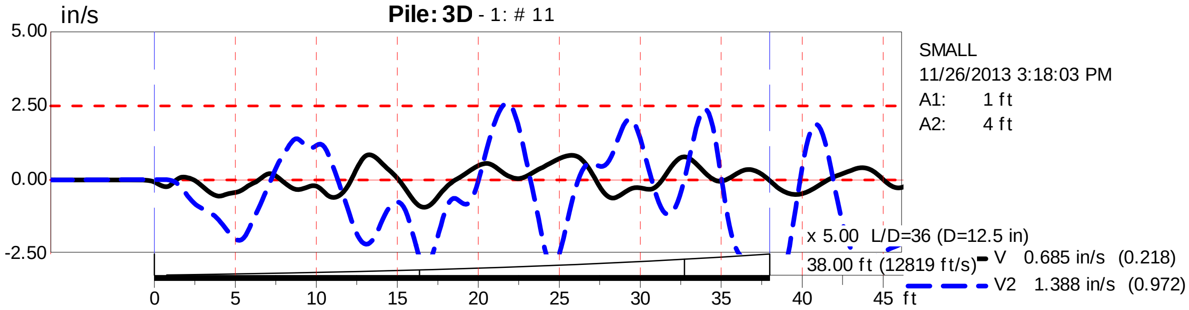




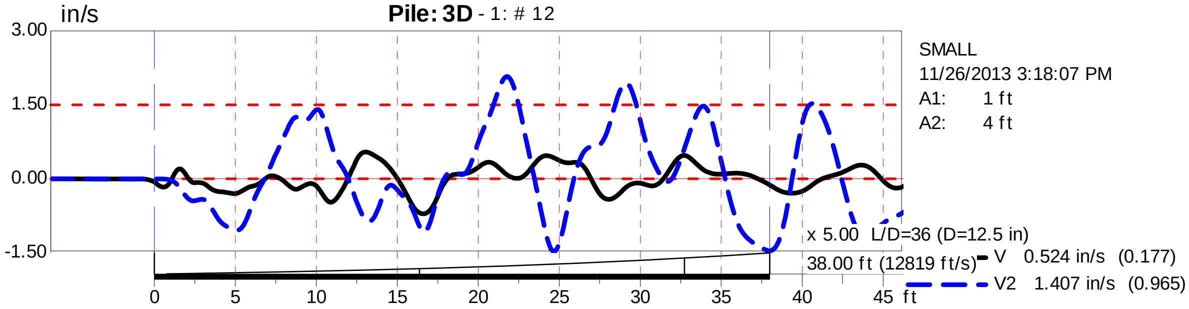




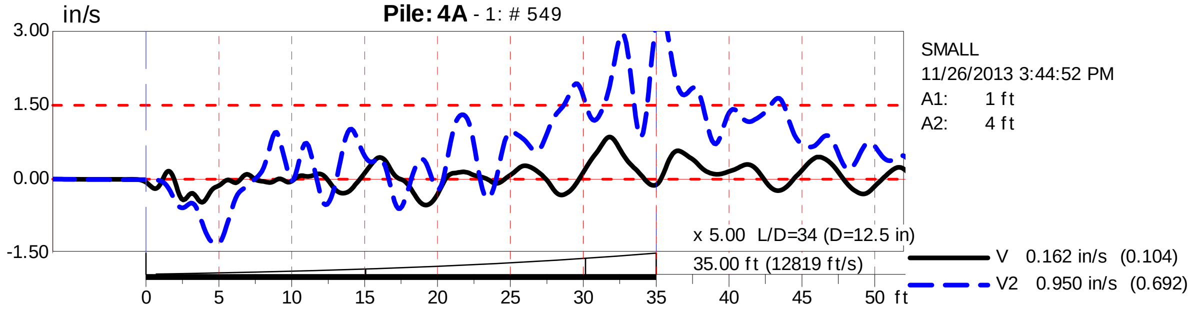
Pile Dynamics, Inc. 12/24/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO



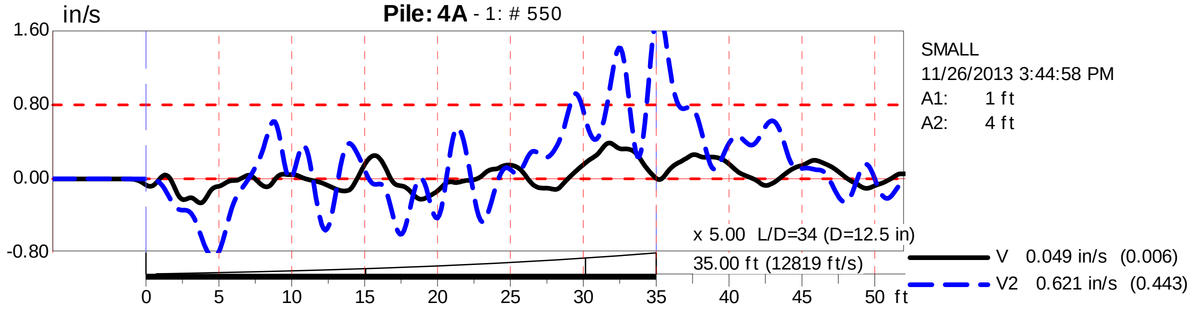
Pile: 3D - 1: # 11



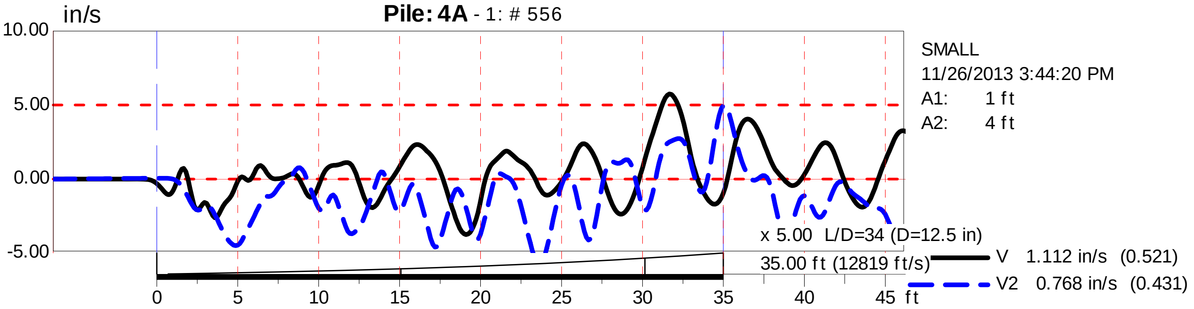
Pile: 3D - 1: # 12



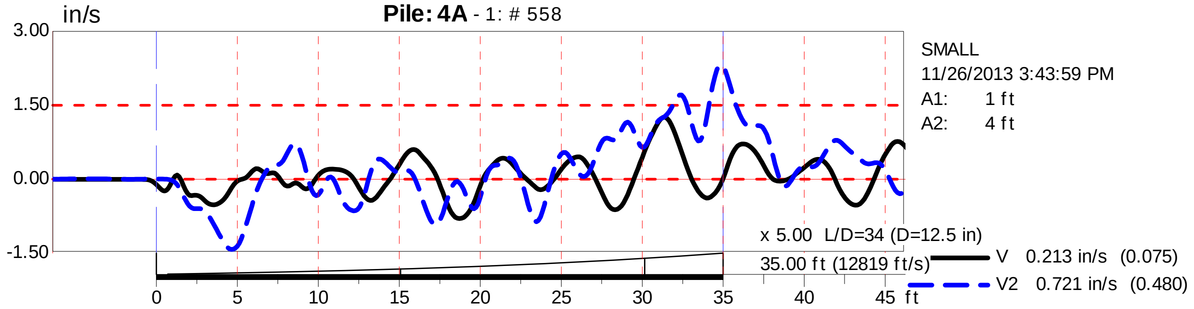
Pile: 4A - 1: # 549



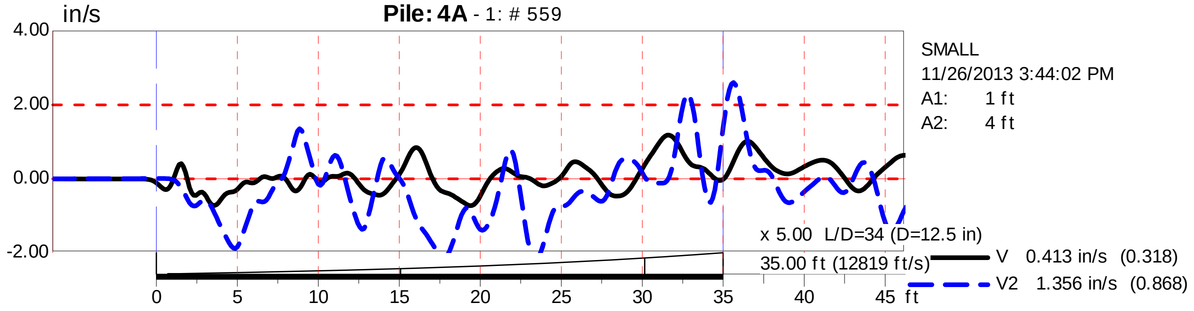
Pile: 4A - 1: # 550



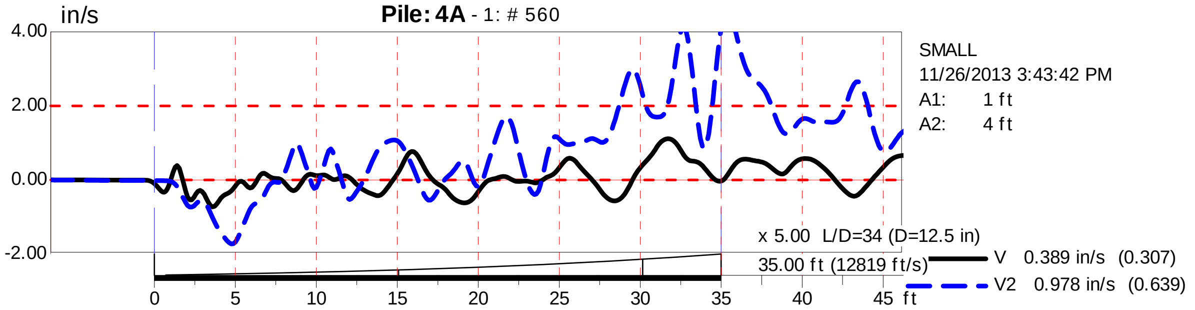
Pile: 4A - 1: # 556

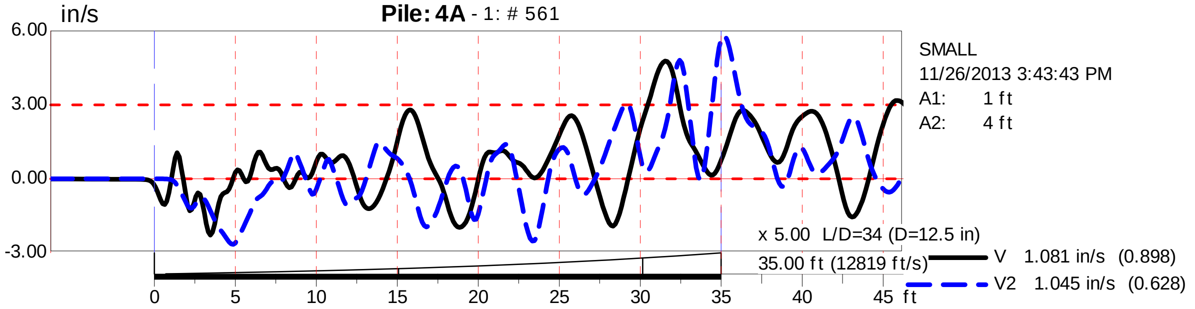


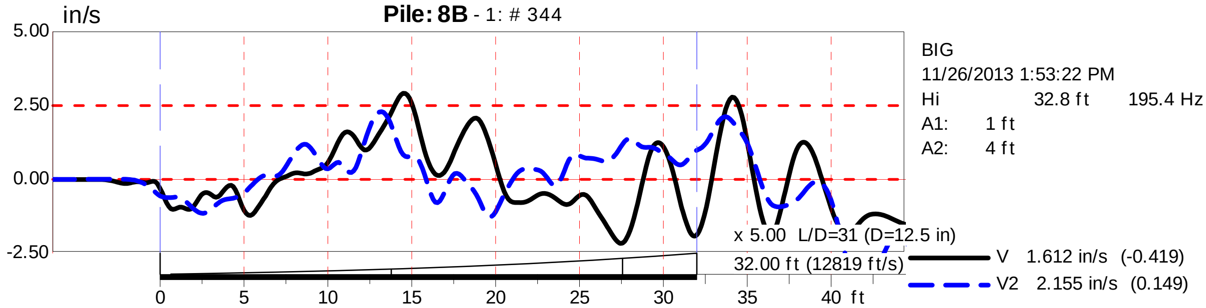
Pile: 4A - 1: # 558



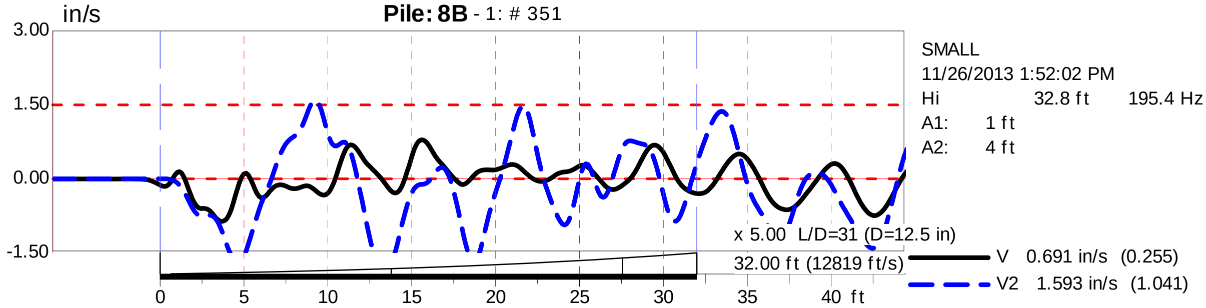
Pile: 4A - 1: # 559


in/s
Pile: 4A - 1: # 560
4.00
2.00
0.00
-2.00
SMALL
11/26/2013 3:43:42 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 0.389 in/s (0.307)
V2 0.978 in/s (0.639)
0
5
10
15
20
25
30
35
40
45 ft

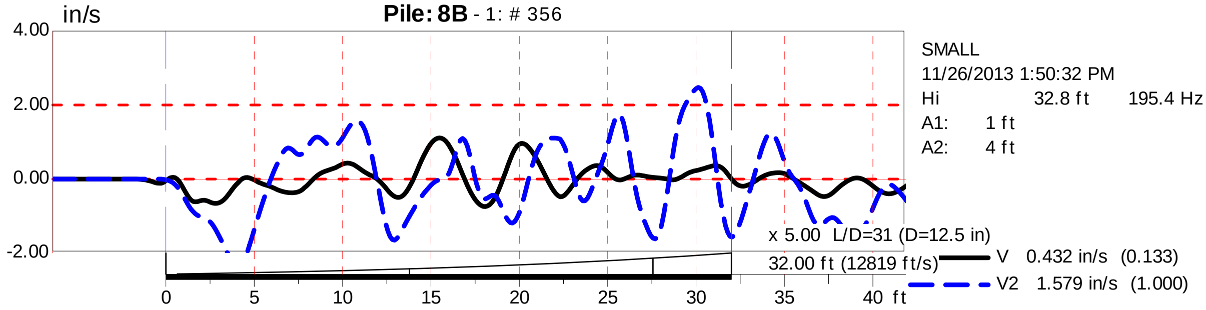

in/s
Pile: 4A - 1: # 561
6.00
3.00
0.00
-3.00
SMALL
11/26/2013 3:43:43 PM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.00 ft (12819 ft/s)
V 1.081 in/s (0.898)
V2 1.045 in/s (0.628)
0
5
10
15
20
25
30
35
40
45 ft



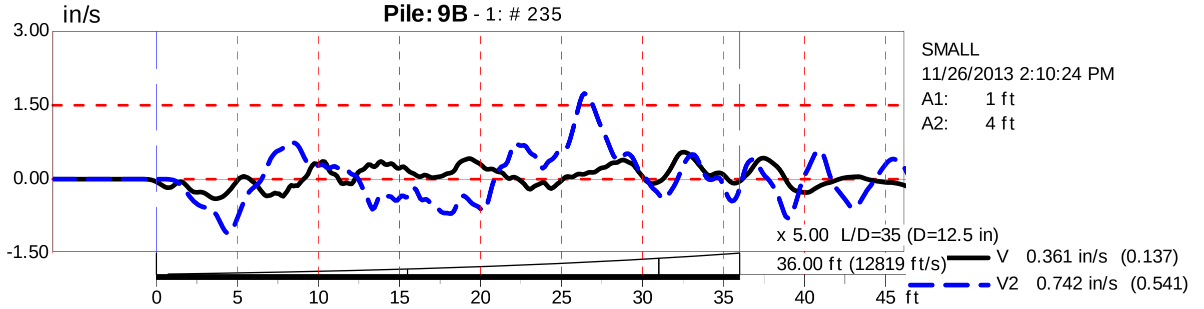
Pile: 8B - 1: # 344



Pile: 8B - 1: # 351

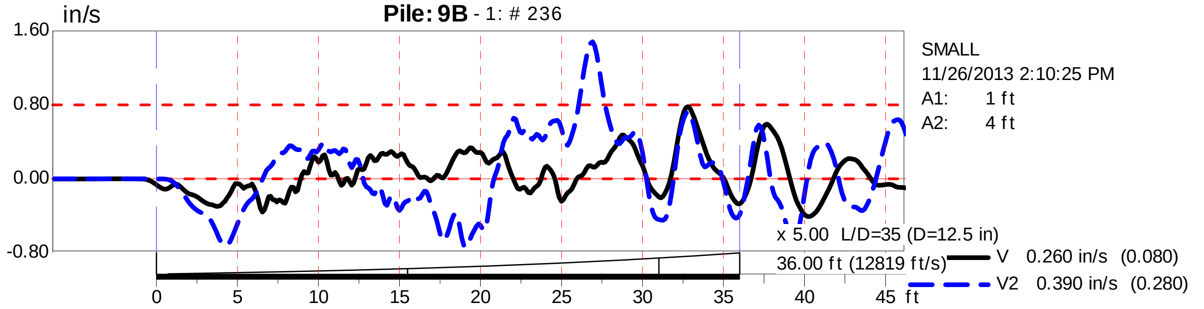


Pile: 8B - 1: # 356


Pile: 9B - 1: # 235

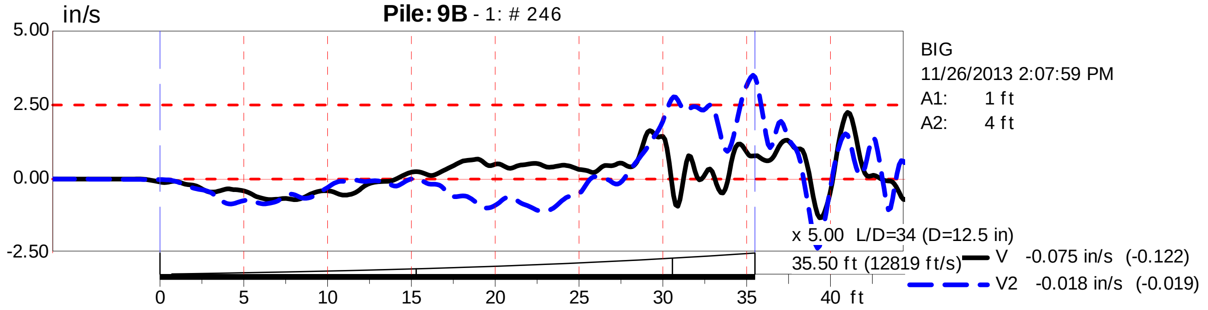
SMALL
11/26/2013 2:10:24 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.361 in/s (0.137)
V2 0.742 in/s (0.541)


Pile: 9B - 1: # 236

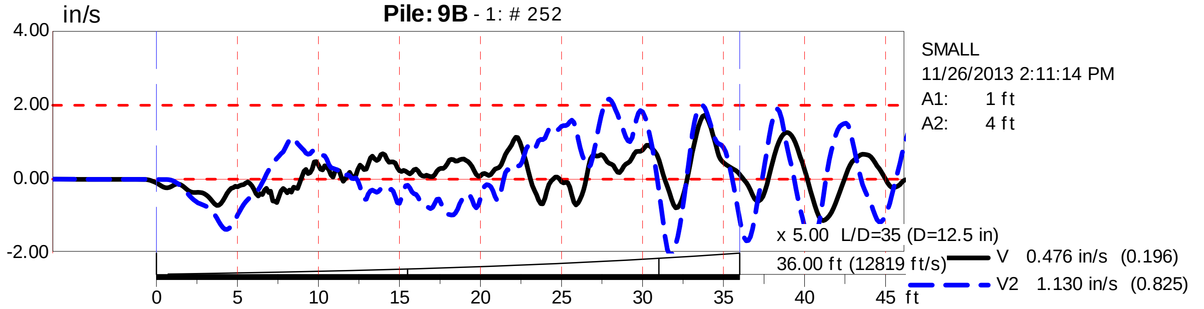
SMALL
11/26/2013 2:10:25 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.260 in/s (0.080)
V2 0.390 in/s (0.280)


Pile: 9B - 1: # 246

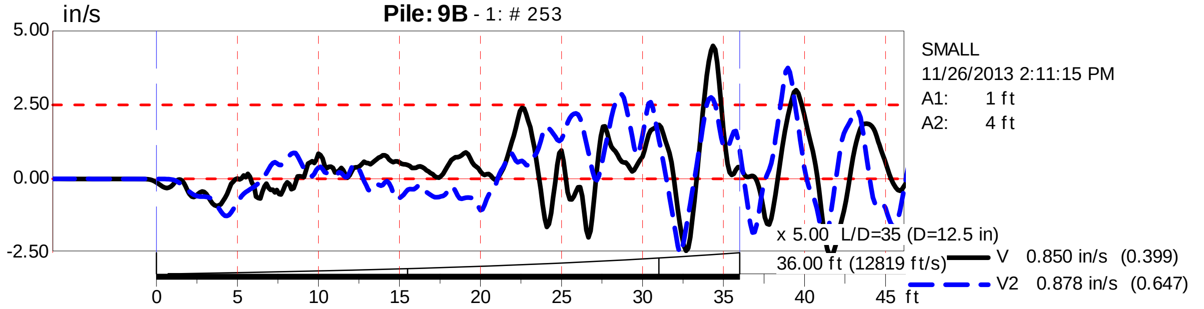
BIG
11/26/2013 2:07:59 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
V -0.075 in/s (-0.122)
V2 -0.018 in/s (-0.019)


Pile: 9B - 1: # 252

SMALL
11/26/2013 2:11:14 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.476 in/s (0.196)
V2 1.130 in/s (0.825)


Pile: 9B - 1: # 253

SMALL
11/26/2013 2:11:15 PM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.850 in/s (0.399)
V2 0.878 in/s (0.647)

Pile Dynamics, Inc. 12/24/2013
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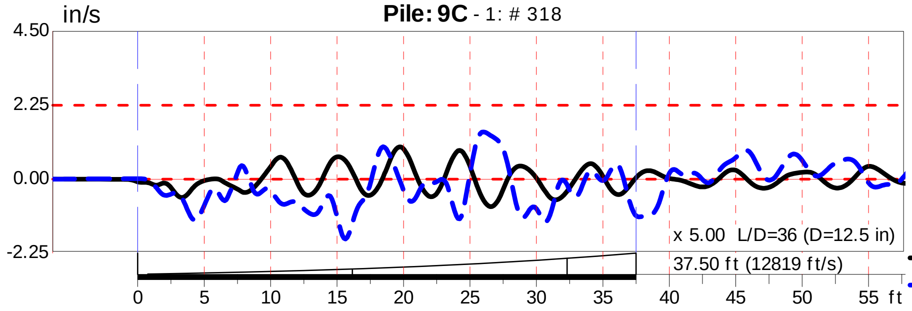
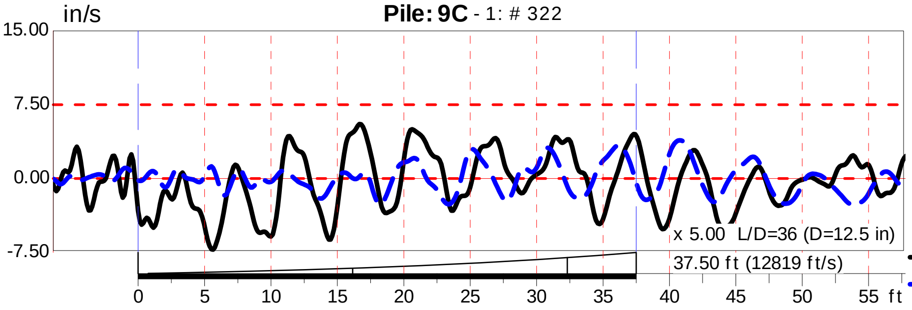
Pile: 9C - 1: # 318



SMALL
11/26/2013 12:57:58 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

V 0.670 in/s (0.311)
V2 0.414 in/s (0.269)

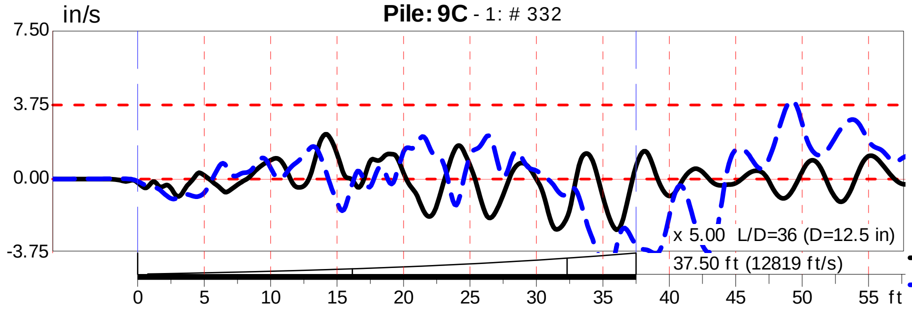
Pile: 9C - 1: # 322



3FT
11/26/2013 12:53:33 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

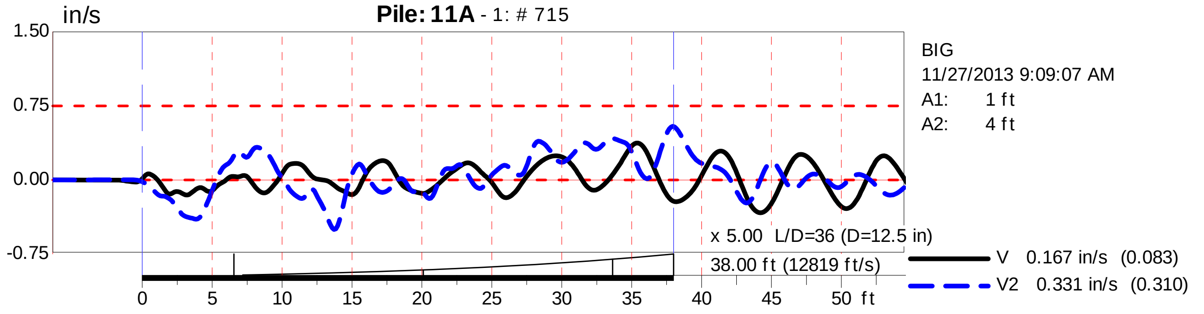
V 4.305 in/s (-5.162)
V2 1.235 in/s (1.214)

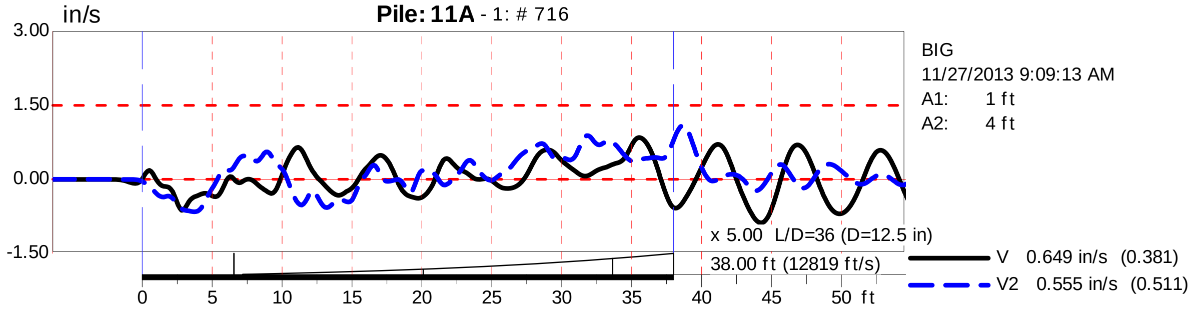
Pile: 9C - 1: # 332

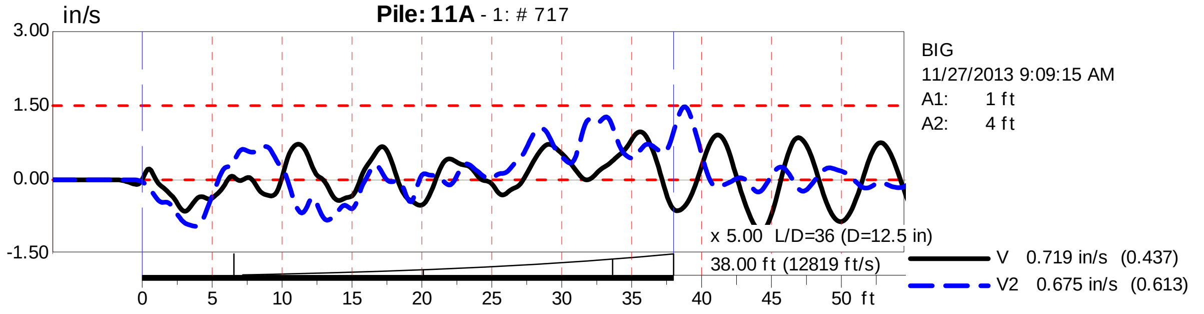


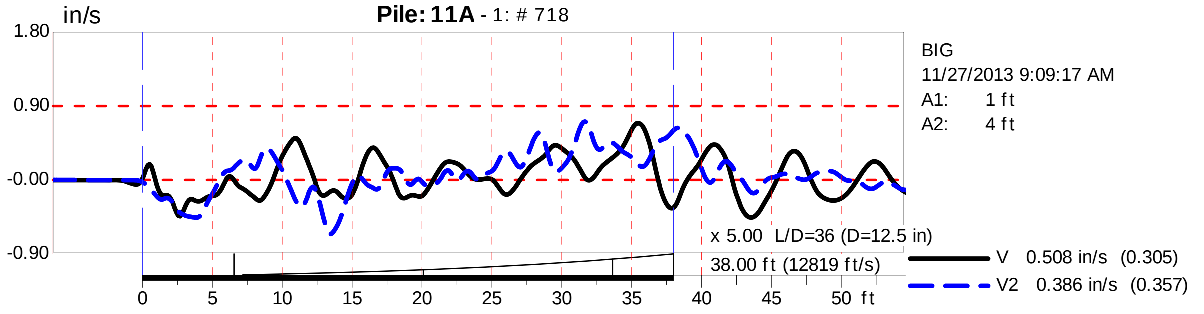
BIG
11/26/2013 1:01:37 PM
Hi 32.8 ft 195.4 Hz
A1: 1 ft
A2: 4 ft

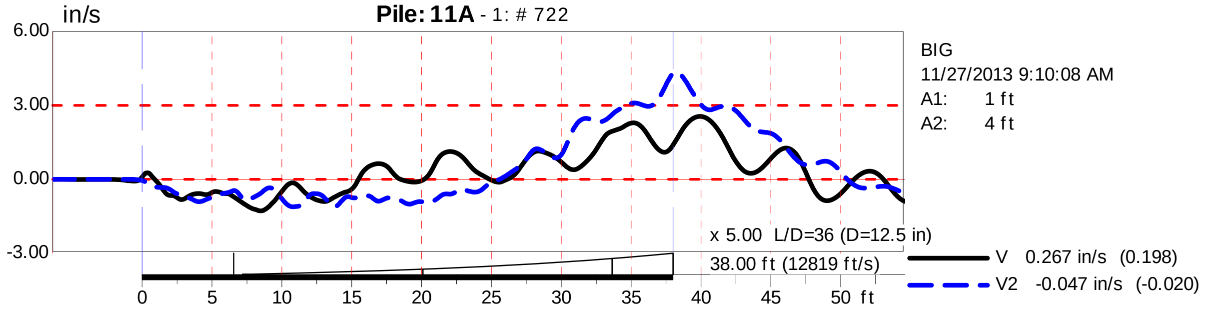
V 1.055 in/s (-0.251)
V2 1.463 in/s (0.059)


in/s
Pile: 11A - 1: # 715
1.50
0.75
0.00
-0.75
BIG
11/27/2013 9:09:07 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.167 in/s (0.083)
V2 0.331 in/s (0.310)
0
5
10
15
20
25
30
35
40
45
50 ft

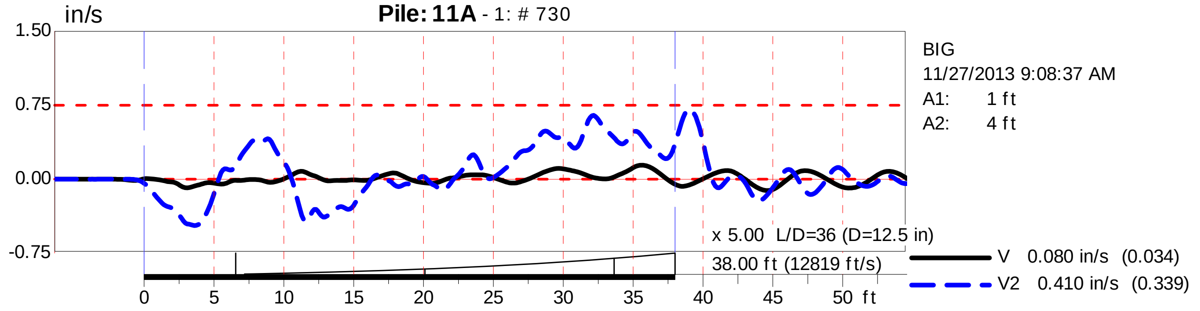

in/s
Pile: 11A - 1: # 716
3.00
1.50
0.00
-1.50
BIG
11/27/2013 9:09:13 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.649 in/s (0.381)
V2 0.555 in/s (0.511)
0
5
10
15
20
25
30
35
40
45
50 ft


in/s
Pile: 11A - 1: # 717
3.00
1.50
0.00
-1.50
BIG
11/27/2013 9:09:15 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.719 in/s (0.437)
V2 0.675 in/s (0.613)
0
5
10
15
20
25
30
35
40
45
50 ft


in/s
Pile: 11A - 1: # 718
1.80
0.90
-0.00
-0.90
BIG
11/27/2013 9:09:17 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.508 in/s (0.305)
V2 0.386 in/s (0.357)
0
5
10
15
20
25
30
35
40
45
50 ft

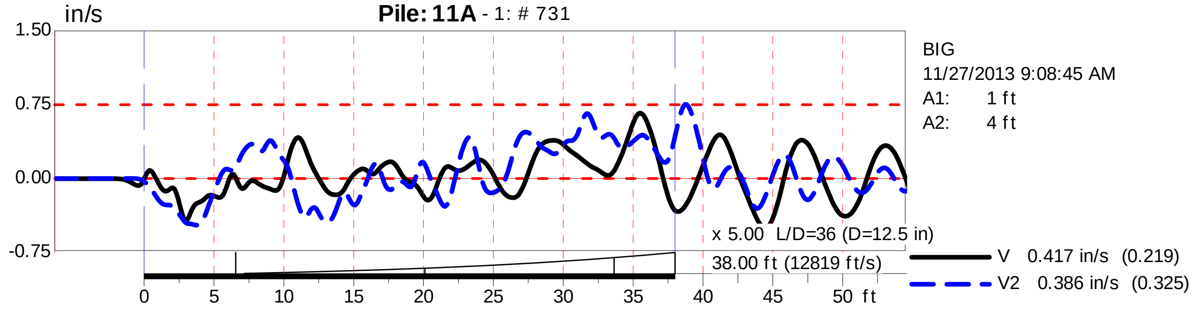

in/s
Pile: 11A - 1: # 722
6.00
3.00
0.00
-3.00
BIG
11/27/2013 9:10:08 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
38.00 ft (12819 ft/s)
V 0.267 in/s (0.198)
V2 -0.047 in/s (-0.020)
0
5
10
15
20
25
30
35
40
45
50 ft

Pile: 11A - 1: # 730



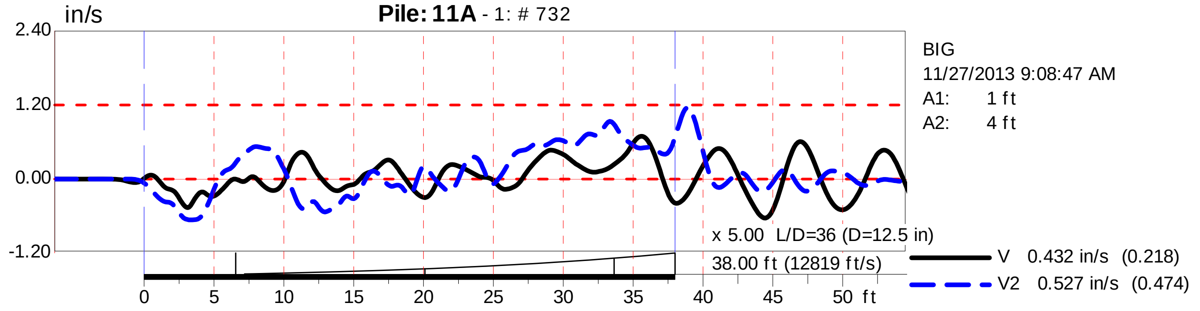
BIG
11/27/2013 9:08:37 AM
A1: 1 ft
A2: 4 ft

Pile: 11A - 1: # 731



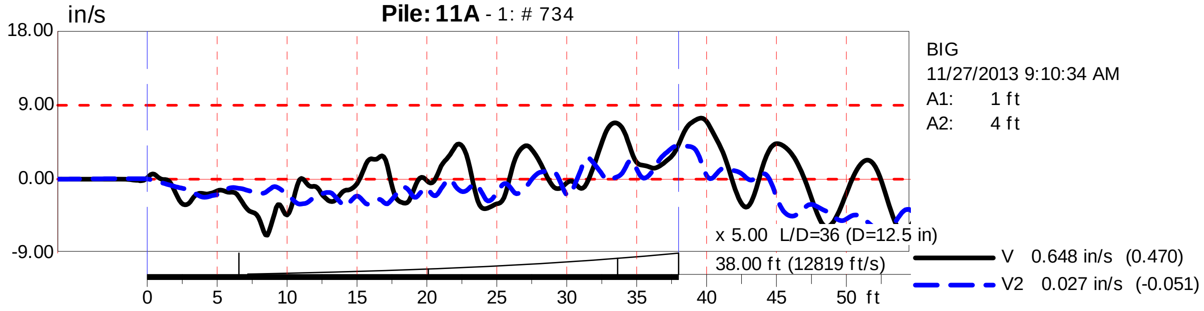
BIG
11/27/2013 9:08:45 AM
A1: 1 ft
A2: 4 ft

Pile: 11A - 1: # 732



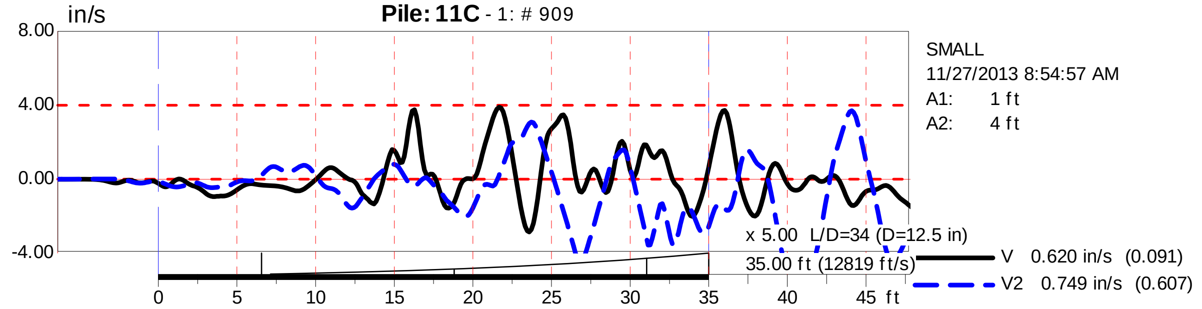
BIG
11/27/2013 9:08:47 AM
A1: 1 ft
A2: 4 ft

Pile: 11A - 1: # 734

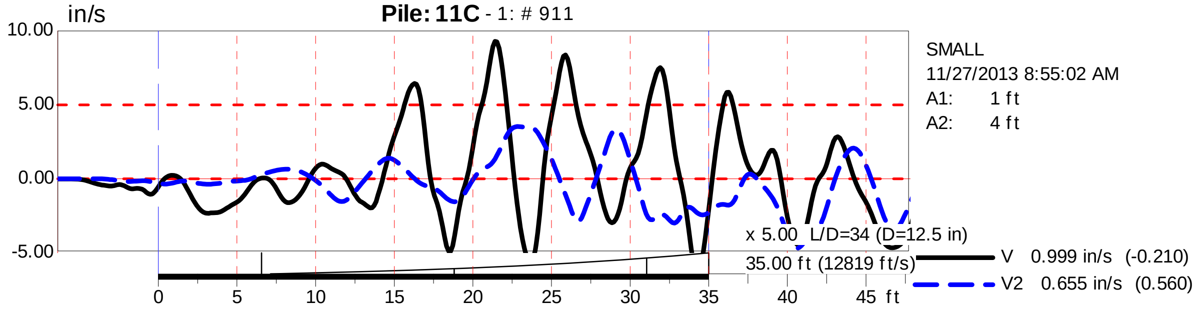


BIG
11/27/2013 9:10:34 AM
A1: 1 ft
A2: 4 ft

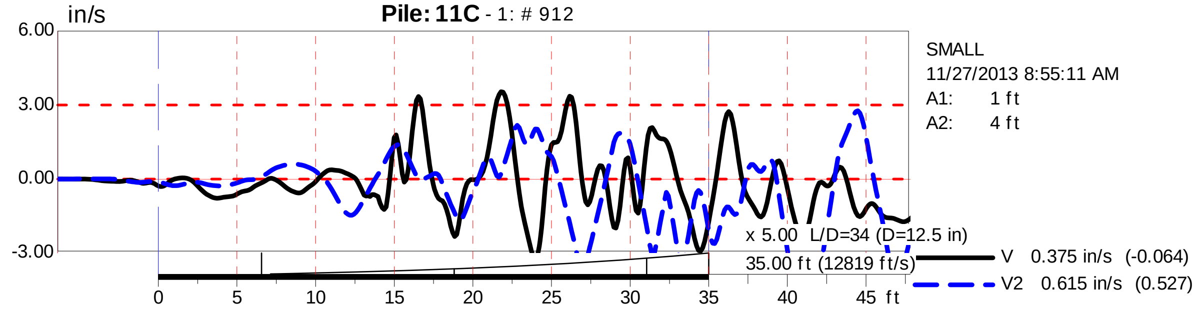
Pile: 11C - 1: # 909



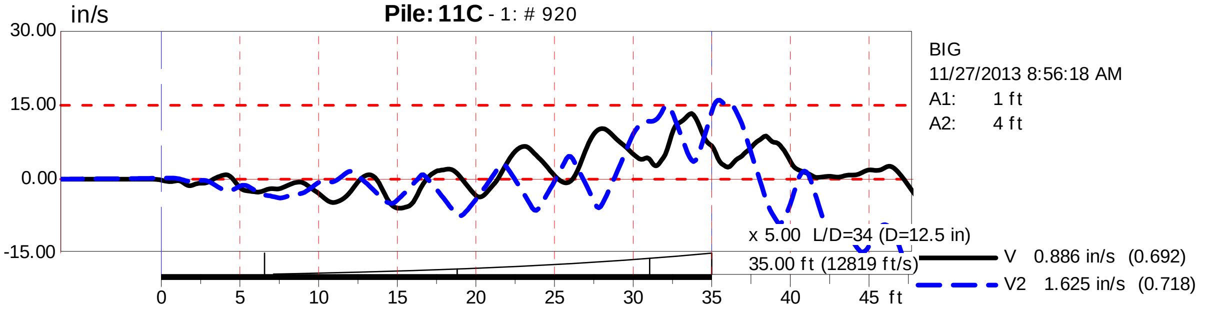
Pile: 11C - 1: # 911



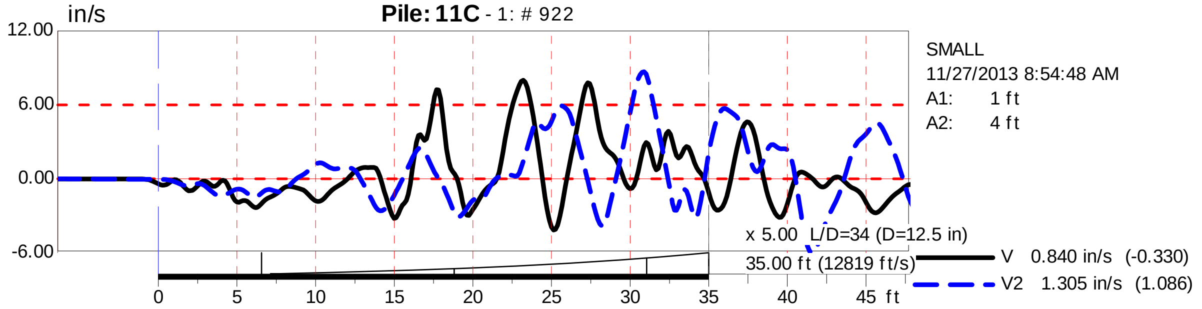
Pile: 11C - 1: # 912



Pile: 11C - 1: # 920



Pile: 11C - 1: # 922



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PIT Raw data
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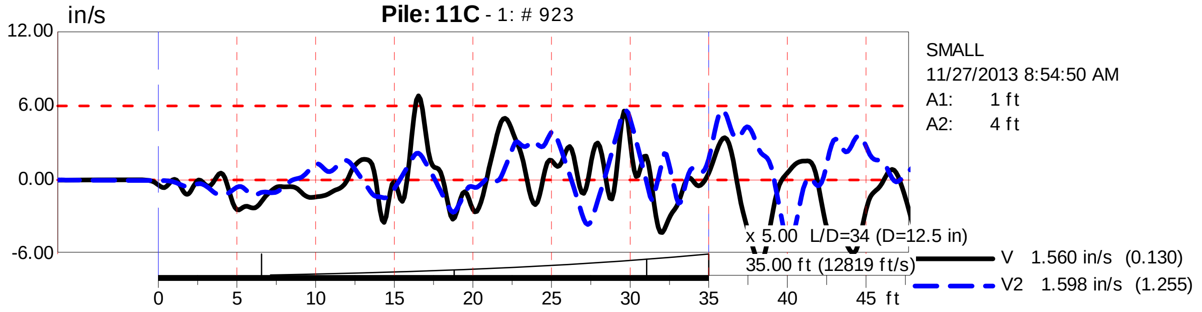

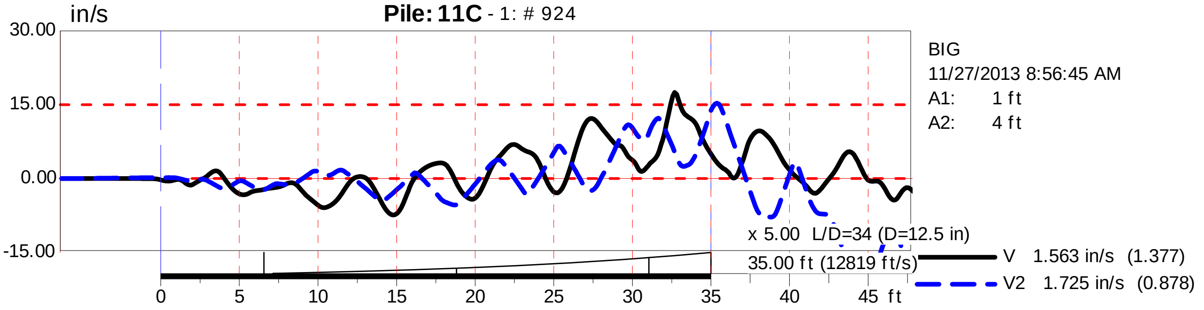

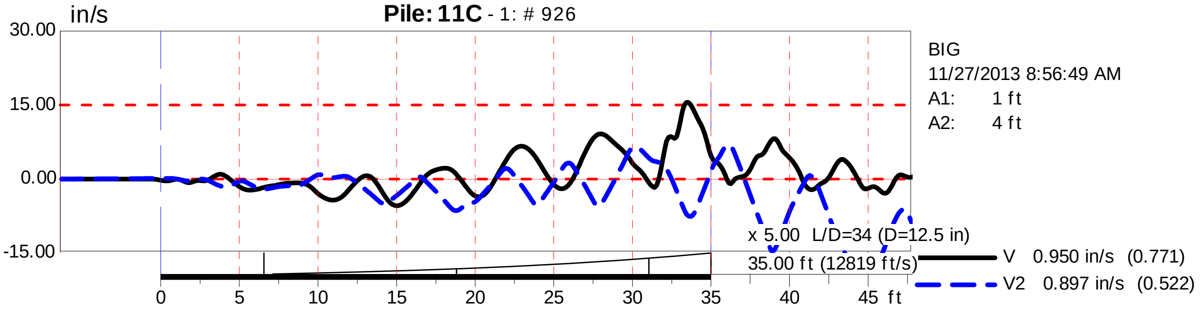

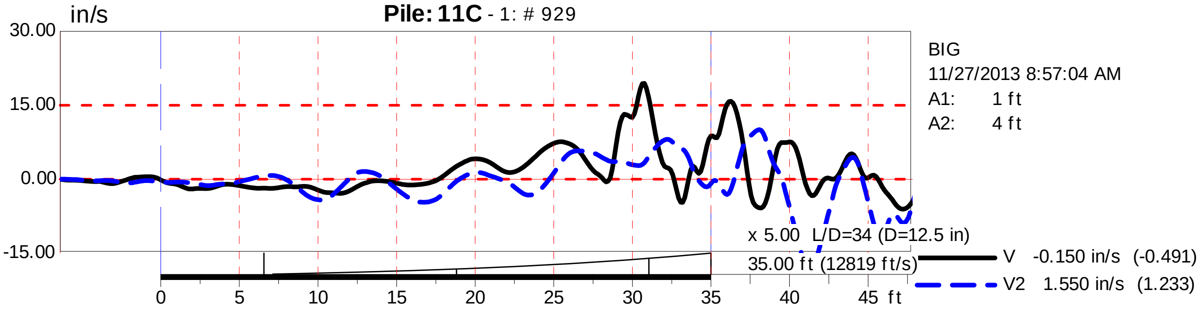

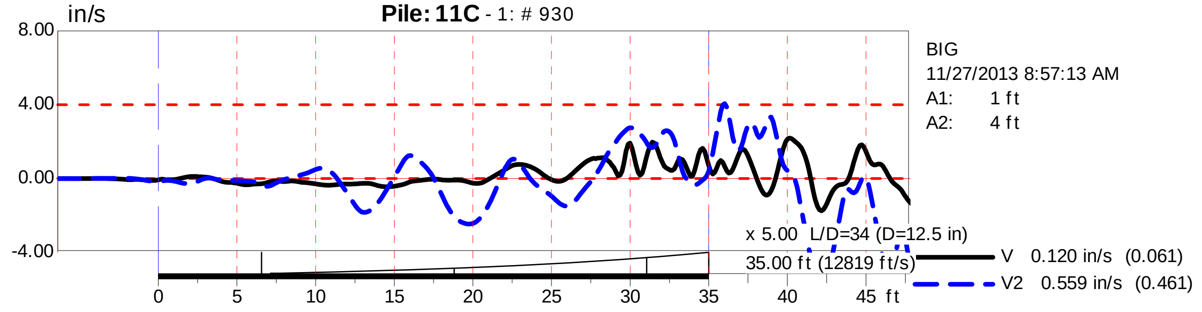

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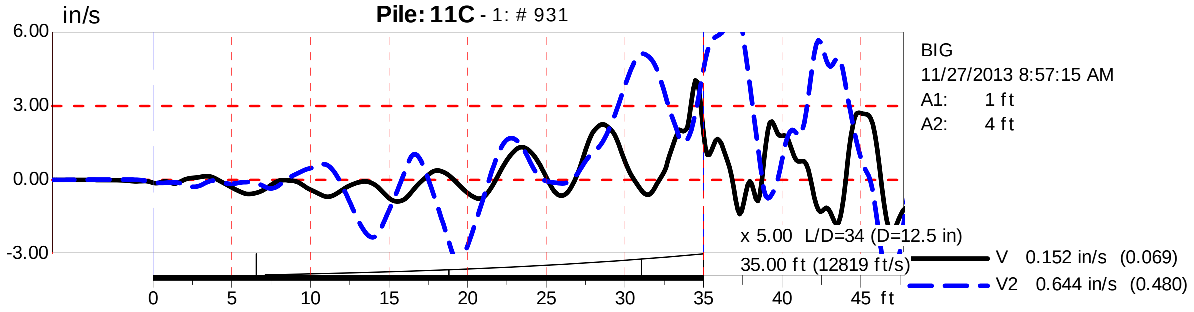
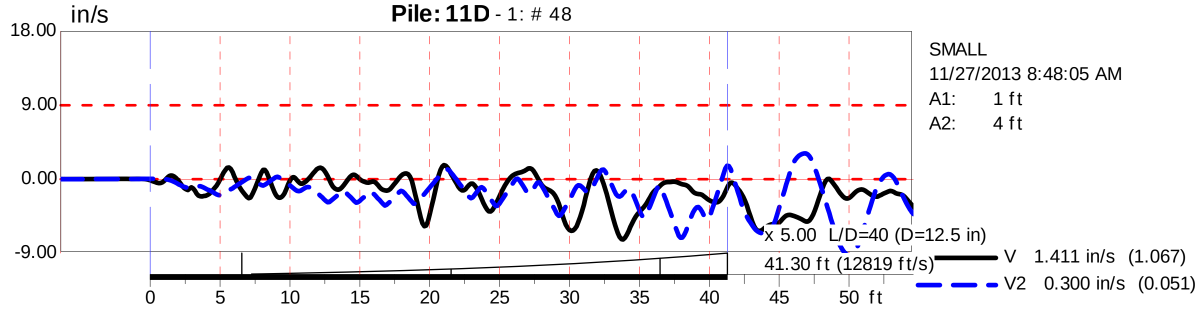
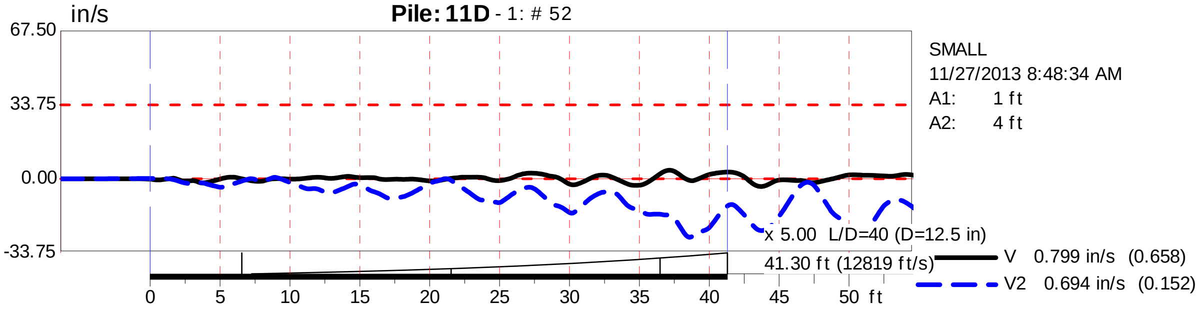
PIT Raw data

C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

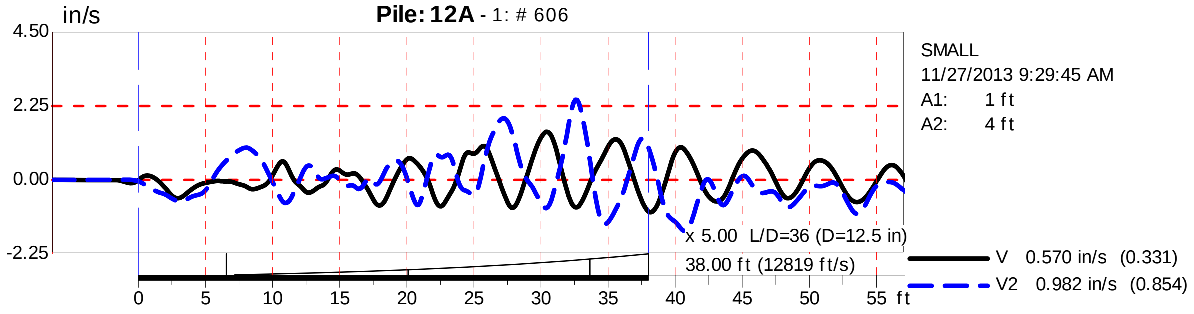


Pile Dynamics, Inc. 12/24/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

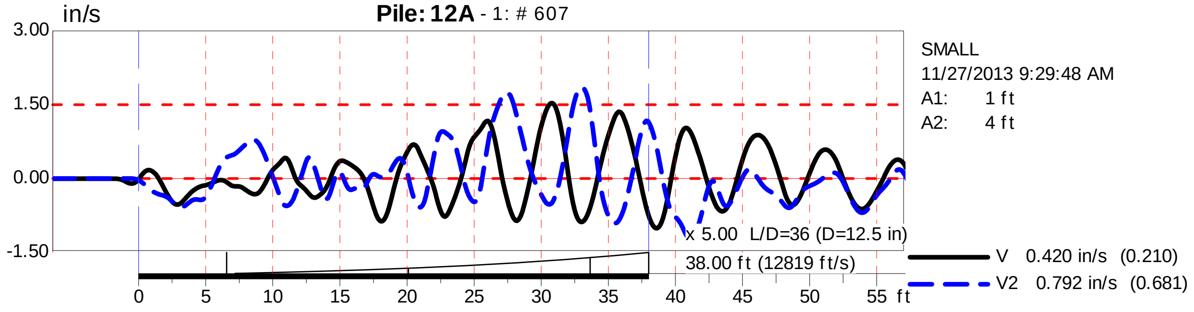




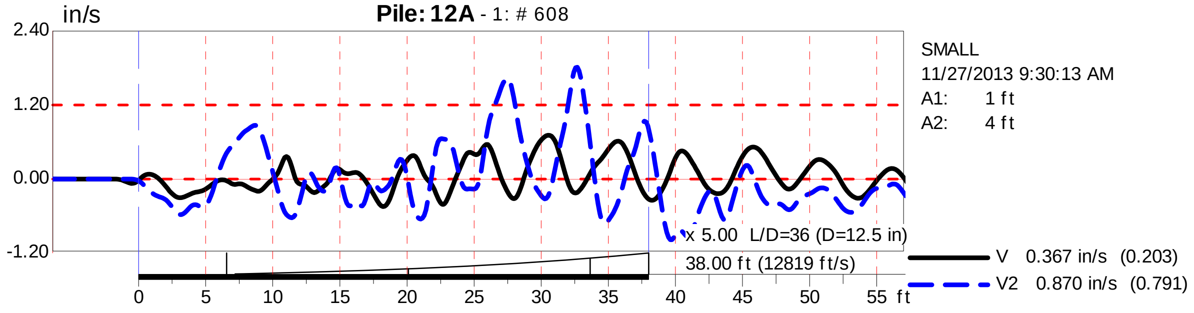
Pile: 12A - 1: # 606



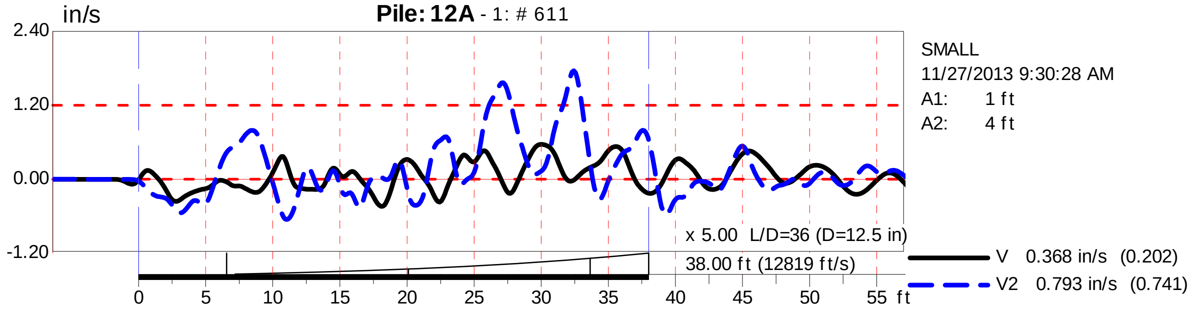
Pile: 12A - 1: # 607



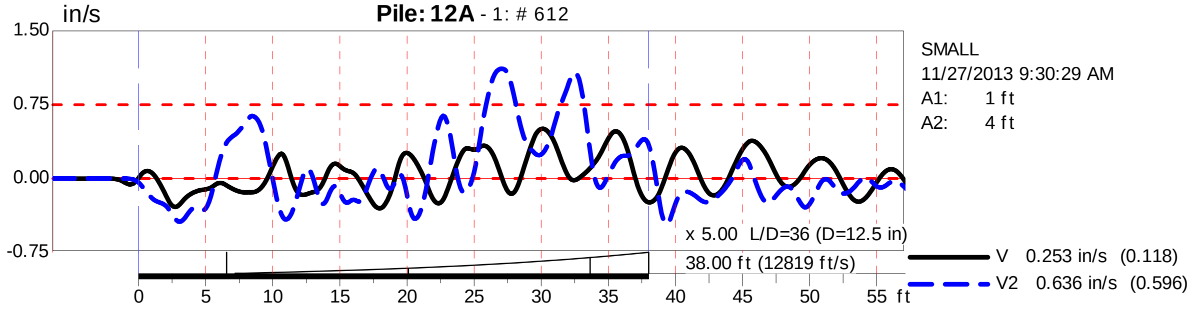
Pile: 12A - 1: # 608



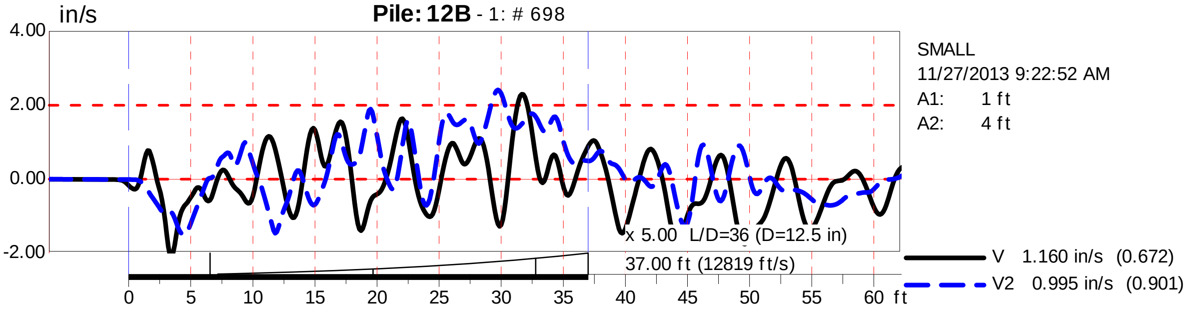
Pile: 12A - 1: # 611



Pile: 12A - 1: # 612



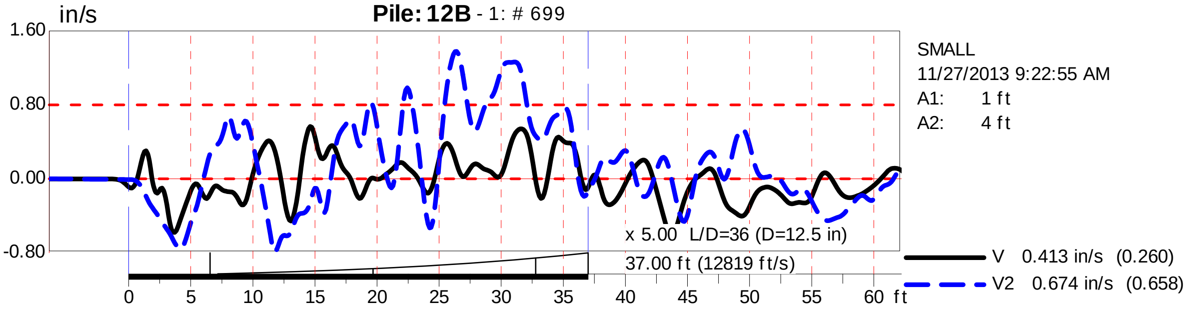
Pile: 12B - 1: # 698



SMALL
11/27/2013 9:22:52 AM
A1: 1 ft
A2: 4 ft

V 1.160 in/s (0.672)
V2 0.995 in/s (0.901)

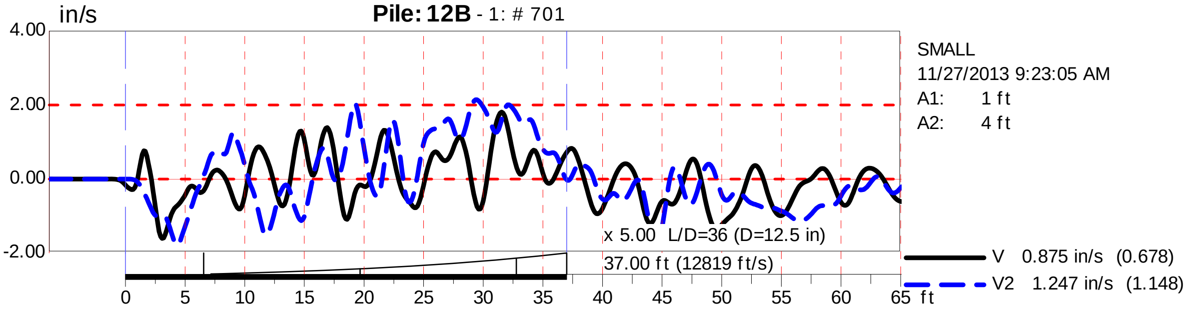
Pile: 12B - 1: # 699



SMALL
11/27/2013 9:22:55 AM
A1: 1 ft
A2: 4 ft

V 0.413 in/s (0.260)
V2 0.674 in/s (0.658)

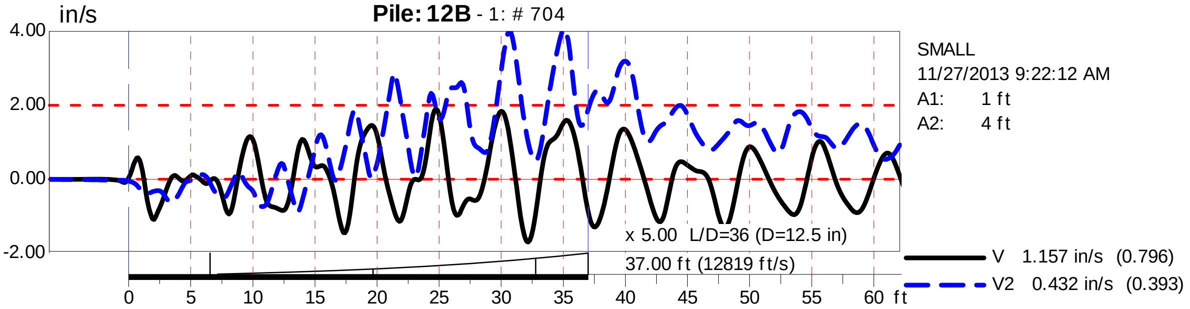
Pile: 12B - 1: # 701



SMALL
11/27/2013 9:23:05 AM
A1: 1 ft
A2: 4 ft

V 0.875 in/s (0.678)
V2 1.247 in/s (1.148)

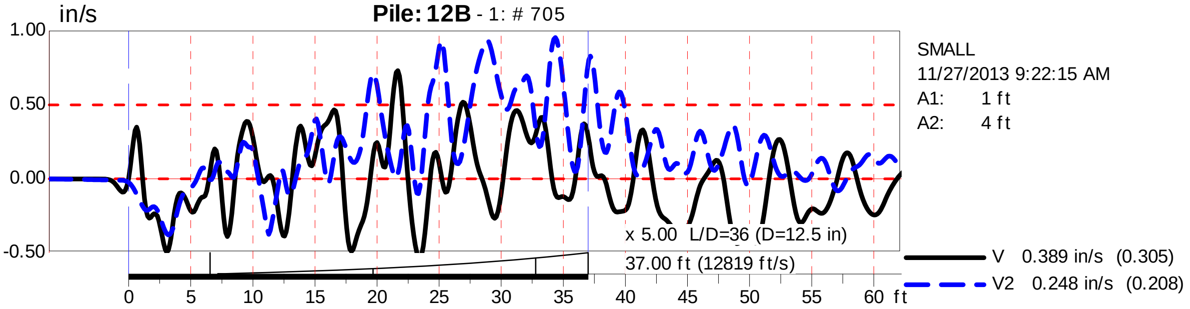
Pile: 12B - 1: # 704



SMALL
11/27/2013 9:22:12 AM
A1: 1 ft
A2: 4 ft

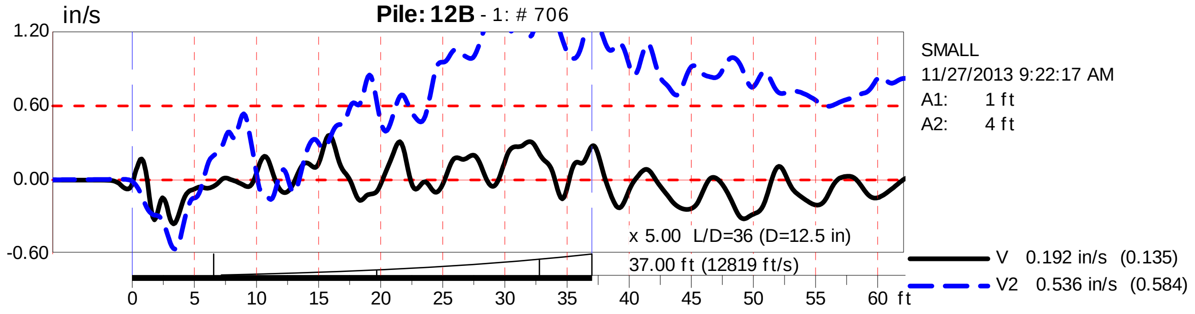
V 1.157 in/s (0.796)
V2 0.432 in/s (0.393)

Pile: 12B - 1: # 705



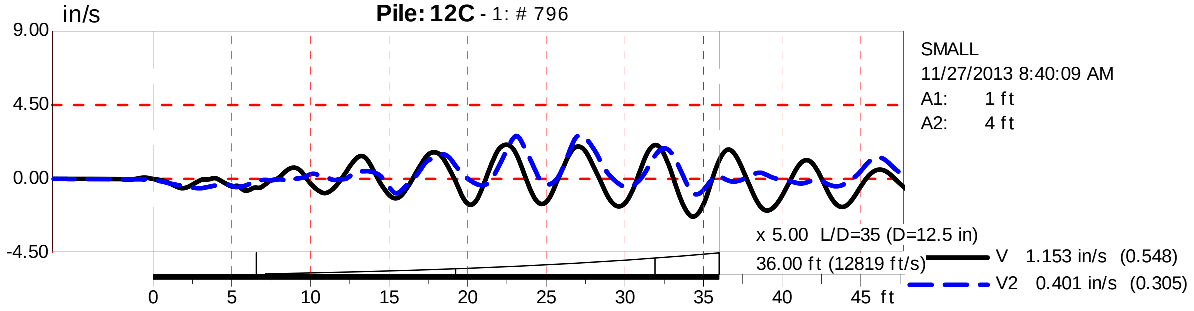
SMALL
11/27/2013 9:22:15 AM
A1: 1 ft
A2: 4 ft

V 0.389 in/s (0.305)
V2 0.248 in/s (0.208)


in/s
Pile: 12B - 1: # 706
1.20
0.60
0.00
-0.60
SMALL
11/27/2013 9:22:17 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55
60 ft
V 0.192 in/s (0.135)
V2 0.536 in/s (0.584)

Pile Dynamics, Inc. 12/24/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

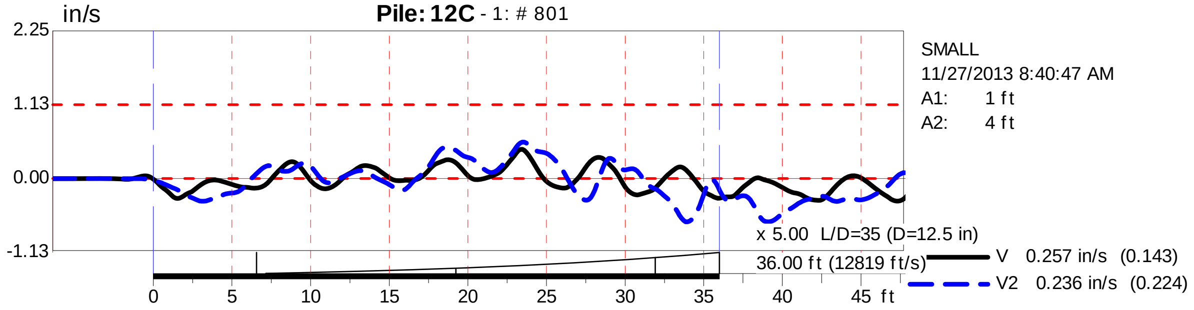
Pile: 12C - 1: # 796



SMALL
11/27/2013 8:40:09 AM
A1: 1 ft
A2: 4 ft

x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 1.153 in/s (0.548)
V2 0.401 in/s (0.305)

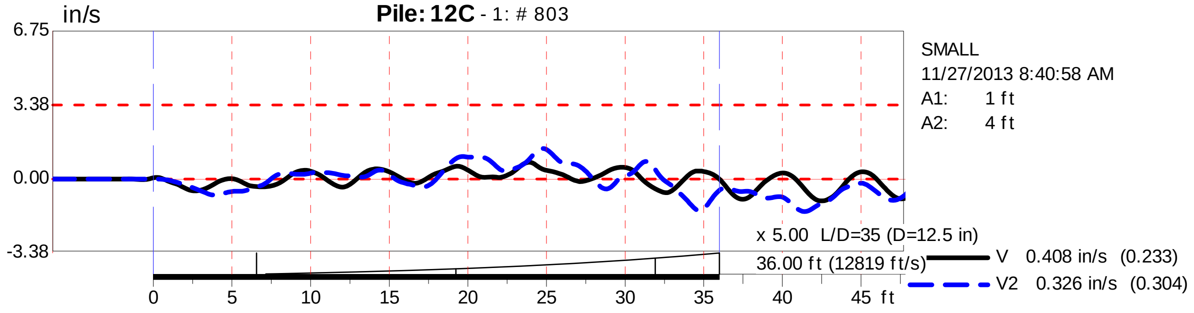
Pile: 12C - 1: # 801



SMALL
11/27/2013 8:40:47 AM
A1: 1 ft
A2: 4 ft

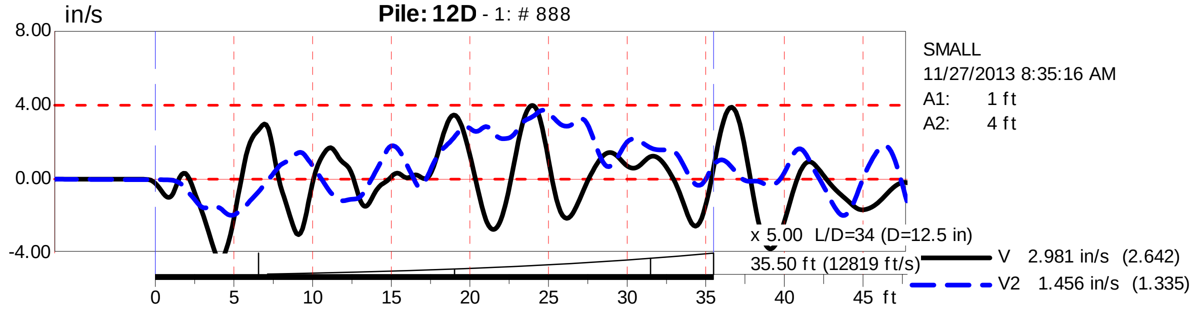
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.257 in/s (0.143)
V2 0.236 in/s (0.224)

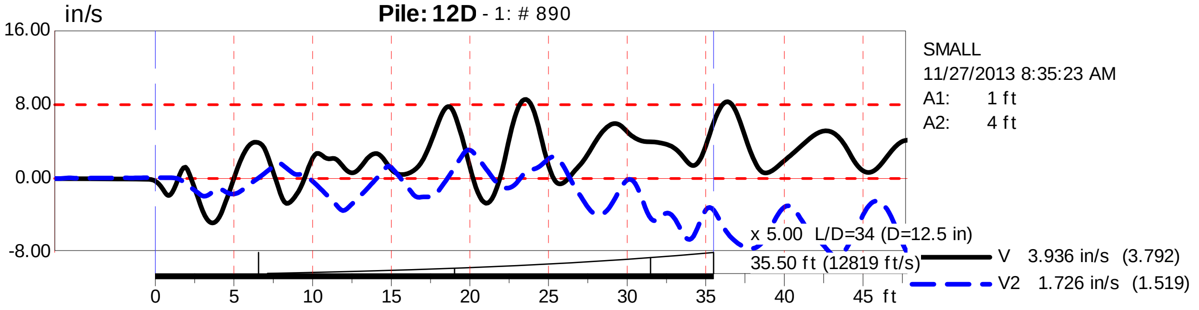
Pile: 12C - 1: # 803

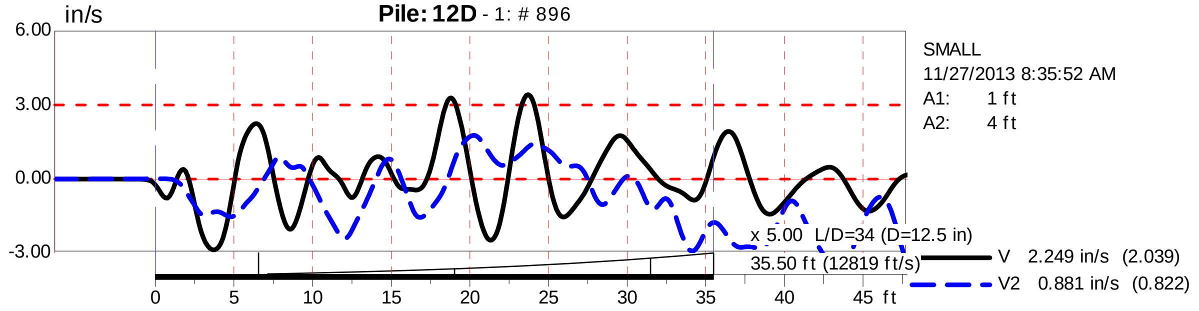


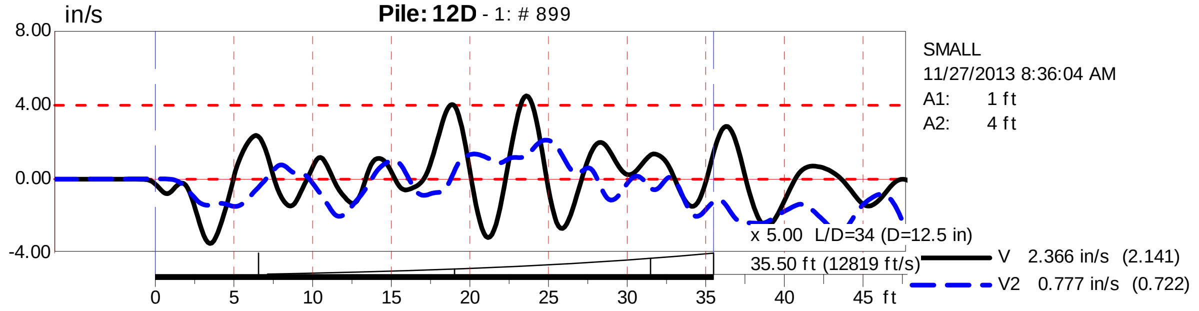
SMALL
11/27/2013 8:40:58 AM
A1: 1 ft
A2: 4 ft

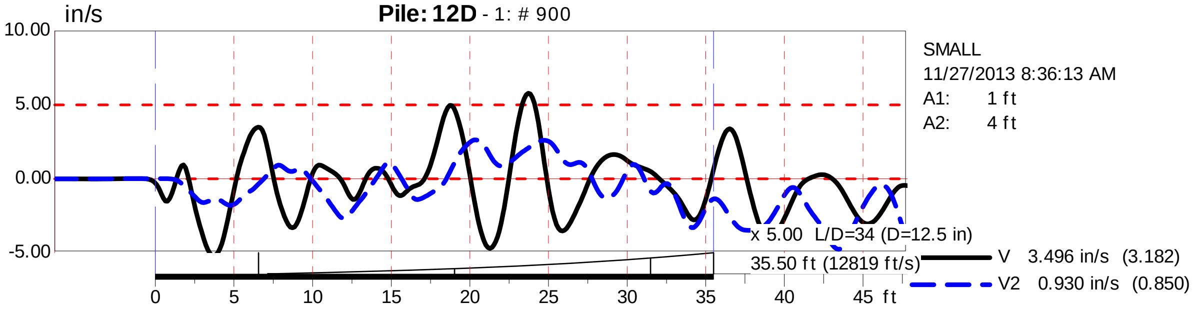
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.408 in/s (0.233)
V2 0.326 in/s (0.304)

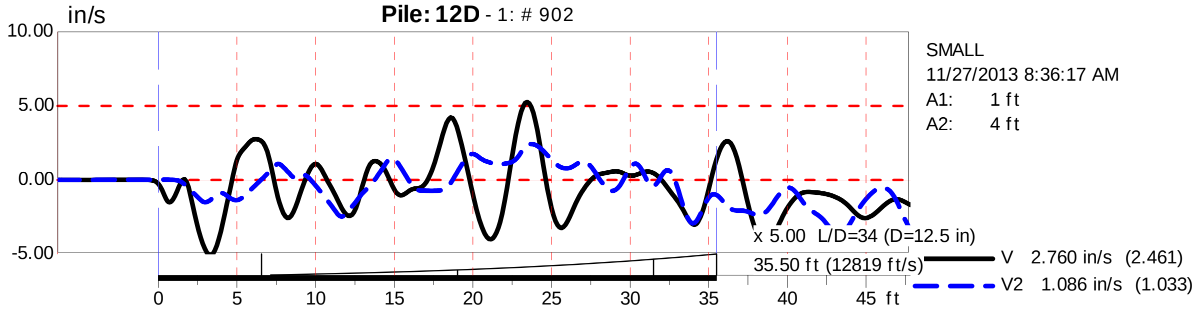

in/s
Pile: 12D - 1: # 888
8.00
4.00
0.00
-4.00
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
SMALL
11/27/2013 8:35:16 AM
A1: 1 ft
A2: 4 ft
V 2.981 in/s (2.642)
V2 1.456 in/s (1.335)

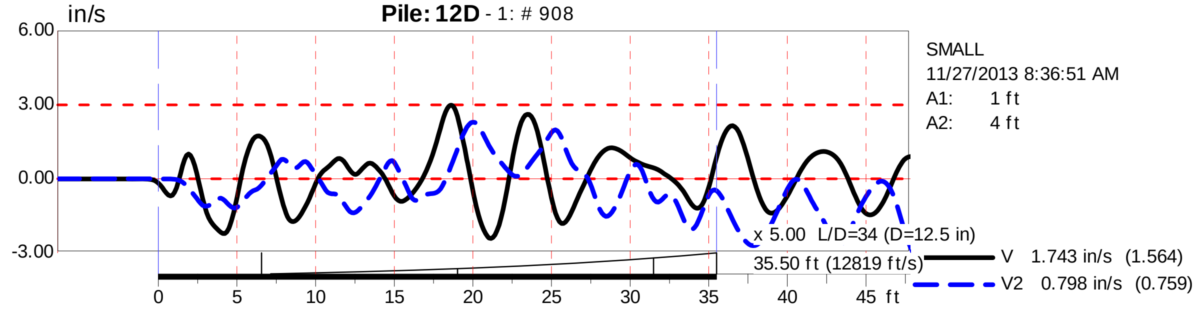

in/s
Pile: 12D - 1: # 890
16.00
8.00
0.00
-8.00
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
SMALL
11/27/2013 8:35:23 AM
A1: 1 ft
A2: 4 ft
V 3.936 in/s (3.792)
V2 1.726 in/s (1.519)


in/s
Pile: 12D - 1: # 896
6.00
3.00
0.00
-3.00
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
SMALL
11/27/2013 8:35:52 AM
A1: 1 ft
A2: 4 ft
V 2.249 in/s (2.039)
V2 0.881 in/s (0.822)

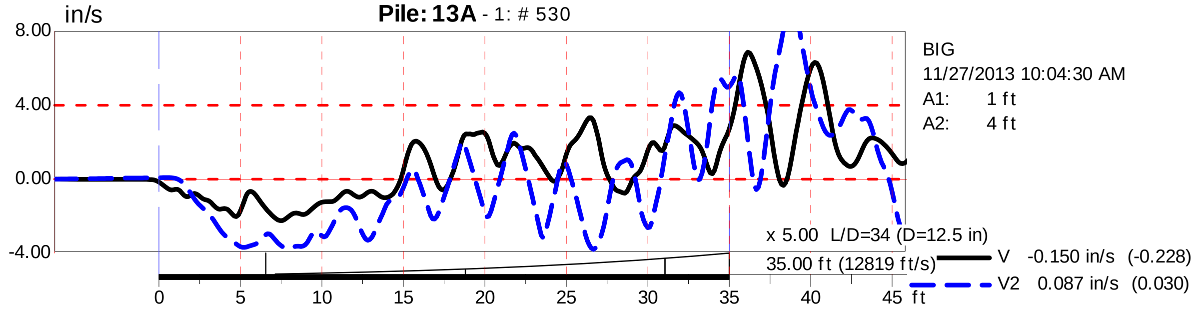

in/s
Pile: 12D - 1: # 899
8.00
4.00
0.00
-4.00
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
SMALL
11/27/2013 8:36:04 AM
A1: 1 ft
A2: 4 ft
V 2.366 in/s (2.141)
V2 0.777 in/s (0.722)


in/s
Pile: 12D - 1: # 900
10.00
5.00
0.00
-5.00
0
5
10
15
20
25
30
35
40
45 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
SMALL
11/27/2013 8:36:13 AM
A1: 1 ft
A2: 4 ft
V 3.496 in/s (3.182)
V2 0.930 in/s (0.850)

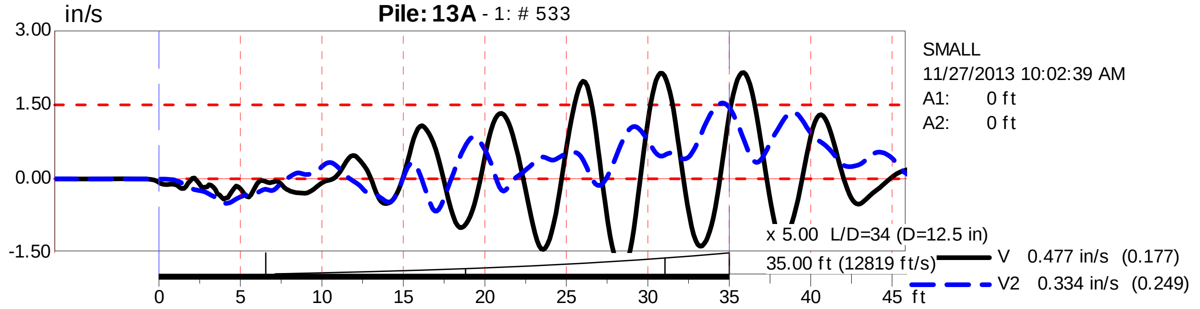

in/s
Pile: 12D - 1: # 902
10.00
5.00
0.00
-5.00
0 5 10 15 20 25 30 35 40 45 ft
SMALL
11/27/2013 8:36:17 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
V 2.760 in/s (2.461)
V2 1.086 in/s (1.033)


in/s
Pile: 12D - 1: # 908
6.00
3.00
0.00
-3.00
0 5 10 15 20 25 30 35 40 45 ft
SMALL
11/27/2013 8:36:51 AM
A1: 1 ft
A2: 4 ft
x 5.00 L/D=34 (D=12.5 in)
35.50 ft (12819 ft/s)
V 1.743 in/s (1.564)
V2 0.798 in/s (0.759)

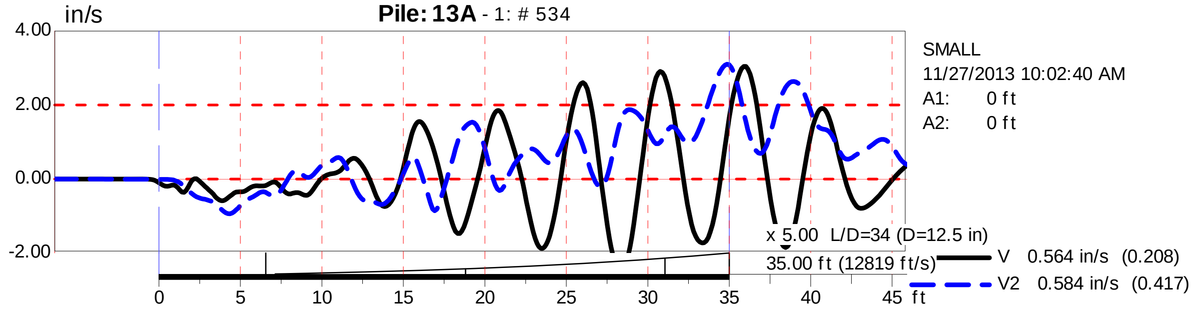
Pile: 13A - 1: # 530



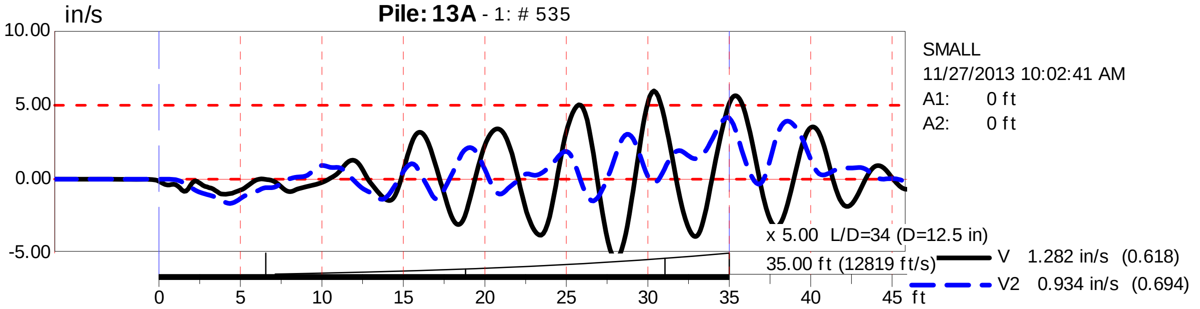
Pile: 13A - 1: # 533



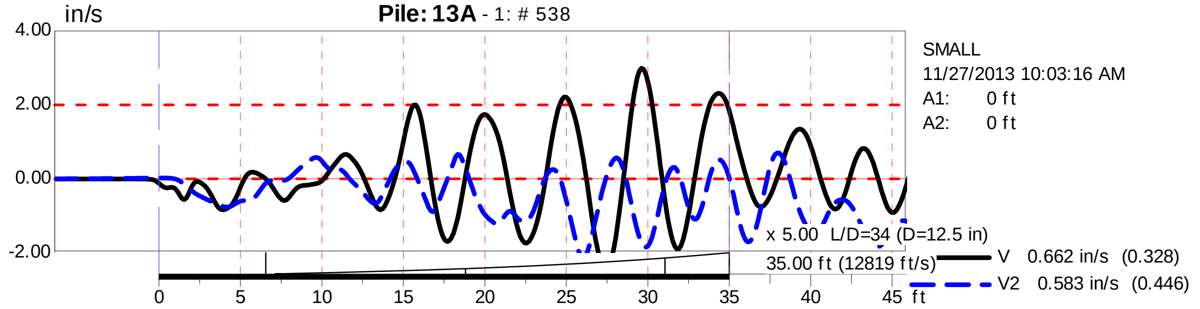
Pile: 13A - 1: # 534



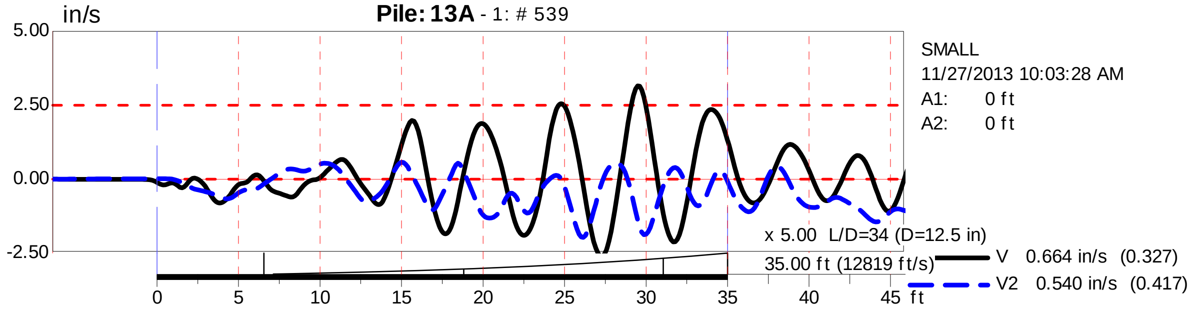
Pile: 13A - 1: # 535



Pile: 13A - 1: # 538

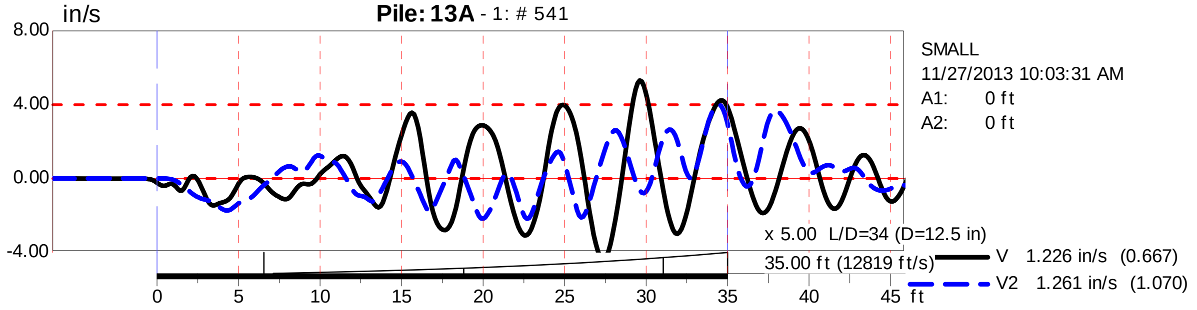


Pile: 13A - 1: # 539



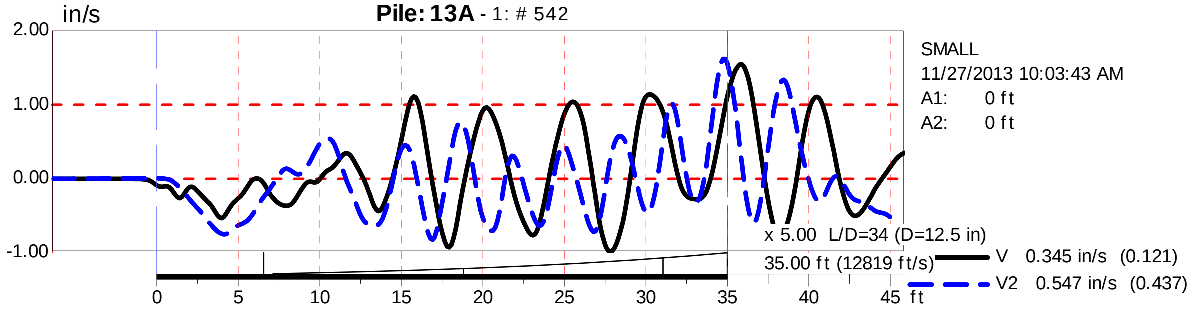
SMALL
11/27/2013 10:03:28 AM
A1: 0 ft
A2: 0 ft

Pile: 13A - 1: # 541



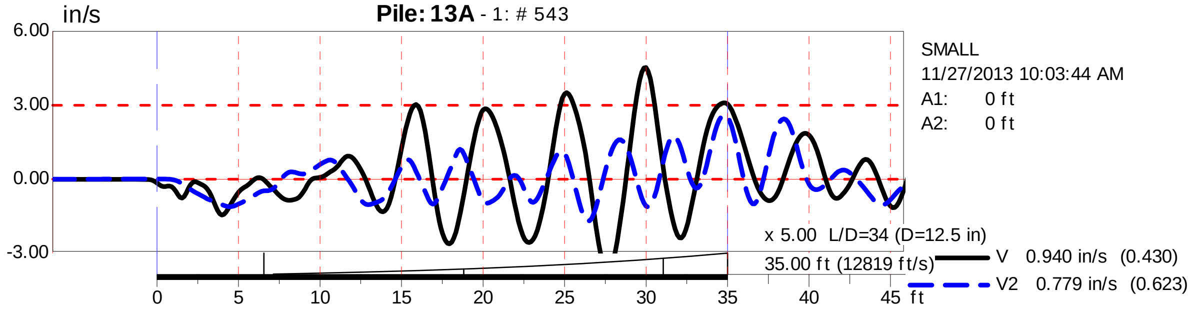
SMALL
11/27/2013 10:03:31 AM
A1: 0 ft
A2: 0 ft

Pile: 13A - 1: # 542



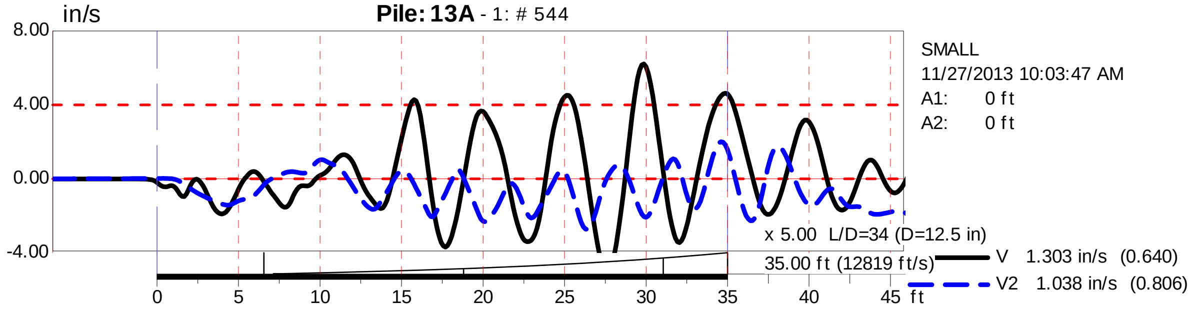
SMALL
11/27/2013 10:03:43 AM
A1: 0 ft
A2: 0 ft

Pile: 13A - 1: # 543

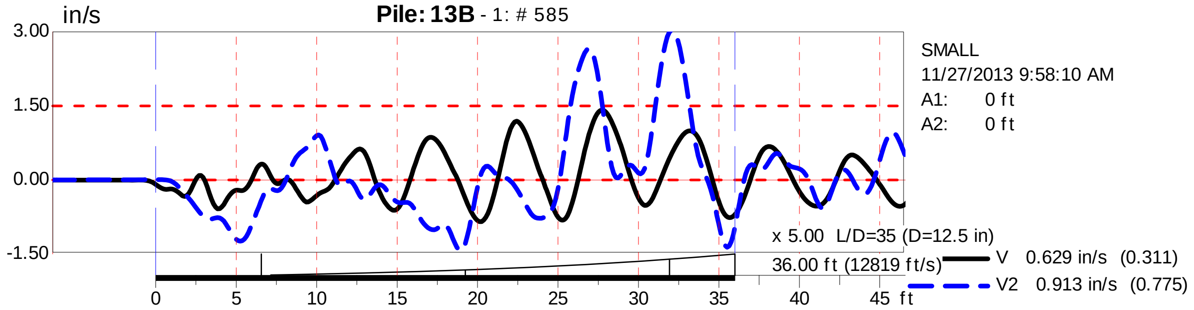


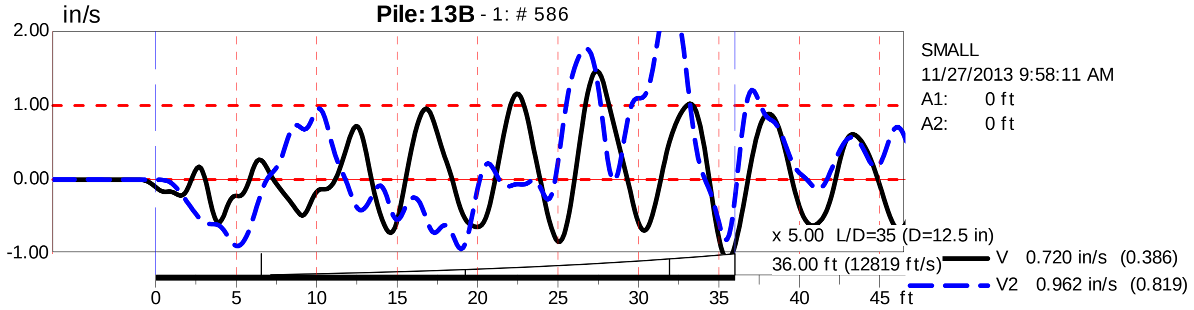
SMALL
11/27/2013 10:03:44 AM
A1: 0 ft
A2: 0 ft

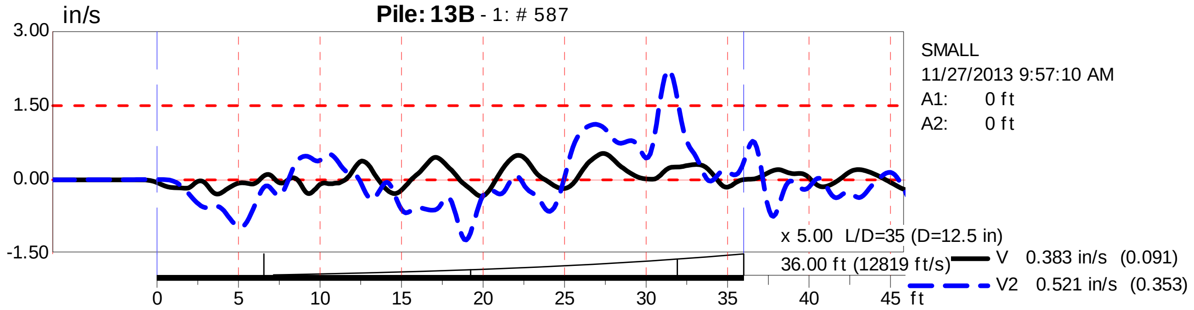
Pile: 13A - 1: # 544

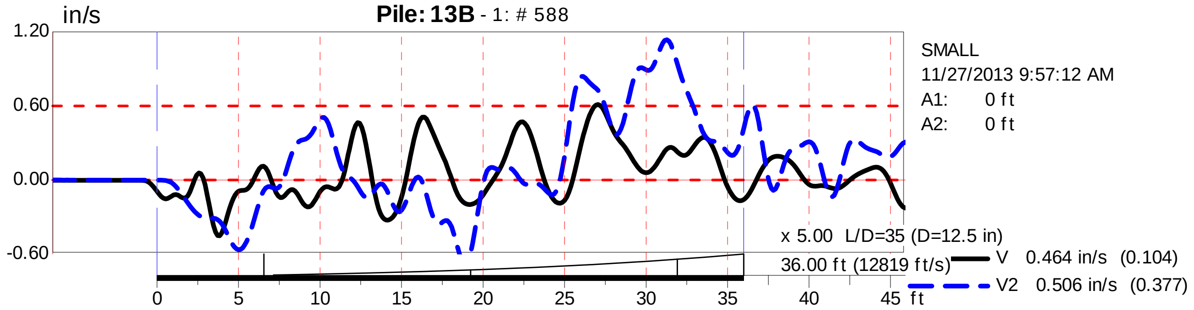


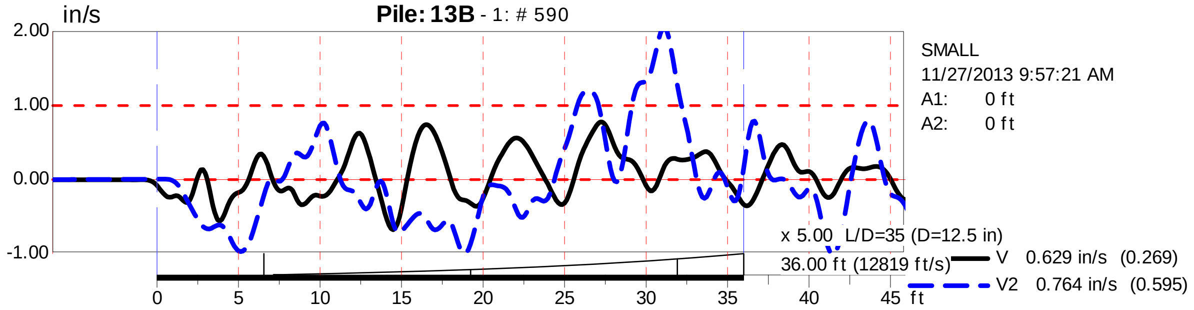
SMALL
11/27/2013 10:03:47 AM
A1: 0 ft
A2: 0 ft


in/s
Pile: 13B - 1: # 585
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 9:58:10 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.629 in/s (0.311)
V2 0.913 in/s (0.775)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 13B - 1: # 586
2.00
1.00
0.00
-1.00
SMALL
11/27/2013 9:58:11 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.720 in/s (0.386)
V2 0.962 in/s (0.819)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 13B - 1: # 587
3.00
1.50
0.00
-1.50
SMALL
11/27/2013 9:57:10 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.383 in/s (0.091)
V2 0.521 in/s (0.353)
0
5
10
15
20
25
30
35
40
45 ft

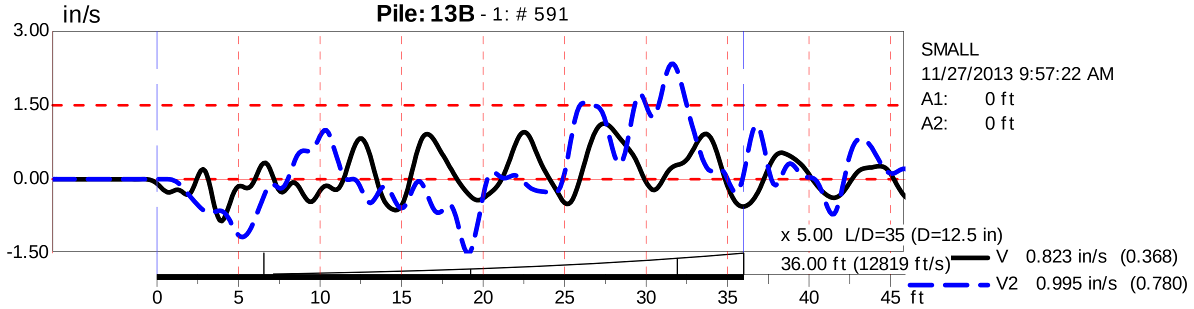

in/s
Pile: 13B - 1: # 588
1.20
0.60
0.00
-0.60
SMALL
11/27/2013 9:57:12 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.464 in/s (0.104)
V2 0.506 in/s (0.377)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 13B - 1: # 590
2.00
1.00
0.00
-1.00
SMALL
11/27/2013 9:57:21 AM
A1: 0 ft
A2: 0 ft
x 5.00 L/D=35 (D=12.5 in)
36.00 ft (12819 ft/s)
V 0.629 in/s (0.269)
V2 0.764 in/s (0.595)
0
5
10
15
20
25
30
35
40
45 ft

Pile Dynamics, Inc.
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT

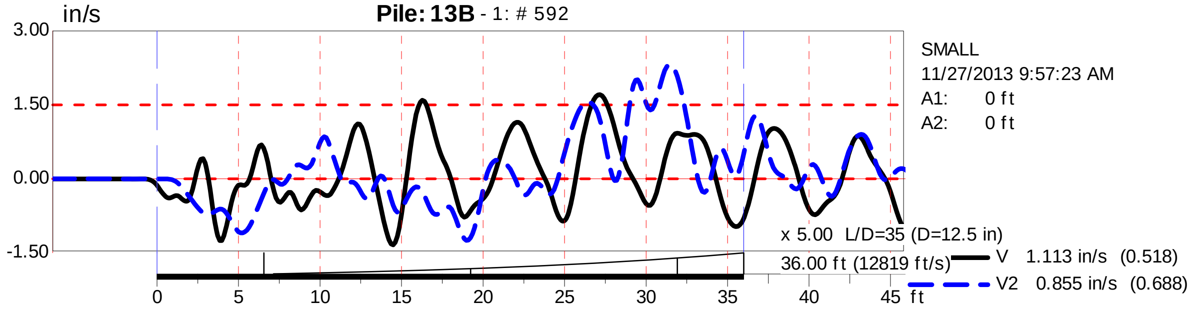
12/24/2013

PIT-W 2009-2.DEMO



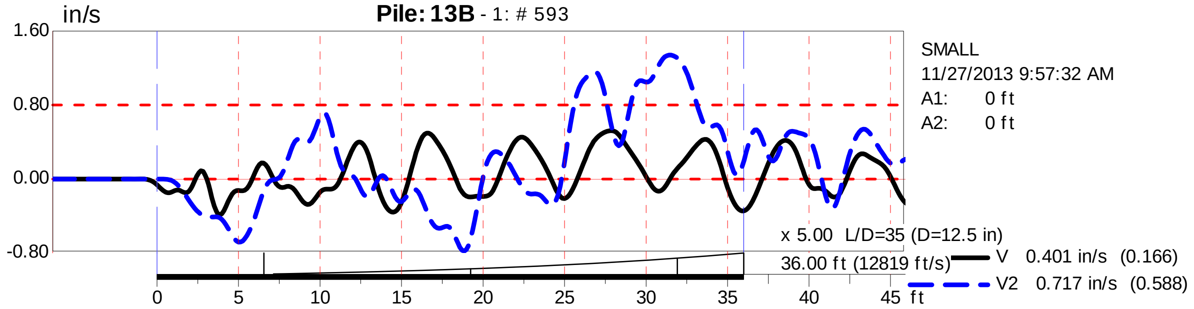
Pile: 13B - 1: # 591

SMALL
11/27/2013 9:57:22 AM
A1: 0 ft
A2: 0 ft



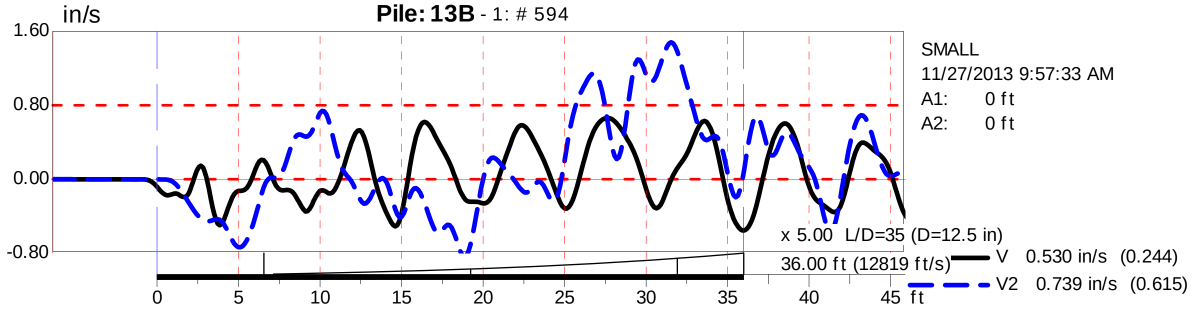
Pile: 13B - 1: # 592

SMALL
11/27/2013 9:57:23 AM
A1: 0 ft
A2: 0 ft



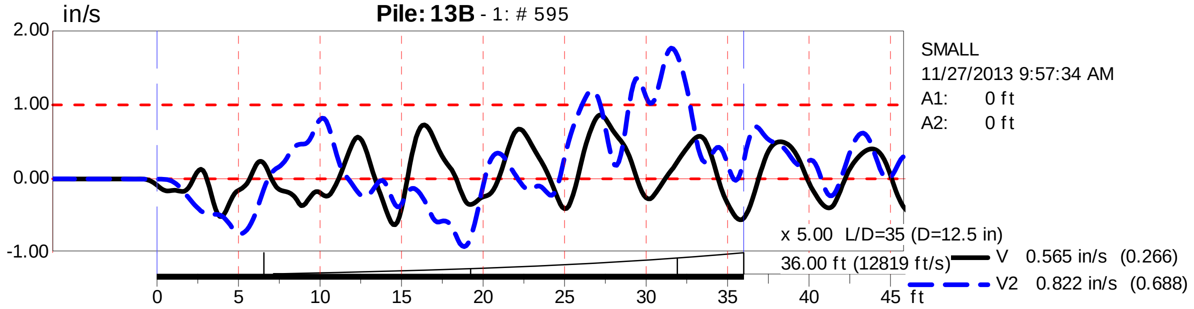
Pile: 13B - 1: # 593

SMALL
11/27/2013 9:57:32 AM
A1: 0 ft
A2: 0 ft



Pile: 13B - 1: # 594

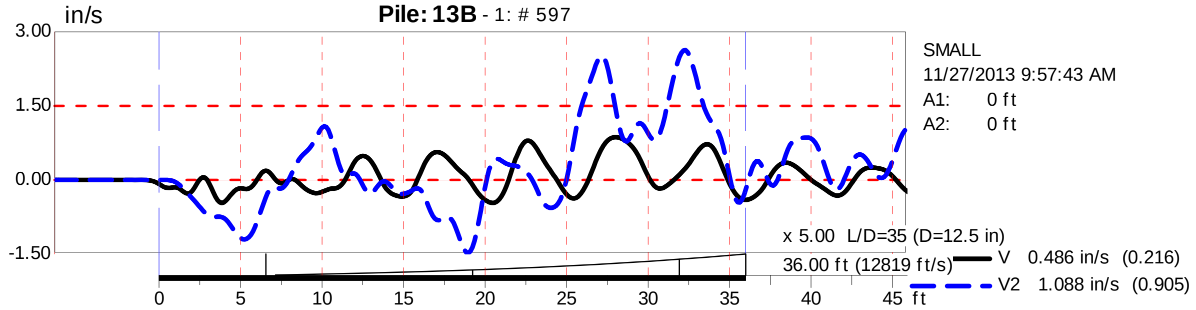
SMALL
11/27/2013 9:57:33 AM
A1: 0 ft
A2: 0 ft

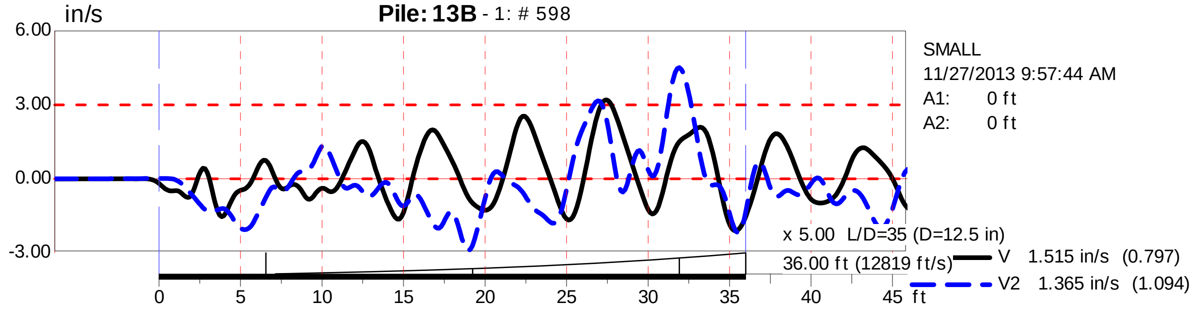


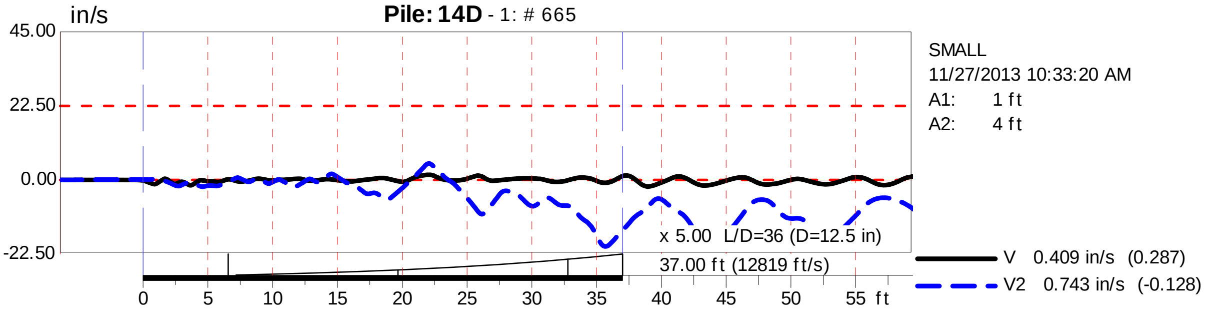
Pile: 13B - 1: # 595

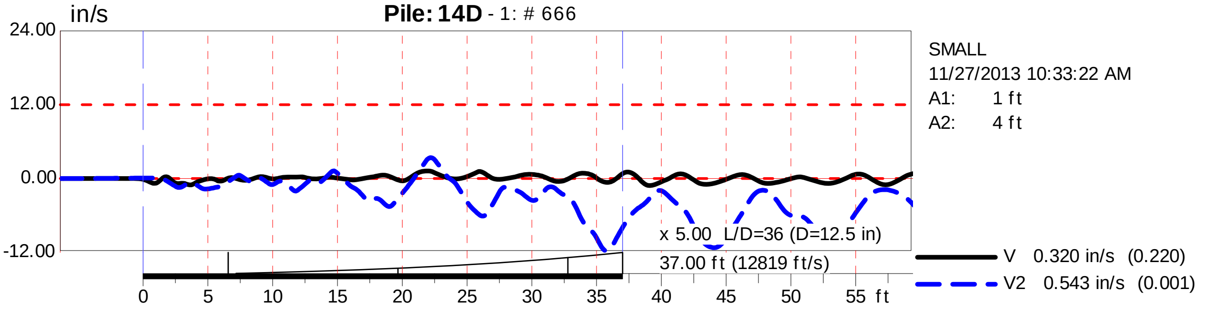
SMALL
11/27/2013 9:57:34 AM
A1: 0 ft
A2: 0 ft

Pile Dynamics, Inc. 12/24/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO






in/s
Pile: 14D - 1: # 665
45.00
22.50
0.00
-22.50
x 5.00 L/D=36 (D=12.5 in)
37.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
SMALL
11/27/2013 10:33:20 AM
A1: 1 ft
A2: 4 ft
V 0.409 in/s (0.287)
V2 0.743 in/s (-0.128)


in/s
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12.00
0.00
-12.00
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0
5
10
15
20
25
30
35
40
45
50
55 ft
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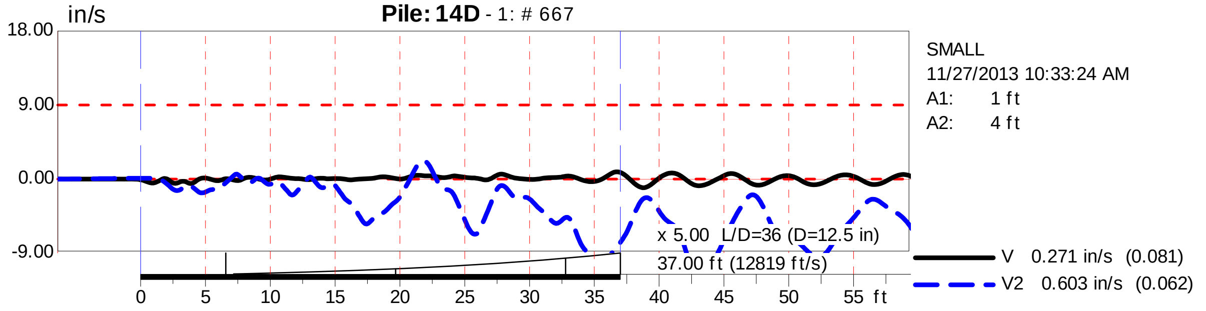
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9.00
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5
10
15
20
25
30
35
40
45
50
55 ft
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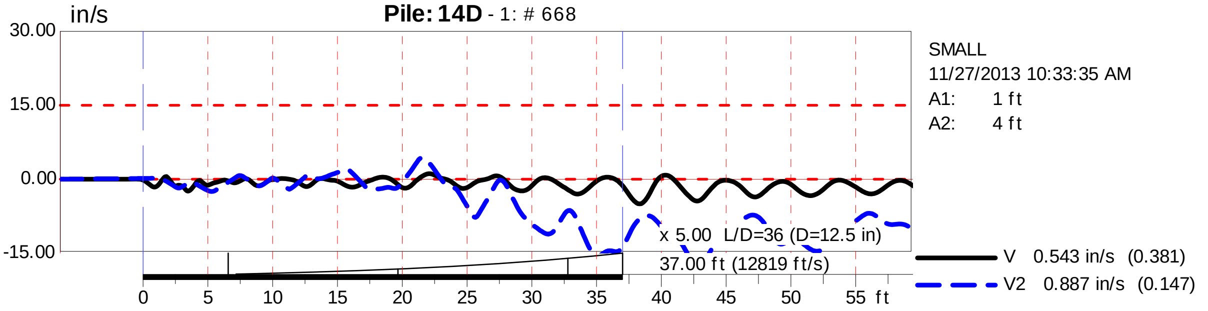
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15.00
0.00
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0
5
10
15
20
25
30
35
40
45
50
55 ft
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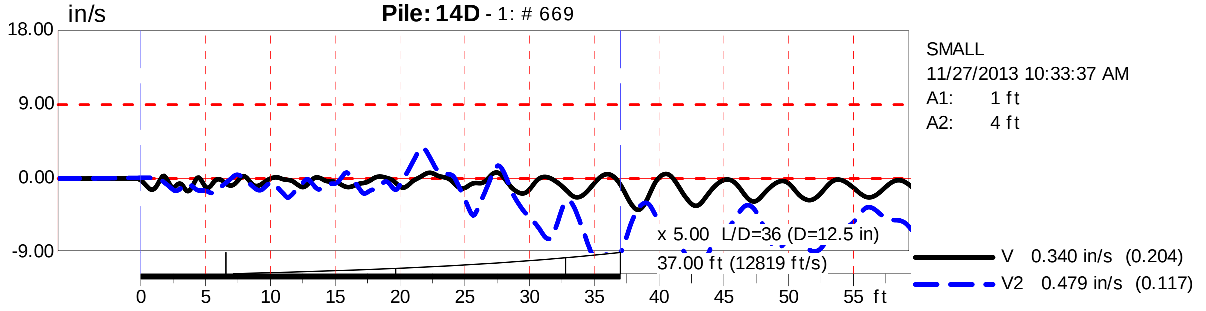
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5
10
15
20
25
30
35
40
45
50
55 ft
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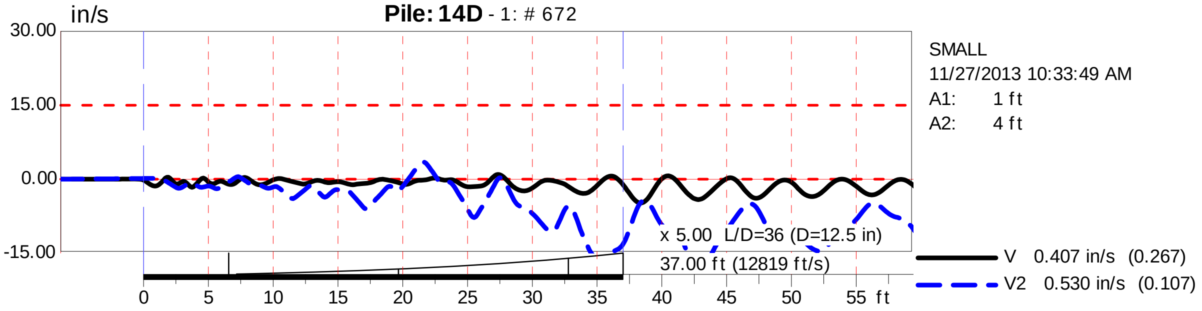
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0.00
-15.00
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0
5
10
15
20
25
30
35
40
45
50
55 ft
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11/27/2013 10:33:49 AM
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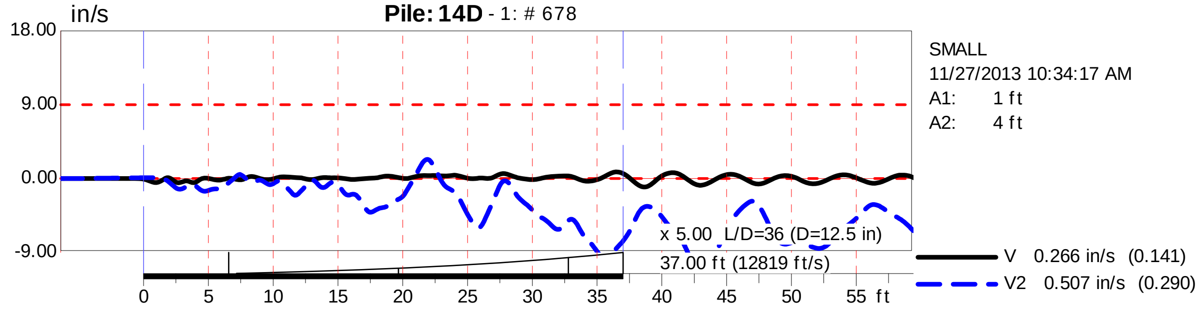
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9.00
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-9.00
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37.00 ft (12819 ft/s)
0
5
10
15
20
25
30
35
40
45
50
55 ft
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11/27/2013 10:34:17 AM
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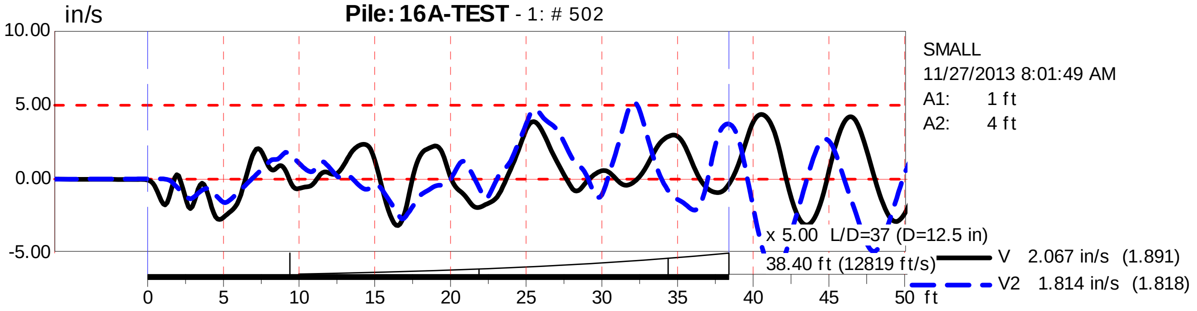
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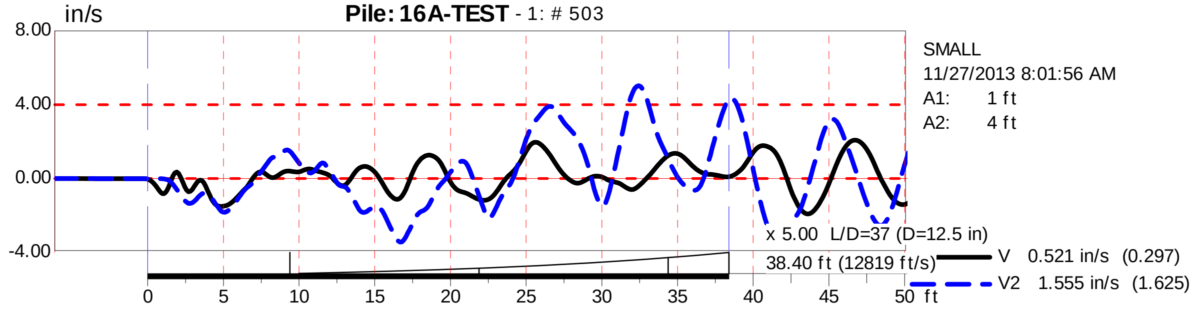
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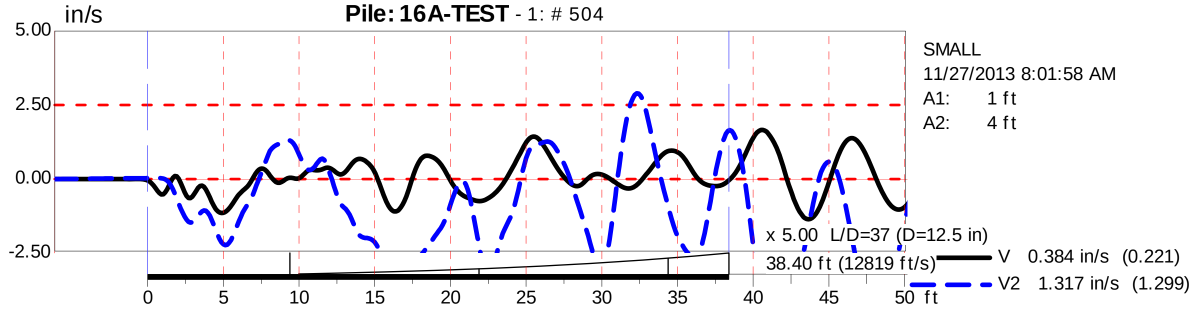
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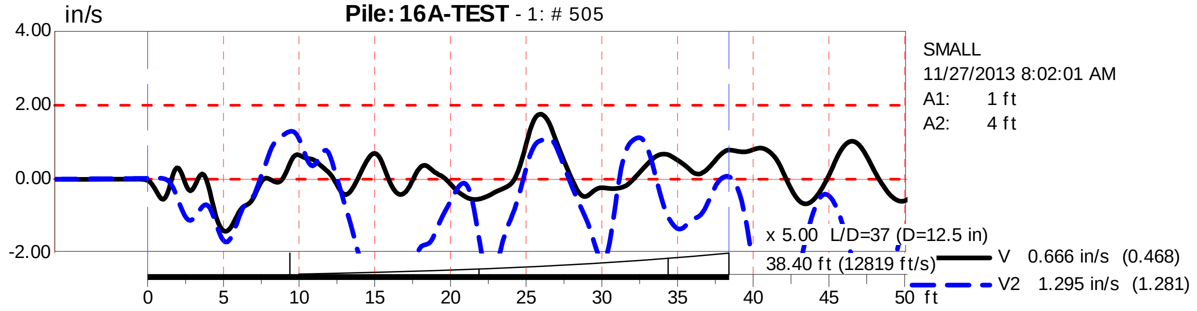
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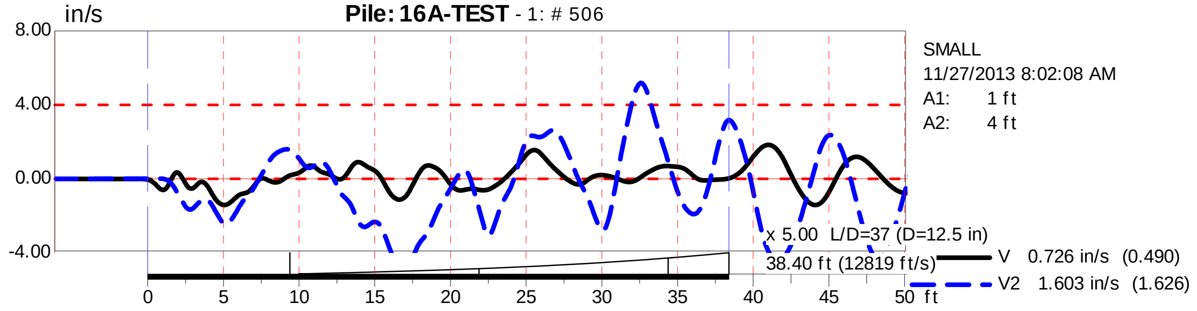
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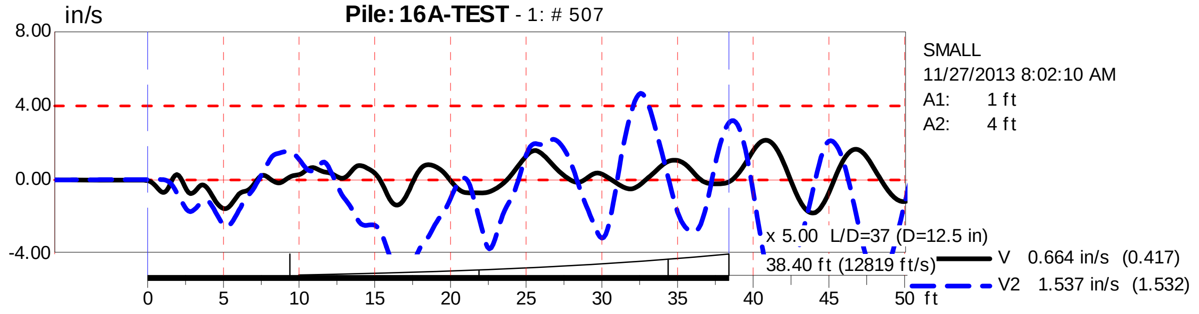
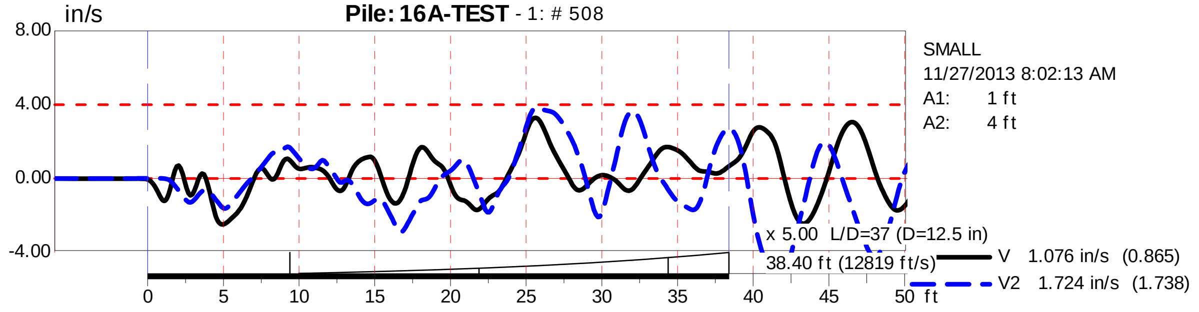
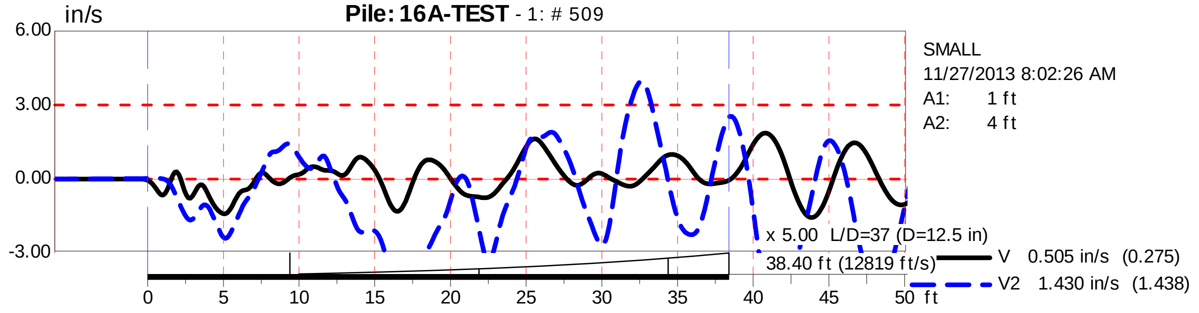
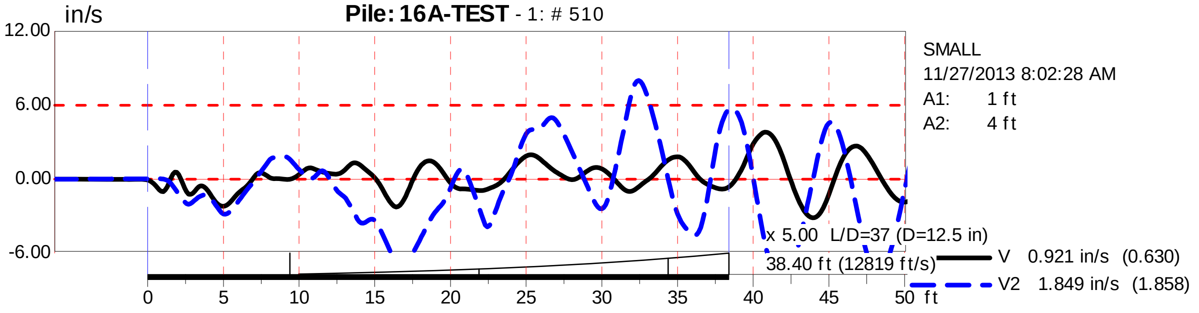
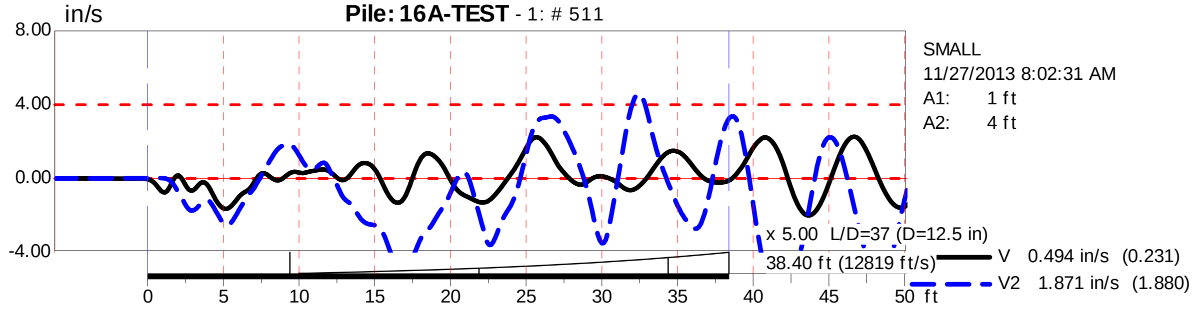
Pile Dynamics, Inc. 12/24/2013
PIT Raw data
C:\...\T13124 - Bellingham Pile Embedment\PIT-data Final.PIT PIT-W 2009-2.DEMO

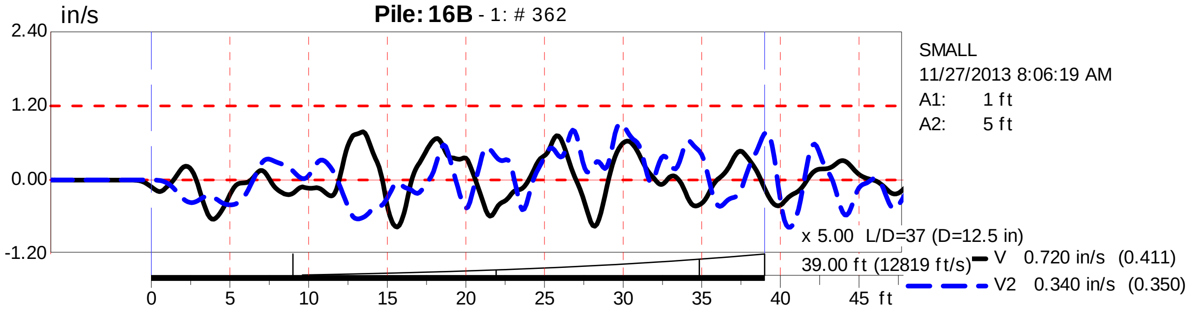











in/s
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1.20
0.00
-1.20
SMALL
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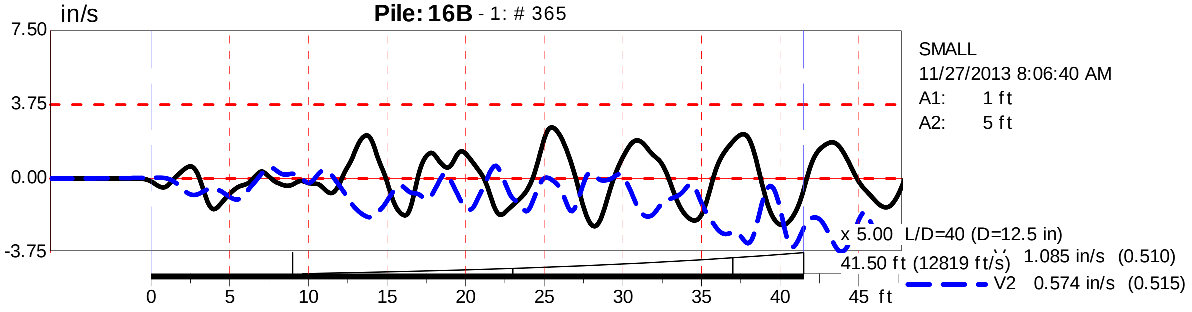
A1: 1 ft
A2: 5 ft
x 5.00 L/D=37 (D=12.5 in)
39.00 ft (12819 ft/s)
V 0.720 in/s (0.411)
V2 0.340 in/s (0.350)
0
5
10
15
20
25
30
35
40
45 ft


in/s
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7.50
3.75
0.00
-3.75
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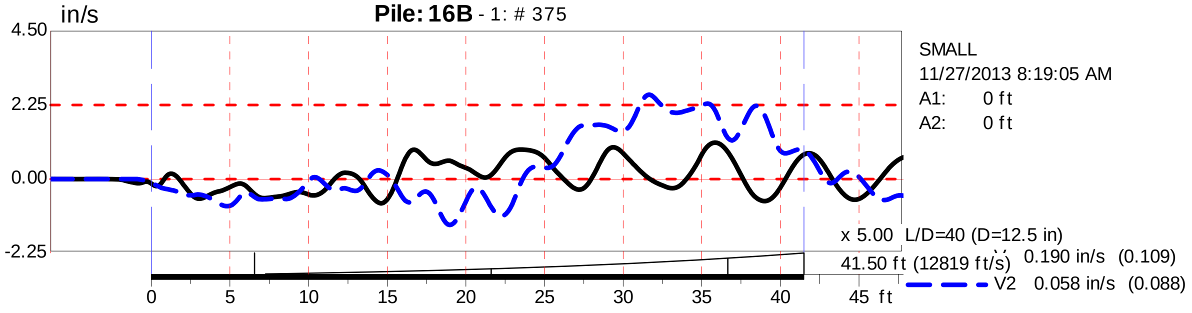
A1: 1 ft
A2: 5 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
1.085 in/s (0.510)
V2 0.574 in/s (0.515)
0
5
10
15
20
25
30
35
40
45 ft


in/s
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4.50
2.25
0.00
-2.25
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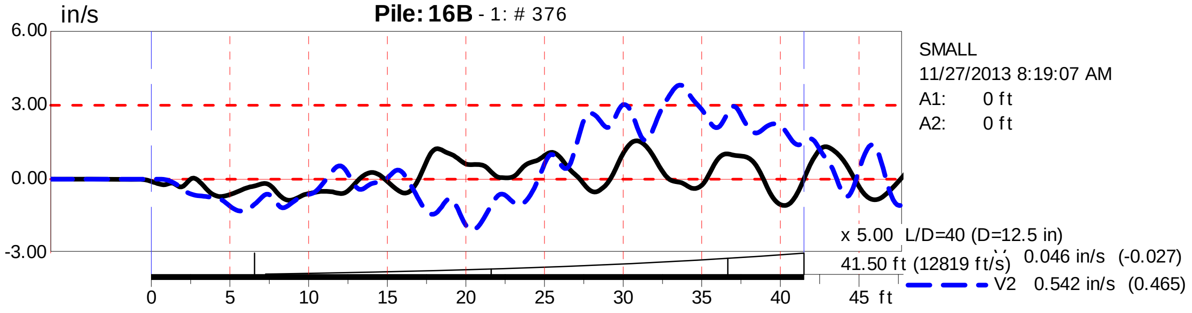
A1: 0 ft
A2: 0 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
0.190 in/s (0.109)
V2 0.058 in/s (0.088)
0
5
10
15
20
25
30
35
40
45 ft


in/s
Pile: 16B - 1: # 376
6.00
3.00
0.00
-3.00
SMALL
11/27/2013 8:19:07 AM
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A2: 0 ft
x 5.00 L/D=40 (D=12.5 in)
41.50 ft (12819 ft/s)
0.046 in/s (-0.027)
V2 0.542 in/s (0.465)
0
5
10
15
20
25
30
35
40
45 ft

APPENDIX G
PROPELLER WASH EVALUATION

1 PURPOSE

The purpose of this evaluation was to assess and quantify the scour potential from vessel traffic in I&J Waterway. This information was used to aid in the development of remedial alternatives for the I&J Waterway Feasibility Study (FS). In particular, these data were used to assess the technical feasibility and determine appropriate materials for engineered capping, particularly beneath the Bornstein Dock, and evaluate the potential for disturbance to sediments adjacent to areas where the US Coast Guard (USCG) operates vessels.

As a vessel or boat moves through the water, the propeller produces an underwater jet. This turbulent jet is characterized by high velocities and is known as propeller wash (or propwash). The propwash analysis was conducted to estimate the velocities caused by the known vessels in the waterway. If these high velocities impact the sea bed, they can contribute to resuspension or movement of surface sediments, resulting in scour. This evaluation also estimated the possible scour depths caused by propwash, and the stable sediment size that would be required to withstand the propwash without scour.

The results of this analysis were used for the following:

- Evaluating potential mixing depths (scour depth) of in situ surficial sediment resulting from predicted propwash velocities to support evaluation of potential disturbance to sediments in the vicinity of USCG vessel operation.
- Estimating stable material sizes required to resist movement due to predicted propwash velocities for application as part of an engineered cap armor layer under the Bornstein dock.

2 DATA USED AND METHODOLOGY

To evaluate the propwash within I&J Waterway the following information was used:

- Water depths based on bathymetry data
- Types of vessels, including their geometries and propulsion characteristics
- Typical vessel operations, including typical areas of operation within the waterway

2.1 Bathymetry and Water Depths

A bathymetric survey was conducted on April 5, 2012 by eTrac and was used to establish the depths that the vessels in the waterway traversed. Bathymetry data are provided in Figure 3-1 in the I&J Waterway RI/FS.

2.2 Vessels

Vessel information for the area was gathered through discussions and correspondence with a representative of the USCG, Lieutenant Scott Higby, and from correspondence with Bornstein Seafoods on typical fishing vessels visiting the Bornstein dock on a regular basis. Table 1 summarizes the vessel specifications for representative vessel types operating in I&J Waterway.

Table 1

Vessel Specifications

Vessel	Length (m)	Draft (m)	Horsepower	Number of Propellers	Propeller Diameter (m)
Response Boat, Defender Class B	7.6	1	225 x 2 engines	2	0.3
Response Boat, Water Jet	13.7	1	825 x 2 engines	2	0.3
Bornstein-*Ocean Hunter*	27	3.66	624	1	1.68

2.3 Methodology to Evaluate Propwash Resuspension

The scour or resuspension depth is estimated by calculating multiple variables based on the sea bed and vessel characteristics, including estimates of critical shear stress of surface sediments and shear stress induced on the bed due to propwash.

Critical shear stress is defined as the minimum amount of shear stress exerted by an outside force, parallel to the sea bed (e.g., water currents), that is required to initiate surface sediment particle motion. Critical shear stress is a property of the surface sediments and is determined by the in situ properties of the sea bed, such as particle size distribution, particle shape, density, and geological history.

Surface sediments for the area have been observed to be primarily silt and clay in the deeper navigation channel, and sand and gravel in the shallower berthing areas. The deeper areas are then assumed to be primarily cohesive sediments. For the cohesive sediments, a critical shear stress was estimated at 1 dyne per square centimeter (cm^2). This assumption is based on research on the critical shear stress of cohesive sediment beds (Ziegler 2002). For the sandy, gravel sediments, a critical shear stress of 1 dyne per cm^2 was also assumed based on research conducted by the U.S. Geological Survey (2008).

Propeller-induced shear stress occurs when the propeller imparts a current velocity over the sea bed, inducing a force on the surface sediments that are parallel to the sea bed. If the propeller-induced shear stress is greater than the critical shear stress of the surface sediments, then initiation of sediment movement is expected.

The propeller velocity was calculated using a method created by Blaauw and van De Kaa (1978), and was outlined in *Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment* (Maynord 1998). This method requires inputs of the propeller diameter, applied engine horsepower, propeller draft (distance from the sea bed to the center of the propeller), and experimentally developed constants that are dependent upon whether the propeller is ducted or not.

Shear stress applied to the sea bed due to propwash was found using estimates for the D_{90}[1] of the surface sediments and the propeller velocity found using the Blaauw and van de Kaa (1978) method. This estimate was calculated using the quadratic stress law outlined in *1D Sediment Transport Morphodynamics, with Applications to Rivers and Turbidity Currents* by Parker (2004).

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[1] D_{90} = Diameter at which 90% of the sediment is smaller.

Potential scour depths were estimated for the various areas where the applied shear stress due to propwash was greater than the critical shear stress values estimated for the sea bed. Potential scour depths were calculated using a method outlined in *Evaluating Sediment Stability at Sites with Historic Contamination* by Ziegler (2002). The magnitude of the scour depth is dependent upon the difference between applied and critical shear stress (excess shear stress). The greater the difference, the greater the scour depth that is calculated. In terms of vessel operations, the power applied to the engines and the propeller, and the water depth under the propeller (propeller draft) are critical factors in determining the excess shear stress and predicted scour depths. The relationship between scour depth and applied power/propeller draft is not linear; and predicted scour depths decrease quickly as either the applied power is decreased or the propeller draft is increased.

2.4 Methodology to Evaluate Stable Particle Size

The physical stability of the sediment bed, or an in situ engineered sediment cap, is based on the bottom velocities caused by currents, waves, and vessel propellers. This evaluation only estimated the stable sediment size for sediment particles (either the existing bed or an armored sediment cap) to withstand the velocities caused by vessel propellers. The propeller velocity was calculated using the method created by Blaauw and van De Kaa (1978), and the stable sediment size under these velocities were found based on a method by Blaauw et al. (1984) and additional research by Maynord (1984); both were outlined in Maynord (1998).

The required stable sediment size for an armor layer of an in situ engineered sediment cap is based on three main criteria: physical stability, filter criteria, and geotechnical stability. This evaluation was specifically conducted to establish the physical stability criteria. Evaluation of the geotechnical stability and filter criteria will be evaluated as part of remedial design.

3 PROPWASH SCENARIOS

Multiple scenarios were run to establish the scour depths for the deeper water and berthing areas, and to optimize the stable grain size required for each area. There were a few scenarios in the pier area for the Bornstein fishing vessel that would be too shallow for the vessel to operate; in these cases, the water level was increased to provide a minimum under-prop clearance of 1.2 meters (m) (Gaythwaite 2004). Table 2 outlines the scenarios run for the various vessels, areas, and horsepower levels.

Table 2

Propwash Velocity, Average Scour Depth, and Stable Sediment Size

Vessel	Area	Power Level (%)	Water Depth (m)	Propwash Velocity (m/s)	Scour Depth (cm)	Stable Sediment Size (cm)
USCG Response Boat, Defender Class B (7.6 m length)	Deeper Water-Silt	30%	5	0.2	N/A	0.8
		50%	5	0.2	N/A	1.1
		80%	5	0.3	N/A	1.6
USCG Response Boat, Water Jet (13.7 m length)	Deeper Water-Silt	30%	5	0.3	N/A	1.9
		50%	5	0.4	N/A	2.7
		80%	5	0.4	N/A	3.7
Bornstein- *Ocean Hunter* (27 m length)	Deeper Water-Silt	30%	5	0.9	0.2	18.1
		50%	5	1.1	0.5	25.4
		80%	5	1.3	1.3	34.7
	Berthing Area- Sand, Gravel	30%	4.8*	1.0	2.0	20.3
		50%	4.8*	1.2	5.5	28.5
		80%	4.8*	1.4	14.1	39.0

Notes:
* A water depth of 4.8 meters was used to allow for 1.2 meters (4 feet) of clearance below the propeller (Gaythwaite 2004).

4 RESULTS

The results for this evaluation are based on average depths at the lowest expected water levels or minimum draft requirements and are, therefore, expected to be conservative and representative of the worst case scenarios for each assumed vessel operation.

The estimates of stable sediment size based on predicted propwash velocities are based on the assumption of zero movement of the predicted material. The methodology used to estimate scour depth (based on predicted propwash velocities) is based on a different set of assumptions using the in situ sediment. Due to the use of these different methodologies, it is possible to calculate relatively small scour depths (based on in situ sediment) and predict relatively large stable sediment sizes. These two evaluations will be developed further during the design phase of the work.

The average scour depth is expected to be insignificant for the two smaller USCG vessels and small for the large fishing vessel. The most extreme scenario evaluated was a water depth of 4.8 m with the Bornstein-*Ocean Hunter* vessel running at 80% power, which leads to an average scour depth of 14 cm (approximately 5.5 inches).

The stable sediment size is found to be 1 to 4 cm (0.4 to 1.5 inches) for the smaller US Coast Guard vessels in the deep areas. The larger *Ocean Hunter* vessel would require stable sediment sizes of approximately 35 to 39 cm (13 to 15 inches) for the deep and pier areas, assuming 80% power. Table 2 outlines the results of the propwash analysis and all of the tested scenarios.

5 RECOMMENDATIONS FOR FEASIBILITY STUDY

The scour evaluation was used to evaluate the use of monitored natural recovery (MNR) and enhanced natural recovery (ENR) in areas where USCG vessels operate and to develop the FS design assumptions for capping under the Bornstein dock. Capping was a retained remedial technology under the Bornstein dock and at the head of the waterway, MNR was retained in the Navigation Channel – East Unit and Coast Guard units, and ENR was a retained remedial technology in the South Bank Unit adjacent to the USCG dock area. All assumptions will be revisited in remedial design.

The cap under the Bornstein dock was assumed to be a total of 3 feet thick and have the following specifications:

- Armor layer with a median size (D_{50}) of 6 inches (23 cm) and a thickness of 1 foot
- Filter layer with a D_{50} of 0.75 inch (2 cm) and a thickness of 6 inches
- Isolation layer consisting of sand with a thickness of 1.5 feet

The size of the armored layer was determined considering the stable sediment sizes for the *Ocean Hunter* (Table 2) and constructability considerations. In particular, 6 inches is approximately equal to the largest stone size that can be cast under the dock without removing the structure prior to placement or using a less efficient means of placement. The thickness of the armored layer was assumed to be double the D_{50}. The size and thickness of the filter layer were determined based on standard cap design equations. The thickness of the isolation layer was based on experience with cap design at other sites.

The cap at the head of the waterway was assumed to be a total of 3 feet thick and have the following specifications:

- Surface layer of sand/gravel with a thickness of 1.5 feet
- Isolation layer consisting of sand with a thickness of 1.5 feet
- Toe trench approximately 3 feet thick and 10 feet wide

The thickness of the surface layer was based on the exposure assumptions for clamming and beach play of 45 cm (1.5 feet) and for erosion protection considering wind and wake waves (rather than direct propwash activity). The thickness of the isolation layer was based on experience with cap design at other sites. The toe trench assumption was based on experience with cap design at other sites.

The ENR layer in the South Bank was assumed to have the following specifications:

- Sand/gravel layer with a D_{50} of 1 inch (2.5 cm) and an average thickness of 1 foot

The size of the ENR layer was determined considering the stable sediment sizes for the USCG response boats (Table 2), also considering the minimal scour depth. The thickness of the ENR layer was based on experience with ENR at other sites.

Other areas where the USCG operates, including in the Navigation Channel – East Unit and Coast Guard units are not expected to be subject to scour from USCG vessel operations. These vessels operate at low speeds in this area, making each of the scenarios simulated unlikely (30%, 50%, 80% power) and therefore conservative. However, none of these scenarios are predicted to cause scour associated with this propwash.

6 REFERENCES

Blaauw, H.G., and van de Kaa, E.J., 1978. Erosion of Bottom and Banks Caused by the Screw Race of Maneuvering Ships. Publication No. 202, Delft Hydraulics Laboratory, Delft, The Netherlands, presented at the Seventh International Harbor Congress, Antwerp, May 22-26.

Blaauw, H.G., van der Knaap, F.C.M., de Groot, M.T., and Pilarcyk, K.W., 1984. Design of Bank Protection of Inland Navigation Fairways. Publication No. 320, Delft Hydraulics Laboratory, Delft, The Netherlands.

Gaythwaite, John W., 2004. Design of Marine Facilities for the Berthing, Mooring, and Repair of Vessels. Second Edition. ASCE Press.

Maynord, S.T., 1984. Riprap Protection on Navigable Waterways. U.S. Army Corps of Engineers Waterways Experiment Station, Technical Report HL-84-3.

Maynord, S.T., 1998. Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment. EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL. Available from: http://www.epa.gov/glnpo/sediment/iscmain/appnda.pdf.

Parker, G., 2004. 1D Sediment Transport Morphodynamics, with Applications to Rivers and Turbidity Currents. November 2004. Available from: http://cee.uiuc.edu/people/parkerg/morphodynamics_e-book.htm.

U.S. Geological Survey, 2008. Simulation of Flow, Sediment Transport, and Sediment Mobility of the Lower Coeur d'Alene River, Idaho. Available from: http://pubs.usgs.gov/sir/2008/5093/table7.html.

Ziegler, C.K., 2002. Evaluating Sediment Stability at Sites with Historic Contamination. Environmental Management 29(3): 409-27.

APPENDIX H

PROCEDURES USED TO DEVELOP CONTOURED CONCENTRATION PLOTS AND SURFACE WEIGHTED AVERAGE CONCENTRATIONS FOR CPAHS AND DIOXINS/ FURANS USING IDW

1 INTRODUCTION

This appendix summarizes the data and methods used to develop surface weighted average concentrations (SWACs) for I&J Waterway sediments for the Remedial Investigation/Feasibility Study (RI/FS). This analysis was performed for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins/furans to support the human health risk screening of these sediments.

2 DATASETS USED

Available surface data from recent studies in and near I&J Waterway with acceptable quality assurance/quality control protocols and detection limits were used in the analysis. Datasets included the following:

- I&J Waterway Surface Sampling (2005)
- I&J Waterway RI/FS – Supplemental Investigation (2012)
- I&J Waterway (2013)

3 DATA PRE-PROCESSING AND TREATMENT OF NON-DETECTS

Results of data pre-processing steps for data locations in and near I&J Waterway are provided in Tables H-1 and H-2 for cPAHs and dioxins/furans, respectively. The following procedures were used in data pre-processing:

- **Averaging of Duplicates and Co-located Sample Stations.** Where multiple values were available for a test sample due to availability of field duplicates or the reanalysis of archived samples, or where sample stations were co-located, the average value for that sample station was used in the interpolations.
- **Calculation of Total cPAH TEQ.** For calculation of total cPAH values as benzo(a)pyrene toxic equivalents quotient (TEQ) values, total cPAH TEQ calculations were performed individually at each test location.
  - **cPAH TEQ calculations.** TEQ calculations were performed using the California Environmental Protection Agency toxic equivalency factor (TEF) values approved for use under the Model Toxics Control Act (MTCA) and Sediment Management Standards (SMS) regulations.

  - **Treatment of non-detects during totaling.** Where individual compounds were not detected, they were assumed to be present at half of the reported method detection limit (MDL) for these total cPAH TEQ calculations.
  - **Averaging.** If duplicate test results were available at a given station, the individual cPAH TEQ values for each test result were calculated, and then the average of these values was used for mapping. The resulting TEQ values are provided in Table H-1.

- **Calculation of Total Dioxins/Furans TEQ.** For calculation of total dioxin/furan values as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) TEQ values, total dioxin/furan TEQ calculations were performed individually at each test location.
  - **Dioxin/furan TEQ calculations.** 2,3,7,8-TCDD has been identified as the most potent of the dioxin/furan congeners and exhibits both carcinogenic and non-carcinogenic toxicity to humans. Sixteen other dioxin/furan congeners have been identified as having similar mechanisms of toxicity as 2,3,7,8-TCDD. Under MTCA (Washington Administrative Code [WAC] 173-340-708(8d)), this group of congeners is evaluated using the TEQ approach in which the individual congener concentrations are adjusted by their respective 2,3,7,8-TCDD TEF (Van den Berg et al. 2006) and summed into a total dioxin/furan TEQ.
  - **Treatment of non-detects during totaling.** No dioxin/furan analytes were non-detect.
  - **Averaging.** If duplicate test results were available at a given station, the individual dioxin/furan TEQ values for each test result were calculated, and then the average of these values was used for mapping. The resulting TEQ values are provided in Table H-2.

4 SOFTWARE USED FOR INVERSE DISTANCE WEIGHTING DEVELOPMENT

The data contouring and associated geostatistical data analysis was performed using the ArcMap, Spatial Analyst tool (ESRI, version 10.1). All data analysis protocols used during development of the Inverse Distance Weighting (IDW) surface and the SWAC values were consistent with ESRI-defined procedures.

5 DATA TRANSFORMATIONS

Figures H-1a and H-2a illustrate the distribution of the cPAH and dioxin/furan concentrations respectively for samples in I&J Waterway. As is common with environmental datasets, the data do not follow a normal (i.e., bell-curve) distribution. In situations where data are not normally distributed, they must be transformed using either logarithmic or power transformations in order to avoid errors in the IDW surface development process. Figures H-1b and H-2b illustrate the distribution of the same dataset when transformed using a logarithmic transformation (specifically the natural log transformation). As shown in Figures H-1b and H-2b, the transformed data follow the traditional bell-curve pattern as required to minimize potential errors in the IDW surface development.

The natural log transformation (see Equation 1) changes the original variable (X) into the transformed variable (Y).

$$Y\ (x) = \ln(Z(x))\ for\, \lambda = 0 \tag{1}$$

Normality was optimized by applying the natural logarithm to the datasets that most effectively minimized skewness, kurtosis, and the standard deviation in the same order of importance.

6 INVERSE DISTANCE WEIGHTING

The IDW surfaces were developed using ESRI's Spatial Analyst. Spatial Analyst was selected over GeoStatistical Analyst because the IDW tool within Spatial Analyst better accounts for shorelines in the IDW surface, which are of particular importance to I&J Waterway. IDW development requires selection of a number of parameters, including: 1) the power parameter; 2) the maximum number of neighbors; 3) the search method used for IDW development; and 4) shoreline barriers. The first two parameters were selected using a Root Mean Square Error (RMSE) analysis and the second two parameters were selected based on consideration of the characteristics of I&J Waterway. The parameter settings selected are as follows:

- **Power Parameter.** The power parameter determines the influence of a known data point on the estimated IDW grid concentration. The larger the value, the less influence distant data points have on the estimated concentration. Power parameters that yield reasonable results tend to be between 0.5 and 3 (ESRI 2013). A power of 2 was selected for cPAHs and dioxins/furans based on what produced the lowest RMSE.
- **Maximum Neighbors.** The number of points selected for the IDW calculation (neighbors) can be modified to change the relative importance of points closer to or farther from a location. The maximum number of neighbors selected for both cPAHs and dioxins/furans was 4 based on what produced the lowest RMSE. This is consistent with IDW methods performed for other environmental datasets (AECOM 2012).
- **Search Radius.** A variable search radius was used for this analysis. For each location, the search radius was large enough to select four neighbors. The variable search radius was used to create a smooth interpolation across the full extent of the area of interest. In particular, a variable search radius is effective for creating IDW surfaces where the distance between points is variable (e.g., for interpolating from nearshore areas many points out into offshore areas with fewer points).
- **Shoreline Barriers.** A simple geometry vector line dataset was digitized following the shoreline of I&J Waterway and extending north and south along the shoreline to the extent of the sample data. This shoreline dataset was then used as a barrier input to prevent the IDW tool from interpolating across land.

7 FINAL CONTOUR DEVELOPMENT

Contouring of the IDW surface was developed using ArcMap. This involves three steps.

- **Grid Development:** First the grids of IDW concentration are developed using the transformed data and each of the preceding IDW parameter settings using ESRI's Spatial Analyst IDW tool.
- **Reverse Transformation:** The resultant grid (of transformed data) is run through a reverse transformation to generate corresponding grid points with concentration estimates in standard concentration units (e.g., micrograms per kilogram). The reverse transformation is conducted for each point in the grid using Equation 2 below. This reverse transformation preserves the contour relationships between the

grid points developed using the IDW protocol but reflects them in the appropriate concentration units.

$$Y = e^{x} \tag{2}$$

- **Final Map Development:** The IDW surface is then contoured to produce the final map in standard concentration units.

The concentration contours provide estimated concentrations only. In particular, areas away from sample locations are based on interpolations. These interpolations will be revisited during remedial design testing.

8 PREDICTED POST-CONSTRUCTION CONCENTRATIONS

The pre-construction SWACs (i.e., baseline SWACs) were calculated in ArcGIS based on the IDW surface. Post-construction SWACs were calculated assuming that surface sediment concentrations in areas that have been actively remediated (i.e., dredged, capped, or remediated with enhanced natural recovery) equal the natural background concentration. For cPAHs, the natural background concentration of 16 micrograms TEQ per kilogram dry weight (µg TEQ/kg dw) was rounded to 15 µg TEQ/kg dw for this analysis, and the practical quantitation limit was used for dioxins/furans (5 nanograms [ng] TEQ/kg dw). These predicted post-construction concentrations are based on the anticipated concentrations of a clean sand layer placed following dredging, the sand/gravel material placed for enhanced natural recovery, or the material used for capping. These predictions apply to the condition immediately following construction, which are likely to increase approximately toward regional background concentrations over the long-term due to diffuse sources.

Areas that have not been actively remediated (i.e., areas remediated with monitored natural recovery or areas outside of the remediation area) were assumed to have concentrations equal to the baseline IDW surface. The Site-wide SWAC following construction for each alternative was calculated based on a combination of the IDW surface and post-construction surface based on the remediation areas for the alternative.

9 REFERENCES

AECOM, 2012. *Inverse Distance Weighting Methodology for Interpolating Surface Sediment Chemistry.* Prepared for Lower Duwamish Waterway Group for submittal to U.S. Environmental Protection Agency, Seattle, Washington, and Washington State Department of Ecology, Bellevue, Washington. October 31, 2012.

ESRI, 2013. ESRI ArcMap Version 10: ArcMap Help – Geostatistical Analyst. Retrieved October 11, 2013.

Van den Berg, M., L.S. Birnbaum, M. Denison, M. De Vito, W. Farland, M. Feeley, H. Fiedler, H. Hakansson, A. Hanberg, L. Haws, M. Rose, S. Safe, D. Schrenk, C. Tohyama, A. Tritscher, J. Tuomisto, M. Tysklind, N. Walker, and R.E. Peterson, 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. *Toxicological Sciences* 93(2):223-241.

TABLES

Table H-1
Summary of cPAH Data for IDW Development

Location	X	Y	Horizontal Datum	Sample Date	Depth Interval	Concentration (µg TEQ/kg dw)	Natural Log Transformed Concentration (µg TEQ/kg dw)
IJW-SS-01	1239700.907	644121.977	NAD83WAN	8/31/2005	0 - 12 cm	59	4.1
IJW-SS-02	1239735.765	644283.619	NAD83WAN	8/31/2005	0 - 12 cm	46	3.8
IJW-SS-03	1239790.033	644133.434	NAD83WAN	9/1/2005	0 - 12 cm	245	5.5
IJW-SS-04	1239822.745	644270.185	NAD83WAN	9/1/2005	0 - 12 cm	104	4.6
IJW-SS-05	1239858.066	644416.003	NAD83WAN	8/31/2005	0 - 12 cm	100	4.6
IJW-SS-06	1239917.932	644301.583	NAD83WAN	8/31/2005	0 - 12 cm	2475	7.8
IJW-SS-07	1240025.277	644579.656	NAD83WAN	8/31/2005	0 - 12 cm	143	5.0
IJW-SS-08	1240112.714	644531.545	NAD83WAN	9/1/2005	0 - 12 cm	232	5.4
IJW-SS-09	1240149.910	644615.286	NAD83WAN	8/31/2005	0 - 12 cm	149	5.0
IJW-SS-10	1240235.002	644570.267	NAD83WAN	9/1/2005	0 - 12 cm	1154	7.1
IJW-SS-11	1240156.364	644709.420	NAD83WAN	8/31/2005	0 - 12 cm	504	6.2
IJW-SS-12	1240111.438	644453.721	NAD83WAN	9/1/2005	0 - 12 cm	512	6.2
IJW-SS-13	1239974.863	644479.779	NAD83WAN	9/1/2005	0 - 12 cm	62	4.1
IJ12-01	1240215.399	644774.228	NAD83WAN	4/25/2012	0 - 12 cm	533	6.3
IJ12-02	1240156.589	644615.952	NAD83WAN	4/24/2012	0 - 12 cm	89	4.5
IJ12-03	1240021.290	644592.103	NAD83WAN	4/24/2012	0 - 12 cm	113	4.7
IJ12-04	1240117.121	644446.429	NAD83WAN	4/24/2012	0 - 12 cm	705	6.6
IJ12-05	1239981.511	644487.042	NAD83WAN	4/24/2012	0 - 12 cm	71	4.3
IJ12-06	1239872.939	644418.694	NAD83WAN	4/24/2012	0 - 12 cm	57	4.0
IJ12-07	1239818.068	644235.413	NAD83WAN	4/24/2012	0 - 12 cm	66	4.2
IJ12-58A/ IJ12-08A	1239783.233	644127.071	NAD83WAN	4/24/2012	0 - 12 cm	135	4.9
IJ13-SS-101/ IJ13-SS-151	1239976.980	644336.970	NAD83WAN	8/20/2013	0 - 12 cm	915	6.8
IJ13-SS-102	1239881.590	644244.900	NAD83WAN	8/20/2013	0 - 12 cm	1340	7.2

Notes:

cm = centimeter

cPAH = carcinogenic polycyclic aromatic hydrocarbon

IDW = Inverse Distance Weighting

µg TEQ/kg dw = microgram toxic equivalents quotient per kilogram dry weight

Table H-2
Summary of Dioxin/Furan Data for IDW Development

Location	X	Y	Horizontal Datum	Sample Date	Depth Interval	Concentration (ng TEQ/kg dw)	Natural Log Transformed Concentration (ng TEQ/kg dw)
IJ12-01	1240215.398	644774.228	NAD83WAN	4/25/2012	0 - 12 cm	26	3.3
IJ12-02	1240156.589	644615.952	NAD83WAN	4/24/2012	0 - 12 cm	21	3.0
IJ12-03	1240021.290	644592.103	NAD83WAN	4/24/2012	0 - 12 cm	10	2.3
IJ12-07	1239818.068	644235.412	NAD83WAN	4/24/2012	0 - 12 cm	12	2.5
IJ12-08A/IJ12-58A	1239783.233	644127.071	NAD83WAN	4/24/2012	0 - 12 cm	33	3.2
IJ12-11	1239240.814	643796.934	NAD83WAN	4/24/2012	0 - 12 cm	9.5	2.3
IJ12-04	1240117.121	644446.429	NAD83WAN	4/24/2012	0 - 12 cm	36	3.6
IJ12-05	1239981.511	644487.042	NAD83WAN	4/24/2012	0 - 12 cm	20	3.0
IJ12-06	1239872.939	644418.694	NAD83WAN	4/24/2012	0 - 12 cm	15	2.7
IJ13-SS-101/ IJ13-SS-151	1239976.980	644336.970	NAD83WAN	8/20/2013	0 - 12 cm	36	3.6
IJ13-SS-102	1239881.590	644244.900	NAD83WAN	8/20/2013	0 - 12 cm	58	4.1

Notes:

cm = centimeter

IDW = Inverse Distance Weighting

ng TEQ/kg dw = nanogram toxic equivalents quotient per kilogram dry weight

FIGURES

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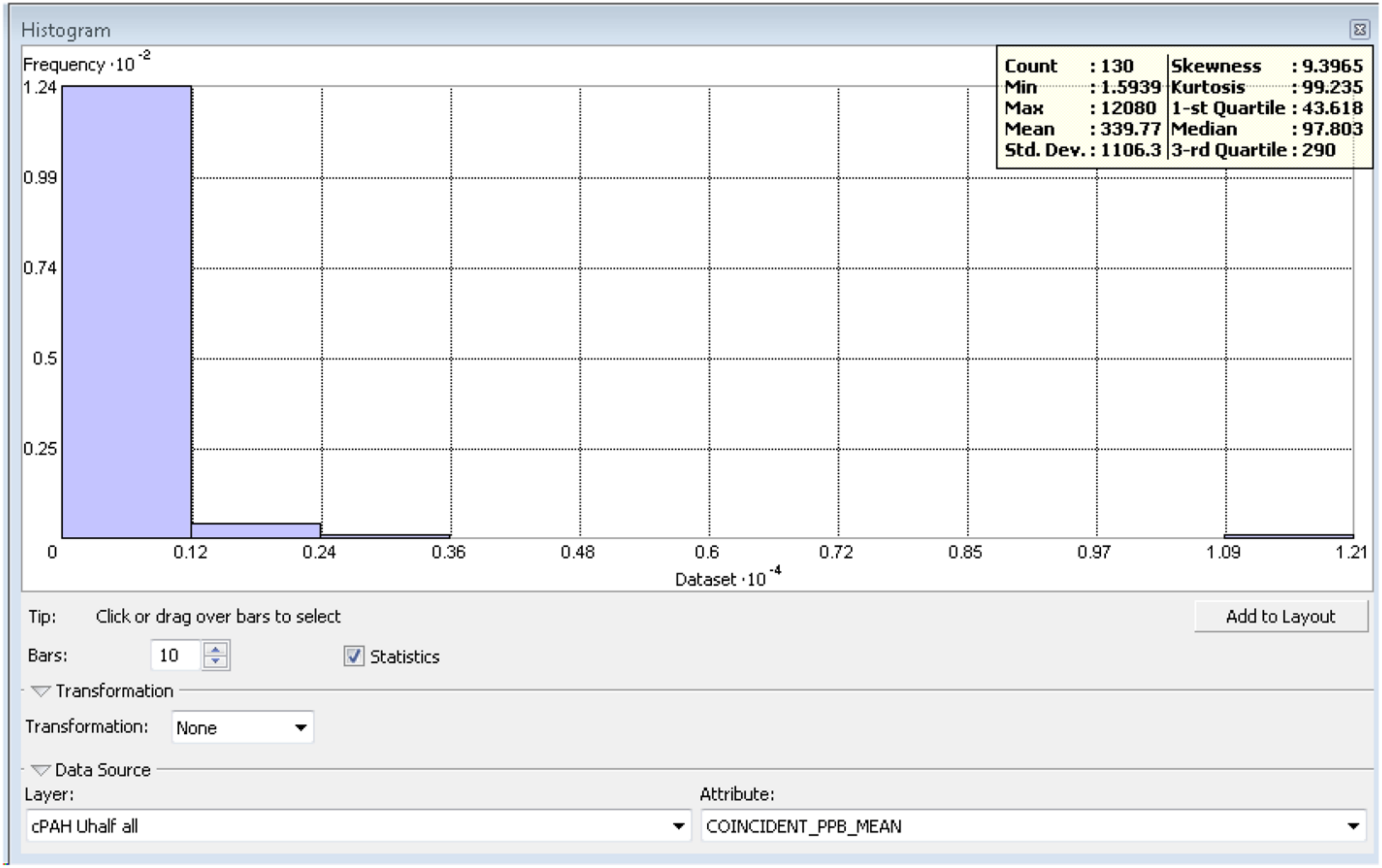


Count	: 130	Skewness	: 9.3965
Min	: 1.5939	Kurtosis	: 99.235
Max	: 12080	1-st Quartile	: 43.618
Mean	: 339.77	Median	: 97.803
Std. Dev.	: 1106.3	3-rd Quartile	: 290

Tip: Click or drag over bars to select

Bars: 10

☑ Statistics

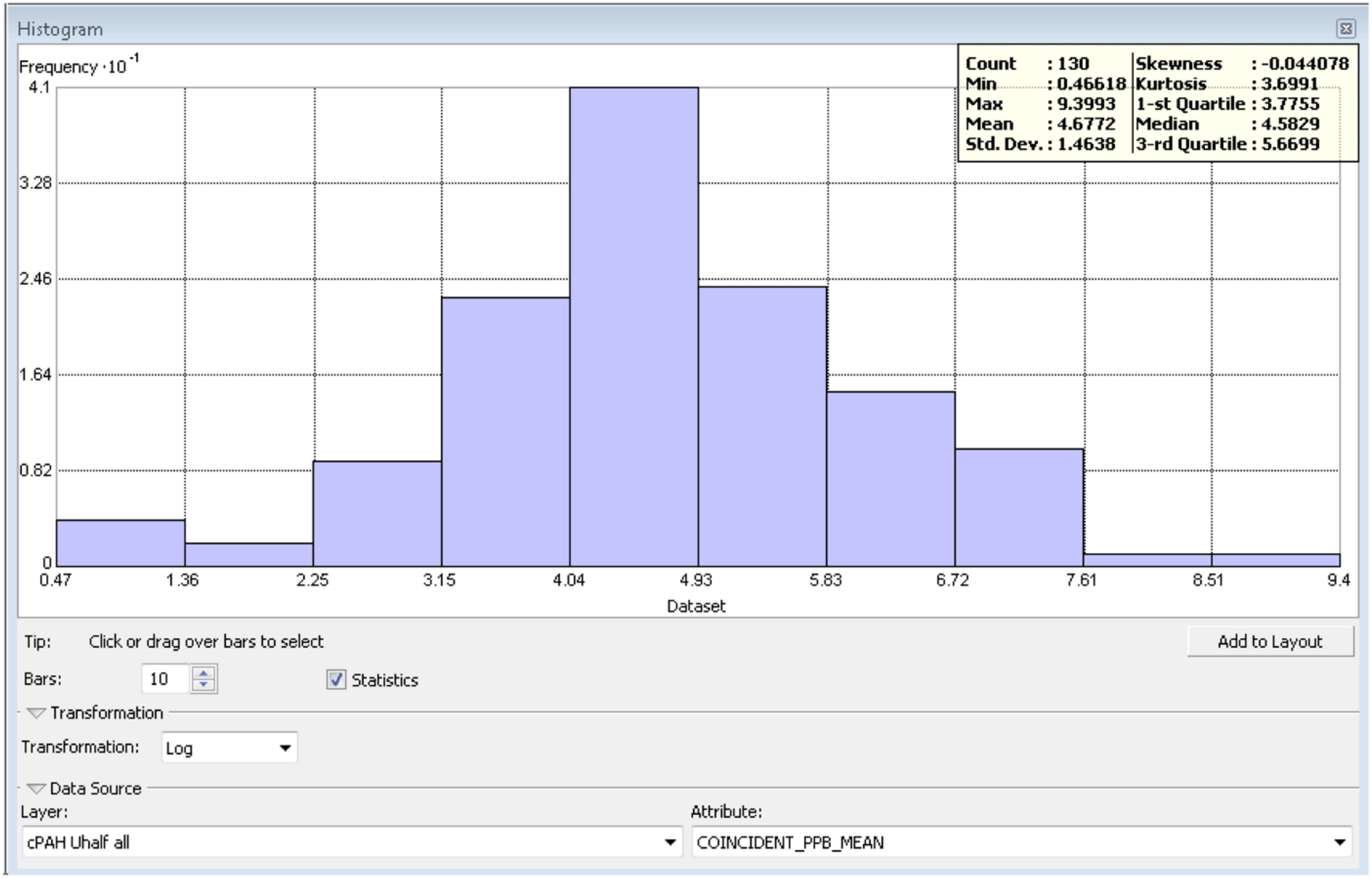
Transformation: None

Layer: cPAH Uhalf all

Attribute: COINCIDENT_PPB_MEAN

Notes:
Transformation = None
x-axis = concentration (parts per billion)
y-axis = count * 10

Figure H-1a
Distribution of Total cPAH TEQ for Untransformed Data
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



```
Count     : 130        Skewness     : -0.044078
Min       : 0.46618    Kurtosis     : 3.6991
Max       : 9.3993     1-st Quartile : 3.7755
Mean      : 4.6772     Median       : 4.5829
Std. Dev. : 1.4638     3-rd Quartile : 5.6699
```

Bars: 10

☑ Statistics

Transformation: Log

Layer: cPAH Uhalf all

Attribute: COINCIDENT_PPB_MEAN

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Figure H-1b
Distribution of Total cPAH TEQ Data After Log Transformation
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

ANCHOR QEA

Notes:
Transformation = Natural Log
x-axis = concentration (parts per billion)
y-axis = count * 10

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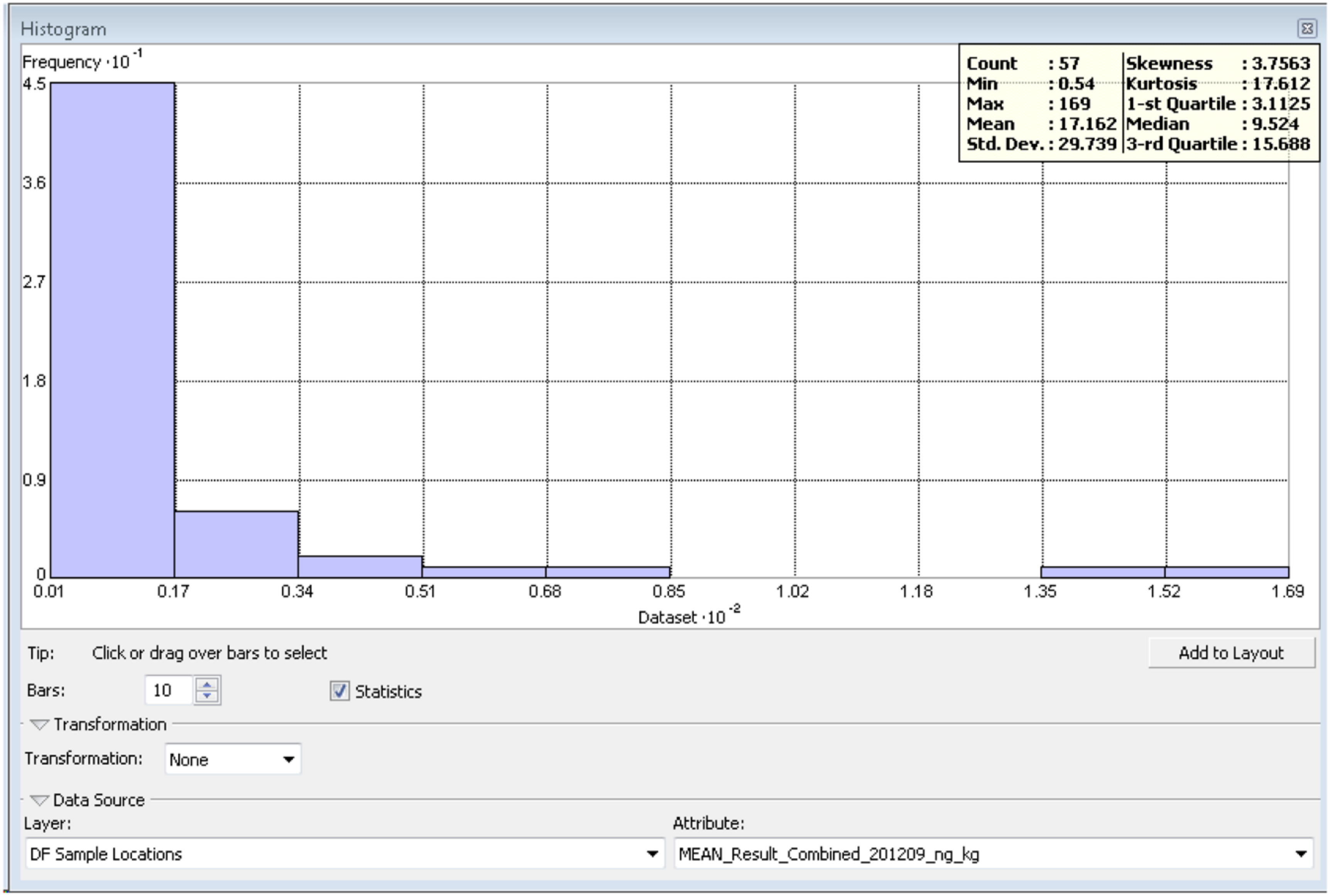


Count : 57
Min : 0.54
Max : 169
Mean : 17.162
Std. Dev. : 29.739
Skewness : 3.7563
Kurtosis : 17.612
1-st Quartile : 3.1125
Median : 9.524
3-rd Quartile : 15.688

Tip: Click or drag over bars to select

Bars: 10

☑ Statistics

Transformation

Transformation: None

Data Source

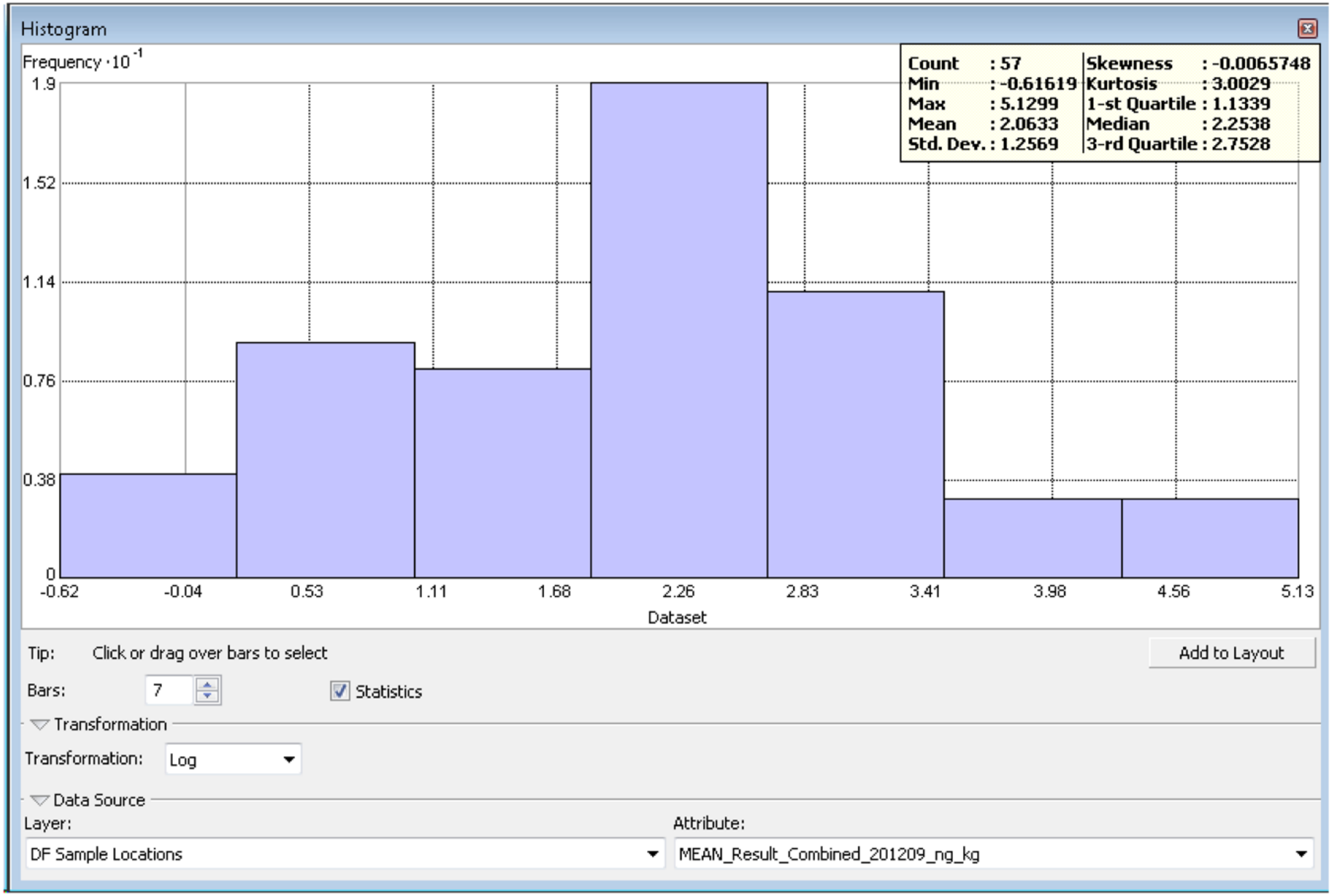
Layer: DF Sample Locations

Attribute: MEAN_Result_Combined_201209_ng_kg

ANCHOR QEA

Notes:
Transformation = None
x-axis = concentration (ng/kg)
y-axis = count * 10

Figure H-2a
Distribution of Dioxin Furan for Untransformed Data
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



Count : 57
Min : -0.61619
Max : 5.1299
Mean : 2.0633
Std. Dev. : 1.2569
Skewness : -0.0065748
Kurtosis : 3.0029
1-st Quartile : 1.1339
Median : 2.2538
3-rd Quartile : 2.7528

Tip: Click or drag over bars to select

Bars: 7

☑ Statistics

Transformation

Transformation: Log

Data Source

Layer: DF Sample Locations

Attribute: MEAN_Result_Combined_201209_ng_kg

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Notes:
Transformation = Natural Log
x-axis = concentration (ng/kg)
y-axis = count * 10

Figure H-2b
Distribution of Dioxin Furan Data After Log Transformation
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham