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Vancouver Energy
Cultural Resources Geoarchaeological Investigation Report

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Vancouver Energy

Cultural Resources Geoarchaeological Investigation Report

EFSEC Application for Site Certification No. 2013-01
Docket No. EF131590
30 April 2015

Prepared for

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Table of Contents

Section

List of Tables

List of Figures

List of Photographs

List of Appendices

1. Introduction and Background

The proposed Vancouver Energy project is located at the Port of Vancouver (Port) in Vancouver, Washington (Figure 1). The proposed facility will receive crude oil by freight rail, temporarily store it on site, and convey it to marine vessels for shipment via the Columbia River. The project includes rail unloading and office, a storage area, a series of transfer pipelines, a marine terminal, and a boiler building, as well as associated temporary laydown and construction areas. The project will be constructed on Port land.

The area of potential effect (APE) is defined as the area where an undertaking may directly, through ground-disturbing activities, or indirectly cause changes in the character or use of historic properties. The APE of the project is south of NW Lower River Road and north of the Columbia River (Figures 1 and 2). The western boundary of the proposed project APE is the western limit of the former Alcoa aluminum plant at Terminal 5. The northeastern limit of the project APE is demarcated by a zone of undeveloped wetland. The eastern portion of the project, including Berths 13 and 14, are in the Port's Terminal 4. The project APE is divided into the following "area" groupings, as illustrated in Figure 1, Figure 2, and Figure 3.

- Area 200 – Rail Unloading – located at Terminal 5 of the Port
- Area 300 – Storage – located at Parcel 1A of the Port
- Area 400 – Marine Terminal – located at berths 13 and 14 at the Port
- Area 500 – Transfer Pipelines – located between areas 200, 300, and 400
- Rail Infrastructure – located at Terminal 5 of the Port

The proposed project is subject to the jurisdiction of the Washington State Energy Facility Site Evaluation Council (EFSEC) because the project is expected to ship over 50,000 barrels of crude oil per day over marine waters. The project will also require approval from the U.S. Army Corps of Engineers (USACE) for in-water work related to the rehabilitation of the existing Berths 13 and 14. Archaeological Investigations Northwest, Inc. (AINW), prepared a cultural resource report for submittal to USACE (Fuld et al. 2013) and prepared sections regarding the cultural resources for the State Environmental Policy Act (SEPA) submittal to EFSEC.

The Washington State Department of Archaeology and Historic Preservation (DAHP) provided SEPA scoping comments and comments on the Vancouver Energy project Application for Site Certification submitted to EFSEC in August 2013, noting the possibility that construction impacts may reach native soils—soils that may be intact below the fill—and the potential for native soils retaining evidence of an archaeological site (Scoping letter to EFSEC from Gretchen Kaehler, dated 18 December 2013; Email from Sonia Bumpus, EFSEC, to Irina Makarow, BergerABAM, dated 2 January 2014, relating the comments on the Application for Site Certification by Robert Whitlam, DAHP).

DAHP made specific recommendations for the observation of buried soils, one of which was to prepare a subsurface sampling plan. AINW prepared a geoprobe work plan (AINW 2014) and the plan was reviewed by DAHP, USACE, and consulting Tribes. The work plan addressed the DAHP comments by proposing geoarchaeological survey probes to sample the APE, which would provide information to create a three-dimensional subsurface map of native soils, and eliminate the need for additional archaeological survey. The approved work plan, dated 30 October 2014, detailed the procedures for collecting and recording the samples, as well as procedures for mitigating impacts to archaeological resources, if identified. The plan was approved by USACE, DAHP, and Tribes. On 6 November 2014, Misty Thorsgard and Jordan Mercier from the Confederated Tribes of the Grand Ronde toured the APE and observed the geoarchaeological fieldwork. AINW performed geoarchaeological survey of the Facility APE from November 4 through November 24, 2014. In total, 39 geoprobe borings were completed and analyzed.

The geoarchaeological investigation was designed to identify deeply buried archaeological deposits and archaeologically sensitive landforms along the former shoreline of the Columbia River. This geoarchaeological investigation was designed to sample not only the buried surface immediately beneath the fill, but also to identify naturally buried, older landforms which may lie below flood deposits. These buried features of the landscape are inaccessible using traditional archaeological pedestrian survey and shovel testing or augering, because the Port of Vancouver is capped by up to 7.6 meters (m) (25 feet [ft]) of fill. The subsurface investigation was designed to test below the fill cap, to the maximum depth of construction impact (Figure 3). These construction impact techniques include extensive use of stone columns to a maximum depth of 21.3 m (70 ft) below the surface. The process for installing stone columns does not bring sediments to the surface for inspection by archaeologists, so construction monitoring was excluded as a means of mitigating impacts to buried cultural resources. No pre-contact or historic-period artifacts or archaeological features were found during the geoarchaeological investigation. No monitoring of construction activities is needed in Areas 200, 300, and 400. If the depth of impact will exceed 3.05 m (10 ft) below surface, which would be a change from the current plan, monitoring during construction in Area 500 would be appropriate.

2. Project Description and Location

The proposed project is in the Port's industrial area, bounded on the north by NW Lower River Road and the Columbia River to the south (Figures 1 through 3). It is within the city of Vancouver, in Clark County, Washington. The proposed project APE is within Sections 18, 19, and 20 of Township 2 North, Range 1 East, Willamette Meridian.

The APE for the project includes laydown and construction areas, plus a storage area, a series of transfer pipelines, a marine terminal, a rail unloading area and office, and a west boiler (Figure 2). The possible depth of construction impacts varies at the different areas to be developed and may be as deep as 21.3 m (70 ft) in some areas. The construction depths are noted in Figure 3.

The project proposes to construct three administrative support buildings, up to two additional rail loops, a rail unloading facility, a boiler/steam building, and a parking area along the northern boundary of Terminal 5, on the south side of NW Old Lower River Road (Area 200 in the present study, Photo 1). Proposed building footprints of two of the administrative support buildings measure approximately 316 square meters (m^2) (3,400 square feet [ft^2]) and the third measures 232 m^2 (2,500 ft^2). The proposed rail unloading facility includes a 15-m (50-ft) tall building with a building footprint measuring approximately 564x28 m (1,850x91 ft). The building will accommodate three parallel rail tracks with 30 unloading stations, for a total of 90 stations. Each unloading station will include walkway gratings, drip containment pans between rails, and a 1.5-m (5-ft) deep concrete containment trench housing the offloading header pipe and conduits for utility lines. The boiler/steam building footprint measures approximately 279 m^2 (3,000 ft^2). Pedestrian bridges are proposed for access to rail loops from the administrative support buildings, and to the inside area of the rail loop.

The project proposes to construct a crude oil storage area with up to six storage tanks and parking area in Parcel 1A, south of NW Lower River Road immediately east of Farwest Steel (Area 300 in the present study, Photo 2). Proposed storage tanks are approximately 15 m (48 ft) tall and 73 m (240 ft) in diameter. The storage tanks will be enclosed by a 1.8-m (6 ft) high containment berm. A pump storage basin is proposed for the west side of the contained area. Smaller buildings for control equipment, motor control centers, fire suppression equipment, and fire water pumps are proposed in Parcel 1A as well.

Marine vessel loading will occur at existing Berths 13 and 14 on the Columbia River at about River Mile 103.5 (Area 400 in the present study, Photo 3). The project proposes to install piping, jib cranes, a moveable gangway, an observation and control platform, dock safety unit, pipe trays, and lighting on the existing dock that serves Berths 13 and 14. When marine vessels are being loaded with crude oil, vapors from vessel tanks will be collected and combusted to control emissions. Vapors will be piped from the dock to a series of eight vapor combustion units, which will consist of a 32x16 m (100x50-ft) concrete slab for equipment and eight 2.5-m (8-ft) diameter steel stacks approximately 8 m (25 ft) tall.

The project proposes a combination of above- and below-ground steel pipes to transfer crude oil from rail cars to the storage area and marine vessels. Most pipes will be above ground, but at roadway or rail crossings, some piping will be housed in underground steel casings (Area 500 in the present study, Photo 4). The project proposes up to three, approximately 61 centimeter (cm) (24-inch [in]) diameter, 549-m (1,800-ft) long pipes to collect unloaded crude oil at rail unloading stations. Three approximately 61-cm (24-in) diameter, 1,676-m (5,500-ft) long pipes are proposed to connect the rail unloading facility to the storage area located in Parcel 1A. Two approximately 61- to 76-cm (24- to 30-in) diameter, 1,615-m (5,300 ft) long pipes are proposed to connect the storage area with Berths 13 and 14. One approximately 15-cm (6-in) diameter, 1,615-m (5,300-ft) long pipe is proposed to return crude oil from Berths 13 and 14 to the storage tanks in the event of a shutdown. One approximately 41 to 56-cm (16- to 22-in) diameter, 183-m (600-ft) long proposed pipe will deliver hydrocarbon vapor generated during loading of vessels to the proposed vapor combustion units. The pipes will be placed for the most part above ground and impacts to the ground will be minimal in depth.

3. Environmental Setting

The proposed project is on the floodplain of the Columbia River, in an area currently dominated by industrial uses but surrounded by scattered marshes, wildlife areas, and agricultural parcels. Vancouver Lake is approximately 1 kilometer (km) (0.6 mile [mi]) to the northwest. Material dredged from the Columbia River blankets Port property (McGee 1972:Plate 56). Topographically, the project area is flat, but substantial fills have raised the entire area above the flood zone to an elevation of approximately 10 m (33 ft) above sea level (asl), and the fill cap steeply slopes down to the shoreline. The present-day environmental setting has been substantially altered from the historic landscape. Today, the APE is covered by gravel, asphalt, sand, or fill materials related to Port and earlier developments. Vegetation is generally limited to sparse grasses, non-native weedy herbaceous vegetation, and shrubs.

Prior to substantial alterations of the landscape, early maps and aerial photographs show the current project area as a low-elevation wetland along the floodplain. For example, a 1951 aerial photograph shows the shoreline and inland areas much as they were prior to development when wetlands extended between the Columbia River and Vancouver Lake (Figure 4). The 1860 General Land Office (GLO) map reveals small floodplain lakes slightly inland from the shoreline surrounded by marshy areas on either side of the current project area (GLO 1860). The project APE formerly encompassed wetland prairies and scrub forest that were used historically for agriculture, dairying, pasture lands, and orchards. The twentieth century saw a decrease in agricultural land use and a concurrent increase in industrial uses. By 1991, the area had been completely covered by dredge deposits (Fuld et al. 2013).

Vancouver Lake and the bottomlands to the south lie in a channel which was originally incised by Missoula floodwaters during the Pleistocene (Peterson et al. 2011:285). The final stages of the Missoula floods passed through the area just prior to 14,271-13,739 calendar (cal) years (yrs) before present (B.P.) (Benito and O’Connor 2003; Minor and Peterson 2013). This trough became an active channel of the Columbia River. The deepest parts of Vancouver Lake were isolated from the main channel between 4,810 and 4,420 cal yrs B.P. after a bend in the river channel was cut off by a sandbar, which created a slackwater pool that allowed fine-grained silts and clays to settle onto sandier overbank deposits. The river channel slowly migrated westward, and the scroll bar marking the western edge of Vancouver Lake dates to between 2,860 and 2,740 cal yrs B.P. (Peterson et al. 2014). The ridges and swales present within the trough today formed within the last 2,500 years (Davis and Ames 1994; Peterson et al. 2014). This date marks the end of a period of extensive channel restructuring (Bourdeau 2004), when the sandy floodplain was crisscrossed with discharge channels (Minor and Peterson 2013). The data from the present study support this chronology, as discussed in the following **Observed Stratigraphy** and **Interpretations** sections of this report.

Although the APE is presently capped by fill, adjacent parcels to the north of Lower River Road remain undeveloped, and these provide a view of the landscape as it existed before filling. Parcels north of Lower River Road consisted of ridge-and-swale bottomlands scattered with permanent and seasonal wetlands and a few larger ponds (Buchanan and Reese 2008; Davis and Ozbun 2011; Jenkins and Davis 2012). The ridges and swales were vegetated with grasses, sedges, cottonwood, willow, thistle, and blackberry. The terrain ranged in elevation from 3 to 8 m (10 to 26 ft) asl. Prior to construction of the Jail Work Center, which is bordered to the east by Area 500, the unfilled terrain lay at an elevation of 6 m (20 ft) asl, just north of a filled, 4.6- to 6-m (15- to 20-ft) deep gully that carried runoff into the Columbia River (Moore et al. 1997). The historic terrain, as recorded in 1860, was forested with flood-tolerant cottonwood and ash (Moore et al. 1997).

A great deal of sediment was deposited by the Columbia River during seasonal floods over the last 2,500 years. Historic records indicate that seasonal flooding has regularly exceeded 8 m (26 ft) asl, and often approached 9 m (30 ft) asl, after record-keeping began in 1827 (Chance and Chance 1976). As Figure 5 shows, a flood reaching 8.2 m (27 ft) asl could easily inundate the project area and the entire bottomlands, if the Port's lands were not built up with fill to elevate it above flood levels. At Fort Vancouver, within central Vancouver, Chance and Chance (1976) counted eight flood strata post-dating 1825 alone.

The events which shaped the landscape are recorded in sediment maps, which summarize the major depositional processes in the area, and soil maps, which inform about the environmental conditions that have weathered and modified those sediments after they were laid down. The sediments within and around the project APE are mapped as unconsolidated *Quaternary alluvium (Qa)*, with some dune sand, loess, and artificial fill (Phillips 1987) (Figure 6). The higher lands east of the project APE are capped by gravel-sized and sand-sized Missoula Flood deposits, and an erosional surface of the Troutdale Formation is exposed as bluffs at the edge of the floodplain (Phillips 1987; Trimble 1963). Troutdale gravels as well as Missoula gravels, sands, and silts may all still be present below a cap of alluvial sediment laid down subsequently by the Columbia River over the course of 14,000 years. The characteristics of these sediments are described below.

- *Quaternary alluvium* consists of medium to fine sand and silt, forming bars, islands, and low terraces, and varying in thickness from less than 15 m (50 ft) to up to 50 m (165 ft) (Phillips 1987; Trimble 1963).
- *Gravel-sized flood deposits* consist of rounded, well-sorted, stratified and foreset-bedded pebble and cobble gravel, which may be present within a sandy volcanic matrix (Phillips 1987; Trimble 1963).
- *Sand-sized flood deposits* consist of coarse to very fine quartz sand as well as silt and clay, lying in massive deposits to a thickness for more than 30 m (100 ft) (Phillips 1987; Trimble 1963).
- *Troutdale Formation Pliocene-Miocene continental sedimentary deposits* consist of well-indurated to weakly consolidated, well-sorted and bedded sands and gravels, with glassy sands and well-rounded pebbles and cobbles of variable composition, lying 45 m (148 ft) thick (Mundorff 1964; Phillips 1987; Trimble 1963).

The soil maps reveal great local variation in the slope and texture of the Quaternary alluvial deposits (U.S. Department of Agriculture, Natural Resources Conservation Service [USDA-NRCS] 2015) (Figure 7). Although most of Terminal 5, where the Alcoa aluminum plant was constructed in the 1940s, is mapped as Fill land, the bottomlands were mapped prior to filling. Within the project APE, Areas 400 and 500 fall within a zone of Pilchuck fine sand, while the Area 300 ridge and swale landscape encompasses both Newberg silt loam and Sauvie silty clay loam. Area 200 is bordered by Pilchuck fine sand to the east, and both Sauvie silty clay loam and Sauvie silt loam to the west, with pockets of Newberg silt loam. The subsurface survey conducted during the present study provides further information about the buried soils beneath the fill.

- *Pilchuck soils* are well-drained soils which form in relatively flat deposits of recent sandy alluvium within floodplains, above 3.3 m (10 ft) asl (USDA-NRCS 2006a). They form on sandbars associated with river channels. The ochric epipedon is relatively low in decayed plant matter. These soils are defined by a very dark gray A horizon of fine, loose, single grain sand over a series of fine, loose, single grain sand and loamy sand C horizons characterized by a color transition from dark grayish brown to very dark gray to dark gray, capping a basal horizon of black, loose, single grain gravelly sand.
- *Sauvie soils*, like Pilchuck soils, form in relatively flat alluvium, but are poorly drained, and are silt and clay rather than sand (USDA-NRCS 2000). They are specific to floodplain settings along the lower Columbia River, at elevations above 3.3 m (10 ft) asl. Like Newberg soils, they have a mollic epipedon formed by the long-term presence of decaying plant matter, typically grasslands. Sauvie soils are defined by a very dark grayish brown A horizon of subangular blocky silty clay loam with common rootlets over a series of dark grayish brown, subangular blocky silty clay loam B horizons, characterized by iron mottling, atop a dark grayish brown C horizon of very fine sandy loam with brown and gray redox mottles.
- *Newberg soils* are well-drained soils which form in relatively flat loamy and sandy alluvium at floodplain elevations above 3.3 m (10 ft) asl (USDA-NRCS 2006b), but are loamier and contain more organic matter than Pilchuck soils. They have a mollic epipedon formed by the long-term presence of decaying plant matter. Newberg soils are defined by a dark brown A horizon of granular to subangular blocky, friable fine sandy loam. There is no B horizon, and the A horizon transitions to a series of loose, single grain, grayish brown or pale brown C horizons of stratified sand, loamy sand, and sandy loam.

The distribution of these soil types indicates that two major types of environment were established just prior to filling. Areas 400 and 500 fall atop a sandbar or series of bars deposited relatively recently by river flooding. Area 300 lies within an established ridge and swale wetland, with elevated sandy deposits intermixed with low-lying silt and clay deposits. These organic-rich deposits show evidence of plant cover, probably grasslands and meadows.

4. Cultural Setting

The following sections provide the archaeological, ethnographic, and historical information for the project that has largely been reviewed and presented in the cultural resource report for the project: *Cultural Resource Review for the Tesoro Savage Vancouver Energy Distribution Terminal Project, Vancouver, Clark County, Washington* (Fuld et al. 2013). The 2013 overview has been updated below by the addition of recent studies. The cultural setting is presented to provide a context for the interpretation of the geoarchaeological data obtained during the Geoprobe borings.

4.1 Native Peoples – Prehistoric Period

The archaeological record for the Columbia River bottomlands (also known as the Portland Basin) region is typically limited to sites dating to the last 3,000 years, as land subsidence coupled with rising sea levels have altered the river channels such that thick layers of sediment lie on top of some sites, while others have been lost to erosion (Ames 1994; Pettigrew 1990). Sites are located along major waterways, including the Columbia and Willamette Rivers, and Vancouver Lake. Several large village sites dating to later periods have been well studied; these include the Cathlapotle site (45CL1) near Ridgefield, the Meier site (35CO5) near Scappoose, Oregon, and the Sunken Village site (35MU4), which is located on Sauvie Island (Ames et al. 1992, 1996; Croes et al. 2007). Older sites, those predating 3,000 to 3,500 years, tend to be found in uplands at higher elevations. In Clark County, older sites are found on terraces well above floodplains. Excavations at Sunset Ridge (45CL488) and Morasch Terrace (45CL428) in Camas and Gee Creek (45CL631, 45CL632, and 45CL810) southwest of Ridgefield have been dated to older than 5,500 years ago and some as early as the Late Pleistocene (Ozbun and Reese 2003; Punke et al. 2009; Woodward and Associates 1996). These sites demonstrate that older, datable archaeological deposits are located within Clark County; however, such sites are less common in the bottomlands.

Late Prehistoric Native Peoples of the lower Columbia region and the greater Northwest Coast area are considered to be complex hunter-gatherers (Ames and Maschner 1999). This socioeconomic structure is based on a hunter-fisher-gatherer mode of subsistence rather than agricultural practices, and had sophisticated social structures and cultural traditions usually found in agricultural societies. Lower Columbia River groups were residentially sedentary and lived in large plankhouses, were socially stratified by wealth and ascribed status, and maintained some of the highest population densities in native North America (Ames and Maschner 1999).

4.2 Native Peoples – Contact Period

The Columbia River bottomlands region is within the traditional territory of Chinookan-speaking peoples, specifically those who spoke the Multnomah dialect (Silverstein 1990:534). Chinookan-speaking groups possessed cultural traditions bearing similarities to groups on the Pacific Northwest Coast as well as the Columbia Plateau (Silverstein 1990). Chinookan-speaking peoples were ethnohistorically documented as living in large villages comprised of one or more plankhouses along major waterways (Moulton 1990).

The Cowlitz, an inland group, regularly traveled to the Columbia River bottomlands. The Cowlitz people were culturally distinct from neighboring tribes, including the Chinook (Hajda 1990). The Lower Cowlitz spoke a Salish dialect and occupied the lower reaches of the Cowlitz River and its tributaries.

Subsistence was based on seasonal availability and included seasonal fish runs of salmon, sturgeon, eulachon, and freshwater fishes; birds; aquatic mammals; and land mammals, primarily deer and elk. Plant foods were seasonal as well and included berries, nuts, and roots, as well as bulbs and tubers such as camas and wapato. Camas and wapato were especially important resources and harvested in excess for trade (Hajda 1990). People maintained permanent winter villages along the major waterways and temporarily moved to hunting, fishing, and gathering locations for parts of the year (Silverstein 1990).

4.3 Euroamerican Settlement – Historical Overview

By the 1840s, most of Clark County, including the project area, was claimed by the Hudson’s Bay Company (HBC), a British fur-trading enterprise that established Fort Vancouver in 1825 east of the project area. The HBC used the north shore of the Columbia River, in the vicinity of the APE, for farming, pasture land, and dairying (GLO 1854; Moore et al. 1997).

The GLO map from 1863 shows Parcel 1A within the former Donation Land Claim (DLC) of H. Van Allman (DLC No. 57). Henry Van Allman was born in Switzerland and immigrated to the Oregon Territory in 1847. In that same year, Van Allman settled his DLC of 311.37 acres (Clark County Genealogical Society 1989). In 1859, Joseph Petrain purchased the Van Allman DLC and used the land for grazing livestock and agriculture (Downing 1883 as cited in Moore et. al 1997). Terminal 5 is within the former DLC of J. H. Matthews, who settled here in 1852 (DLC No. 44) (GLO 1863; Clark County Genealogical Society 1989).

The original course of Lower River Road (now NW Old Lower River Road) is shown on the early GLO maps and the 1897 U.S. Geological Survey (USGS) 15-minute quadrangle map for Portland, Oregon (USGS 1897). The road originally paralleled the Columbia River along the natural terrace above the shoreline, which passed through the current project APE. By 1905, the road was shifted north in the current alignment of NW Old Lower River Road (USGS 1905, 1954).

The 1929 Metsker map for Township 2 North, Range 1 East, Willamette Meridian, depicts Parcel 1A as part of a larger property owned by the Grays Harbor Lumber Company, and Terminal 5 as owned by the Spokane Portland and Seattle Railway (Metsker Maps 1929; Van Arsdol 1964 as cited in Moore et al. 1997).

The Port was established in 1912 and soon entered into a contract with G. M. Standifer Construction Corporation to build a shipyard (to the east of the current project area) to aid the World War I effort. Terminal 1 at the Vancouver Landing was acquired in 1925, and a grain export facility was constructed in 1934 at Terminal 2. Harbor cranes were acquired at Terminal 2 for unloading large shipments in 1959. Terminals 3 and 4 were developed by 1963. According to the 1992 SEPA Environmental Checklist, the berths included in the APE were planned for construction in 1993. In 2009, the Port acquired acreage formerly owned by the Evergreen and Alcoa aluminum industries to develop the Port's marine Terminal 5. The rail loop at Terminal 5 was completed in 2010 (Port of Vancouver USA 2014).

5. Previous Cultural Resource Studies

In 2013, AINW reviewed records available online from the Washington Information System for Architectural and Archaeological Records Data, and materials in the AINW library, to determine whether archaeological or historic-period resources had been identified within or near the project APE (Fuld et al. 2013). The records search was also done to determine if surrounding areas had been previously surveyed for archaeological resources that might extend into the APE. Subsequent to the 2013 review, two other archaeological or cultural resource studies have been conducted either within (Fuld and Tisdale 2015) or adjacent to (Hambelton et al. 2014) the Vancouver Energy project APE. No archaeological resources have been identified within or near the project APE. The records reviewed indicate several cultural resource studies have been previously conducted within the APE and archaeological resources have been previously recorded in the vicinity of, but not within, the current project APE. Table 1 summarizes the previous studies, and Figure 7 shows their locations. These studies are discussed in more detail below.

The entire APE is located within the Level A, or high (80 to 100 percent) probability on the Clark County archaeological predictive model. It also is a "Survey Highly Advised: Very High Risk" area in DAHP's Washington Statewide Predictive Model.

Table 1. Previously Recorded Cultural Resource Studies

Author	Date	Area investigated	Findings
Thomas and Welch	1982	Parcel 1A	- 20th century dairy farm (outside APE) - Section of original Lower River Road (outside APE) - Dredge fill from shoreline to 244 m (800 ft) inland
Forgeng and Reese	1993	Parcel 1A	- No cultural resources - Dredge fill up to 1.6 m (5.3 ft) deep on the southern half
King	1995	Parcel 2 (north of APE)	- 45CL408 (outside APE; not shown on Figure 7)
Thomas	1995	Cogentrix Power Plant (north of APE)	- No cultural resources - Dredge fill up to 3 to 4.5 m (10 to 15 ft) deep
Moore et al.	1997	Clark County Jail Work Center	- No cultural resources - Dredge fill up to 1.2 m (4 ft) deep - Sterile native soils identified
Ellis and Mills	1998	Clark County Jail Work Center	- No cultural resources

Author	Date	Area investigated	Findings
Becker and Roulette	2003	Terminal 5	- No cultural resources - Dredge fill up to 6 m (20 ft) deep on Columbia River bank and up to 1.2 to 2.7 m (4 to 9 ft) thick further inland
Zehendner and Fagan	2008	Columbia River shoreline	- No cultural resources - Dredge fill deposition has substantially changed the shape and elevation of shoreline
Reese	2009a	Terminal 4 Parcel 1A	- No cultural resources - Dredge fill
Reese	2009b	Terminal 4 Pond Reconstruction	- No cultural resources - Dredge fill 3 to 6 m (10 to 20 ft)
Fagan and Zehendner	2009	Terminal 5	- No cultural resources - Dredge fill deposition has substantially changed the shape and elevation of shoreline
Hetzel et al.	2009	West Vancouver Freight Access Terminal 5 Clark County Jail Work Center	- No cultural resources - Dredge fill
Chapman and Blaser	2010	Terminal 5	- No cultural resources - Dredge fill
Davis and Ozbun	2011	Parcel 2 (north of APE)	- No cultural resources - Sterile native soils identified
Jenkins and Davis	2012	Parcel 2 (north of APE)	- No cultural resources - Sterile native soils identified
Fuld and Reese	2012	Clark County Jail Work Center	- No cultural resources - Dredge fill and disturbance
Hambelton et al.	2014	Port of Vancouver Trail (north of APE)	- No cultural resources
Fuld and Tisdale	2015	NWP River Road Relocation (Terminals)	- No cultural resources

The project APE is within the boundary of the Vancouver Lakes Archaeological District (45DT101). The district encompasses 3,706 acres of Columbia River floodplain, as well as Vancouver Lake, Lake River, Lewis River, Bachelor Island, and several other lakes, streams, and marshlands. The south bank of the Lewis River forms the northern boundary of the district. The Columbia River forms the western and southern boundaries of the District. The BNSF Railroad forms the eastern boundary, from the Columbia River to the Lewis River.

The Vancouver Lakes Archaeological District included 125 sites in 1982 when it was determined eligible for listing in the National Register of Historic Places (NRHP) (Burd 1982). Sites identified within the District boundary subsequent to the determination of eligibility in 1982 are not officially part of the District, although many may be considered significant sites. The district includes a variety of micro-environments, such as seasonally wet prairies, marshes, tidal beaches, and wooded areas along terraces that supported a diverse array of resources and archaeological sites. The seasonally flooded, shallow wetlands south of Vancouver Lake once supported extensive fields of wapato. Wapato was an important staple tuber for the local people, and harvest required navigating the shallow marshes around Vancouver Lake using boats (Blukis Onat 1997). Wapato camps would have been placed near the flooded marshes.

The bottomlands south of Vancouver Lake are dotted with dozens of prehistoric sites, primarily scatters of fire-cracked rock, lithic debitage, and stone tools from ephemeral campsites on elevated ridges and along the rim of Vancouver Lake. The closest archaeological site is 45CL768, a multi-component archaeological site located [redacted] of the project APE. It is located [redacted] The prehistoric component includes [redacted]. The historic component includes [redacted] (Buchanan and Reese 2008). A possible village site, 45CL126, lies [redacted] downstream from the APE and is described in detail in Fuld et al. (2013:7-8).

In situ artifacts have not been noted on the surface in the Vancouver Lake bottomlands at elevations below 3.6 m (12 ft) asl (Spencer and Williams 2004). Residential sites, in particular, are located above the annual high water mark of 4.8 m (16 ft) asl (Ames 1994). The proximity of the project APE to both a major river channel and a productive wetland/lake complex makes it a possible location for seasonal human activity. The waterfront location of the project APE calls for a careful study of its potential to house a village site.

Historic-period sites reflecting early settlement of Clark County include refuse disposal sites and the remains of homesteads, structures, orchards, and farms. Historical maps show agricultural buildings adjacent to the APE (see the discussion of Area 400 in the section entitled **Interpretations**).

Within the project APE, multiple archaeological surveys have identified no eligible resources (Table 1; Figure 8). The studies span the time from 1982 to 2015, and no evidence of an archaeological site has been found within or near the Vancouver Energy project APE during these studies. The Columbia River shoreline portion of the APE has been buried by dredged fill since the beginning of these studies (early 1980s). But elsewhere in the APE, in many cases the earlier surveys were performed prior to filling and paving, and were able to sample native soils. For example, several studies at Parcel 1A in the northeastern part of the project tested the area by shovel testing and backhoe (Forgeng and Reese 1993; Thomas and Welch 1982). Portions of Terminal 4 also were surveyed prior to filling, although most encountered evidence of modification related to the general industrial uses of the area (Ellis and Mills 1998; Fuld and Reese 2012; Moore et al. 1997; Reese 2009a). Nearly all of the APE within Terminal 5, the western portion of the project APE, had been filled or developed for the aluminum plant prior to archaeological surveys, except for the area immediately north of Old River Road, which has been shovel tested; the shovel tests excavated as part of these surveys were adjacent to, but not within, the current APE (Davis and Ozbun 2011; Jenkins and Davis 2012; King 1995).

An archaeological survey was conducted in 2008 immediately north of the project, on the opposite side of NW Lower River Road (Buchanan and Reese 2008). Several shovel tests were excavated along the north side of the road, and 22 shovel tests in all were excavated on the 50-acre parcel. The landscape consisted of low rolling hills and swales, and shallow ponds were common. Archaeological site 45CL768, described above, was identified during this survey. The Native American and historic-period components had been previously known by the prior landowner, but not recorded. The resource was found above the edge of a lake or large pond that has persisted on maps from the beginning of historical times. Notably, an older oak tree stands within the archaeological site.

Based on the previous archaeological studies within and near the project APE, it appears that archaeological sites in the vicinity would be expected on landforms that rise above the level of typical Columbia River floods. No archaeological sites have been found in the APE, although much of it was filled as well as paved and developed prior to archaeological survey. The surveys that have encountered native soils within and adjacent to the APE have not found resources within the lowlands, and lowlands appear to have occupied the APE prior to development. Landforms, now buried, that would have held significant archaeological sites would be those that were not within a wetland and where there was some stability in the landform. The geoarchaeological study was designed to identify those areas.

6. Geoarchaeological Field Methods

For the present survey, 39 geoarchaeological borings were collected using a Geoprobe (Table 2; Figure 8). The Geoprobe is a mobile and compact, track-mounted, direct-push hydraulic drill rig which collects continuous cores in intact 1.5-m (5-ft) segments, within a plastic sleeve (Photos 5 through 7). This sleeve can be cut open in the field for immediate inspection and sampling, although it can be capped and stored for later analysis or transport to a laboratory facility. The diameter of the samples measures 6.4 cm (2.5 in) (for the MC-5 sampling system) or 8.3 cm (3.25 in) for the DT-32 sampling system. The DT-32 system proved unstable in the saturated sands within the project APE. A phenomenon known as heave occurs when saturated sediment encounters the low-pressure void created by the continuous sampling casing used by the DT-32 system. This pressure differential causes sediment to rush up the sampling tube, destroying the integrity of the sample. The slightly smaller diameter MC-5 system does not produce such a pressure differential and proved to be the most suitable for use in the Vancouver Energy project APE. All but two of the borings were collected using the MC-5 system.

Table 2. Geoprobe Borings Excavations

Area	Boring No.	Depth of Boring	Reason for Termination
200	B5	16.8 m/ 55 ft	5 ft below fluvial sands
200	B6	15.2 m / 50 ft	5 ft below fluvial sands
200	B7	15.2 m / 50 ft	5 ft below fluvial sands
200	B8	16.8 m/ 55 ft	5 ft below fluvial sands
200	B9	13.7 m / 45 ft	reached Pleistocene gravel
200	B10	15.2 m / 50 ft	5 ft below fluvial sands
200	B11	21.3 m / 70 ft	maximum depth of impact
200	B12	13.7 m / 45 ft	5 ft below fluvial sands
200	B13	13.7 m / 45 ft	5 ft below fluvial sands
200	B14	13.7 m / 45 ft	5 ft below fluvial sands
300	B18	16.8 m/ 55 ft	reached Pleistocene gravel
300	B19	15.2 m / 50 ft	reached Pleistocene gravel
300	B20	13.7 m / 45 ft	reached Pleistocene gravel
300	B21	12.2 m / 40 ft	reached Pleistocene gravel
300	B22	16.8 m/ 55 ft	reached Pleistocene gravel
300	B23	16.8 m/ 55 ft	reached Pleistocene gravel
300	B24	10.7 m / 35 ft	reached Pleistocene gravel
300	B25	10.7 m / 35 ft	5 ft below fluvial sands
300	B26	10.7 m / 35 ft	5 ft below fluvial sands

Area	Boring No.	Depth of Boring	Reason for Termination
300	B27	10.7 m / 35 ft	5 ft below fluvial sands
300	B28	12.2 m / 40 ft	reached Pleistocene gravel
300	B29	12.2 m / 40 ft	reached Pleistocene gravel
300	B30	12.2 m / 40 ft	reached Pleistocene gravel
300	B31	10.7 m / 35 ft	5 ft below fluvial sands
300	B32	10.7 m / 35 ft	5 ft below fluvial sands
300	B36	10.7 m / 35 ft	reached Pleistocene gravel
300	B37	12.2 m / 40 ft	reached Pleistocene gravel
300	B38	12.2 m / 40 ft	reached Pleistocene gravel
300	B39	10.7 m / 35 ft	5 ft below fluvial sands
400	B1	16.8 m/ 55 ft	5 ft below fluvial sands
400	B2	16.8 m/ 55 ft	5 ft below fluvial sands
400	B3	16.8 m/ 55 ft	5 ft below fluvial sands
400	B33	16.8 m/ 55 ft	5 ft below fluvial sands
400	B34	19.8 m / 65 ft	maximum depth of impact
400	B35	15.2 m / 50 ft	5 ft below fluvial sands
500	B4	3.05 m / 10 ft	maximum depth of impact
500	B15	3.05 m / 10 ft	maximum depth of impact
500	B16	3.05 m / 10 ft	maximum depth of impact
500	B17	3.05 m / 10 ft	maximum depth of impact

Note: Appendix A has detailed data for each boring.

The project APE was subdivided into four areas based on the depth of the planned impacts (Table 3; Figure 2). The borings were collected continuously to coarse Pleistocene gravels, or a depth of 1.5 m (5 ft) below the surface of river channel sands, or to the maximum depth of construction impact in the area (Figure 3), whichever was shallower. The maximum depth of each boring is presented in Table 2. To minimize cross-contamination, the drilling equipment was washed (decontaminated) with water in between borings. After the completion of each boring, the resulting holes were re-filled with a grouting compound to maintain the stability of the sediment matrix, and to seal any gaps which could introduce contaminants into the groundwater.

Table 3. Depth of Construction Impacts by Area

Area	Depth of Construction Impact	Maximum Depth of Fill	Maximum Depth of Borings	Number of Borings
200	21.3 m/70 ft	6.1 m/20 ft	21.3 m/70 ft	10
300	21.3 m/70 ft	6.1 m/20 ft	21.3 m/70 ft	19
400	19.8 m/65 ft	7.6 m/25 ft	19.8 m/65 ft	6
500	3 m/10 ft	4 m/13 ft	3 m/10 ft	4
600	1.4 m/4 ft	6.1 m/20 ft	None	None
			TOTAL	39

The boring locations were recorded using a Trimble Geo XT Global Positioning System unit. Elevations for each location were extracted from LiDAR bare earth elevation data with an accuracy of within 30 cm (Puget Sound LiDAR Consortium 2005). In the northeast corner of Area 300, the land had been filled after the LiDAR data were collected. These points on new fill were assigned a revised elevation equal to the average of the surrounding points. Although filling and grading have slightly altered the terrain within the APE since the creation of the LiDAR digital elevation model (DEM), the bare earth elevations have not changed significantly. The DEM was used to analyze local flood levels.

The borings were split, photographed, and described in the field under the supervision of AINW's Senior Geoarchaeologist, Eva Hulse, PhD, RPA. Stratigraphic transitions and inclusions were noted, and the sediments were described using standard lithological terminology for texture, structure, consistency, and stratigraphic transition type. Colors were recorded using the Munsell system[1]. The complete boring logs are presented in Appendix A. The sediments were carefully inspected for evidence of archaeological deposits, including, but not limited to:

- color changes or charcoal enrichment associated with hearth features and trash dumps;
- debris associated with making stone tools;
- burned bone or shell;
- fragments of wood or fiber which may be associated with fishing technology;
- historic materials, such as ceramic, metal, and glass; and
- changes in color, texture, structure, and consistency associated with a buried soil.

Table 4. Radiocarbon Dates from Samples Collected during this Study

Boring No.	Sample No.	Depth of Sample	Beta Analytic No.	Conventional Radiocarbon Age	Calibrated Radiocarbon Age
B14	50-01	10.3-10.39 m / 33.8-34 ft	Beta-400235	1300 ± 30 B.P.	1,290 to 1,180 cal yrs B.P.
B30	85-01	9 m / 29.6 ft	Beta-400236	2740 ± 30 B.P.	2,920 to 2,910 cal yrs B.P. and 2,880 to 2,770 cal yrs B.P.
B33	92-01	12 m / 39.5 ft	Beta-400237	50 ± 30 B.P.	255 to 225 cal yrs B.P. and 135 to 115 cal yrs B.P. and 70 to 35 cal yrs B.P. and post-0 cal yrs B.P.
B35	97-01	12 m / 39.5 ft	Beta-400238	2490 ± 30 B.P.	2,730 to 2,460 cal yrs B.P.

Subsamples were collected for further laboratory analysis. Well-preserved plant remains were common below the water table in most of the borings. Selected plant remains were sent to Beta Analytic, Inc., for radiocarbon analysis (Appendix B). Four samples were submitted for radiocarbon dating, and the resulting dates range in age from the modern or historic period to 2,920 to 2,910 cal yrs B.P. (Table 4). Tephra (volcanic ash) was noted in some of the borings. The tephra content of these samples was confirmed through microscopic analysis in AINW's laboratory, and three selected samples were sent to the Washington State University Geoanalytical Lab for analysis by Franklin Foit (Table 5; Appendix C). Throughout this report, these radiocarbon dates are presented as calibrated dates in calendar years B.P. All dates were calibrated using the IntCal13 radiocarbon curve. Beta Analytic reports the calibrated as well as uncalibrated (conventional) radiocarbon ages of analyzed samples. Some dates reported in older publications were calibrated using an older version of the radiocarbon curve, or were presented in

[1] All colors are classified according to the 2009 revision of the Munsell system.

conventional form. These have been recalibrated by AINW using IntCal13 within the Clam radiocarbon calibration package for the R statistical computing environment (Blaauw 2010). In each case, the conventional radiocarbon date is presented in the footnotes for this report.

Sediments from completed borings were discarded in ungraveled areas near each sampling location, with one exception. The Port required that sediments and water used to clean equipment while working in Area 200 be stockpiled in sealed drums and tested for contaminants in accordance with Port procedures prior to disposal. BergerABAM and the Port coordinated the testing and disposal of the drummed sediments. Lab results showed that contaminants were below levels, which would require special disposal. The drummed sediments and decontamination water were disposed of by the Port after the testing was completed (Memorandum from BergerABAM dated 29 January 2015).

Table 5. Volcanic Tephra Analysis Results

Boring No.	Sample No.	Subsample	Depth of Sample	Best Compositional Match	Source	Calibrated Radiocarbon Age
B8	33-01	glass 1	15.1-15.2 m / 49.5-49.9 ft	Mazama set O	Crater Lake, Southern Oregon	7,627 ± 150 cal yrs B.P.
		glass 2	15.1-15.2 m / 49.5-49.9 ft	Mount St. Helens set Ye	Mount St. Helens, Southwest Washington	began at 4,221 to 4,439 cal yrs B.P., and ended by 2,965-3,249 cal yrs B.P.
B35	98-01	glass 1	13.67 m / 45 ft	Mazama set O	Crater Lake, Southern Oregon	7,627 ± 150 cal yrs B.P.
		glass 2	13.67 m / 45 ft	Dusty Creek	Glacier Peak, Northern Washington	5,780 to 5,830 cal yrs B.P.
				Rock Mesa	South Sister, Central Oregon	1,810 to 2,497 cal yrs B.P.
B36	100-01	none	7.1 m / 23.3 ft	Mount St. Helens set Ye	Mount St. Helens, Southwest Washington	began at 4,221 to 4,439 cal yrs B.P., and ended by 2,965-3,249 cal yrs B.P.

7. Observed Stratigraphy

The 39 borings are described in sets according to area: Area 200, Area 300, Area 400, and Area 500. These areas were developed by the project to reflect the functional areas of the proposed development, and they also happen to encompass four different sequences of landscape development; therefore, the stratigraphic descriptions are grouped in these four areas. This section describes the basic lithostratigraphic units observed within each area, and summarizes the chronological data obtained via radiocarbon analysis and volcanic tephra analysis and sourcing of volcanic tephra. A detailed examination of environmental changes over time is presented in Interpretations. Fence diagrams of the major lithostratigraphic units within each area are presented in Figures 10 through 13, and the complete borings logs are included as Appendix A. The major lithostratigraphic units are defined according to physical characteristics as well as position in the chronological sequence and the energy of the depositional environment, and are presented in Table 6 (showing the oldest unit at the bottom of the table), as well as with Figures 10 through 13.

7.1 Area 200 (B5 through B14)

Area 200 is a graveled lot just south of the northern side of the Terminal 5 rail loop (Photo 1). The ten borings in Area 200 showed little stratigraphic diversity, and can be described as a group (Figure 10; Appendix A). The native floodplain sediments are mantled by between 2.83 and 4.43 m (9.28 and 14.53 ft) of sandy fill (Unit 6b), characterized by poorly sorted, loose, single grain fine-to-coarse grained sand with subangular 2-cm (0.8-in) gravel and occasional fragments of concrete and wood. The fills are variable in color and inclusions, but are typically dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2) in color, and show some evidence of weathering in the form of iron oxidation. The upper fill is 20 to 40% gravel, while the lowermost layers are predominantly sandy dredge fill. Boring B5 contained a band of black (GLEY 1 2.5/N), ashy sediment from 2.93 to 3.9 m (9.6 to 12.79 ft) below surface (bs). This sediment appeared to be industrial in origin and was given only a visual inspection for texture and structure.

Table 6. Lithostratigraphic Units

Unit[2]	Setting	Description
6b	dredge fill	granular to single grain, friable to loose, poorly sorted gravelly sand
6a	redeposited fill overbank deposits with swale ponds	single grain, loose, poorly sorted medium and coarse sand interbedded with fine silt
5b	rooted[3] sand	subangular blocky, firm, well-sorted silty sand
5a	rooted, organic silt	subangular blocky, firm, clay silt and sandy silt showing soil horizonation
4	sandy floodplain	weakly subangular blocky, very friable, well-sorted fine and very fine sands, gradually fining and coarsening
3b	floodplain pond	subangular blocky, firm silt, sandy silt, and clay silt, with wood and plant fragments
3a	sandy floodplain	alternating layers of weakly subangular blocky, very friable, well-sorted fine sands, and loose, single-grain, poorly sorted fine-to-coarse sands
2b	shallow river channel	loose, single grain, fine-to-medium, poorly sorted sand with occasional wood fragments and MSH set Ye[4] tephra
2a	floodplain pond	subangular blocky, firm silt and clay silt, with MSH set Ye tephra
1	major river channel	deeply-bedded, loose, single grain, poorly sorted fine-to-coarse sand with increasing 2-cm rounded pebbles towards the base of the stratum

The fill (Unit 6b) caps a buried A horizon which formed in silty alluvium (Unit 5a) over fine, loose sand (Unit 4). The buried A horizon is a firm, subangular blocky to granular, very dark grayish brown (10YR 3/2) clay silt or sandy silt. This horizon varies in thickness from 6 to 25 cm (2.36 to 9.84 in), and the upper portion appears to be truncated in borings B7, B8, B11 and B12. The upper profile of the buried surface

[2] "Unit" refers to "Lithostratigraphic Unit" as shown in Figures 10 through 13.
[3] "rooted" indicates the presence of roots and rootlets, associated with an earlier vegetated surface that was buried.
[4] MSH set Ye refers to the Mount St. Helens set Ye eruption, as discussed in the text describing Area 200.

rises and falls across Area 200, marking the outlines of sandy ridges mantled with soil. The massively bedded sand of Unit 4 gradually transitions to well-sorted, very fine- to fine-grained, friable, subangular blocky sand, alternately banded with oxidized dark grayish brown (10YR 4/2) and organic-rich very dark gray (10YR 3/1) laminae (Unit 3a). The banding represents individual accumulations of organic matter buried and reburied by subsequent inputs of alluvial sediment during flood events. Gradual fining and coarsening within the sandy deposit suggests gradual and episodic changes in water flow over the area, as during floods. The background soil color tends to be a weakly oxidized dark grayish brown (10YR 4/2), but redoximorphic mottling due to saturation with water is particularly pronounced (a Munsell chroma of 3 or higher) across all borings in the B horizon at a depth of 4.30 to 5.86 m (14.1 to 19.22 ft) bs, and again just above the permanent water table at a depth of 8.01 to 8.69 m (26.3 to 28.51 ft) bs. Permanently waterlogged, oxygen-reduced sediments, marked by a Munsell chroma of 1 (or N, on the Gley scale), are consistently present below the oxidized layer marking the depth of the permanent water table.

Well-preserved wood and plant fragments were collected from localized silty deposits (Unit 3b) within the fine-grained alluvial sand. Boring B6 contained a localized deposit of silt from 7.45 to 9.14 m (24.44 to 29.99 ft) bs, and again from 12.0 to 12.2 m (39.37 to 40.02 ft) bs. Rooted silt contained roots and rootlets left by plants which once grew on a now-buried surface. This rooted silt was present in boring B11 from 9.39 to 10.66 m (30.01 to 34.97 ft) bs, beneath a mantle of silty sand. These may be remnants of localized floodplain ponds and shallow marshes which were inundated and capped by fine sand as shallow floodplain channels changed course. The base of this suite of shallow channel and pond deposits transitions abruptly to a higher-energy fluvial deposit below. Plant fragments (Sample 50-01) collected from silty sand between 10.3 and 10.39 m (33.79 and 34.09 ft) bs in boring B14 returned a radiocarbon date of 1,290 to 1,180 cal yrs B.P. (Beta-400235) (Table 4; Appendix B)[5]. This date estimates the age of the transition to a shallow floodplain from the more energetic environment reflected in the sediment below.

Below 11.0 m (36.09 ft) bs, the loose, single grain sand coarsens to poorly sorted fine to coarse grains, ranging in color from very dark gray (5Y 3/1) to black (Gley 1 2.5/N) (Unit 2b). The unconformities separating unique depositional events lie at intervals greater than 1 m (3.28 ft). Wood and plant fragments decreased with depth across all borings. The wood may have been deposited in backwaters along the river's edge during flood stages, and the depth of wood reflects the former contours of the landscape (Photo 8). West of boring B8, no wood fragments were found below 12.0 m (39.37 ft) bs. The easternmost four borings (B5 through B8) contained wood and plant fragments to a depth of 15.0 m (49.21 ft) bs. In boring B8, the deepest wood fragments are associated with white, rounded, 2-millimeter (mm) (0.08-in) diameter pumice lapilli (Photo 9). A pumice sample (Sample 33-01) was sent to the Washington State University GeoAnalytical Lab for glass analysis by Dr. Franklin Foit. This sample was a compositional match for the Mount St. Helens Ye (MSH set Ye) eruption, with trace amounts of older, redeposited Mazama set O eruption tephra[6] (Table 5; Appendix C). The set Ye eruption took place near the mid-point of a series of set Y eruptions which commenced no earlier than 4,221-4,439 cal yrs B.P.[7] (Crandell et al. 1981; Mullineaux 1996). The eruption episode completed no later than 2,965 to 3,249 cal yrs B.P.[8] (Crandell et al. 1981; Mullineaux 1996). This dates the separation of the backwater from the

[5] Conventional radiocarbon date of 1300 ± 30 yrs B.P. calibrated by Beta Analytic using IntCal13.

[6] The Mazama set O eruption dates to 7627 ± 150 cal yrs B.P. Tephra from this massive eruption is widespread and its presence in alluvium is not surprising (Zdanowicz et al. 1999).

[7] Conventional radiocarbon date of 3900 ± 50 yrs B.P. calibrated by AINW using IntCal13.

[8] Conventional radiocarbon date of 2960 ± 50 yrs B.P. calibrated by AINW using IntCal13.

main river channel to between 4,439 and 2,965 cal yrs B.P. As discussed below in the description for Area 300, other parts of the APE contain unmixed MSH set Ye tephra.

7.2 Area 300 (B18 through B32, B36 through B39)

Area 300 is a graveled lot lying east of the Farwest Steel facility, and south of NW Lower River Road (Photo 2). Although they lie only 0.8 km (0.5 mi) to the east, the 19 borings in Area 300 encompass an older landform and represent a different suite of depositional events than Area 200 (Figure 11; Appendix A). As with Area 200, Area 300 is mantled with between 2.78 and 5.63 m (9.12 and 18.47 ft) of stratified sandy fill, with common 0.25- to 2-cm (0.09- to 0.79-in) rounded and subangular pebbles (Unit 6b). The fills range in color from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2), and range in texture from loose, single grain, poorly sorted fine to coarse sand, to firm, subangular blocky, sandy clay silt. The lower margin of the fill transitions abruptly to a buried surface, present as a layer of rooted, friable, granular sand and subangular blocky silty sand measuring between 11 and 105 cm (4.33 and 41.33 in) in thickness (Unit 5b). This rooted sand represents the pre-fill land surface, and has developed a very dark gray (10YR 3/1 or 5Y 3/1) A horizon. Below the rooted sediment is a clear transition to a deposit dominated by dark gray (10YR 4/1) to very dark gray (10YR 3/1) angular blocky, firm silt and clay silt (Unit 5a over Unit 2a). These fines extend from 4.20 to 10.26 m (13.77 to 13.66 ft) bs. Radiocarbon analysis of plant fragments (Sample 85-01) isolated from organic sediments at 9.01 m (29.56 ft) bs in B30—0.39 m (1.28 ft) above the abrupt transition to coarser sandy fluvial sediments—returned two likely date ranges: 2,920 to 2,910 cal yrs B.P. and 2,880 to 2,770 cal yrs B.P. (Beta-400236) (Table 4; Appendix B)[9].

Between 5.02 and 8.14 m (16.47 and 26.7 ft) bs, in borings B22, B23, B25, B27, B29, B31, B32, and B36 through B39 lie interbedded layers of oxidized, dark grayish brown (10YR 4/2) very fine to fine subangular blocky, friable silty sand, and black (10YR 2/1) angular blocky, firm silt and clay silt (Unit 5a). The darker bands are the result of accumulated decayed plant material, while the oxidized bands indicate intermittent drying. As in Area 200, this suggests shallow, seasonally inundated wetland ponds, capped by new sediment during floods. The banded silts of Unit 5a are separated from the very dark gray (5Y 3/1) silts of Unit 2a by a deposit of fine sand. Below the banded sediment, a thin 0.2-cm (0.08-in) layer of very fine grained, sandy, white tephra is present in some borings (B22, B25, B31, B36 [Photo 10]). The tephra band is present between 17 and 58 cm (6.69 in and 22.83 in) above the lower boundary of the Unit 2a silt where the base of Unit 2a meets a clear erosional unconformity with poorly sorted sand (Unit 1). A sample of this tephra (Sample 100-01) was submitted for glass analysis, and it is a compositional match to the MSH set Ye eruption, between 4,439 and 2,965 cal years B.P. (Table 5; Appendix C). Notably, no redeposited Mazama set O tephra was mixed in, confirming that this deposit represents a primary ash fall associated with the original eruption, rather than a deposit of older material that was re-mobilized after a landslide or other erosional event.

The slackwater environment which allowed these fines to accumulate is quite different from that represented by the sediments below. The fines settled downwards into a loose matrix of fine- to coarse-grained, poorly sorted sand (Unit 1), forming a transitional band of very dark grayish brown (10YR 3/2), subangular blocky, plastic sandy clay retaining some signs of weathering and soil formation—specifically, slight oxidation, vertical pores lined with gray clay, and small white flakes of mineral precipitate. These mineral flakes were first noted during field analysis on November 6, 2014, and while they have a chalky appearance consistent with fragments of bone or shell, microscopic analysis revealed no biological structures (Sample 84-01 as shown in Photo 11). Silts and clays gradually decrease with depth, and the deeper very dark gray (10YR 3/1) sand is loose and single grain, with grain size ranging from fine to

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[9] Conventional radiocarbon date of 2740 ± 30 yrs B.P. calibrated by Beta Analytic using IntCal13.

coarse. This sandy deposit traces the contours of an old erosional surface sloping from 5.85 m (19.19 ft) bs in the east, down to 15.13 m (49.64 ft) bs in the west.

In most of the borings (B18 through B25, B27 through B30, B36 through B38), rounded 2-cm (0.78-in) pebbles were encountered near the base of the boring (Photo 12). As with the Unit 1 sand above, the surface of these gravels slopes downward from east to west, with a high point of 8.02 m (26.31 ft) bs in B 24 and a low point of 15.95 m (52.33 ft) bs in B18. Previous geotechnical borings by Geotechnical Resources, Inc. (2013) demonstrate that this gravel deposit is continuous and massive, and represents the basal matrix within the project area. This gravel corresponds to the unconsolidated gravels laid down during the Missoula floods in the late Pleistocene, as described by Phillips (1987) and Trimble (1963).

7.3 Area 400 (B1 through B3, B33 through B35)

Area 400 lies along the Columbia River waterfront within the CalPortland facility, and extends eastward along an access road running to the south of the Subaru lot (Photo 3). The six borings in Area 400 lie within the former shoreline of the Columbia River, and the dynamic setting is reflected in highly variable stratigraphy and an overall lack of stable buried surfaces (Figure 12; Appendix A).

Boring B1, on the far western edge of the project area, contains the only sequence which reflects landform stability. Here, 3.88 m (12.73 ft) of poorly sorted, fine- to coarse-grained sandy dark gray (10YR 4/1) dredge fill (Unit 6b) mantles 2.21 m (7.25 ft) of firm, granular dark grayish brown (10YR 4/2) clay silt with iron mottling and small flecks of charcoal (Unit 5a). Very little plant matter was present near the interface with the Unit 6b fill above, and the presence of iron mottling near the top of the buried surface indicates a truncated A horizon transitioning to a B horizon with some surface scraping prior to filling. The grayish brown (10YR 4/2) sediment below the clay silt shows development of an oxidized B horizon. The parent sediment comprises a sequence of 5-cm (1.97-in) thick bands of alternately fine-grained sandy silt and coarser silty sand. This sequence extends to a depth of 8.63 m (28.31 ft) bs (Unit 4). The banded silt and sand suggests an overbank basin which repeatedly developed isolated ponds. Below this slackwater sequence, there is an abrupt transition to a higher energy depositional environment, with 1-cm (0.39-in) thick bands of dark grayish brown (10YR 4/2) medium to coarse sand alternating with 10- to 20-cm (3.94- to 7.87 in) bands of fine- to medium-grained sand (Unit 2b). A distinctive band of dark yellowish brown (10YR 3/6) iron enrichment between 10.15 and 10.67 m (33.3 and 35.0 ft) bs marks the permanent water table. Below 14.73 m (48.33 ft) bs, the fine- to medium-grained sand transitions abruptly to poorly sorted, black (10YR 2/1) fine- to medium-grained sand with a distinctive band of 0.2-cm (0.08-in) rounded pale pumice lapilli mixed with wood fragments from 14.96 to 15.12 m (49.08 to 49.61 ft) bs. This stratum is morphologically similar to that identified as MSH set Ye in Area 200. However, a similar tephra in boring B35 was not a compositional match for MSH set Ye, so a direct correlation cannot be drawn.

Borings B2, B3 and B33 through B35 encompass a less stable sequence of events than B1. The transition between dredge fills and the original shoreline is obscured by the fact that the initial stages of filling were eroded and redeposited by the flowing river. The surface fill extends to between 4.44 and 7.47 m (14.57 and 24.51 ft) deep; it is a very dark gray (10YR 3/1) to dark gray (10YR 4/1) single-grain, loose, sandy dredge fill with occasional pebbles and wood fragments. It caps an overbank flood deposit (Unit 6a) that is between 0.99 and 5.81 m (3.25 and 19.06 ft) thick. These are classified as redeposited fills rather than entirely natural deposits, because they are modern in age and post-date the start of dredging and filling in the area. The youngest, uppermost overbank deposits are marked by the presence of 5- to 10-cm (1.97- to 3.94-in) thick bands of firm, subangular blocky clayey silts, typically very dark gray (10YR 3/1) in color, indicating an isolated pond setting. Indeed, a 1960 aerial photograph (Figure 14) shows that Area 400 encompassed overbank ponds on the landward side of a sandy levee. The relatively modern age of the silty deposits is supported by radiocarbon dating. A sample of rooted silty clay (Sample 92-01) collected from the deepest rooted silt at 12.04 m (39.5 ft) bs in boring B33 returned a strong likelihood of dating to 0 cal yrs B.P., 70 to 35 cal yrs B.P., 135 to 115 cal yrs B.P., or 255 to 225 cal yrs

B.P.[10] (Beta-400237) (Table 4; Appendix B). These silts are interbedded with poorly sorted, loose, single grain, fine to medium and medium to coarse very dark gray (10YR 3/1) sand deposited on top of the pond silts by a high-energy fluvial setting, as high water episodically breached the levee. The deepest silt deposits slope downward from west to east, from an average depth of 8.66 m (28.22 ft) bs across borings B1 through B3 to a maximum depth of 12.19 m (39.99 ft) bs in boring B33 at the western end of Area 400. The interbedded fine and coarse layers of Unit 6a are a distinct signature of this part of the project APE, and do not appear in the other areas in the present study.

The redeposited fills of Unit 6a and the homogeneous Unit 6b fills cap a gradual accumulation of fining and coarsening, moist, subangular blocky, very dark gray (Gley 1 3/N) sands, indicative of a shallow fluvial setting subject to episodic surges of high water (Unit 2b). These gradually transition to a thicker deposit of very dark gray (Gley 1 3/N), poorly sorted, fine- to coarse-grained, friable, moist, subangular blocky sand. This deposit was left by the flowing water of a major river channel. A wood fragment (Sample 97-01) collected from between 12.02 and 12.03 m (39.44 and 39.47 ft) bs in boring B35, from the upper part of this sandy stratum, returned a radiocarbon date of 2,730 to 2,460 cal yrs B.P.[11] (Beta-400238) (Table 4; Appendix B). Boring B35 also encountered a band of rounded pale pumice lapilli (Sample 98-01) mixed with wood fragments at a depth of 13.67 m (44.85 ft) bs. These are not a compositional match to any known MSH or Mt. Hood tephra, the two sources most likely to deposit pumice into the watershed (Table 5; Appendix C). As outlined in Appendix C, the closest chemical matches are the 1,810 to 2,497 cal yrs B.P. Rock Mesa eruption of South Sister volcano near Bend, Oregon[12], and the 5,780 to 5,830 cal yrs B.P. Dusty Creek eruption of Glacier Peak in northern Washington.[13] The lack of a good local match for this pumice may indicate a currently undated Mt. Hood eruption (Franklin Foit, personal communication February 6, 2015). As in Area 200, redeposited Mazama set O tephra was mixed with the unidentified pumice.

7.4 Area 500 (B4, B15 through B17)

Area 500 is oriented north-south along the CalPortland access road, between the Jail Work Center and the Subaru lot (Photo 4). Because of the shallow depth of proposed disturbance to this area, these borings only extended to a depth of 3.05 m (10 ft) bs (Figure 13; Appendix A). All borings were dominated by dark gray (10YR 4/1) to dark grayish brown (10YR 4/2), loose, single grain, gravelly sand fill (Unit 6b). Boring B4 contained sandy fill (Unit 6b) to its base. Borings B15, B16, and B17 contained between 1.49 and 2.4 m (4.89 and 7.87 ft) of Unit 6b fill atop a truncated buried A horizon marked by plant fragments (Unit 5a). The color of this truncated horizon varied with the extent to which the uppermost organics had been graded prior to filling, and ranged from gray (10YR 5/1) to very dark brown (10YR 2/2) to brown (10YR 4/3). In B15 and B16, this buried surface is a subangular blocky, friable silt (Unit 5a), with a clear transition at 2.5 m (8.20 ft) bs to subangular blocky, friable, brown (10YR 4/3) very fine sand (Unit 4). In B17, the soil formed in a poorly sorted fine to coarse, loose, single grain deposit of very dark gray (5Y 3/1) sand, which transitions abruptly at 2.68 m (8.79 ft) bs to very dark gray (5Y 3/1) subangular blocky, friable, very fine sand (Unit 4). No tephra or datable organic samples were present in any borings.

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[10] Conventional radiocarbon date of 50 ± 30 yrs B.P. calibrated by Beta Analytic using IntCal13

[11] Conventional radiocarbon date of 2490 ± 30 yrs B.P. calibrated by Beta Analytic using IntCal13

[12] Conventional radiocarbon date of 2150 ± 150 years from Fierstein et al. (2011), calibrated by AINW using IntCal13

[13] Calibrated date for Dusty Creek eruption from Foit et al. (2004) and Hallett et al (2001)

8. Interpretations

The lithostratigraphic units described in the previous section reflect significant changes in the landscape within the APE since the final Missoula floods passed through the Portland Basin at the end of the Pleistocene. These environmental changes, and their potential impacts on human settlement in the area, are explained below. Schematic cross sections of the surveyed areas are presented as fence diagrams in Figures 10 through 13. The landform types represented in the cross sections have been linked to the sediments within the borings according to the framework laid out by Minor and Peterson (2013) and Peterson et al. (2014) for the development of the Columbia River floodplain within the Portland Basin. For the purposes of the present study, the following modifications to this framework have been made.

- Oxidized silts/clays are classified with Marsh deposits, since oxidation indicates exposure to above-water conditions. In some parts of the APE, the original vegetation mat was stripped away prior to filling, so the remaining truncated A horizon and underlying oxidized B horizon serve as proxies for seasonally dry land.
- For the present study, floodplain channels are subdivided into shallow and major channels to reflect the specific morphology of the landscape south of Vancouver Lake, which is creased by large and small sloughs as well as the main channel of the Columbia River.

8.1 Area 200

Age	Environmental Setting
Present to 75 years ago	Fill
75 to 1,290 years ago	Area 200 is isolated from the main river channel, leaving scroll-bar ridges and ponded swales that are periodically capped by river sand.
1,290 to 4,439 years ago	A shallow backwater forms in the eastern half of Area 200, trapping logs and debris. The MSH set Ye tephra is deposited early in the development of this backwater.
4,439 to 14,000 years ago	A major channel of the Columbia River meanders westward through Area 200.

The sediments in Area 200 are classified as *Quaternary alluvium* after Phillips (1987) and Trimble (1963). There is evidence of repeated inundation by shallow flooding, as with overbank deposition on the landward side of a natural riverfront levee. Sauvie series soils have developed within the silty sediments forming the historic surface of the landscape. Two sandy ridges were seen to peak in borings B8 and B12, and these ridges are capped by truncated A and B horizons. These are the remains of sandy scroll bars which were graded prior to filling as preparation for construction of the Alcoa plant in the 1940s. Below this, alternating bands of finer and coarser sediment indicate an early basin or overbank swale pond subject to regular flooding. Couplets of dark and oxidized bands of silts and sands reflect repeated A and B horizon formation and burial, and the depth of wood fragments in the eastern half of the area suggests a protected backwater or overbank zone on the landward side of a natural levee. The MSH set Ye tephra dates the separation of the backwater from the main river channel to sometime between 4,439 and 2,965 cal yrs B.P. This broad window corresponds with the dates reported by Peterson et al. (2014) for the formation of Vancouver Lake (4,810 to 4,420 cal yrs B.P.), as well as the age of the scroll bar marking its western edge (2,860 to 2,740 cal yrs B.P.). The western part of Area 200 separated from the main river around 1,290 to 1,180 cal yrs B.P., and is associated with a scroll bar and swale complex that post-dates the final development of Vancouver Lake. These dates capture the gradual westward meandering of the Columbia River as it passed over the project area, leaving scroll bars and swales to the east.

The well-drained terrain of the scroll bar ridges would have been suitable for short-term camps, but the low-lying relief would have been inundated on a seasonal basis and permanent settlement would have been impossible. However, the tops of the ridges were truncated prior to filling, in preparation for construction of the Alcoa plant starting in 1940, and ridge-top sites may have been scraped away at that time. No evidence of human settlement was observed in the borings in Area 200.

8.2 Area 300

Age	Environmental Setting
Modern	Fill
20 to 75 years ago	A stable ridge and swale wetland experiences seasonal flooding.
75 to 2,965 years ago	Floodplain pond or ponds are infilled by silt, and a seasonally-flooded vegetated wetland forms.
2,965 to 4,439 years ago	Stable floodplain pond or ponds experience seasonal accumulations of decayed plants and new sediment. The MSH set Ye tephra is deposited not long after the first pond forms.
4,439 to 14,000 years ago	A major channel of the Columbia River meanders westward through Area 300, leaving an extensive pond protected by a hypothetical scroll bar levee.

The sediments in Area 300 are classified as *Quaternary alluvium*, with the exception of the deepest gravels. These fit the description of Pleistocene Gravel-sized flood deposits brought in by the Missoula floods, after Phillips (1987) and Trimble (1963). The uppermost rooted A horizon tends to be coarser than the underlying laminated silts and clays, and resembles a Pilchuck soil, which formed in sands on top of a silty deposit bearing Sauvie series A and B horizons. Rooted sand and sandy silt forms the historic surface, and represents sand ridges deposited by wind and water on top of the silts and clays that accumulated within and eventually filled in an older, long-lasting floodplain pond. The pond itself formed shortly before a fine layer of MSH set Ye tephra settled to the bottom of the pond sediments. Below this, an important environmental change is marked by an abrupt cessation of coarse-grained sand accumulation, which was replaced by fine particles which could only have settled out of ponded water.

The most likely explanation for the change to fine-grained deposits after earlier coarse-grained deposits is that as the Columbia River meandered westward over several thousand years, it deposited coarse sands and then formed a scroll bar which acted as a natural levee and isolated Area 300 from the main flow. A localized deposit of rooted sand and silt is present between 8 and 11 m (26.2 and 36 ft) bs, and predates a more or less unbroken sequence of unrooted silt and clay. This rooted sand and silt may represent the first overbank deposit, which was buried by an accumulation of unrooted silt after the project area was completely cut off from the Columbia River. The same tephra which marks the end of the fluvial period in Area 200 (between 4,439 and 2,965 cal yrs B.P.) also marks the start of the ponded period in Area 300, which shows that Area 200 was still within the main channel as Area 300 became a pond. These depositional contexts match well with the findings of Peterson et al. (2012), who documented these tephras within paleochannel sands at depths of 10 to 20 m (32.8 to 65.6 ft) bs, and within rooted floodplain muds at depths between 4 and 6 m (13.1 to 19.7 ft) bs.

The evidence for a westward shift in the channel between 4,439 cal yrs B.P. (the oldest date for the MSH set Ye eruption) and 1,180 cal yrs B.P. (the youngest date for the channel sands in Area 200) movement supports recent findings by Peterson et al. (2014), Minor and Peterson (2013), and Peterson et al. (2012). The basal deposit of late Pleistocene rounded gravels is the footprint of the original channel of the Columbia River which scoured a path through Missoula flood deposits, as Minor and Peterson (2013) have shown for nearby areas of Portland and Vancouver.

Area 300 contains substantial evidence of well-preserved soils from a stable ridge-and-swale landscape, but no evidence of well-drained high ground which would have been suitable for permanent human settlement. This wetland could have supported wapato, migrating waterfowl, and other plants and animals important to Native people. However, a permanent settlement within the wetland would have been impossible. Ridges may retain scatters of fire-cracked rock and lithic debitage representing short-term use.

8.3 Area 400

Age	Environmental Setting
Present to 55 years ago	Fill
55 to 65 years ago	Redeposited fill is incorporated into a sandy levee, protecting one or more swale ponds
65 to 2,730 years ago	The area becomes isolated from the main channel and a shallow sandy terrace forms. One or more swale ponds emerge after a sandbar becomes a permanent levee.
2,730 to 14,000 years ago	A major channel of the Columbia River flows through the area. An unknown tephra is deposited in a protected backwater when the sandy surface was at 13.7 m (45 ft) below the modern surface.

The sediments in Area 400 are classified as *Quaternary alluvium*. Within Area 400, all borings show evidence that the most recent native soils formed in a shallow floodplain environment prior to filling. Borings B2, B3 and B33 through B35 contain silts left by an intermittent pond or ponds which formed in a swale on the landward side of a sandy levee on the margin of the Columbia River. Aerial photographs dating to 1951, 1952, and 1960 show the variability of sandbar locations over the course of nine years alone (Figure 14). The soil horizonation in boring B1 fits the Sauvie series, and this stable surface likely represents the bank of a small inlet fed by a stream visible in 1951 and 1952, whereas borings B2, B3, and B33 through B35 show a cross-section of the shifting sandbar environment of the waterfront. The deepest pond deposits on the eastern end of Area 400 were modern in age according to a radiocarbon date, and represent the surface just prior to the first stages of filling. Underlying deposits show that the land within Area 400 began to emerge from the main channel of the Columbia River between 2,730 to 2,460 cal yrs B.P., which is the age of the uppermost purely fluvial sand.

Area 400 was targeted during the geoprobe excavations as the area with the greatest potential to harbor a substantial village site, if the appropriate terrain existed in the past. Indeed, a structure and orchard are depicted at the west end of Area 400 on a 1909 navigation map (Figure 15). Appropriate terrain would include a hill or terrace exceeding 8.2 m (27 ft) asl in elevation, adjacent to the river channel, showing soil formation which would indicate that the landform was stable, uneroded, and vegetated. The data demonstrate that this type of landform was not present within Area 400. Instead, the sediments are evidence of a highly unstable channel margin environment, with low-lying terrain that was frequently inundated. No evidence of the nearby historic structure or farm was found in the borings, and no stable soils were present until filling. Prior to filling, it would have been a zone of dynamic, constantly shifting sandbars, with pools of standing water as areas became isolated from the main river channel.

8.4 Area 500

Age	Environmental Setting
Present to 20 years ago	Fill
20 to 1,180 years ago	Wetland becomes farmland and forest.
1,180 to 4,439 years ago	Sometime during this broad window, a natural scroll bar levee isolates the area. Water pools in scroll bar swales, and sandy ridges grow vegetation.
4,439 to 14,000 years ago	A main channel of the Columbia River flows through the area.

The sediments in Area 500 are *Quaternary alluvium*. The sample depth is limited by the shallow proposed impacts to this area, and did not exceed 3.05 m (10 ft) bs. Area 500 contains the buried remnants of a vegetated sandy ridge as well as evidence of a buried swale pond which had filled with silt. The sandy ridge was much more substantial and well-drained than any found within Areas 300 or 200, and was stable enough to develop Newberg soil horizonation. Although no datable materials were obtained from the borings, Area 500's position east of Area 200 to the east, west of Area 300, and north of Area 400 allows an estimate of landform age. This area would have become isolated from the main river channel sometime between 4,439 cal yrs B.P. and 1,180 cal yrs B.P., at which point a ridge and swale wetland formed. Area 500 displays the best evidence of stable, well-drained soils which would have been suitable for human settlement. The dune ridge may have the potential to house scatters of fire-cracked rock and lithic debitage from seasonal camps.

9. Summary and Recommendations

AINW performed geoarchaeological survey of the Facility APE from November 4 through November 24, 2014. In total, 39 geoprobe borings were completed and analyzed (Table 2; Figure 9). **No pre-contact or historic-period artifacts or archaeological features were found.**

Wetland, channel margin, and river channel sediments were present below the surface layer of sandy fill, and showed no signs of historic or modern disturbance, other than grading prior to filling. The sediments were dated using radiocarbon analysis of well-preserved plant and wood fragments, and tephra composition matching known volcanic eruptions. These dates show that the initial shift from river channel to shallow floodplain wetland took place shortly before the MSH set Ye tephra was deposited between 4,439 and 2,965 cal yrs B.P. Human occupation earlier than this would be precluded by the river channel setting. The river channel continued its gradual westward migration across the area through at least 1,290 cal yrs B.P., leaving behind a wetland landscape marked by low sandy ridges and numerous small ponds subject to seasonal flooding. The late Holocene wetland would have been a productive environment for hunting and gathering by Native peoples, but frequent flooding of the low-lying terrain would have prevented people from establishing enduring villages. The terrain documented in this study resembles that just to the north of the project APE, south of Vancouver Lake, where the only recorded traces of human settlement are the remnants of discarded tools and cooking fires on ridges near marshes and farmsteads on high ground. The best-preserved buried remnants of this type of sandy ridge were found in the Area 500 borings, although no indicators of human activity were present in the borings.

No monitoring of construction activities is needed in Areas 200, 300, and 400 because the sediments show no evidence of stable soils, only of frequently-flooded, low-lying land dominated by small ponds, marshes, and shallow floodplain channels. The dune ridge present in Area 500 north of the CalPortland facility may have been suitable for a seasonal camp. The current impacts will be no deeper than 3.05 m (10 ft) bs for the placement of the pipelines which will largely be above-ground, not buried. **If the depth of impact will exceed 3.05 m (10 ft) bs, monitoring during construction in Area 500 would be appropriate**.

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11. List of Acronyms and Abbreviations

AINW: Archaeological Investigations Northwest, Inc.

APE: area of potential effect

asl: above sea level

B.P.: before present

bs: below surface

cal: calendar

DAHP: Washington State Department of Archaeology and Historic Preservation

DEM: digital elevation model

DLC: Donation Land Claim

EFSEC: Energy Facility Site Evaluation Council

Facility: Vancouver Energy

ft: foot or feet

ft^2: square foot or square feet

GLO: General Land Office

HBC: Hudson's Bay Company

km: kilometer

m: meter or meters

m^2: square meter or square meters

mi: mile

MSH set Ye: Mount St. Helens set Ye eruption

NRCS: Natural Resources Conservation Service

NRHP: National Register of Historic Places

Port: Port of Vancouver USA

SEPA: State Environmental Policy Act

USACE: U.S. Army Corps of Engineers

USDA: U.S. Department of Agriculture

USGS: U.S. Geological Survey

yrs: years

Figures

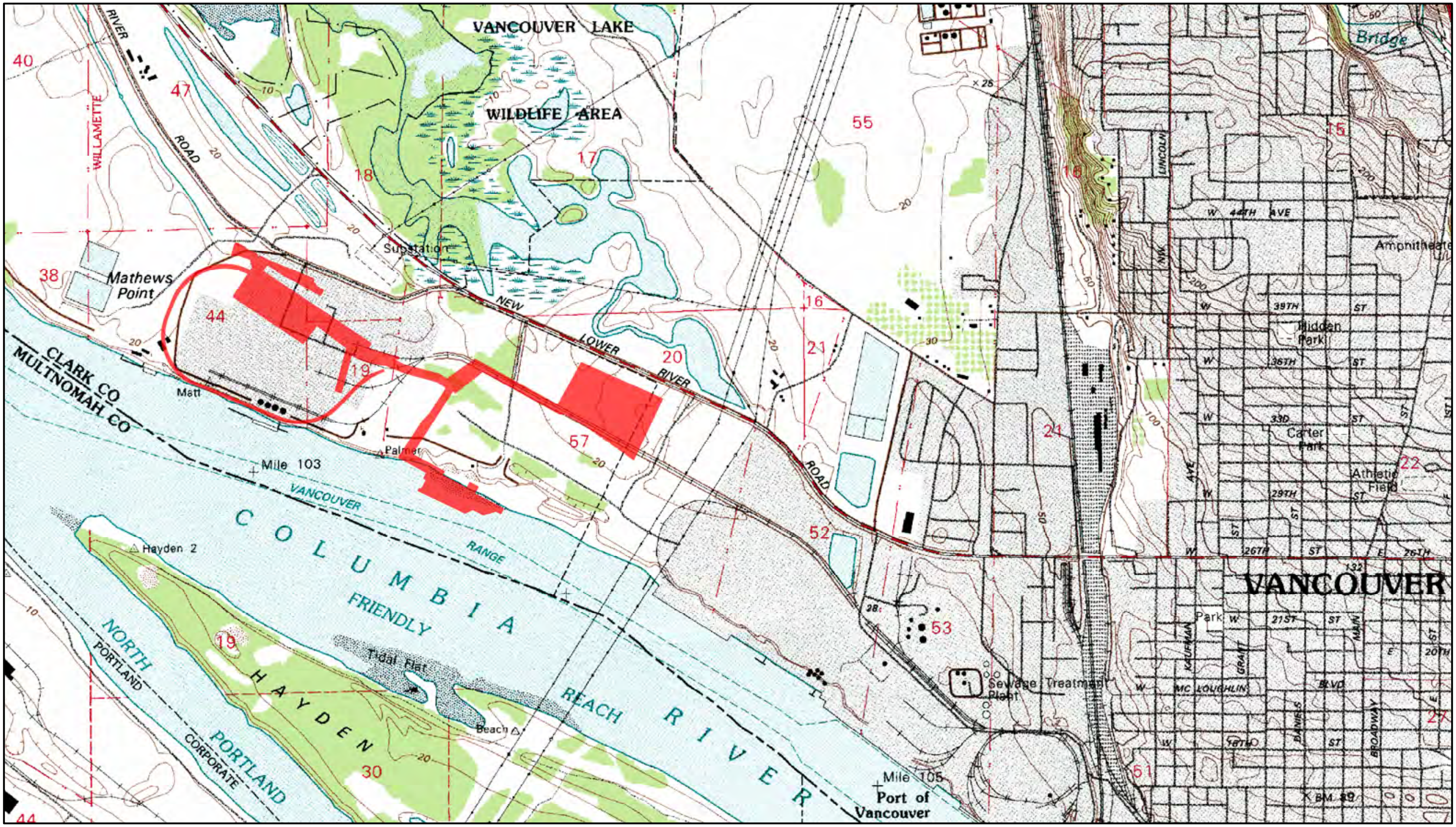


Figure 1 - The Vancouver Energy Project APE

LEGEND

Project APE

0 0.5 1
Kilometers

0 0.5 1
Miles

N

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Date: April 2015

Map Notes: Basemap- U.S. Geological Survey. Vancouver quadrangle, Washington [map]. 1990. 1:24,000. 7.5 Minute Series.

Tesoro Savage Petroleum Terminal LLC

Figure 2 - The Vancouver Energy Project APE Facility Design Elements

Date: April 2015

Map Notes: Basemap - Aerial photo dated July 2010, courtesy of ESRI World Imagery Service

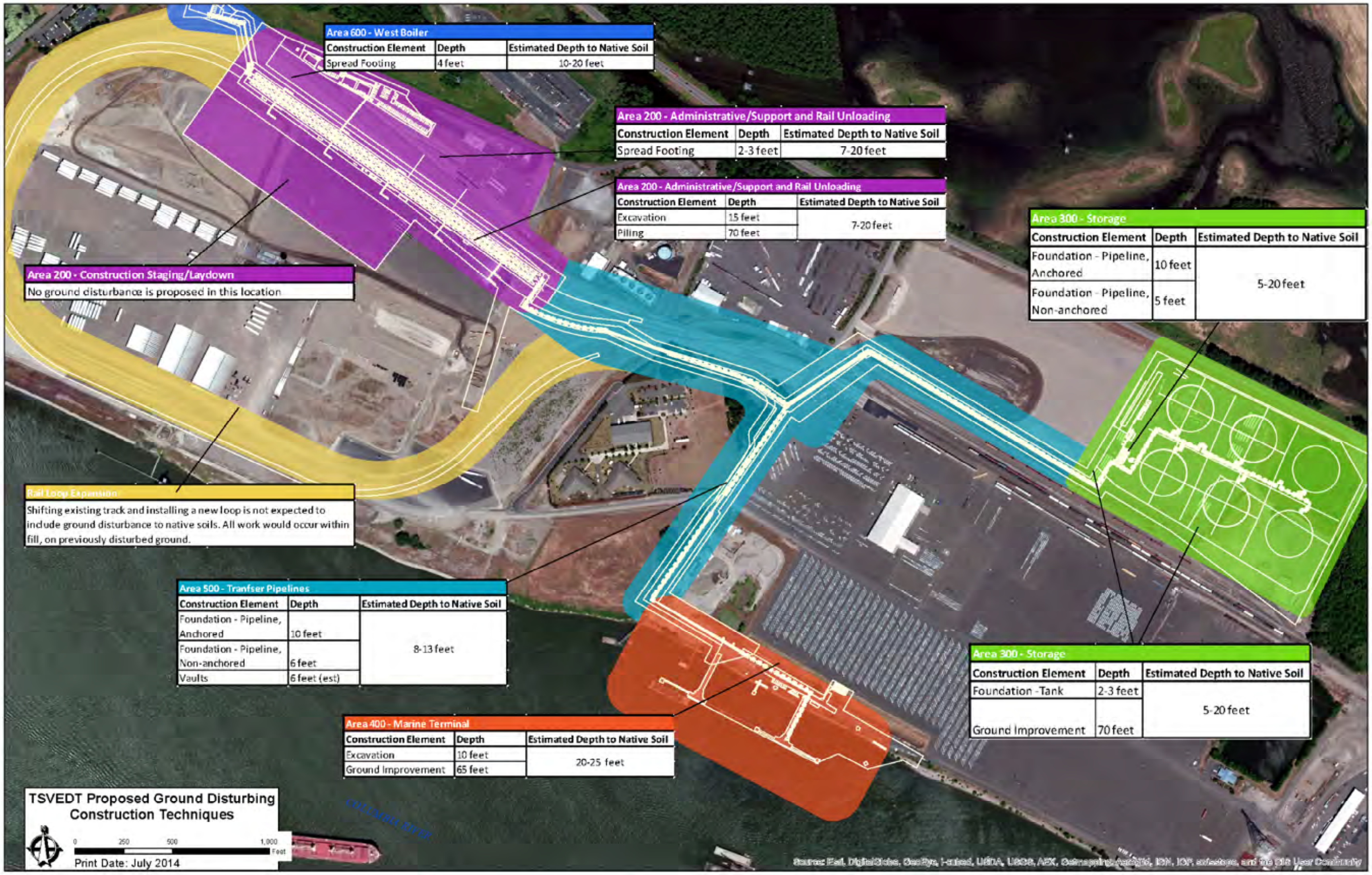


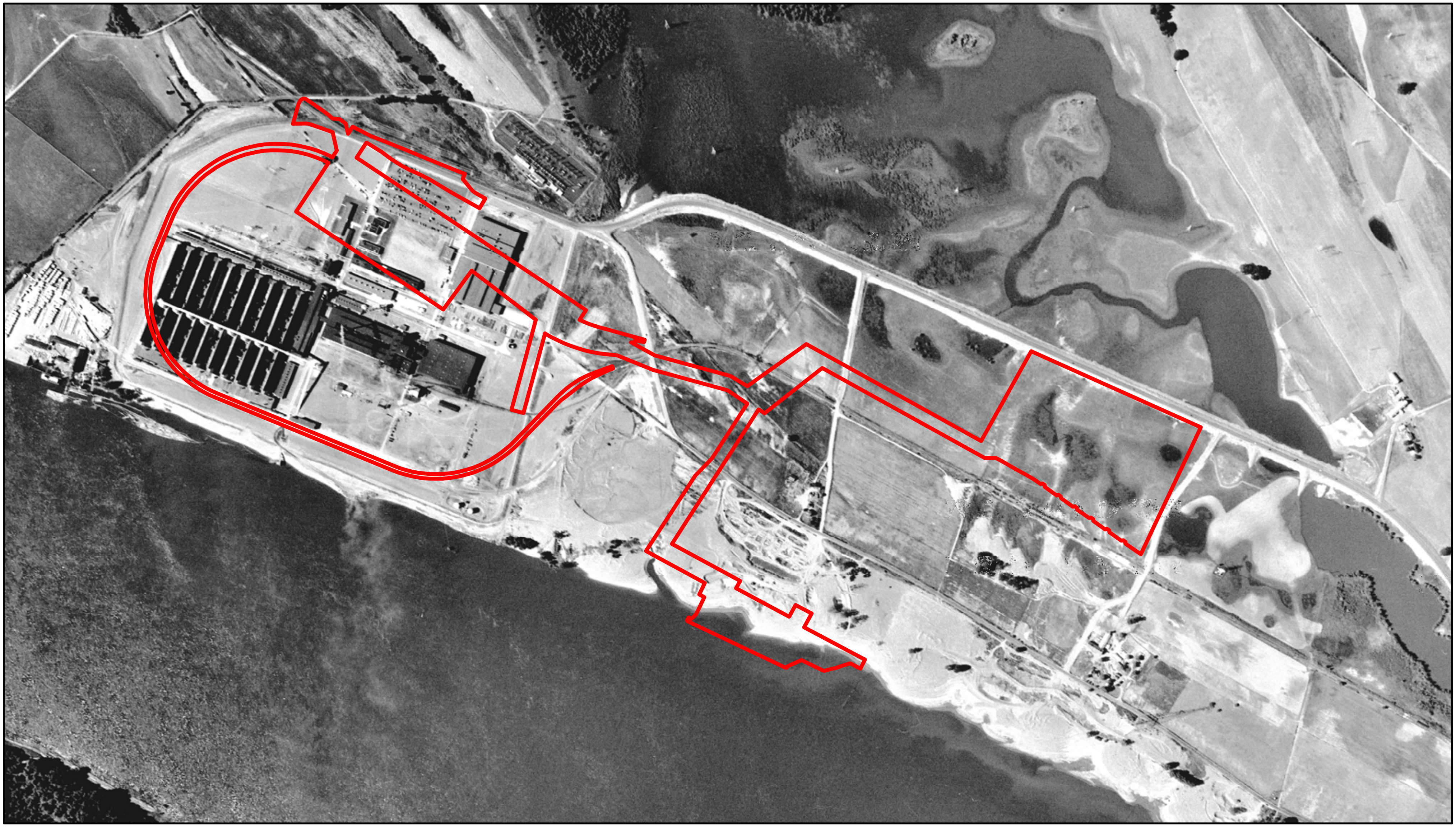
Figure 3. Vancouver Energy Project's Proposed Ground Disturbing Construction Techniques.

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Date: April 2015

N



VANCOUVER ENERGY
Tesoro Savage Petroleum Terminal LLC

Figure 4. 1951 Aerial Photograph

LEGEND

Project APE

0 250 500
Meters

0 500 1,000 2,000
Feet

N

Date: April 2015
Map Notes: Basemap - Aerial photo dated October 25, 1951, Data available from the U.S. Geological Survey

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Figure 5. 27-foot Elevation Flood Zone

LEGEND

Project APE

Max Flood - ft asl

3.5 - 27

27 - 222.8

0 250 500

Meters

0 500 1,000 2,000

Feet

N

Date: April 2015

Map Notes: Basemap -Aerial photo dated July 2010, courtesy of ESRI World Imagery service

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Figure 6. Surficial Geology

LEGEND

Project APE

Surfical Geology - Phillips 1987

Quaternary alluvium, dune sand, loess, and artificial fill

Water

0 250 500 Meters

0 500 1,000 2,000 Feet

N

Date: April 2015

Map Notes: Basemap -Aerial photo dated July 2010, courtesy of ESRI World Imagery service

Figure 7. Soils

LEGEND

Project APE

Soil Types

Fn - Fill land
NbA - Newberg silt loam 0-3% slope
NbB - Newberg silt loam 3-8% slope
PhB - Pilchuck fine sand 0-8% slope

SmA - Sauvie silt loam 0-3% slope
SmB - Sauvie silt loam 3-8% slope
SpB - Sauvie silty clay loam 0-8% slope
W - Water

0 250 500
Meters

0 500 1,000 2,000
Feet

N

VANCOUVER ENERGY
Tesoro Savage Petroleum Terminal LLC

Date: April 2015
Map Notes: Basemap -Aerial photo dated July 2010, courtesy of ESRI World Imagery service

Figure 8. Previous Cultural Resource Studies

LEGEND

- Project APE
- Port of Vancouver's Terminal 4 Pond Reconstruction Project - Reese 2009b
- Port of Vancouver Terminal 4 Improvements Project - Reese 2009a
- Predetermination: Clark Public Utilities Substation at Jail Work Center - Fuld and Reese 2012
- Clark County Jail Work Center - Moore et al. 1997; Ellis and Mills 1998; Clark County Jail Work Center - Moore et al. 1997
- Port of Vancouver Alcoa/Evergreen Development Project - Fagan and Zehendner 2009
- Alcoa Remediation Project - Becker and Roulette 2003
- West Vancouver Freight Access Project - Hetzel et al. 2009; West Vancouver Fright Access Project - Hetzel et al. 2009
- Aloca Vancouver Sediment Remediation Project - Zehendner and Fagan 2008
- Port of Vancouver Proposed WRI Coal Terminal - Thomas and Welch 1982
- Port of Vancouver Parcel 1 Project - Forgeng and Reese 1993
- Cogentrix Power's Proposed Gas-Fired Turbine Electric Generation Facility - Thomas 1995
- Port of Vancouver Terminal 4 Improvements Project - Reese 2009a
- Port of Vancouver's Terminal 4 Pond Reconstruction Project - Reese 2009b
- Port of Vancouver Terminal 5 Bulk Potash Project - Chapman and Blaser 2010
- Port of Vancouver Parcel 2 Project - Davis and Ozbun 2011
- Predetermination: 3103 NW Lower River Road - Jenkins and Davis 2012
- Predetermination: Clark Public Utilities Substation at Jail Work Center - Fuld and Reese 2012
- Port of Vancouver Trail - Hambelton et al. 2014
- NWP River Road Relocation Project - Fuld and Tisdale 2015

N

0 250 500
Meters

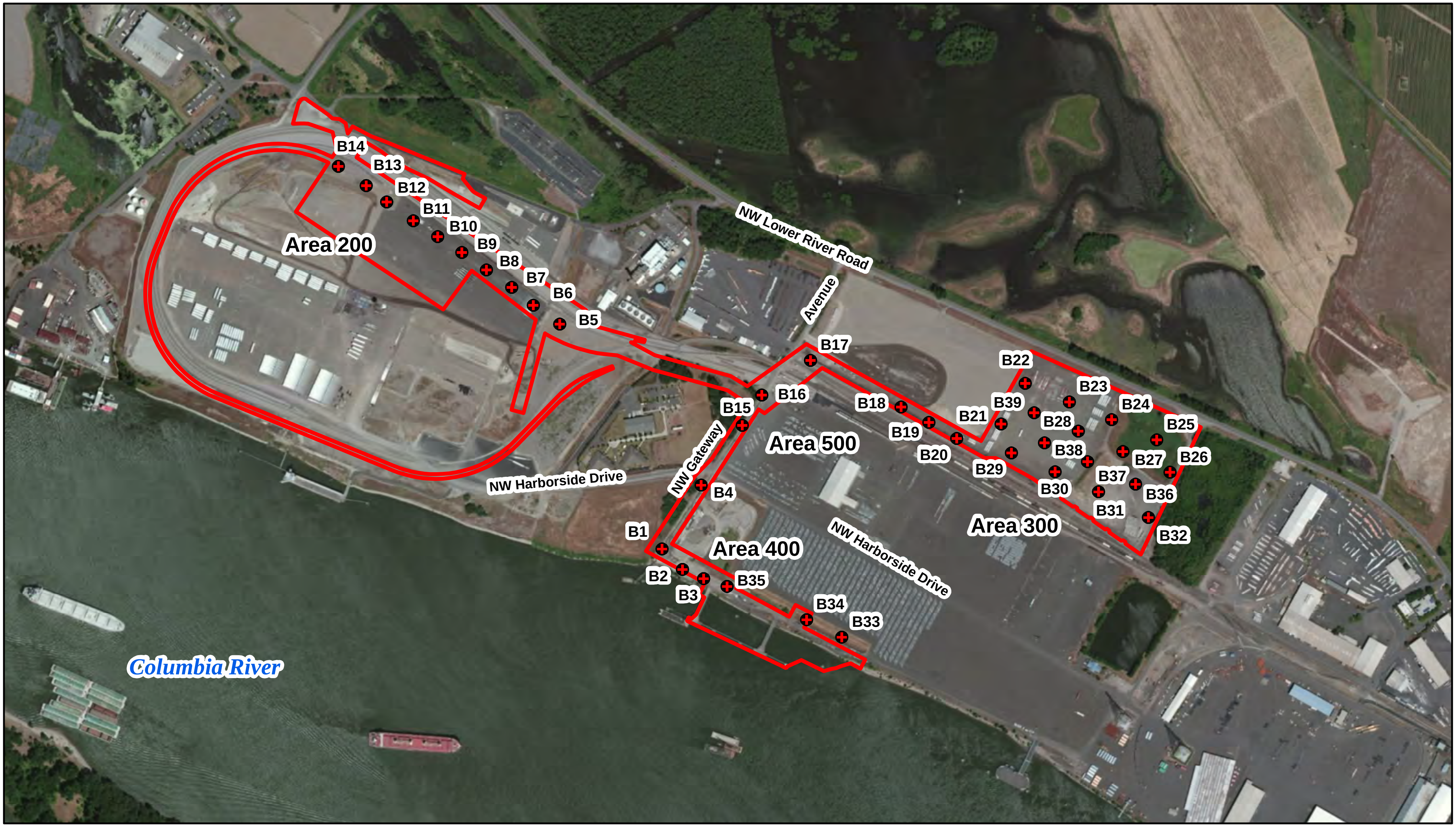
0 500 1,000 2,000
Feet

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Date: April 2015

Map Notes: Basemap -Aerial photo dated July 2010, courtesy of ESRI World Imagery service



VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Figure 9. Geoprobe Locations

LEGEND

Project APE

Geoprobe Bore

Date: April 2015

Map Notes: Basemap -Aerial photo dated July 2010, courtesy of ESRI World Imagery service

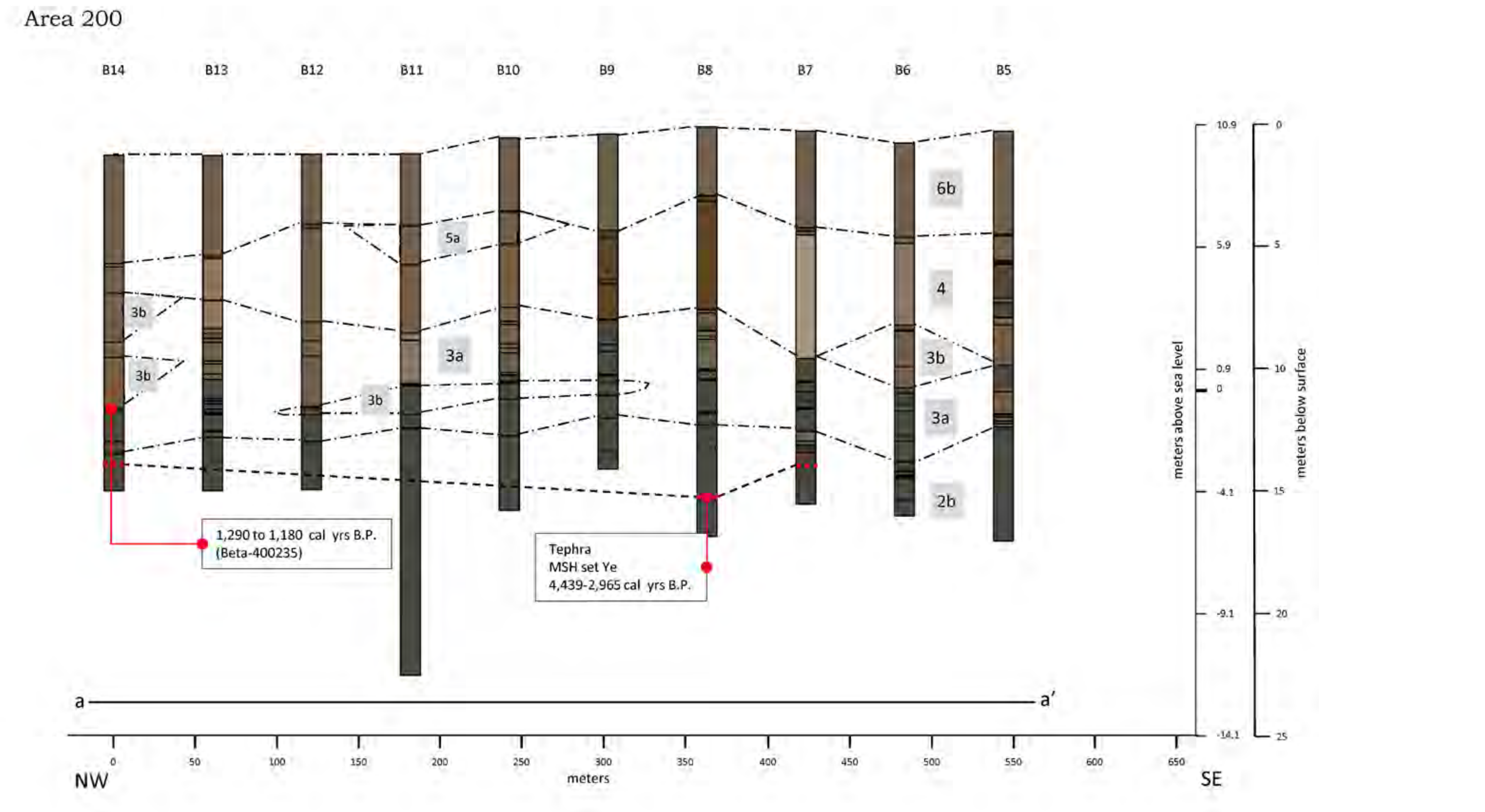


Figure 10. Area 200 Lithostratigraphic Units

LEGEND

- Link between units
- Tentative link between units
- Colors reflect Munsell colors of strata
- White pumice lapilli, similar to MSH set Ye tephra
- Stratigraphic transition (for detailed data, see Appendix A)

Location

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Date: April 2015

Map Notes: See Table 3 for description of units.

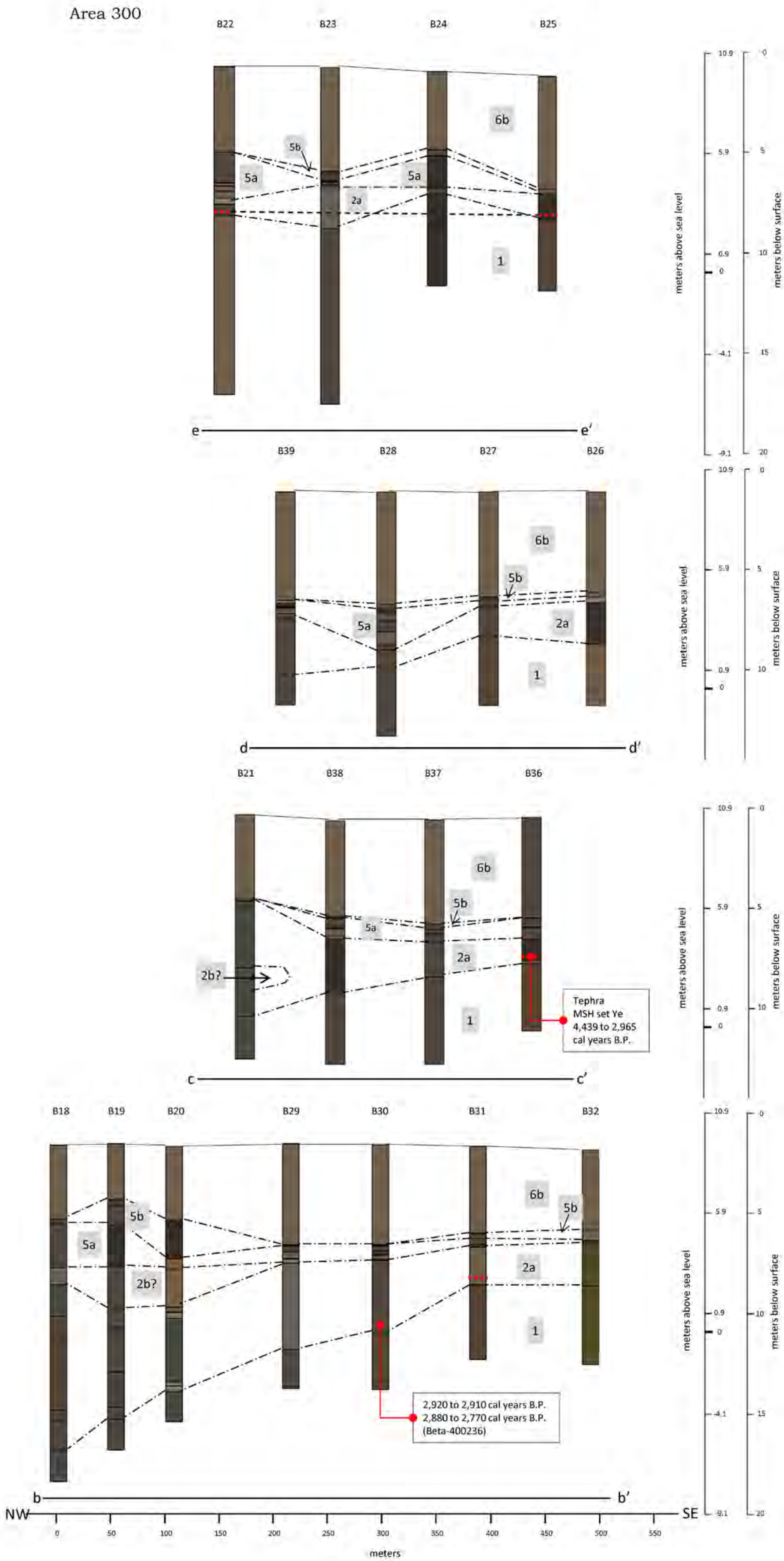


Figure 11. Area 300 Lithostratigraphic Units

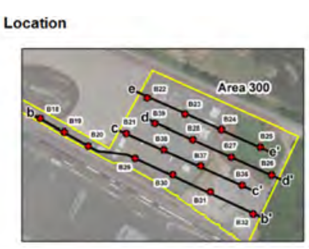
LEGEND

- Link between units
- Tentative link between units
- Stratigraphic transition (for detailed data, see Appendix A)
- Colors reflect Munsell colors of strata
- White pumice lapilli, similar to MSH set Ye tephra

Date: April 2015

Map Notes: See Table 3 for descriptions of units.

Tesoro Savage Petroleum Terminal LLC



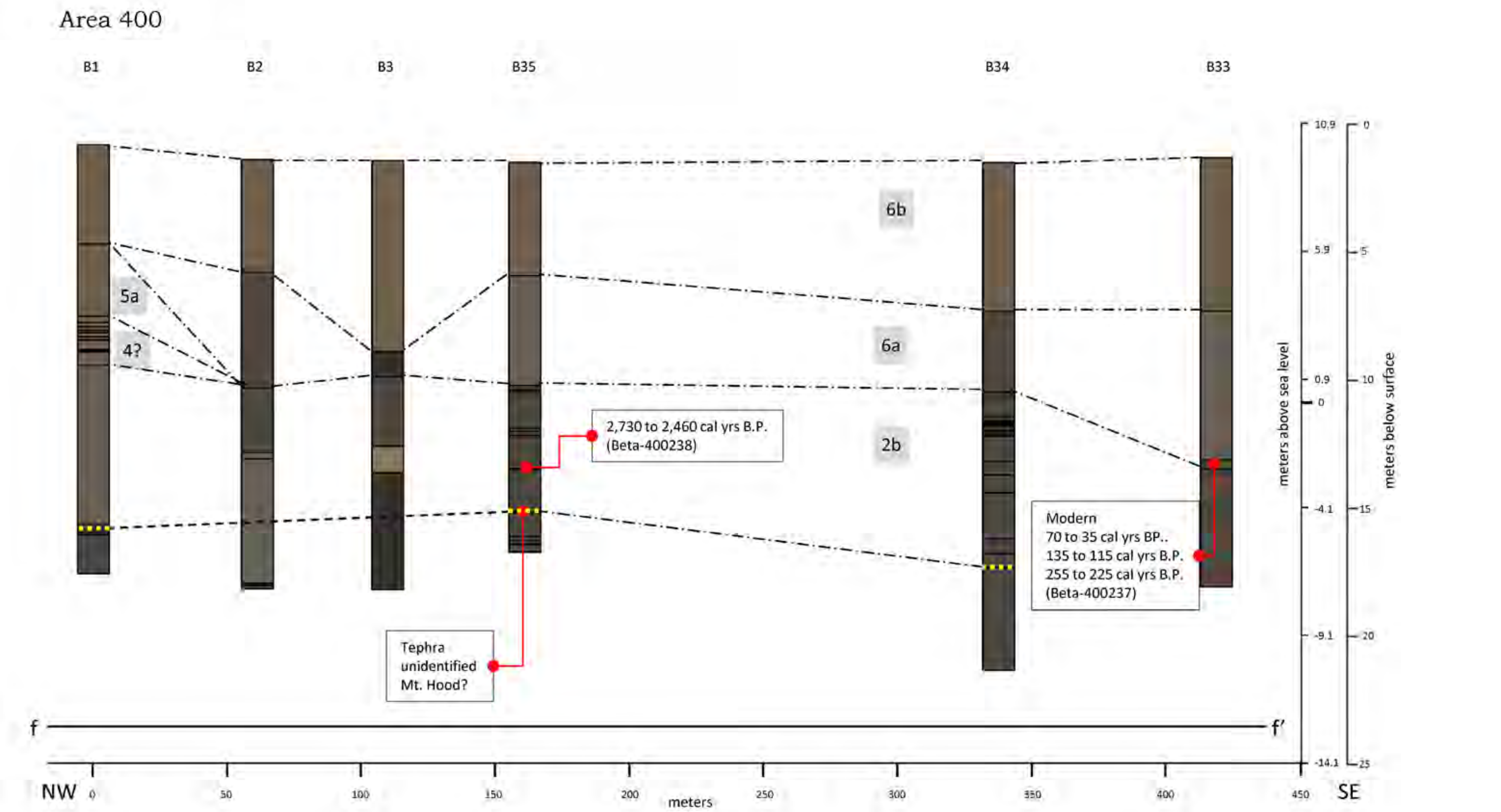


Figure 12. Area 400 Lithostratigraphic Units

LEGEND

- Link between units
- Tentative link between units
- Colors reflect Munsell colors of strata
- White pumice lapilli, similar to unidentified possible Mt. Hood tephra
- Stratigraphic transition (for detailed data, see Appendix A)

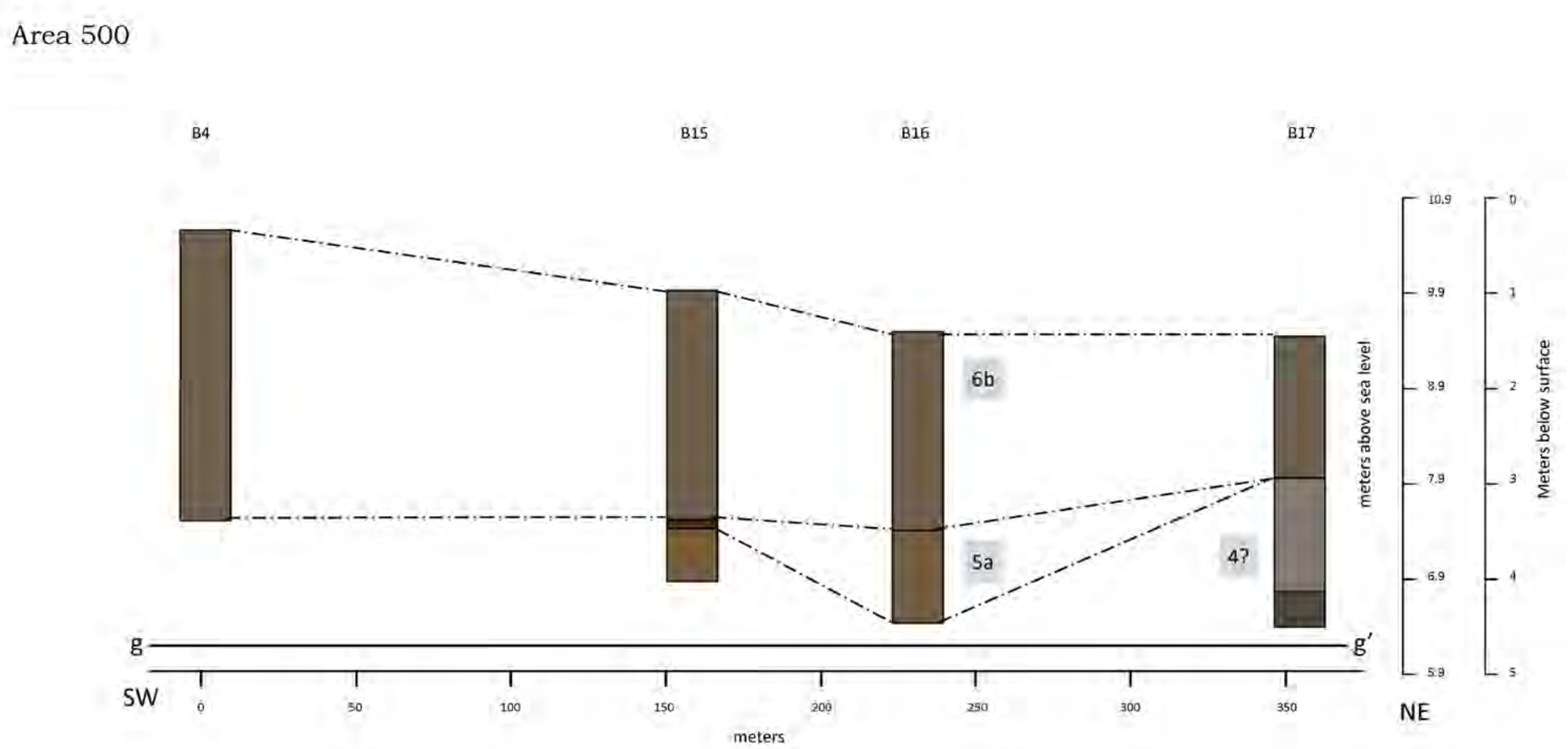
Location

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Date: April 2015

Map Notes: See Table 3 for descriptions of units.



Tesoro Savage Petroleum Terminal LLC

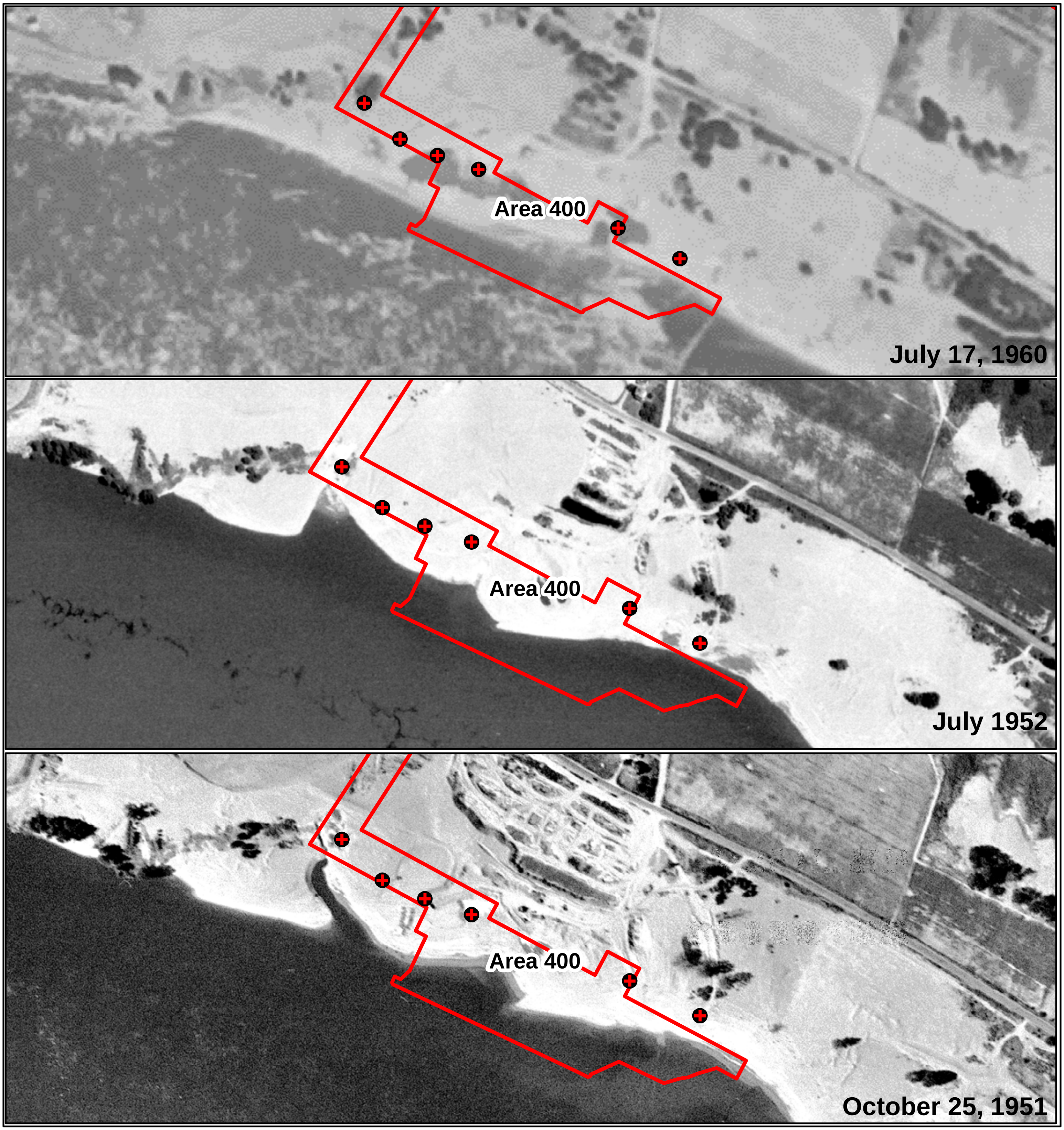
Figure 13. Area 500 Lithostratigraphic Units

LEGEND

- Link between units
- Stratigraphic transition (for detailed data, see Appendix A)
- Colors reflect Munsell colors of strata

Location

Date: April 2015
Map Notes: See Table 3 for descriptions of units.



VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Figure 14. Area 400 Historic Aerial Photographs

LEGEND

Project APE

Monitored Geoprobe Bore

0 50 100 200
Meters

0 250 500 1,000
Feet

N

Date: April 2015

Map Notes: Basemap - Aerial photos dated October 25, 1951, July, 1952, and July 17, 1960. Data available from the U.S. Geological Survey

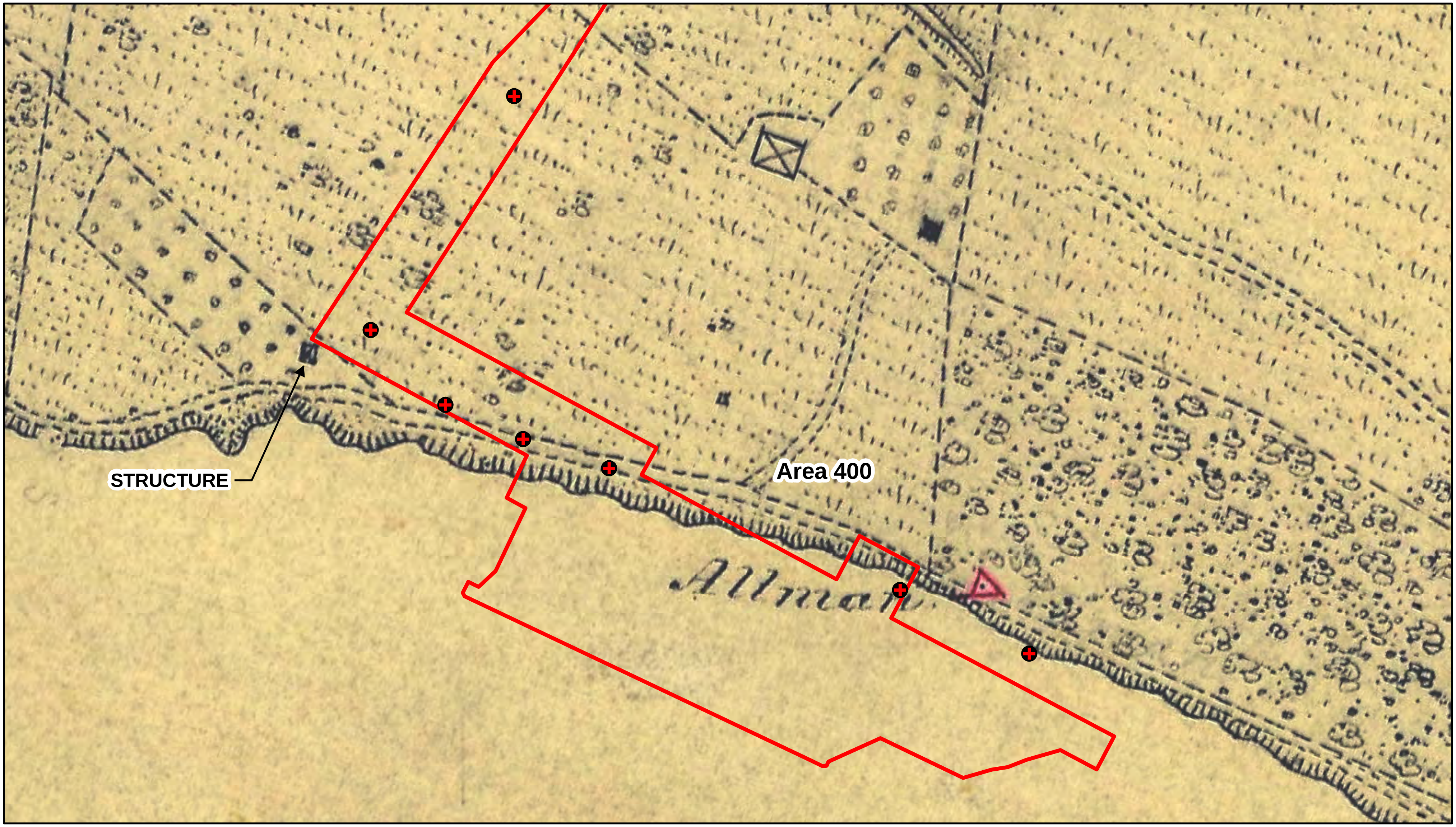


Figure 15. 1890 Structures and Shoreline in Area 400

LEGEND

Project APE

Monitored Geoprobe Bore

0 50 100 200
Meters

0 250 500 1,000
Feet

N

VANCOUVER ENERGY

Tesoro Savage Petroleum Terminal LLC

Date: April 2015

Map Notes: Basemap - Columbia River Navagation Map (USCGS 1890)

Vancouver Energy
Cultural Resources Geoarchaeological Investigation Report
EFSEC Application for Site Certification No. 2013-01
Docket No. EF131590

Photographs

Photo 1. Area 200, looking northwest towards the location of boring B5, marked in the foreground.

Photo 2. Area 300, looking east towards the location of boring B21, marked in the middle distance.

Photo 3. Area 400, looking northwest towards the location of boring B3, marked in the foreground.

Photo 4. Area 500, looking southwest towards the location of boring B15, marked in the middle distance.

Photo 5. Geoprobe rig collecting samples in Area 300.

Photo 6. Geoprobe samples under analysis in Area 300, with Geoprobe visible in the background.

Photo 7. Geoprobe samples after splitting, sampling, and analysis.

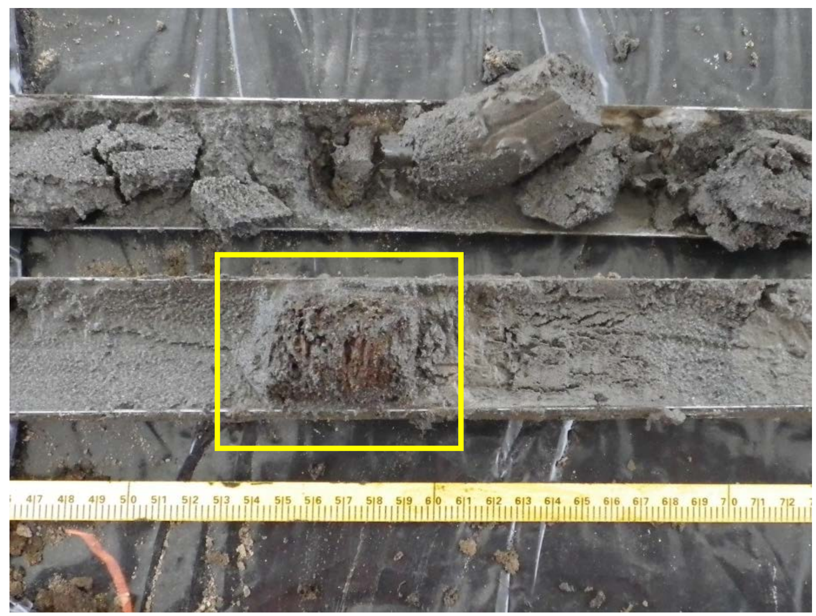


Photo 8. Waterlogged, buried wood in boring B5 at 11.5 to 11.6 m (37.7 to 38 ft) bs.

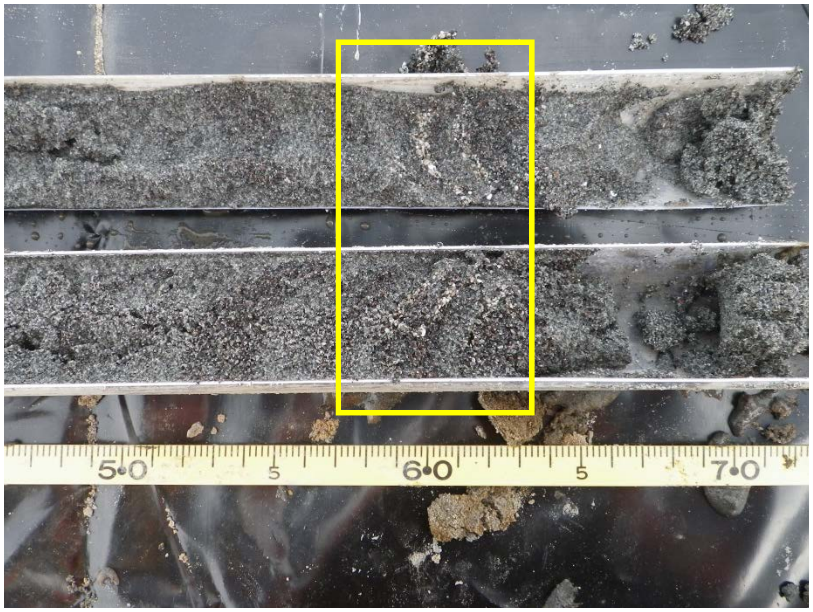


Photo 9. The white pumice lapilli in boring B7 at 13.6 m (44.6 ft) bs resemble those analyzed from boring B8, which was sourced to MSH set Ye.

Photo 10. The white, fine-grained tephra visible at 6.99 m (22.9 ft) bs in boring B25 resembles the sample analyzed from boring B36, which was sourced to MSH set Ye.

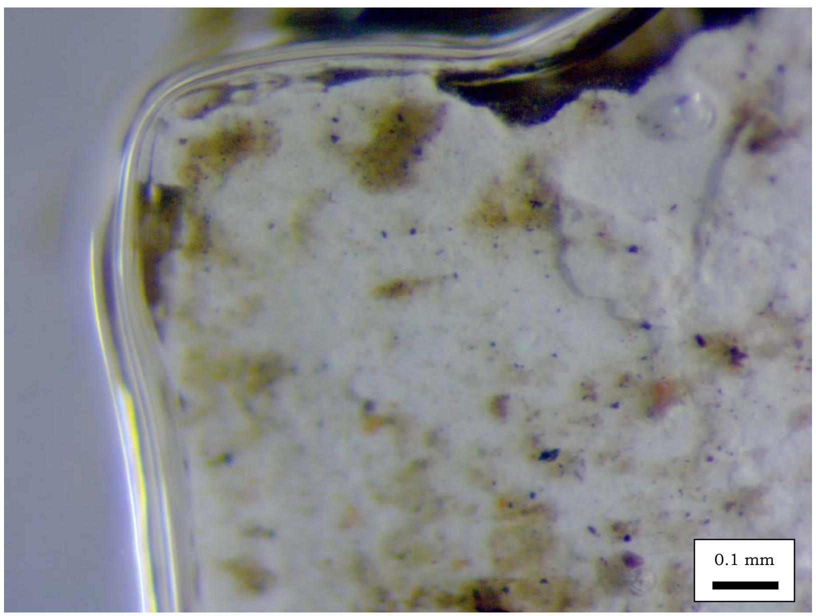


Photo 11. Microscopic examination of the white flecks found at 8.9 m (29.2 ft) bs in boring B28 shows no biological structures, and reflects mineralization during soil weathering.

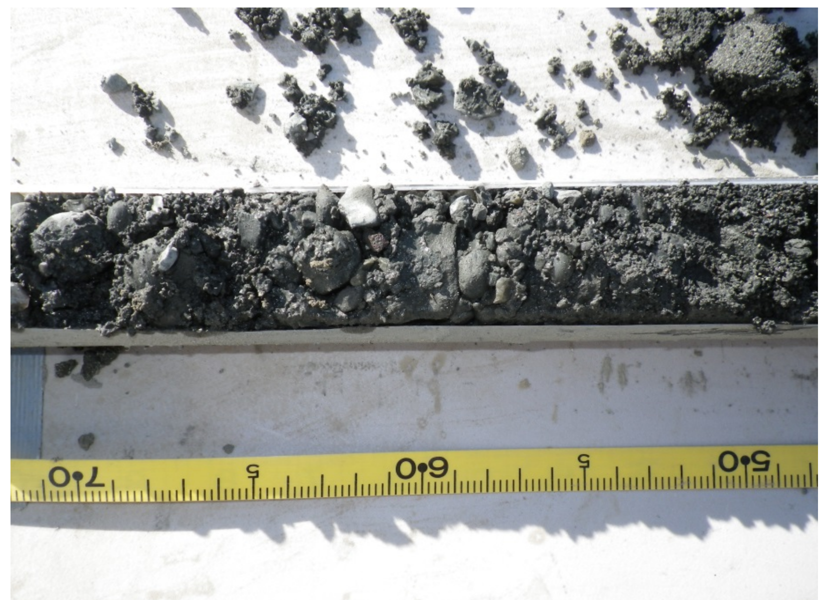


Photo 12. Rounded and subrounded Pleistocene gravels are present from 16.5 to 16.8 m (54.1 to 55.1 ft) bs at the base of boring B18.

Vancouver Energy

Cultural Resources Geoarchaeological Investigation Report

EFSEC Application for Site Certification No. 2013-01

Docket No. EF131590

Appendix A

Boring Logs

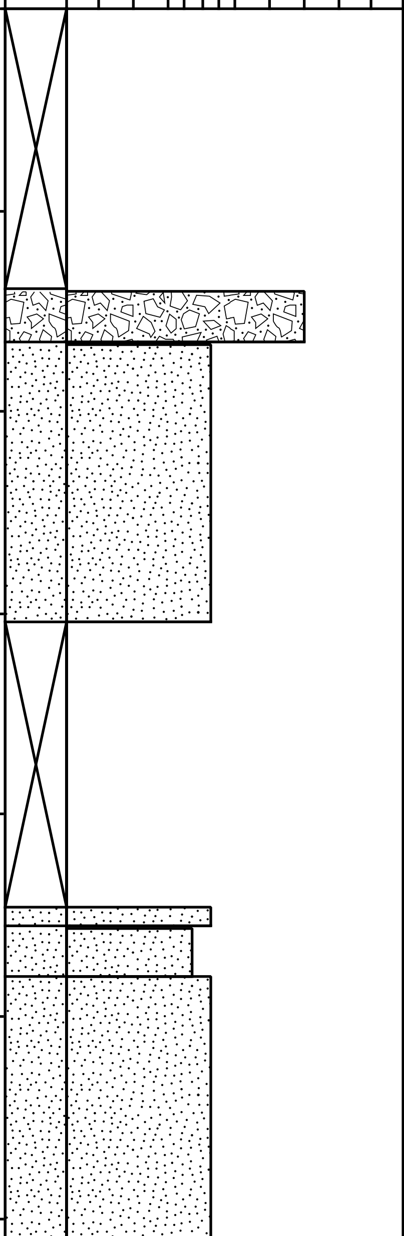
B1 / E. Hulse / 11-19-14
UNIT
SCALE (m)
LITHOLOGY
clay
silt
vf f m c vc
gran
pebb
cobb
boul
MUD
SAND
GRAVEL
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
2b
4
6b
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
S with few c grains, bands of Si at 1623-1624, 1636-1637, 1642-1643, 1645
10YR3/1
sbk-sg
fri-lo
poorly sorted with wood frags and 0.2 cm rounded white grains from 1496-1512, pumice & glassy frags present (unident. Mt. Hood tephra?)
10YR2/1
sg
lo
s.a. 1184-1220 but grayer
10YR3/1
sbk
fri
s.a. 1184-1220 but looser, more saturated, abrupt color change at 1473
10YR3/4
sbk
fri
s.a.a. but more Si color change at 1303
10YR3/1
sbk
fri
10YR4/2
sbk
fri
10YR4/2
sbk
fri
moderately well-sorted, rounded, 3 cm stone at 1174-1178, mc S at 1206-1207
10YR4/1
sbk
fri
10y4/2
sbk
fri
reddish brown, bands of mc S at 1027-1028, 1035-1036, 1040, 1061-1062
10YR3/6
sbk
fri
abrupt color change at 1015 cm
10y4/2
sbk
fri
poorly-sorted, rounded grains, band of mc S at 870-874, 890 and 907 cm
10YR4/1
sbk
fri
more firm, sbk than above (652-669), notable Fe mottles
10YR4/2
sbk
fi
10YR4/2
10YR4/2
10YR4/2
sbk
sbk
sbk
fi
fri
fi
10YR4/2
sbk
fri
10YR4/2
sbk
fi
10YR4/2
sbk
fi
10YR4/2
sbk
fi
10YR4/2
sbk
fri
Charcoal fleck, Fe mottling
10YR4/2
sbk
fi
10YR4/2
sbk
fri
Some Fe mottling
10YR4/2
sbk
fi
slightly sandier below 580 cm, few charcoal smears
10YR4/2
gr-sbk
fi
Fe mottling, few possible smears of charcoal, no inclusions, buried surface
10YR4/2
gr-sbk
fi
band of sbk CS from 282-284 and 289-290, c S from 294-296
10YR4/1
sg
lo
poorly sorted
10YR4/1
sg
lo
crushed concrete
sg
lo

B2 / D. Cox / 11-21-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	crushed rock to 3 cm	10YR3/2	gr	lo
	poorly sorted, med to fine grain	5Y5/1	gr, sg	fi
	up to 3 cm crushed rocks	10YR5/3	gr	lo
	occasional rock to 130 cm, poorly sorted	10YR6/2	sg, gr	lo
	poorly sorted, med. grain	10YR3/3	gr, sg	lo
	poorly sorted, coarse to med. grain	10YR4/2	gr, sg	lo
	poorly sorted, med to fine grain	10YR4/2	gr, sg	fi
6a	poorly sorted, slight silt banding	10YR5/4	sbk	fi-fri
	Iron staining, organic debris, Iron concretions at 443 (between silt)	10YR3/1	sbk	fi
	Probably slump, rock to 2 cm	10YR4/4	gr	lo
	poorly sorted, varies with slightly banded lens of med to coarse sands, no rock slightly lighter then slightly darker	10YR4/4	sg	lo
	Same Seds as above (different color), 732-734 silt band	10YR4/2	sg	lo
	Same Sediment, abrupt transition (color)	10YR4/2	sg	lo
		10YR3/1	sg	lo
		5Y3/1	sbk	fi
	Banded silts/sand lens, well-sorted fine sands (approx. 8 strips of silt/sand same color	5Y4/1	gr	fi
2b	moist, medium to fine grain	5Y3/1	gr-sg	fi
	moist, poorly sorted med & fine grain	5Y4/1	gr-sg	fi
		5Y4/1	gr-sg	fi
	saturated, fine to med coarser sand with depth, few small organics	5Y4/1	sg-gr	fi
	moist, poorly sorted, med grain	10YR4/1	sbk	fi
	moist, poorly sorted, med grain	10YR4/1	sbk	fi
	poorly sorted	10YR5/2	gr-sg	fi
	same seds, (color) grd tran	10YR5/2	gr-sg	fi
		10YR5/1	gr-sg	fi
	f Sand grains	5Y3/1	sg-gr	fi
		5Y3/1	sbk	fi
	end of boring	5Y3/1	sbk	fi

B3 / D. Cox / 11-21-14
UNIT
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay silt vf f m c vc gran pebb cobb boul
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
6b
6a
2b
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
rock/gravel/sands fill 10YR3/1 sg lo
Dredge sands 10YR4/1 sg lo
poorly sorted 10YR4/1 sg lo
10YR4/1 sg lo
10YR3/1 sg lo
10YR5/1 sg lo
10YR3/3 sbk fi-fri
moist, poorly sorted, decaying organic lens, grey color (10YR5/4) at 437-439 cm 10YR3/1 sg fi-fri
organics/wood 10YR2/1 gr f-fri
poorly sorted, medium to fine grain, few organics 10YR3/1 sg lo
poorly sorted, medium to coarse grain, few organics 10YR3/1 sg fi
3 cm alluvial gravels, poorly sorted, med grain coarsening sand with depth 10YR3/1 sg fi
few alluvial gravels, poorly sorted, coarse grain 10YR2/1 sg fi
organics (buried surface?) 10YR2/1 sbk fi
becoming saturated 10YR2/1 sbk fi
med to fine grain with bands of clay silt (10YR5/3) throughout (8-6-809), (824-827), (839-846) 10YR4/1 sbk fi
poorly sorted medium to coarse grain 10YR3/1 sg lo
moist, medium to fine grain 10YR4/1 sg lo
moist, medium with bands of coarse S, possible crossbedding 10YR3/1 sg lo
Fe oxidized 10YR4/1 sg lo
moist, poorly sorted, woody chunk at 1170-1173 (10YR3/6 above woody debris, 10YR5/3 below wood), gradual color grading, Fe oxidized at upper portion 10YR3/6, 10YR5/3 sg lo
poorly sorted, moist 10YR2/1 sg lo
moist, med to fine grains, poorly sorted 10YR2/1 sg lo
10YR2/1 sg lo
poorly sorted, few c grains and 1 cm pebbles 10YR2/1 sbk fri

B4 / D. Cox / 11-24-14

UNIT	SCALE (m)	LITHOLOGY	MUD SAND GRAVEL (clay, silt, vf, f, m, c, vc, gran, pebb, cobb, boul)	INCLUSIONS	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b					fill, poorly sorted, some silt	10YR4/1	sg	lo
					Banded sands, poorly sorted, coarse to medium grains, dark to light bands	10YR4/1	gr-sg	lo
	1							
	2							
						10YR4/1	gr-sg	lo
					poorly sorted, medium to fine grains	10YR3/2	gr-sg	lo
						10YR4/1	gr-sg	lo
	3							

B5 / K. Fuld and E. Hulse / 11-13-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	crushed stone and brick, crushed gravel	10YR7/1	sg	lo
6b	sand with 3cm subangular gravels, crushed stone at 126-130cm	10YR4/2	g-sg	fri
6b	poorly sorted, band of loose sg GS from 183-202 cm	10YR4/2	sg	lo
6b	black ashy material, may be contaminated, did not examine	10YR2/1	gr	fri
6b	did not examine	10YR2/1	gr	fri
6b	s.a. 168-193 cmbs, crushed stone/gravel from 413-419	10YR4/2	sg	lo
4	Fe stained, coarsens downwards	10YR3/2	sbk	fi
4	moist	10YR4/2	sbk	fri
4	dark from 514-520, gray from 520-528	10YR3/2?10YR2/2?1-0YR4/1	sbk	fri
4	moist, sorted into 0.4 cm layers, becomes more poorly- sorted with depth, vf S with broken stone/gravel at 544-547 cm	10YR1/2	gr-sg	fri
4	banded dark from 552-570 and 583-597; charcoal flecks throughout, broken 1 cm stone at 594 cm	10YR2/1, 10YR3/2	sbk	fri
4	546-609, charcoal at 672 cm, dark from 677-684	10YR3/2	sbk	fri
4	shattered concrete(?) or mortar at 698-699	10YR4/2	gr-sg	fri
4	dark from 715-718 and 729-733, charcoal at 745 and 757	10YR2/1, 10YR3/2	sbk	fri
4	coarsens downwards, poorly sorted sand, finely laminated with dark angular vesicular stone (basalt?) at 791-792	10YR4/2	sbk	fri
4	moist, well sorted, charcoal flecks at 820 and 869 cm, some light FE mottling at 884 and 910-912	10YR4/3	sbk	vfri
4	well sorted	10YR4/3-10YR4/2	sbk	fri
4	color change, wood from 989-996, plant frags at 1035 cm	5Y3/1	sbk	fri
3a	saturated, coarsens downards from vf to m grains, faint tan mottles at 1105-1108, plant frags at 1119-1120	5Y3/1	sbk	fri
3a	coarsens downwards from vf to mf, three distinct pinkish, glassy silt tan 0.4 cm Csi bands at top of strat, plant frags at 1145-1146	10YR6/3	sbk	fri
3a	fine-mf, plant frags at 1162-1163	10YR4/1-5Y3/1	sbk	fri
3a	wood at 1176-1180	10YR4/1	sbk	fri
3a		10YR4/1	sbk	fri
2b	fines downwards to vf from mf	5Y3/1	sbk	fri
2b	moist, coarsens downwards from fm to poorly sorted fmc S, dark, sg-gr from from 1324-1331, vf from 1357-1359, plant material at 1329-1330	5Y3/1	sbk	vfri
2b	saturated, with gray Si particles, break	5Y3/1	gr	fri
2b	break	5Y3/1	gr	fri
2b	Si decreases with depth, notable mica flecks below 1500	5Y3/1	gr	fri
2b	poorly sorted fmS, mica flecks, darker 1cm bands below 1650 cm	5Y2.5/1	gr	fri


B6 / E. Hulse / 11-17-14
UNIT
2b
3a
3b
4
6b
SCALE (m)
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
LITHOLOGY
MUD
clay
silt
SAND
vf f m c vc
GRAVEL
gran
pebb
cobb
boul
INCLUSIONS
NOTES
may be slump?
with wood frags--same wood as in 1365-1372?
mostly fm grains
moderately well-sorted
wood, water-logged
poorly sorted, notable 0.2 cm subangular coarse grains
poorly sorted
poorly sorted
common plant frags
well-sorted, plant frags below 1185
with laminae of plant frags
poorly sorted
saturated
well-sorted, mica, fines downwards
wet, poorly-sorted fmc, color change at 10-20 cm
well-sorted, plant frag at 985 cm
some Fe mottles
saturated, plastic/massive
saturated, coarsens downwards to SIsk, vfSiS
SiS from 675-730, fs from 730-745
coarsens downwards to weakly sbk, fri, fS
with mica coarsens downwards to vfri weakly sbk, fS
coarsens downwards to fri, sbk, vfS, silty A horizon?
well-sorted
poorly sorted, one subrounded gravel (2 cm) at 147 cm
poorly sorted with 20% rounded and angular 1 cm gravels
rounded-subrounded, 0.5-1 cm
plastic end cap from liner trapped at 85 cm, color change from 85-95 cm
MUNSELL
5Y2.5/1
5Y2.5/1
5Y2.5/1
5Y2.5/1
5Y3/1
5Y2.5/1
5Y3/1
5Y2.5/2
5Y2.5/1
Gley1 2.5/N
5Y2.5/1
5Y2.5/1
5Y3/1-5Y2.5/1
10YR4/3
10YR4/2
10YR4/2
10YR4/2
10YR4/2
10YR4/2
10YR4/2
10YR4/2
10YR4/2
10YR5/2
10YR6/2
10YR3/2-10YR4/2
5Y2.5/1
10YR4/2
10YR4/2
10YR3/2
10YR3/3
10YR3/3-10YR6/1
STRUCTURE
sg
n.a.
sbk
sg
sg
sbk
sg
sbk
sbk
sbk
sg
sbk
sbk
fri
sbk
abk
sbk
gr-sg
CONSISTENCY
lo
n.a.
fri
fri-fi
fri
v fri
plas-tic
fi
vfri
vfi

B7 / E. Hulse / 11-17-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b		10YR3/2	gr-sg	lo
6b	ashy	10YR7/1	sg-gr	lo
6b	well-sorted	10YR4/2	sg	lo
6b		10YR4/4	abl	fi
6b	poorly-sorted, few lenses of vf SiS	10YR4/2	sg	lo
6b		10YR4/2	sg	lo
6b	shattered stone in lo sg vfSiS	10YR4/2	sg	lo
6b	40% 0.5-1 cm angular gravels	10YR3/2	sg	lo
6b	well-sorted with bands of poorly sorted fmc S,	10YR3/1	sg	lo
6b	malleable, oxidized at 298-299 cm	10YR3/2	abk	fi
6b	fill	10YR3/2	abk	fi
6b	poorly-sorted with subangular 0.5-1cm gravels	10YR4/2	sbk	fi
6b	40% subrounded 1-2 cm gravels	10YR3/7	gr	fi
4	Fe mottles	10YR3/2	sbk	fri
4	coarsens downwards to vfS	10YR4/3	abk	fi
4	coarsens downwards to lo sg fs	10YR6/2	sbk	fri
4	fines downwards to sbk, fri, vf SiS	10YR5/2	sg	lo
4	coarsens downwards to well-sorted vf S	10YR3/2	sbk	fri
4	coarsens downwards to fri sbk fS	10YR4/2	sbk	fri
4	well-sorted	10YR4/2	sbk	fri
4	well-sorted, fines downwards from 723-724	10YR4/2	sbk	fri
4		10YR4/2	sbk	fri
4	Fe mottles, fines downwards from 756-757	10YR5/2,10YR3/6	sbk	fri
4		10YR4/3	sbk	fri
4		10YR4/2	sbk	fri
4	with Fe mottles, coarsens downwards to fri, sbk, fS from 906 to 907	10YR4/2	sbk	fri
3a		10YR4/2	sbk	fri
3a	saturated and loose from 930-970 cm, coarsens downwards slightly, charcoal or wood at 1000 cm	5Y3/2	sbk	fri
3a	coarser from 1015 to 1017 and 1020 to 1022, wood at 1014	5Y3/1	sbk	vfri
3a	well-sorted	5Y2.5/1	sg	lo
3a	S with few plant/wood fragms, coarsens to mS from 1062-1064	5Y3/1	sbk	fri
3a	saturated	5Y3/1	sg	lo
3a	saturated, plant frags at 1105, and 1124-1132	5Y3/1	sbk	lo
3a	wood plant frag at 1143 cm, saturated	5Y3/1	sbk	v fri
3a	color change, saturated, small plant frags	10YR3/1	sbk	fri
3a	coarsens downwards to fm sbk S, pinkish lens of Si at 1183-1184--diatomaceous glassy Si	5Y2.5/1, 2.5YR6/2	sbk	v fri
2b	some mica	5Y3/1	sbk	fi
2b	poorly sorted, with some Si, variable composition, wet	5Y4/1	sg	lo
2b	coarsens downwards to m moderately well-sorted S, wood frag at 1279 cm	5Y4/1	sbk	fri
2b	poorly sorted, common f S from 1286-1287 cm coarsens downwards to C S from 1292-1294, then fines	5Y2.5/1	sg	lo
2b	well-sorted, with wood from 1298-1307 cm	5Y3/1	sbk	fri
2b	lenses of vf SiS at 1319-1321 and 1324-1325, subrounded pebbles at 1329-1330, dark (5Y2.5/1) bands of sand below 1350 cm, pale coarse lapilli from 1359-1362cm--pumiceous, volcanic, no discrete glassy shards--in 3 separate laminae. Like MSH set Y tephra.	5Y3/1	sbk	fri
2b	poorly sorted with few sbk 0.5 cm pebbles, mica flecks, saturated	5Y2.5/1	sg	lo

B8 / E. Hulse / 11-18-14

UNIT | SCALE (m) | LITHOLOGY | MUD SAND GRAVEL | INCLUSIONS | NOTES | MUNSELL | STRUCTURE | CONSISTENCY

Units: 6b (top), 4, 3a, 2b

Notes	Munsell	Structure	Consistency
0.5-1 cm angular gravels	10YR3/3	sg-gr	lo
crushed concrete/stone, pale Si powder, some brick	10YR7/1	gr-sg	vfri
poorly-sorted (dredge fill), lenses of Si, Fe oxide at 130 and 135 cm	10YR4/2	gr-sg	fri
like 85-152 cm, poorly sorted, few coarse grains, no Si, banding from 262-283 cm	10YR4/2-10YR3/2	gr-sg	vfri
dark with plant frags from 283-291, Fe mottling, below 291 cm, buried A/native sed.	10YR3/1-10YR3/3	abk	fi
well-sorted, coarsens downwards at 388 cm to well worted homogeneous fS, weakly sbk, vfri	10YR3/4-10YR5/2	sbk	fi
well-sorted	10YR4/2	sbk	fri
some Fe mottles, coarsens downwards to vfS	10YR4/2	sbk	fri
friable, coarsens downwards	10YR4/2	sg	lo
fines downwards	10YR5/3	sg-sbk	lo-fri
some redox mottles from 605-609 cm	10YR4/2	sbk	fri
coarsens to vfs at 691 cm, faint Fe mottling	10YR4/2	sbk	fri
oxidized, fines downwards from 725-730 cm	10YR5/2	sbk	vfri
coarsens downwards to fS	10YR4/2	sbk	fri
	10YR4/2	sbk	fri
Fe mottling, coarsens downwards to vf SiS	10YR4/3	abk	fi
Coarsens downwards	10YR4/2	sbk	fri
	10YR4/2	sbk	fri
	10YR4/2	sbk	fri
	10YR4/2	sbk	fri
	5Y4/2	sbk	fri
	10YR4/2	sbk	fri
plant frags	5Y2.5/1	sbk	fri
	5Y3/1	sbk	fri
few plant frags.	5Y3/1	sbk	fri
saturated, many wood to plant frags from 998-1005, and 1018-1022, and 1028-1030	5Y3/1	sbk	fri
poorly-sorted	5Y3/1	sg	lo
plant frags at 1042 and 1049	5Y3/1	sbk	fri
poorly-sorted, few coarse grains, wet	5Y3/1	sg	lo
Si around plant frag at 1161 cm	5Y2.5/1	sg	lo
wet, wood	5Y3/1	sg	lo
well-sorted, wet, Si from 1212-1215	5Y3/1	sbk	v fri
color change	10YR4/2	sbk	fri
fairly well-sorted	5Y3/1	sg	lo
mostly S, some Si	5Y3/1	sg	lo
pinkish lens	2.5YR5/2	sg	fri
less well-sorted, wet, common angular reddish grains	5Y3/1	sg	lo
	5Y3/1	abk	fri
few lenses of Si, large mica flakes	5Y3/1	sg	lo
poorly sorted, wet, few C grains, 1 g mica flakes, few 0.5 cm rounded pebbles at 1474 cm, coarsens at 1505-1510	5Y3/1	sg	lo
wood frags mixed with white rounded pumice lapilli, MSH set Y tephra	5Y2.5/1	sg	lo
moderately well-sorted	5Y3/1	sg	lo
moderately well-sorted, lens of 10YR4/3 brown f SiS at 1585-1588 --no apparent tephra--occasional lenses of Si, end of boring	5Y3/1	sg	lo

B9 / E. Hulse / 11-18-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
	0.5-1 cm angular gravels	10YR4/2	sg-gr	lo
	crushed concrete, dusty white Si, angular gravels	10YR7/1		
	dredge fill, poorly sorted, mixed with clasts of SSI common 1-2 cm angular G, some brick frags	10YR4/2	gr	fri
	poorly sorted	10YR4/2	sg-gr	vfri
		10YR4/2	sg-gr	vfri
	20% angular gravels, Fe oxidation from 396-397	10YR3/4-5Y3/1	gr	fri
4	plant frags at 396-397 cm (buried surface), charcoal at 415 cm, coarsens to vfs from 415-420 cm, abrupt color change but no texture change	5Y3/1	abk	fri
4	common Fe mottles, charcoal at 434 cm	10YR3/4	sbk-gr	fi
4	coarsens downwards to fri, sbk, fS	10YR4/4 10YR5/3	sbk sbk	fri fri
4		10YR4/2	abk	fi
4	oxidized	10YR3/4	sbk	fri
4		10YR4/2	sbk	fri
4	band of SSi from 750-752 cm, color change but not texture change at 754 cm	10YR4/3	sbk	fri
4		5Y3/1	abk	fi
3a	alternating 3cm bands, saturated	5Y3/1	sbk	fri
3a	charcoal at 890 cm	5Y2.5/1	sbk	fri
3a	plant frags at 952 cm	5Y3/1	sbk	fri
3a	well-sorted	5Y3/1	sg-gr	lo
3a	saturated	5Y3/1	sbk	vfri
3b	plant frags at 1058 cm	5Y3/1	sbk	vfri
3a	wet, mottled with Si from 1150-1160 cm	Gley 1 3/N	sg	lo
2b	poorly-sorted, mottled with clasts/lenses of vf S and Si	Gley 1 3/N	sbk	fri
2b	poorly-sorted, common reddish grains--red grains are volcanic--	Gley 1 2.5/N	sg	lo
2b	greenish, well sorted with few reddish grains	Gley 1 2.5/5GY	sg	lo
2b	poorly-sorted with rounded pebbles at 1256-1258 cm	Gley 1 4/N	sg	lo
2b	well-sorted	Gley 1 4/N	sg	lo
2b	poorly -sorted with common reddish grains, few 0;5 cm subrounded pebbles	Gley 1 2.5/N	sg	lo
2b	no inclusions, end of boring	Gley 1 3/N	sg	lo

B10 / E. Hulse / 11-19-14
UNIT
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay silt vf f m c vc gran pebb cobb boul
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
6b
5a
4
3a
3b
3a
2b
1 cm angular gravels
10YR4/2
gr-sg
lo
poorly-sorted sand, gray from 82-91, Fe oxidized from 91-94, lenses of very fine S below 140 cm
10YR4/3?10YR3/1?1-0YR3/4?10YR4/2?10-YR4/3
gr
v fri
lenses of very fine sand
10YR4/3
well-sorted
10YR4/2
color change
5Y3/1
poorly-sorted, color change at 95 cm
plant frags.
Gley1 2.5/N
abk
color change from 408-417, Fe oxidation at 417, coarsens downwards to SiCS from 431-435
10YR4/2-10YR3/1-10-YR4/2
wet
10YR4/3
soft/-fri
well-sorted, fines downwards from 596-610 (more vf SiS)
10YR5/3-10YR4/4
coarsens downwards
fine sand grains increase with depth
fi?fri
fri/s-oft
weakly sbk
Fe mottling increases
Fe mottling
color change
gray, saturated
5Y3/1
v soft
plant frags, coarsens downwards to fSSi
soft/-fri
coarsens downwards , saturated
Gley 1 2.5/N
with plant frags
wood fragments at 1287-1288, 1303
5Y2.5/1
Gley 1 3/N
alternating bands of well-sorted mS with poorly sorted fmc S, very dark from 1333 to base, wood frags at 1323 cm
Gley 1 2.5/N
sg
alternating bands of well-sorted mS with poorly sorted fmc S, CSi from 1402-1403cm, bluish oxidation from 1423-1469, bands of CS stop at 1492
alternating bands of well-sorted mS with poorly sorted fmc S, bluish oxidation from 1539-1606, wood frags at 1613-1666, large mica flakes below 1613, end of boring

B11 / D. Cox / 11-19-14

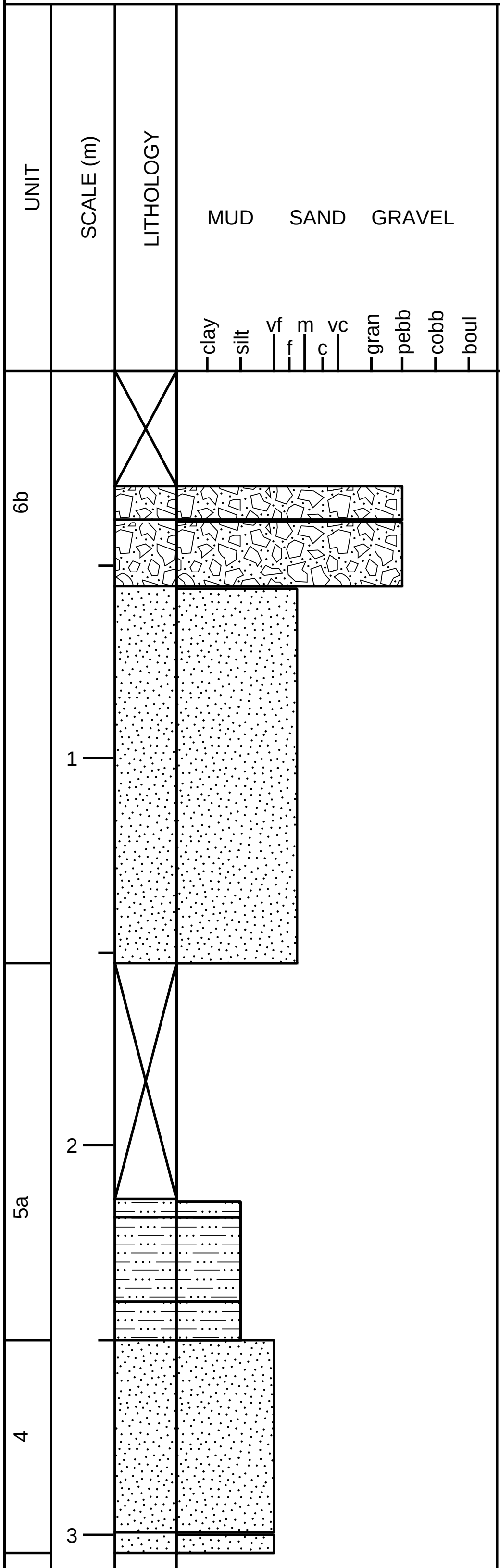
B12 / E. Hulse / 11-21-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b		10YR2/1	sg	lo
	light, angular grains	10YR5/1	sg	lo
	fmc grains, 20% gravel	10YR3/1	gr	fri
	Crushed concrete, white poorly sorted, 10% angular, subagnular 2 cm pebbles	10YR3/2	gr	fi
	poorly sorted, layered with friable SiS	10YR3/2	sg	lo
	poorly sorted, 10% C grains	10YR3/1	sg	lo
4	gr below 293 cm	10YR3/2	abk	fi
	Well-sorted, finely banded lighter and darker	10YR4/2	sbk	fri
	some mica, well-sorted	10YR5/2	sbk-sg	fri
	faint banding	10YR5/3	sbk-sg	fri
3a	Si increases from 685-686 coarsens downwards	10YR4/3 10YR4/3	sbk-sg sg	fri fi-fri
	coarsens downwards over longer interval	10YR4/3	sg	fi-fri
		10YR3/2	sg	fi-fri
	some Fe mottling	10YR3/2	sg	fi-fri
	some Fe mottling	10YR3/2	sg	fi-fri
		10YR4/2	sg	lo
		10YR4/2	sbk	fri
3b	Fe mottled, decayed organics at 866 cm	10YR4/2	sbk	fri
	Sandier from 880-882 and 899-901, common plant frags below 890, wood frag at 893-895	Gley 1 3/N	abk	fri
	868-915, coarsens at 1009-1014	Gley 1 3/N	abk	fri
		Gley 1 3/N	abk	fri
3a	saturated wood frag at 1063	5Y4/1 Gley 1 3/N	sbk sbk	fri fri
		Gley 1 3/N	sbk	fri
	plant frags., coarsens downwards	Gley 1 3/N	sbk	fri
2b	banded, alternates, coarse from 1177-1178, 1185-1188, 1195-1197, 1205-1209	Gley 1 3/N	abk	fri
	poorly sorted, coarsens downwards	Gley 1 2.5/N	sg	lo
	S less coarse than above, fines downwards, banded, Si from 1325-1327, poorly sorted fmc S from 1249-1272, end of boring	Gley 1 3/N	sg	lo

B13 / E. Hulse / 11-24-14
UNIT
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
6b
1
2
3
4
5
6
7
8
9
10
11
12
13
4
3a
2b
angular 1-2 cm gravels
10YR4/2 gr fri
poorly sorted, angular stone at 141 cm and 129 cm
10YR3/2 sbk vfri
10YR3/2 sbk vfri
mica flecks, wood/plant frags at 305 cm (decomposed)
10YR4/2 sbk fi
Fe mottling, likely A horizon, coarsens downwards
10YR3/3 sbk fri
well-sorted, faintly banded
10YR5/3 sbk fi
Fines downwards
10YR4/3 sbk fri
10YR4/3 abk fri
well-sorted
10YR4/3 sbk vfri
10YR4/3 abk fi
10YR5/3 sbk vfri
10YR5/3 sbk vfri
CSi with redox mottles, coarsens downwards
10YR4/2 abk-sbk fi
moist, well-sorted, oxidized
10YR4/2 sbk fri
10YR4/2 sbk fri
Fe mottles, increase in vf S with depth
10YR4/2 abk fi
redox mottles
10YR4/2 sbk fri
10YR4/2 sbk fri
10YR4/2 abk fri
10YR4/2 sbk fri
10YR4/2 sbk fri
redox mottles, color change
10YR4/1 abk fri
5Y2.5/1 abk fi
saturated
5Y2.5/1 sbk fri
coarsens downwards
5Y2.5/1 sbk fri
5Y2.5/1 sbk fri
plant frag.
5Y2.5/1 sbk fri
5Y2.5/1 sbk fri
5Y2.5/1 sbk fri
5Y2.5/1 sbk fri
5Y2.5/1 sbk fri
saturated, vc S present below 1100 cm
5Y3/1 sg lo
poorly sorted, many vf and vc grains
5Y3/1 sg lo
saturated
poorly sorted, banded fine and coarse
5Y3/1 sbk fri
poorly sorted
5Y3/1 sg lo
poorly sorted, fmc to 1200 cm, then moderately well sorted fm S below 1200 cm with few fine bands of coarser grains
5Y3/1-Gley 1 2.5/N-Gley 1 3/N sg lo
poorly sorted
Gley1 3/N sg lo
well-sorted, banded with poorly sorted fmc S from 1274-1285, 1303-1313, 1338, 1343-1344, 1350, 1363, end of boring
Gley1 3/N sbk fri

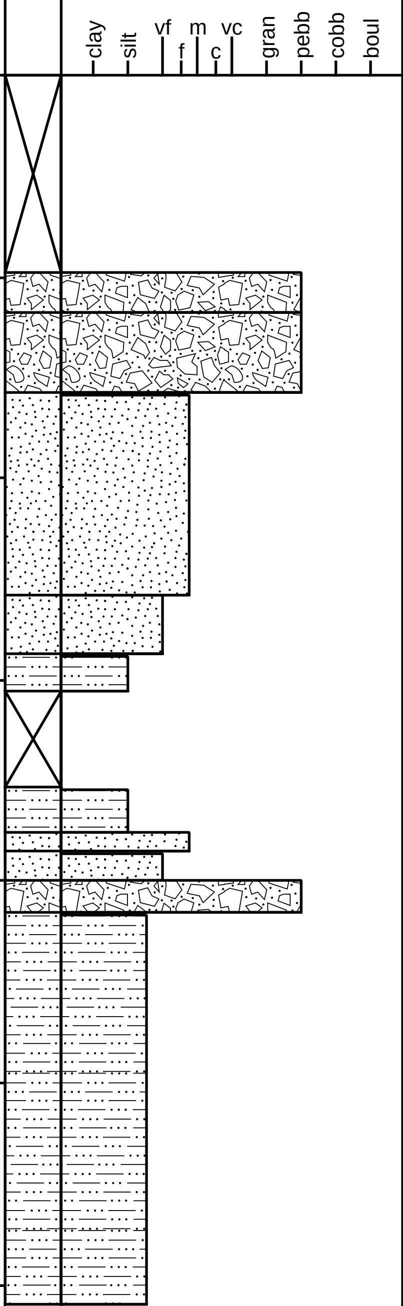
B14 / E. Hulse / 11-24-14

B15 / E. Hulse / 11-13-14



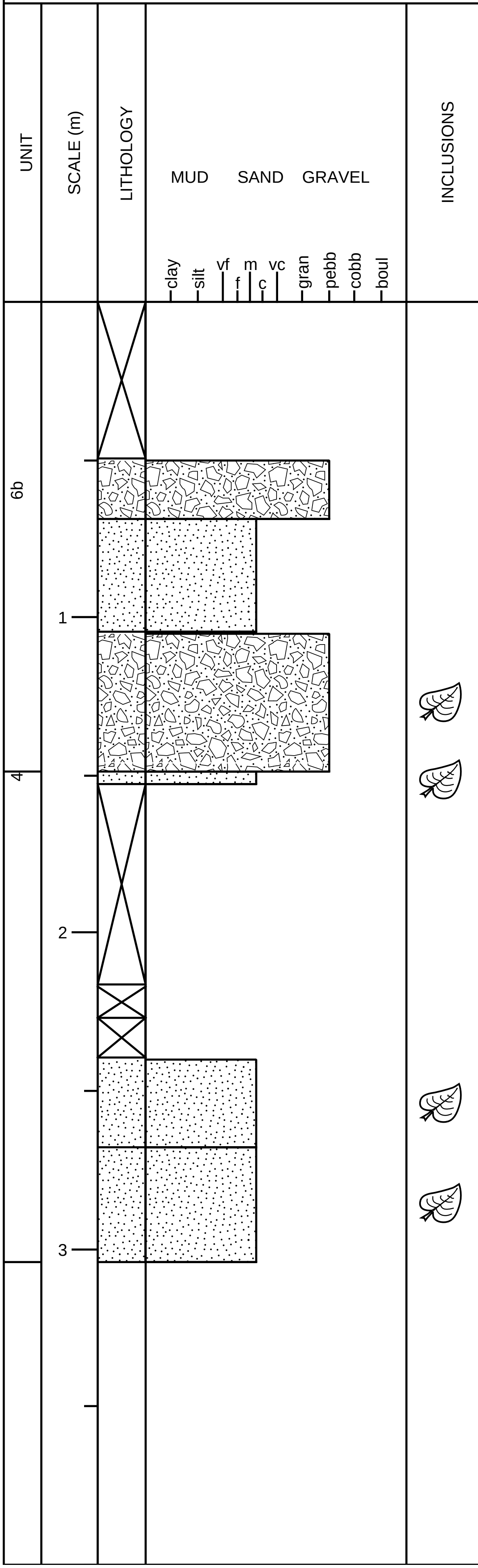
UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	black, road/asphalt	10YR2/1	gr	lo
6b	pale brown	10YR4/2	gr	vfri
6b	Sand with some gravel	10YR4/2	sg	lo
5a		10YR4/2	sbk	fi
5a		10YR4/1	sbk	fi
5a		10YR2/2	sbk	fi
4		10YR4/4	sbk	fri
4		10YR4/3	sbk	fri

B16 / E. Hulse / 11-12-14



UNIT	SCALE (m)	INCLUSIONS	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b			angular SiSG	10YR2/1	sg	lo
			pale, angular gravels in vf SiS	10YR7/1	gr	lo-vfri
			S w/ some C grains, dark band of Si at 122 cm	10YR4/1	sg	lo
	1					
				10YR3/1	abk	fri
				10YR2/1	abk	fri
				10YR2/1	abk	fri
				10YR4/1	sg	lo
	2		pale	10YR7/1	sg	lo
			angular grains	10YR2/1	sg	lo
5a			poss. truncated A horizon from 208-213, many plant frags	10YR4/3	sbk	fri
						
	3					

B17 / E. Hulse / 11-24-14



NOTES	MUNSELL	STRUCTURE	CONSISTENCY
black, asphalt	10YR2/1	gr	vfri
poorly sorted with band of vfi CSi at 87-93 cm	10YR4/2	sg	lo
20% subrounded 1-2 cm gravels, plant frags, color change at 108 cm	10YR3/4?10YR2/1	gr	fri
poorly sorted, plant frags	10YR5/1	sg	lo
plant frags	5Y3/1	sg	lo
plant frags, coarsens from 297-302 cm	5Y3/1	sbk	fri

B18 / D. Cox / 11-12-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	poorly sorted, organics	10YR4/1	sg	lo
6b	poorly sorted, few crushed rocks 70-90	10YR4/2	sg	lo
6b	—	10YR4/2	sg	lo
6b	Graveliest to 2 cm, color transition	10YR3/2	sbk	fi
6b	color change between 230-233 to 10YR3/2	10YR4/1	sbk	fi
6b	—	10YR5/4	abk	fi
6b	—	10YR6/1	sg	lo
5a	mottled, very few very fine rootlets, iron stain	10YR4/1	sbk	vfi
5a	color transition, very few fine rootlets, some fri structure	10YR5/2	sbk	fi
5a	very fine rootlets	10YR5/3	sbk	vfi
5a	no rootlets	10YR4/2	sbk	vfi
5a	portions friable consistence	10YR5/3	sbk	fi
5a	Dry, many rootlets and organic debris, some fine sands; nice buried landform	10YR3/1	sbk	fri
5a	Moist	10YR3/1	sbk	fri
5a	rootlets, mottles dark and lighter	10YR4/1	sbk	fi
5a	Few rootlets	5Y4/1	sbk	fi
5a	no rootlets, color transition	10YR3/1	sbk	fi
5a	Fe staining, saturated	10YR5/2	sbk	fi
5a	Saturated, increase in fine sands	10YR5/2	sbk	fi
5a	Less fine sands, saturated	10YR5/2	sbk	fi
5a	—	10YR5/2	sbk	fi
2b	Bands of heavy iron concentrations, moist to saturated, color transition, medium to fine grains	10YR4/1	sg	fi
2b	seds without iron staining, saturated	10YR3/1	sg	fi
2a	woody pieces, very few fine rootlets	5Y3/1	sbk	fi
2a	Some clays, occassional small woody pieces(organics)	10YR3/2	sbk	fi
2a	Some areas with more fine sands, no visible organics	10YR3/2	sbk	fi
2a	moist	10YR3/2	sbk	fi
2a	dry	10YR3/2	sbk	fi
2a	dry, organic debris, very few, very fine rootlets	10YR3/2	sbk	fi
2a	dry, no organics	10YR3/1	sbk	fi
1	dry, sub rounded alluvial gravels up to 3 cm, some organics	10YR3/1	sbk	fri
1	—	10YR3/1	gr	fi
1	poorly-sorted; from 1595-1625 rounded 1 cm pebbles, common below 1645; some Si at base of 1652	10YR3/1	sg	lo
1	rounded 1-2 cm pebbles with coarse sand, end of boring	10YR3/1	sg	lo

Unit	Notes	Munsell	Structure	Consistency
6b	fmc angular grains, 1-3 cm angular gravels, lighter from 77-86	10YR2/1 w/ 10YR4/1 band	sg	lo
6b	well-sorted, SiG from 109-113; few rounded 0.5 cm pebbles	10YR3/1	sg	lo
6b	rounded 1-4 cm gravels common below 134 cm	10YR3/3	sbk	fri
6b	shattered stone at 270-277 cm	10YR4/1	gr	fri
5b	many roots, rootlets, buried historic surface	10YR3/1	sbk	fri
5b	slump? Few rounded pebbles	10YR3/1	gr-sbk	fi
5b	vf grains, shattered stone at 397-398 cm, rootlets from 400-403,	5Y2.5/2	sbk	fi
5a	dark A horizon from 403-428, becomes gray, vfS grains	5Y2/1?5Y3/1	abk	fi
5a	coarsens downwards to vf SiS with mica , saturated from 569-595, slightly oxidized	10YR4/1?10YR4/3	abk-sbk	fi
2b	saturated, well-sorted; plant frags at 799 cm and 808 cm; band of f-m S from 807-813, fines downward to f/vf S again	5Y3/1	sbk	fri
2a	vf S grains, plant frags, esp. at 835 cm and 846 cm; vf SiS from 898-904 and 848-874 (coarsens dowards, then repeats sequence)	5Y3/1	sbk	fri
2a	mica flecks	5Y3/1	sbk	fri
2a	few vf S grains & mica flecks, homogeneous	5Y3/1	abk	fri, pl
1	many roots, plant frags, coasening downwards	5Y3/1	abk	fi, pl
1	small plant frags throughout	5Y3/1	sbk	fi-fri
1		5Y3/1	sbk	fi, sl-ightl-y pl
1		5Y3/1	sbk	fi, sl-ightl-y pl
1	west, vf grain S, some mica	5Y3/1	sbk	pl
1	coarsens downwards	5Y3/1	gr-sbk	fri-fi
1	coarsens downwards, few 0.25 cm rounded pebbles	5Y3/1	sbk	fri
1	poorly-sorted, coarsens downwards, angular-subangular grains, lens of fm SiS at 1482-1485 cm, subrounded 1-3 cm pebbles common below 1494 cm. SiS lens not homogeneous in composition. May be volcanic in origin but doesn't look like tephra.	5Y3/1	sg	lo


B20 / D. Cox / 11-12-14
UNIT
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
6b
5b
5a
2b
2a
1
1
2
3
4
5
6
7
8
9
10
11
12
13
10YR2/1 sg lo
poorly sorted, crushed rocks, sands
10YR4/3 gr fi-fri
crushed rocks, sands, silts
10YR3/2 sbk fi
10YR7/1 sg-gr fi
10YR3/1 sbk fi
Plug from Geoprobe shoe; slump
10YR3/1 sbk fi
poorly sorted, slump, dry, wood and organics, rootlets, small brick or burned earth, quatzite
10YR3/1 sg-gr lo
buried surface
10YR2/1 sbk fi-fri
no visible organics, moist/saturated
10YR2/1 sbk fi-fri
dry, few rootlets
10YR2/1 sbk fi-fri
some clays, fining down and lightening, color transition
10YR2/1 sbk fi
lightening and iron staining beginning, few rootlets
10YR4/1 sbk fi
iron staining, few rootlets
10YR4/3 sbk fi
Slightly less plastic, color transition
10YR4/3 sbk fi
5Y3/1 sbk fi
Few rootlets
5Y3/1 sbk fi
Wood debris collected at 825 cm
5Y4/1 sg-gr fi
Slightly more silt
5Y5/1 sg-gr fi
no visible rootlets
5Y3/1 sbk fi
No organics, No iron, some greenish staining
5Y5/1 sbk fi
A few organics near 1170, coarsens downwards to f S
5Y5/1 sbk fi
moist, some silt, some organics
5Y5/1 sg fi
Woody debris at transition from above, no visible rootlets
5Y5/1 sbk fi
Rounded 1 cm pebble at 1299 cm, coarsens downwards to fmc poorly sorted S at 1355 cm, rounded 2 cm pebble at 1370 cm, end of boring
5Y2.5/1 sbk sbk

B21 / E. Hulse and K. Fuld / 11-7-14

B22 / E. Hulse and D. Cox / 11-4-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	Rounded fill gravels in coarse sand matrix	10YR3/2	sg	lo
	poorly-sorted	10YR4/1	sg-gr	fri
	poorly-sorted	10YR3/2	sg-gr	fri
	poorly-sorted	2.5Y3/1	sg-gr	fri
		2.5/3/1	sg-gr	fri
		10YR3/3	sbk	fi
	40% rounded gravels (0.5-4 cm)	10YR3/2	sbk	fi
	0.5-2 cm rounded gravels in matrix	10YR3/1	gr	fri
		10YR3/1	gr	fri
		10YR4/1	sbk-gr	fri
	oxidized, few 3 cm rounded pebbles	10YR3/3	sgk-gr	fri
	few 3 cm rounded pebbles	10YR4/1	abk	fi
	poorly-sorted, few 1 cm rounded pebbles	2.5Y3/1	gr	fri
	poorly-sorted	2.5Y5/1	sg	lo
5a	roots/rootlets, buried surface	10YR3/1	sbk	fri
	many rootlets	10YR2/1	sbk-gr	fi-fri
	color change	10YR2/2	sbk-gr	fi-fri
	color change	10YR2/1	sbk-gr	fi-fri
	increased clay, decrease in sand	10YR3/1	sbk-gr	fi-fri
	some oxidized mottling, below 530 very few to no rootlets	10YR4/1	abk	fi
	increasing clays with depth	2.5YR4/1	sbk	fi
	mottled, very few fine rootlets,	10YR4/1, 10YR4/2	sbk	fi
	moist (saturated)	10YR4/2	sbk	fi
2a	mottled, very few fine rootlets, increase in iron accumulation with depth	10YR5/2 w/ 2.5Y5/1	sbk	fi
	Tephra, like MSH set Y	2.5Y7/1	gr	fri
	No rootlets, organic enrichment	10YR3/1	abk	vfi
	No rootlets, increase in iron with depth	10YR4/2	abk	fi
	CSi w/ vf S	10YR4/2	mass	fi
	Mineral concentrations--1/8& 3/16	10YR3/3	sbk	fi
1	poorly sorted, no rootlets, saturated	10YR4/2	mass	fi
	poorly sorted, slightly smaller grained than above, no rootlets	10YR3/1	sg	fi
	poorly sorted, mottled, no rootlets, band of Fe oxidation (10YR5/3) at 1006-1010 cm	10YR3/1	sg	fi
	Same sediments, no redox	10YR3/1	sg	fi
	slump, saturated, poorly sorted, variable composition	10YR3/1	sg	fri
	poorly sorted, variable composition, laminae (0.25-0.5 cm) wide	10YR3/1	sg	fri
	color change and increased fine particle component; poorly sorted sand	10YR4/1	sg	fri
	poorly-sorted, Si mud in spaces between grains, increasingly compact with depth; did mud forced in by Geoprobe?	10YR3/3	sg	lo-fri
	poorly sorted; coarse angular grains, variable composition, rounded 2 cm pebble at 1335 cm	10YR2/1	sg	fri-fi
	medium to coarse sands, subrounded to subangular gravels up to 3 cm, some brown silt integrated into sands (may be due to Geoprobing), poorly sorted	10YR4/1	sg	fri
	Same sediments without brown silt sediments, increase in coarse sands, poorly sorted	10YR2/1	sg	fri
	poorly-sorted, wet, variable composition, angular rounded grains. No rocks? May be slump at bottome of core from sitting overnight, end of boring	10YR2/1	sg	fri

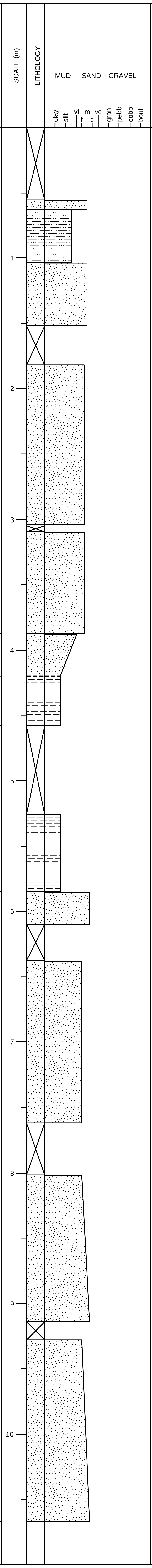
B23 / E. Hulse / 11-5-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	Gravel (2 cm)	10YR2/2	gr	fri
6b	lenses of gravel and coarse sand, rootlets, burned material	2.5Y3/3	sbk	fi
6b	Gravel (2-3 cm)	2.5Y3/2	gr	fi-h
6b	poorly sorted, angular, 0.25-3 cm	10YR3/1	sg	lo
6b	SCSi with 50% subrounded 0.25-2 cm gravels	10YR4/1	gr	fri
6b	Angular gravels 0.25-1.0 cm	10YR3/1	sg	lo
6b	SG with brick	10YR4/2	gr	fri
6b	coarse grained	10YR3/2	gr	fri
6b	angular 2 cm gravels in med grain sand matrix	10YR3/1	sg	fri
6b	well-sorted	5Y4/1	sbk	fi
6b		5Y4/1	abk	fi
6b	like 404-409	5Y3/1	sbk	fi
6b	like 409-415	10YR3/1	abk	fi
6b	poorly sorted, rounded 1 cm pebble at 432 cm	10YR3/1	gr	fri
6b	like 421-426, rootlet visible at 438 cm	10YR3/1	abk	fi
6b	poorly sorted with 3 cm pebbles, some clay on pebbles	10YR3/1	gr	fri
6b	well-sorted, sand with silt, silt laminae (0.5 cm)	5Y3/1	gr	fri
5b	well-sorted, many rootlets, likely historic surface	5Y3/1	sg	lo
5b	color change	5Y2.5/1	sg	lo
5b	color change, root at 553 cm, fining downward (most notably from 563-565 cm)	GLEY 1 2.5/N	sg	lo
5b	fine rootlets	10YR3/1	sbk	fri
5b	moist, coarsens downwards from vf at top to med at base, well-sorted	GLEY 1 3/N	sg	lo
5b	some organic flecks at 587 cm	GLEY 1 3/N	sbk	fri
5b	mica flecks, well-sorted	GLEY 1 3/N	sbk	fri
2a	sandy band from 600-601, dark laminae at 603 and 605 and 608; Gley 1 4/N with 10YR2/1	GLEY 1 4/N	abk	fri
2a	may be slump, dark laminae; Gley 1 4/N with 10YR2/1 bands	Gley 1 4/N	sbk	fi
2a	not slump, predominantely 10YR2/1 with bands of GLEY 1 4/N, coarsens downwards to vf Ssi at 635 cm, mica flecks	10YR2/1	sbk	fi
2a	banded with lighter red ox 10YR4/1, mottles (0.2 cm FE concentration), ? 10YR1/4 downwareds	10YR3/1	abk	fi
2a	with increasingly red redox mottles with depth, visible pores	10YR4/1?10YR4/4	sbk	fi
2a	s.a. 662-762	10YR4/2	sbk	fi
2a	s.a.a. without oxidized Fe component, flecks of dark organics,	10YR3/1	sbk	fi
1	s.a.a. but dark, (lightens downwards)	10YR2/1	sbk	fi
1	s.a.a. but color like 662-762, 10YR3/1 with 10YR4/4	10YR3/1	sbk	fi
1	very sandy clay, fm sand grains, poorly sorted, few gray clay-lined vertical, linear (root channels? Pores?) features, top of strat has few coarse rounded grains (3 cm rounded pebble), black flecks	10YR3/1	sbk	fri
1	s.a.a but color change, lightens	10YR3/2	sbk	fri
1	very sandy clay	10YR3/2	sbk	fri
1	wet, poorly sorted, fmc grains resembles strat above but decreased C component	10YR3/1	sg	lo
1	like above but no Si/C component, coarse grains increasingly visible, few rounded 1-2 cm pebbles	10YR2/1	sg	lo
1	slump?, like 995-1067 but band of SiS at 1125-1130, angle of transition suggests slump	10YR2/1	sg	lo
1	like 995-1067, subangular rock fills core at 1215 cm	10YR2/1	sg	lo
1	like 1130-1220, 1-3 cm rounded pebbles of variable composition are common below 1332 cm bs.	10YR2/1	sg	lo
1	few rounded 1 cm pebbles	10YR2/1	sg	lo
1	rounded pebbles (3 cm) fill boring at 1677 cmbs, end of boring	10YR2/1	sg	lo

SCALE (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

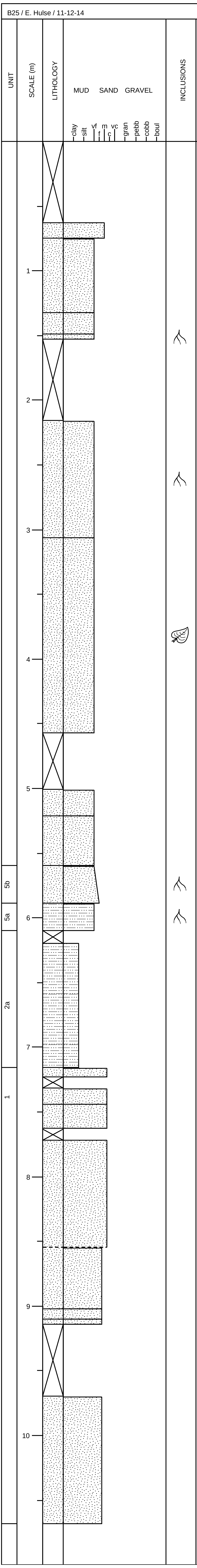
INCLUSIONS

B24 / E. Hulse / 11-11-14



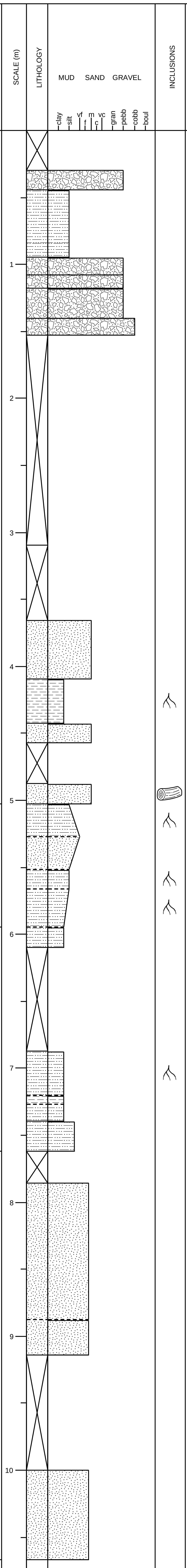
UNIT	INCLUSIONS	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b		poorly sorted w/ broken angular stones	10YR3/1 10YR3/4	sg gr	lo fri
6b		poorly sorted with two bands of angular gravel and SSi (10YR4/3) at 114-120 and 135-147	10YR5/1	sg	lo
6b		poorly sorted, with few C grains	10YR4/1	sg	lo
6b		lenses and clumps of Si	10YR3/1	sg	lo
5b	roots	roots, fines downwards, buried surface	10YR3/1	sbk	fi-fri
5a	roots	few rootlets	10YR2/1	abk	fi-fri
2a		no rootlets, few Fe mottles	5Y4/1	abk	fi-fri
1		poorly sorted, fmc grains	10YR3/2	fr	fi-fri
		moderately well-sorted, rounded 3 cm pebble at 679 cm	10YR2/1	gr	fi
		coarsens downwards to fmc poorly sorted S with few rounded pebbles	10YR2/1	gr	fi
		coarsens downwards, few rounded pebbles, end of boring	10YR2/1	gr	fi

B25 / E. Hulse / 11-12-14



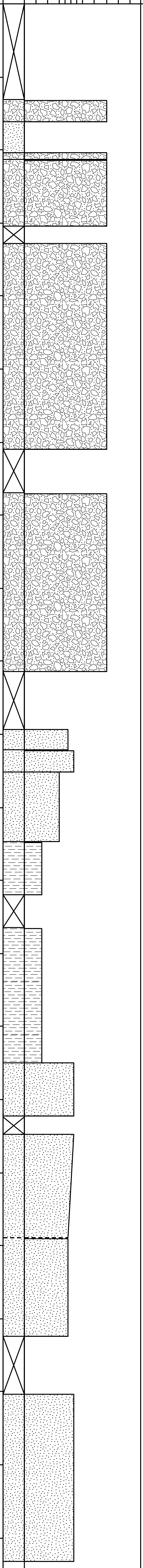
UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
	with rounded 1 cm pebbles	10YR3/1	gr	fri
	with rounded and subangular 1 cm pebbles	10YR4/2	sbk	fri
	with rounded 2 cm pebbles	10YR3/1	gr	fri
	with rootlets	10YR4/3	gr	fri
	with pockets of mf sand, loose/wet from 233-249, rootlets, 1-2 cm angular and rounded gravels	10YR4/2	sbk-gr	fri
	v loose from 330-368, sbk stones (3 cm) from 402-416, band of lo, sg, mf S from 433-437, plant matter from 437-438	10YR4/2-10YR4/3	sbk-gr	fri
	more sandy/granular from 501-506, 1 cm sbk gravels	10YR4/3	sbk-gr	fri
	few organics, abk 1 cm gravels	10YR3/1	gr	fi
5b	SiS with rootlets, coarsens downwards (buried surface), slightly oxidized f S, well-sorted	10YR3/1?10YR4/2	sbk	fri
5a	banded, dark w/ rootlets and Fe oxidized, dark bands at 592-593, 594-595, 596-597, and 603-610	10YR5/3, 10YR2/1	sbk	fri
2a	dark from 620-632, then Fe mottled & lighter, dark band at 694-695, possible tephra at 699 (0.2 cm thick, pale S vf, like MSH set Y tephra), dark band from 701-708	10YR5/1, 10YR3/1	sbk-gr	fi
1	poorly sorted fmc grains	10YR3/2	gr	fri
	poorly sorted fmc grains	10YR3/2	gr	fri
	poorly sorted fmc grains	10YR3/2	gr	fri
	poorly sorted fmc grains, C/Si particles decrease w/ depth	10YR3/2	gr	fri
	poorly sorted with few coarse grains, wet, few sbk 2 cm pebbles	10YR3/1	sg	lo
	increase in brown Si particles	10YR3/3	sg	lo
		10YR3/3	sg	lo
	tan band of vf S at 1041-1042 composed of volcanic seds, tephra may be present	10YR3/1	sg	lo

B26 / D. Cox / 11-11-14



UNIT	INCLUSIONS	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b		poorly sorted	10YR4/1	sg	lo
		dry, silt with amber glass rock, orange near 45 cm	10YR5/1	sbk	fi
		asphalt pieces	10YR4/1	gr	fi-fri
		Crushed rock (Broken cobble?)	10YR7/1	sg	lo
		similar to 95-108	10YR7/1	sbk	fi-fri
		single rock, slight matrix, similar to above around rock	10YR7/1	gr	fri
		poorly sorted, occasional 2 cm alluvial rock; occassional bands moist, dry, most sands	10YR6/1	sg	fi
	rootlets	few rootlets, iron staining, no visible organic debris (besides few fine rootlets)	10YR2/1	sbk	fi
		poorly sorted. Sand with occassional 2 cm alluvial, very slight silt content	10YR3/1	sbk	fi
	woody debris	with larger woody debris at 497	10YR3/1	sbk	fi
5a	rootlets	many fine and medium rootlets	10YR4/1	sbk	fi
		moist, no rootlets, silt increases with depth	10YR5/1	sg	fi
	rootlets	few fine rootlets	10YR2/1	sbk	fi
	rootlets	more than above fine rootlets, increase in clays with depth	10YR2/1	sbk	v fi
2a		No rootlets, mottled with iron staining	10YR5/1	sbk	fi
	rootlets	same sediment as above, few rootlets	10YR5/1	sbk	fi
			10YR3/1	sbk	fi
			10YR5/1	sbk	fi
		moist, mottled with iron staining	10YR4/3	gr	fi
1		moist, with iron, coarser sand with depth	10YR4/3	sbk	fri
		same sediments-little silt--, different color, very little silt if any	10YR4/1	sg	fri
		moist, poorly sorted, end of boring	10YR3/1	sg	fri

B27 / E. Hulse / 11-11-14



UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	Crushed stone		sg	lo
6b		10YR4/1	gr	fri
6b	Crushed stone SSi with sbk 2 cm gravels	10YR3/2	sg gr-sbk	lo fri
6b	Rounded and angular gravels increasing sand with depth, becomes SiS at 250 cm	10YR3/2	gr-sbk	fri
6b	increasingly gr SiS w/ gravel (1-2 cm angular and rounded)	10YR3/2	gr-sbk	fri
6b	rounded 2 cm pebbles at 510 cm	10YR4/1	gr	pl/fri
6b	poorly sorted	10YR4/1	sg	lo
5b	buried surface, few small rootlets at 527-533 cm, likely historic surface, some Fe banding/mottling at 563-574 cm	10YR3/1	sbk	fri
5a	bands of dark and lighter oxidized sediment, dark at 577-578, 580-585, 589-610	light 10YR4/2, dark 10YR3/1	sbk	fi
2a	s.a. 574-610 but not banded, just gradual horizonation from top to bottom. Fe mottles from 660-725 cm. Dark band from 714-720.	10YR3/1?10YR4/2	sbk	fi
1	poorly sorted fmc grains, gray clay slicks	10YR3/2	gr	pl/sti-cky/f-ri
1	decreasing Si/C content with depth, becoming gr, fri S with little clay, poorly sorted fm grains w/ some C grains	10YR3/2	gr	pl/sti-cky/f-ri
1	poorly sorted with few c grains, rounded 1 cm pebble at 879 cm	10YR2/1	sg	lo
1	wet poorly-sorted, increase in c angular grains with depth, decrease in c grains at 1040 to base, end of boring	10YR2/1	sg	lo

SCALE (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

INCLUSIONS: (root symbol, unit 5b)

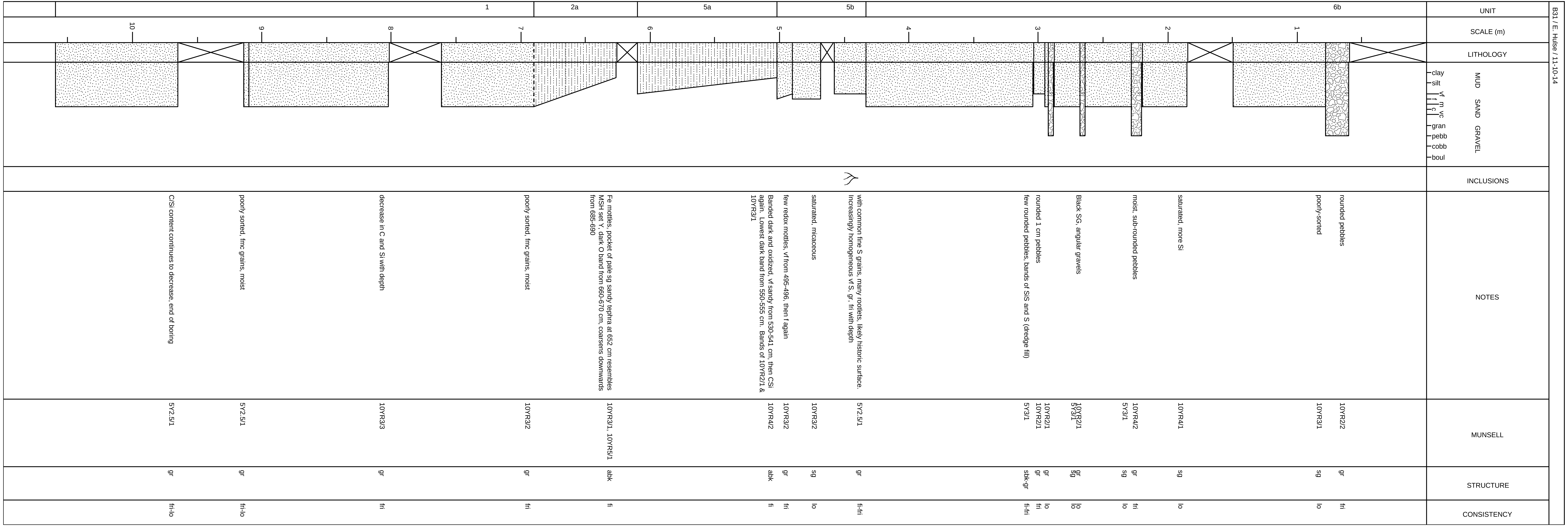
B28 / E. Hulse / 11-6-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	angular and rounded gravels	10YR4/2	gr	fri
	50% 1 cm angular gravels and coarse sand	10YR2/2 10YR3/2	sbk gr	fri lo
	burned material, brick frags, ash, moister/siltier from 255-270 cmbs, insulated copper wire at 268 cmbs	10YR3/2	gr	lo
	1 cm gravels, saturated with silty water	10YR4/2	sg	lo
	mc SiS poorly sorted, rounded pebble and twig at top of strat	10YR3/1	gr	fri
	well sorted, color change from top to bottom, twig or root at 400 cm	2.5Y4/2 at top, 5Y3/1 at bottom	sbk	fri
	moist, moderately well sorted, lensing/banding with above strat from 420-430 cm, rounded pebble at 149 cm	10YR3/1	sg	lo
	coarsens downwards to G, 2-3 cm rounded subangular, some silty water	2.5 Y3/1	sg	lo
	poorly-sorted, few rounded 2 cm pebbles	GLEY 1 3/N	sg-gr	lo
	lenses of clay and sand	GLEY 1 3/N	sbk	fi
	wood frag at 557 cm	2.5Y2.5/1	abk	fi
5a	0.5-1cm rounded gravels	2.5Y3/1	sg-gr	fri
	buried surface, rootlets, lenses of well-sorted fine sand	2.5Y3/1	sbk	fri
	with roots, rootlets, intact Ab horizon	GLEY 1 2.5/N	sbk	fi
	well-sorted, moist, micaceous, fines up to CSi above, also fines at bottom to nex strat	5Y3/1	weakly sbk-gr	fri
	coarsens downwards to abk vf sand with Fe mottles	GLEY 1 3/N	abk	fi
	with mica, Fe oxide banding	10YR4/1	sbk	fri
	with Fe mottles	10YR4/1	abk	fi
	vertical Fe mottles from 669-682, color change at 670 and 682	10YR4/1?5Y5/1 w/ 2.5YR4/4	abk	fi
	heavy Fe oxidation, mottles less clear than strat above	10YR4/2 w/ 2.5 YR4/4	sbk	fri
	some vertical Fe mottliing	10YR4/1	abk	fi
	dark band, yellowish (10YR4/1) from 715-515, possible buried A	10YR4/1 w/ 10YR3/6	gr	fi
	common Fe mottles, (10YR3/6 mottles, 10YR5/6 mottles), color change downwards	10YR4/1?10YR3/6	sbk-gr	fi
	very fine grained	7.5 Y/3.2	gr	fri
2a	some Fe mottling, slight color change downward	2.5Y3/2	abk	fi
	dark organic? Lens,	10YR2/1	abk	fi
		GLEY 1 3/N	abk	fi
1	poorly sorted, common fmc grains--glassy frags but no usable tephras, pale flecks may be calcium?--at 89.2 cmbs	10YR3/1	sbk-gr	fri
	disorganized, may be slump	10YR3/1	sbk-gr	fri
	but well-structured, sbk-gr like 878-915. Gray clay fills pores and channels. Subangular 3-4 cm stones at 1025 cm	10YR3/1	sbk-gr	fri
	wet, fm grains	10YR2/1	sg	lo
	coarsens slightly at base, few rounded 1 cm pebbles, end of boring	10YR2/1	sg	lo

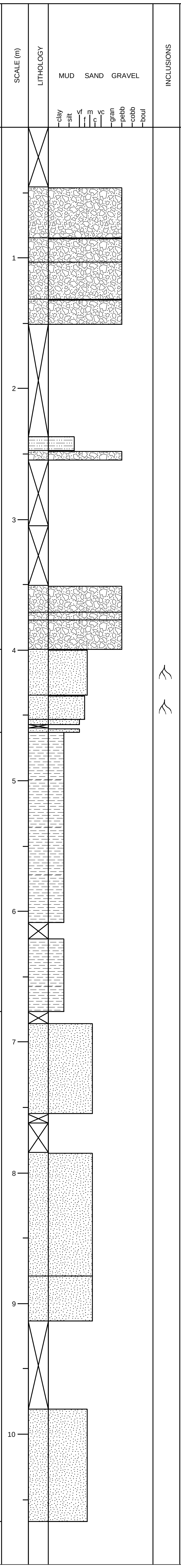
B29 / E. Hulse and K. Fuld / 11-7-14

Unit	Notes	Munsell	Structure	Consistency
6a	Mottled, very gravelly	10YR2/2, 10YR2/1	sbk	fri
	well sorted	10YR4/2	gr	lo
	moderately sorted, SiS with angular-subangular gravels (2 cm)	5Y3/1	gr	lo
	Alternating layers (~2-5 cm thick) of brown SSi and gray crushed gravels, very gravelly, subang-ang brick fragments	10YR4/2, 10YR5/1	sbk-gr	lo
	w/G (angular) , 2 cm angular stones	10YR3/1	gr	fri
	poorly sorted, SiC band from 215-220 cm, and 248-250 cm, angular gravels at 255-260 cm, mottled with 10YR3/4 Si	10YR3/1	gr-sg	vfri-lo
	with 40% angular coarse and rounded 1 cm pebbles	10YR3/3	gr	fi
	angular gravels, moderately well-sorted sand	5Y2.5	gr	fri
	some Si, few angular gravels, well sorted	10YR3/3	gr	fri-lo
	Alternating bands of S & Ssi, pockets with angular gravels, wood, roots, burned wood, charcoal	5Y3/1	sbk-gr	fri-lo
	moderately sorted with angular gravels up to 4 cm max dimension, few coarse grains	5Y3/2	gr	fri-sg
	roots (very fine), buried surface, coarsens downwards	5Y3/2	sbk	fri
	some Si, very fine roots	5Y3/1	sbk	vfri
5a	alternating bands of oxidized and dark, clear transition 570-580 cm	10YR2/1 & 10YR4/2	sbk	fri, lo-fri
	Fines downwards	10YR5/2	gr	vfri
2a	oxidized	10YR4/1	abk	fri
	gradual color change indicating horizination. Darker at top, Fe mottled/oxidized, decreasing oxidation to base. Vf sand present from 650-655 cm, gray vertical lines (root marks?)	10YR3/1-10YR5/1--10YR4/2	sbk-gr	fi
	oxidized with mineral (manganese?) chunks	5Y5/1	sbk	fri
	s.a.a. but color change due to less oxidation	5Y3/1	sbk	fri
	no inclusions	5Y4/1	abk	fi
	s.a.a. but color change and increase in sand at base	10YR2/1	abk	fi
1	poorly-sorted fmc grains	5Y3/1	gr	fri
	coarsens downward, decrease in C	5Y3/1	gr	fri
	poorly sorted with few coarse grains, subangular pebbles at 1195 cm	10YR2/1	sg	fri-lo


B30 / E. Hulse / 11-10-14
UNIT
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay silt vf f m c vc gran pebb cobb boul
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
6b
10YR2/1 gr fri
fm grains, angular 3 cm stone at 90 cm 10YR4/2 gr fri
more Si than above 10YR4/2 sbk fri
Increasingly firm and clayey with depth 10YR3/4 sbk fri
Shattered stone in matrix of s.a.a. 10YR3/4 sbk fri
angular 2-3 cm gravel 10YR2/1 gr lo
10YR4/1 sbk fi
black fm sand, angular stone at 239 cm, rootlet 10YR2/1 sg lo
poorly sorted, rounded 2 cm pebbles at 251 & 270 cm 10YR4/1 sg lo
wood frags, 3 cm pebbles 10YR2/1 gr fi
poorly sorted, few rounded and angular 2 cm pebbles 5Y2.5/1 sg lo
s.a.a. but with Si, rounded 2 cm pebbles 5Y2.5/1 sg lo
lenses of silt, 2-3 cm rounded pebbles 5Y3/1 gr fi
5Y3/1 gr fi
5b
root/veg mat, buried surface 10YR2/1 gr fri
fines downward to 514, then coarsens, common rootlets 5Y3/1 sbk-gr fri
fines downward, rootlets 5Y3/1 sbk-abk fri-fi
5a
rootlets, coarsens downwards from 543-545 to vf well-sorted sand 5Y3/1 abk fi
well-sorted, some mica, coarsens downwards from vf SiS from 545-546. Fe oxidation onlower margin from 552-553 10YR3/1-5YR3/3 sg fi
10YR3/1-10YR4/3 abk fi
s.a.a but oxidized 10YR3/1-10YR4/3 abk fi
color grades from dark (579-595) to oxidized (595-599) to dark (599-610) 10YR3/1, 10YR4/4, 10YR3/1 abk fi
coarsens downwards, saturated, redox mottles 10YR4/1 abk fi
2a
fine rootlets 10YR4/1 abk fi
dark from 704-709, redox mottles from 709 to base, 10YR4/4 mottles 10YR3/1-10YR4/1 sbk-gr fi-fri
with vf S grains, organics at 901 cm -- 2920-2910 cal yrs BP and 2880-2770 cal yrs BP (Beta-400236), mineralization around root hole at 810 cm, some Fe mottling from 797-840 5Y3/1 sbk fi
5Y3/1 sbk fi
1
fmc grains 5Y3/2 gr fri
poorly-sorted 5Y2.5/1 sg lo
rounded 1 cm pebbles from 1210-1220 5Y2.5/1 sg lo
1 2 3 4 5 6 7 8 9 10 11 12


B31 / E. Hulse / 11-10-14
UNIT
SCALE (m)
LITHOLOGY
MUD
clay
silt
SAND
vf f m c vc
GRAVEL
gran
pebb
cobb
boul
INCLUSIONS
NOTES
MUNSELL
STRUCTURE
CONSISTENCY
6b
5b
5a
2a
1
1
2
3
4
5
6
7
8
9
10
rounded pebbles
10YR2/2
gr
fri
poorly-sorted
10YR3/1
sg
lo
saturated, more Si
10YR4/1
sg
lo
moist, sub-rounded pebbles
10YR4/2
5Y3/1
gr
sg
fri
lo
Black SG, angular gravels
10YR2/1
5Y3/1
gr
sg
lo
lo
rounded 1 cm pebbles
10YR2/1
10YR2/1
gr
gr
lo
fri
few rounded pebbles, bands of SiS and S (dredge fill)
5Y3/1
sbk-gr
fi-fri
with common fine S grains, many rootlets, likely historic surface.
Increasingly homogeneous vf S, gr, fri with depth
5Y2.5/1
gr
fi-fri
saturated, micaceous
10YR3/2
sg
lo
few redox mottles, vf from 495-496, then f again
10YR3/2
gr
fri
Banded dark and oxidized, vf sandy from 530-541 cm, then CSi again. Lowest dark band from 550-555 cm. Bands of 10YR2/1 & 10YR3/1
10YR4/2
abk
fi
Fe mottles, pocket of pale sg sandy tephra at 652 cm resembles MSH set Y, dark O band from 660-670 cm, coarsens downwards from 685-690
10YR3/1, 10YR5/1
abk
fi
poorly sorted, fmc grains, moist
10YR3/2
gr
fri
decrease in C and Si with depth
10YR3/3
gr
fri
poorly sorted, fmc grains, moist
5Y2.5/1
gr
fri-lo
C/Si content continues to decrease, end of boring
5Y2.5/1
gr
fri-lo

B32 / E. Hulse / 11-11-14



UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	poorly-sorted 0.5 cm angular gravels	10YR5/2	gr	lo
6b	color change	10YR3/1	gr	lo
6b	erosion control fabric at 103 cm, poorly-sorted, angular 0.25 -1 cm gravels from 120-132	10YR4/2	gr	fri
6b	dark gray SSi, 40% rounded 2 cm pebbles	10YR2/1	abk	fi
6b		10YR2/1	abk	fi
6b	poorly-sorted with 1-2 cm rounded pebbles	10YR4/2	gr	fri
6b	dark gray SSi, 40% rounded 2 cm pebbles	10YR2/1	abk	fi
6b	poorly-sorted with 1-2 cm rounded pebbles	10YR4/2	gr	fri
6b	dark gray SSi, 40% rounded 2 cm pebbles	10YR2/1	abk	fi
5b	moist poorly-sorted w/ some c grains, 0.5 - 1 cm subangular pebbles, many roots/rootlets from 400-415 cm (buried surface)	5Y4/1	sbk	fri
5b	well-sorted, few rootlets	5Y3/1	sbk	fri
5b		5Y2.5/1	sbk	fi
2a	color change (horizonation) from top to base; 463-504: 5Y2.5/1, 504-593: 5Y3/1; 593-609: 10YR5/3	5Y2.5/1, 5Y3/1, 10YR5/3	abk	fi
2a	dark band (10YR4/2) at 645-655 cm and 662-666 cm. Transition unclear--break in core	10YR5/3	abk	fi
1	poorly sorted fmc grains	10YR3/3	gr	fri
1	grades downward, poorly sorted fmc grains, fine C/Si fraction decreases with depth	10YR4/3	gr-sg	fri-lo
1	wet, poorly-sorted	10YR2/2	sg	lo
1	wet, poorly-sorted, fm S with some c grains, end of boring	10YR2/1	sg	lo

B33 / D. Cox / 11-20-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6b	poorly sorted, dredge with up to 2 cm rounded alluvial rocks	10YR5/1	sg	lo
6b	poorly sorted, dredge sands (with a few laminae of fill episodes)	5Y3/1	sg	lo
6b	poorly sorted, occassional 1.5 cm pebble, color transition	10YR5/2	sg	lo
6b	poorly sorted, woody debris (380-382)	10Y6/1	sg	lo
6b	color transition	10Y6/1	sg	lo
6b	some organic smears, less silt with depth	10YR4/1	sg	fri
6b	addition of subrounded pebbles (1.25 cm) and few fine rootlets	10YR5/2	sg	fri
6b	poorly sorted, with some organics and occassional 0.2 cm silt laminae. Finer sand with depth	10YR5/3	sg	fi-fri
6a	iron enclosed (silt lens), fine	10YR4/1	sbk	fi-fri
6a	few fine rootlets, some small silt clods	10YR4/1	sg	lo
6a	moist, few silts, one 3 cm pebble, some iron stained areas	10YR4/2	sg	fi-fri
6a	No visible organics	10YR3/1	sbk	fi
6a	few one cm pebbles, sand increase with depth, color transition	10YR3/1	sbk	fi-fri
6a	Boundary between fill and riverbank? Iron stained	10YR6/8	sg	fi-fri
6a	slightly finer grain, some silts	10YR4/1	sg	fi
6a	no organics	10YR3/1	sbk	fi
6a	poorly sorted, m f grains, color transition	10YR5/3	sg	fi
6a	fine to med grain	5Y4/1	sg	fi
6a	Zone of silts and sand lenses, silt at top (728-731) transitions to bands of sandy silts, sands coarser with depth, few .6 cm pebbles	10YR3/1	sbk	fi
6a	poorly sorted	10YR3/1	sg	lo
6a		10YR3/1	sbk	fi
6a	poorly-sorted	10YR3/1	sg	lo
6a	s.a.a.	10YR3/1	sg	lo
6a		10YR3/1	sg	lo
6a		10YR3/1	sbk	fi
6a		10YR3/1	sg	lo
6a	charcoal/organics 1055-1062	10YR3/1	sbk	fi
6a	same seds as above, no organics, banded sands silts, plastic at base	10YR3/1	sbk	fi
6a	poorly sorted, (high energy event)	10YR2/1	sg	lo
6a		10YR2/1	sg	fi
6a	new high energy event	10YR2/1	sg	lo
6a	some very fine rootlets, some iron staining, iron and rootlets start at 1204 cmbs, radiocarbon results: 0 BP, 70 to 35 cal yrs BP, 135 to 115 cal yrs BP, or 255 to 225 cal yrs BP (Beta-400237)	10YR3/1	sbk	fi
2b	moist, poorly sorted, banded with slight variation in coarse/med sands	10YR3/1	sbk	fi
2b	moist, poorly sorted,	10YR3/1	sg	fi
2b	s.a.a.	10YR3/1	sg	fi

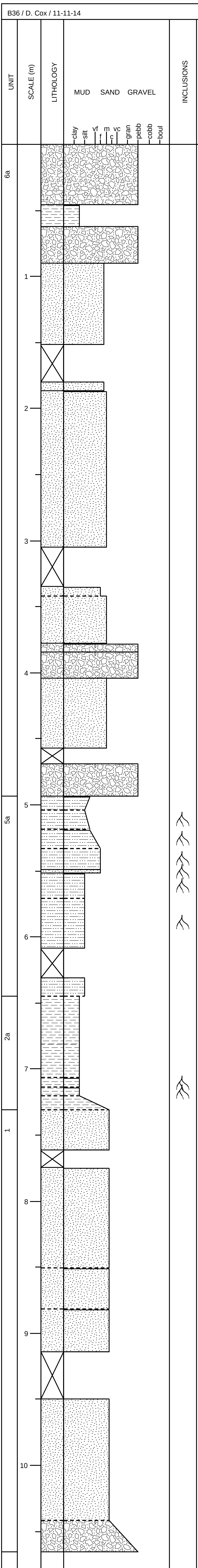
B34 / E. Hulse / 11-20-14

NOTES	MUNSELL	STRUCTURE	CONSISTENCY
O horizon, plants, rootlets	10YR2/1	gr	fri
well sorted, wood frag at 119-120, bands of coase poorly sorted sand below 120 cm to base	10YR5/1	sg	lo
alternating 1-2 cm bands of well sorted mfs lo sg and poorly sorted mc S lo sg notably coase grains from 285-291	10YR5/1, 10YR4/2	sg	lo
poorly-sorted, few coarse grains + 414 cm, becoming moist at bottom	10YR5/1	sg	lo
wood frags at 550-555 cm	10YR4/1	sg	lo
some m S	10YR4/2	sbk	fri
few coarse grains S, charcoal fleck at 567, wood frag at 569-571, charcoal or decomposed wood from 575-578, notable mica flecks below 758,	10YR4/2	sbk	fri
bands/lenses of sg, lo, fs from 582-592, bands of poorly-sorted fmc S lo sg from 598-601 and 606-608. plant frags at 582 cm, 584-587 cm, 595-596 cm	10YR3/1	abk	fi
banded mc poorly-sorted S interbedded with 0.5 cm bands of mf well-sorted S, 0.4 cm band of Si at 740.5 cm all fining downwards to base, common reddish grains	5Y2.5/1	sg	lo
poorly-sorted, moist	5Y3/1	sbk	fri
well-sorted/laminated	5Y3/1	sbk	fri
	5Y3/1	abk	fri
	5Y3/1	sbk	fri
vf grains	5Y3/1	abk	fri
	5Y3/1	abk	fri
iridescent sheen/slick on surface	5Y3/1	sbk	fri
	5Y3/1	abk	fri
	5Y3/1	sbk	fri
	5Y3/1	abk	fri
	5Y3/1	sbk	fri
	5Y3/1	abk	fri
fining downwards to base	5Y3/1	sbk	fri
well-sorted, wet	5Y3/1	sg	lo
	5&3/1	abk	fri
	5Y3/1	abk	fri
s.a. 837-843 but has more vf S	5Y3/1	abk	fri
	5Y3/1	sg	lo
coarsens downwards to vf SiS	5Y3/1	abk	fri
fines downwards	5Y3/1	sg	lo
	5Y3/1	abk	fri
	5Y3/1	sg	lo
coarsens downwards to vf SiS	5Y3/1	abk	fri
fines downwards	5Y3/1	sg	lo
	5Y3/1	sbk	fri
possible slump--poorly sorted	5Y3/1	sg	lo
well-sorted, wet, subrounded 1 cm pebbles at 1125 and 1134 cm, 0.5 cm band of soft Si at 1166cm	5Y3/1	sg	lo
well-sorted, 0.2-0.5 cm lenses of Si at 1180, 1187, 1189, 1202, wood frags at 1184, 1193, 1198-1202, 1205-1215 and 1217 cm	5Y3/1	sbk	fri
saturated, some may be slump	5Y3/1	sg	lo
well-sorted, few silty laminae from 1332-1337	5Y3/1	sg	fri
s.a.a. but no Si	5Y3/1	sg	fri
	5Y3/1	sg	fri
s.a.a. but with Si	5Y3/1	sg	fri
s.a.a laminated wi/ 1-2 cm bands of silt-free mc poorly-sorted S	5Y3/1	sg	fri
well-sorted, wood frags at 1479, coarse S at 1491-1493, 1500-1504, 1523-1524	5Y3/1	sbk	fri
0.2 cm rounded white lapilli at 1580 cm, like unident. Mt. Hood tephra	5Y3/1	sbk	fri
mod. well-sorted, coarser bands from 1600-1626 and 1663 down	5Y2.5/1	sbk	fri
dark organic band at 1700,	5Y3/1	sbk-gr	fri
well sorted S coarsens downward from mf S to C Sand at base, one band of m S at 1792 cm,	5Y3/1	sbk	fri
s.a.a. mc S from 1822-1829	5Y3/1	sbk	fri
poorly sorted, brownish	10YR4/2	sbk	fri
poorly sorted, coarse from 1930-1934	5Y3/1	sbk	fri
well-sorted	5Y3/1	sbk	fri

B35 / E. Hulse / 11-21-14

NOTES	MUNSELL	STRUCTURE	CONSISTENCY
angular gravels, crushed asphalt	10YR2/1	sg	lo
moderately well-sorted, 0.5 cm coarse grains and pebbles	10YR4/2	sbk	fri
color transition to gray	10YR3/1	sbk	fri
s.a.a. but gray vf SSi from 270-273, 279-280, and 287-288, wood at 258-259, 272-273	5Y2.5/1	sbk	fri
poorly sorted, with coarse grains, some Fe oxidation at top of strat from 288-289	10YR4/2	sg	lo
poorly-sorted fm S w/ few rounded 1-2 cm pebbles, wood frag at 336 cm,	10YR3/1	sbk	fri
poorly sorted, some Si at upper edge of strat, wood frag at 438 cm	10YR4/2	sbk	vfri
poorly sorted	10YR3/1	sbk	fri
	10YR3/1	sbk	vfri
poorly-sorted, few 1 cm subrounded pebbles, 10% coarse grains of variable composition, mostly fm grains	10YR4/2	gr-sbk	fri
mod. well-sorted, finely bedded (0.2 cm layers), few beds of CS	10YR3/2	gr	fri
wood frag at 749 cm	5Y2.5/1	sbk	fri
	5Y2.5/1	gr-sbk	fri
banded with 1 cm bands of f S below 758 cm	5Y2.5/1	abk	fi
	GLEY 1 2.5N	sbk	fri
	GLEY 1 2.5N	sbk	fri
saturated	GLEY 1 2.5N	sg	lo
coarsens downwards,saturated, structureless	GLEY 1 2.5N	sg	vlo
bands of f S from 868-869 cm.	10YR2.5/1	abk	fi
band of CSi from 872-873 cm, SiS fines downwards	GLEY 1 2.5N	sbk	fi
coarsens downwards	GLEY 1 2.5N	abk	fi
	GLEY 1 2.5N	sbk	fri
saturated	GLEY1 3/N	sg	lo
wet, coarsens downwards	GLEY1 3/N	sbk	fri
few laminae of Si	GLEY1 3/N	sbk	fri
well-sorted, coarsens downwards to well-sorted mf S	GLEY1 3/N	sbk	fri
wood at 1202-1203, 2730-2460 cal yr BP (Beta-400238)	GLEY1 3/N	mass	so
coarsens downwards to poorly sorted mc S	GLEY1 3/N	sbk	fri
well-sorted, faint darker laminae from 1333-1342 and 1358-1365	GLEY1 3/N	sbk	fri
bands of s.a.a and poorly sorted mc S, wood frag at 1367 cm, rounded white lapilli mixed with wood--unident. Mt Hood tephra	GLEY 1 2.5N	sbk	fri
well-sorted	GLEY1 3/N	sbk	fri
lighter band	GLEY1 3/N	sbk	fri
	GLEY1 3/N	sbk	fri
poorly-sorted	GLEY 1 2.5N	sbk	fri
	GLEY1 3/N	sbk	fri
Banded darker mS in s.a.a	GLEY 1 2.5/N	sbk	fri

B36 / D. Cox / 11-11-14



UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6a	poorly sorted, subrounded pebbles up to 2 cm	10YR3/1	sg	lo
		7.5YR3/4	sbk	fi, pl
	poorly-sorted, subrounded pebbles (up to 2 cm)	2.5YR5/1	sg	lo
	dredge sands	2.5YR6/1	sg	
	well-sorted	2.5YR7/1	sg	lo
	poorly sorted, slightly moist, dredge sands	2.5YR5/1	sg	fo
	fairly well-sorted (may be slump or grinding dust)	2.5YR7/1	sg	lo
	poorly sorted sands, slightly moist, dredge	2.5YR5/1	sg	fi
	subrounded pea gravels (up to .5 cm)	10YR3/4	sbk	fi
	poorly sorted (crushed stone and subrounded gravels up to 3 cm)	10YR4/1	sg	fi
	poorly sorted, moist, dredge	10YR4/1	sg	fi
	Slump, poorly sorted, sand and gravels and rocks subrounded up to 4.5 cm	10YR3/3	sg	lo
5a	Slump, poorly sorted, mix between dredge and native	10YR3/3	sbk	fi
	many fine rootlets and organic debris, fine sands present, small roots as well, no cleaning faces	10YR3/1	sbk	fri
	increase in fine sands, saturated, many fine rootlets, no visible organic debris	10YR3/1	sbk	fri
	few fine rootlets, no visible organic debris, very fine sands present	10YR3/1	sbk	fi
	few fine rootlets, no visible organic debris,	10YR3/1	sg	fri
	very few fine rootlets, organic debris within ped chunks	10YR3/1	sbk	fi
	Dry, mottling between dark brown and grey, fine rootlets, no visible organic debris	10YR2/1	sbk	fi
		10YR2/1	sbk	fi
2a	Iron staining appearing increase with depth	10YR5/1	sbk	fi
	Increase in silt, few rootlets; at 713 (0.1cm) MSH set Y tephra	10YR5/1	sbk	fi
	Few fine rootlets	10YR4/2	sbk	fi
	Fe mottled	10YR5/1	sbk	fi
1	fmc poorly-sorted S, mottled, iron staining and small concretions	10YR3/3	sbk	fi
	fmc mottled gray and brown, iron staining and small concretions, sand increase with depth	10YR3/1	sbk	fi
	fmc saturated, poorly sorted, iron staining	10YR3/1	sbk	fi
	fmc moist, poorly sorted, coarser sand with depth, no iron staining	10YR3/1	sbk	fi
	poorly sorted, moist	10YR3/1	sg	fri
	poorly sorted with 2 cm subrounded alluvial rocks, moist, end of boring	10YR3/1	sg	fri

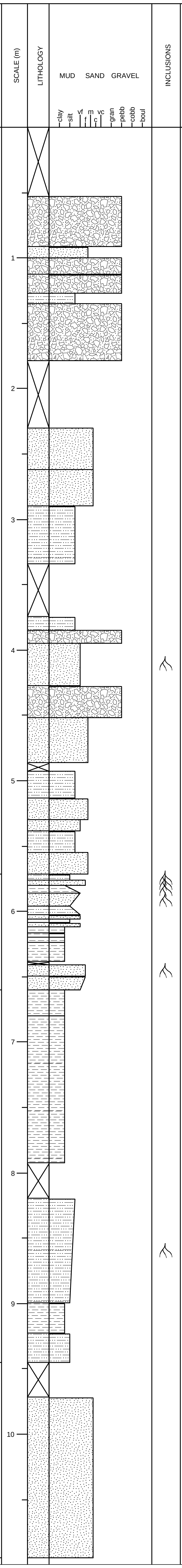
B37 / E. Hulse / 11-11-14

UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6a	broken stone/angular 2cm G	10YR3/2	gr	fri
	poorly-sorted, rounded pebble at 149 cm, few rounded C grains	10YR3/1	sg	lo
		10YR3/1	sg	lo
	poorly-sorted, dry sand, few subangular coarse grains	10YR5/1	sg	lo
		10YR3/1	sg	lo
		10YR3/1	sg	lo
	color change at 382 cm	5Y4/2?5Y3/1	sbk	fri
	poorly sorted, lens of silt at 440-443 cm, lens of burned material at 417-421 cm.	5Y3/1	gr	fi
	rounded 2 cm pebbles and Si at 504-509 cm	5Y3/1	gr	fi
5b	plant frags at 521-526 cm, many roots/rootlets to 544 cm, buried surface	5Y3/1	sbk	fri
	well-sorted, micaceous, Fe enchrichment at base of strat from 566-567	5Y3/1	sbk-sg	fri-lo
	coarsens downwards, oxidized; 5Y3/1 (dark), 5Y4/2 oxidized	5Y3/1, 5Y4/2	sbk	fri
	s.a.a. over a shorter interval	5Y3/1, 5Y4/2	sbk	fri
5a	Fe mottles, dark (5y2.5/1)from 584-600, light (5Y4/2) from 600-602, dark from 602-612	5Y2.5/1, 5Y4/2	sbk	fi
	oxidized	5Y4/2	sbk	fri
2a	Dark (5y2.5/1) from 663-676 cm and 750-762 cm, Fe mottles, root pores, vf S with plants from 730-736 cm	5Y2.5/1, 5Y4/2	sbk	fi
	S grains increase from 780-787	10YR4/1	sbk	fi
1	Poorly-sorted fmc grains, gray clay slicks inside pores, rounded pebble at 849 cm, clay content decresases at 894 cm	10YR3/1	gr-sbk	fri
	Poorly-sorted fmc grains, fine particles decrease with depth	10YR3/1	gr-sg	fri
	No Si/C, coarsens downwards,rounded 2 cm pebbles at 1178 cm	10YR2/1	gr-sg	fri
	poorly sorted, notably finer than above	10YR3/1	sg	fri

B38 / E. Hulse / 11-10-14

NOTES	MUNSELL	STRUCTURE	CONSISTENCY
30% 0.5-1 cm rounded gravels	10YR3/3	gr	v fri
common 1 cm rounded gravels	10YR3/2	sg-gr	fri
shattered angular stone			
10% 1-2 cm rounded gravels	10YR3/2	gr	fri
	10YR4/2	sg-gr	v fri
	10YR4/2	sg-gr	v fri
few angular 3 cm stones,	10YR3/3	sbk	fri
Shattered concrete with pebbles		sg	lo
Few angular 3 cm stones	10YR3/1	fr	fri
	5Y3/1	sbk-gr	fri
poorly-sorted	5Y3/1	gr	fri
lenses of silt	5Y3/1	gr-sbk	fri
poorly-sorted	5Y3/1	sg	lo
peat mat with roots/rootlets (buried surface) with gradual decrease in OSi with depth, moderately well-sorted, with roots, rootlets, fines downwards, then coarsens	10YR2/2	sbk	fri
micaceous (sand), coarsens from vf to f 502-507 cm, color change at 521 cm fines downwards from 524-529	5Y3/1?10YR4/2	sbk	fri
redox mottles, rootlets at 534 cm	10YR4/2	abk	fi
well-sorted, micaceous sand, oxidized	10YR4/2	sbk	fri
some mica, redox mottles, fines downwards	10YR4/2	abk	fi
banded with 1-3 cm dark (10YR2/1) bands and 1-3 cm redox light (10YR4/2) bands, coarsens from 577-578	10YR2/1, 10YR4/2, 5YR4/6	abk	fi
well-sorted, brown redox mottles, fines from 595-596 cm	10YR4/2	sbk	fri
redox mottles, rootlets at 534 cm	10YR2/1	abk	fi
dark bands from 610-620 cm, redox mottles to base, some grey reduced mottles from 745-763	10YR3/1, 10YR5/1, 5YR3/3	abk	fi
dark band at 810-814, gray below that grades to redox again at 837 cm, increase in fmc sand	10YR5/2, 10YR3/1, 10YR4/1, 10YR5/2	abk	fi
gray clay coats some pores, poorly-sorted fmc S	10YR3/1	sbk-gr	fri
gradual color change at 995 cm, subrounded pebbles at 995 cm & 1014 cm, decrease in fine particles with depth	10YR3/1?10YR4/1	sbk-gr	fri
poorly sorted	10YR2/1	sg	lo
banding from 1205-1212 (10YR3/2)	10YR2/1	sg	lo
rounded, G with S like above, end of boring	10YR2/1	sg	lo

B39 / E. Hulse / 11-10-14



UNIT	NOTES	MUNSELL	STRUCTURE	CONSISTENCY
6a	angular gravels	10YR3/1	fr	fri
6a	poorly-sorted	10YR3/2	sg	fri
6a	30% angular gravel, shattered stone at 75-80	10YR2/1	gr	fri
6a	poorly-sorted, rounded pebbles	10YR2/2	gr	fri
6a		10YR4/2	sbk	fi
6a	50% 0.25-1 cm rounded and angular pebbles	10YR3/1	gr	fri
6a		10YR2/2	gr	fri
6a	poorly-sorted	10YR3/2	gr	fri
6a	Sand and gravel in matrix, 0.25-1 cm angular rounded grains	10YR2/2	sbk	fri
6a		10YR2/1	sbk	fri
6a	coarse grains, rounded 2 cm pebbles	10YR3/3	gr	fi
6a	some rootlets at 375 cmbs	GLEY 1 3/N	sbk	fri
6a	common rounded pebbles, some broken	10YR3/1	gr	fri
6a	few coarse grains, subangular pebble at 447 cm	10YR3/1	gr-sg	fri
6a	Slump?	10YR3/1	sbk	fri
6a		5Y3/1	gr-sg	fri
6a	rounded 2 cm pebble, subangular gravels at base of strat	10YR2/1	gr	fi
6a	brick frag, rounded pebble	10YR3/2	sbk	fi
6a	poorly sorted w/ clay lenses; rip-ups, subrounded pebble at 539 cm	5Y2.5/1	gr	fri
5a	many rootlets (buried surface)	5Y2.5/1	sbk	fi
5a	few rootlets	5Y3/1	abk	fi
5a	well-sorted, few rootlets, fines upward to strat above and downward to strat below	5Y3/1	gr	fri
5a	some Fe mottles, coarsens downwards	10YR4/1	abk	fi
5a	well-sorted, oxidized	10YR3/4	sg	fri
5a	banded dark & oxidized Fe for next 27 cm	10YR4/1	sbk-gr	fri
5a	Slump? , saturated, rootlet	10YR3/1	sg	sbk
5a	fining downwards to vf SiS, Fe oxidation	10YR4/1	sbk	fri
2a	dark/organic, Fe oxidation at 647 cm	10YR3/1	abk	fi
2a	Fe oxidation mottles	10YR5/1,10YR4/1	abk	fi
2a	some Fe mottles, vertical fining downwards, rootlet at 805-812 cmbs	10YR4/1	abk	fri
2a		10YR3/1	abk	fi
2a	color change from above	GLEY 1 3/N	sbk-gr	fi
1	poorly sorted, Si to 1030 cm	10YR3/1,10YR2/1	gr	fri

Appendix B
Beta Analytic Inc. Radiocarbon Dating Analyses Report

BETA

Consistent Accuracy . . .
. . . Delivered On-time

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

January 16, 2015

Dr. Eva Hulse
AINW
3510 NE 122nd Ave.
Portland, OR 97230
United States

RE: Radiocarbon Dating Results For Samples 13-2102-50-01, 13-2102-85-01, 13-2102-92-01, 13-2102-97-01

Dear Dr. Hulse:

Enclosed are the radiocarbon dating results for four samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

When interpreting the results, please consider any communications you may have had with us regarding the samples. As always, your inquiries are most welcome. If you have any questions or would like further details of the analyses, please do not hesitate to contact us.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Eva Hulse | Report Date: 1/16/2015

AINW | Material Received: 12/22/2014

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 400235	1340 +/- 30 BP	-27.5 o/oo	1300 +/- 30 BP

SAMPLE : 13-2102-50-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 660 to 770 (Cal BP 1290 to 1180)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 400236	2810 +/- 30 BP	-29.3 o/oo	2740 +/- 30 BP

SAMPLE : 13-2102-85-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 970 to 960 (Cal BP 2920 to 2910) and Cal BC 930 to 820 (Cal BP 2880 to 2770)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 400237	130 +/- 30 BP	-29.7 o/oo	50 +/- 30 BP

SAMPLE : 13-2102-92-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (plant material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1695 to 1725 (Cal BP 255 to 225) and Cal AD 1815 to 1835 (Cal BP 135 to 115) and Cal AD 1880 to 1915 (Cal BP 70 to 35) and Post AD 1950 (Post BP 0)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 400238	2470 +/- 30 BP	-23.5 o/oo	2490 +/- 30 BP

SAMPLE : 13-2102-97-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (wood): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 780 to 510 (Cal BP 2730 to 2460)

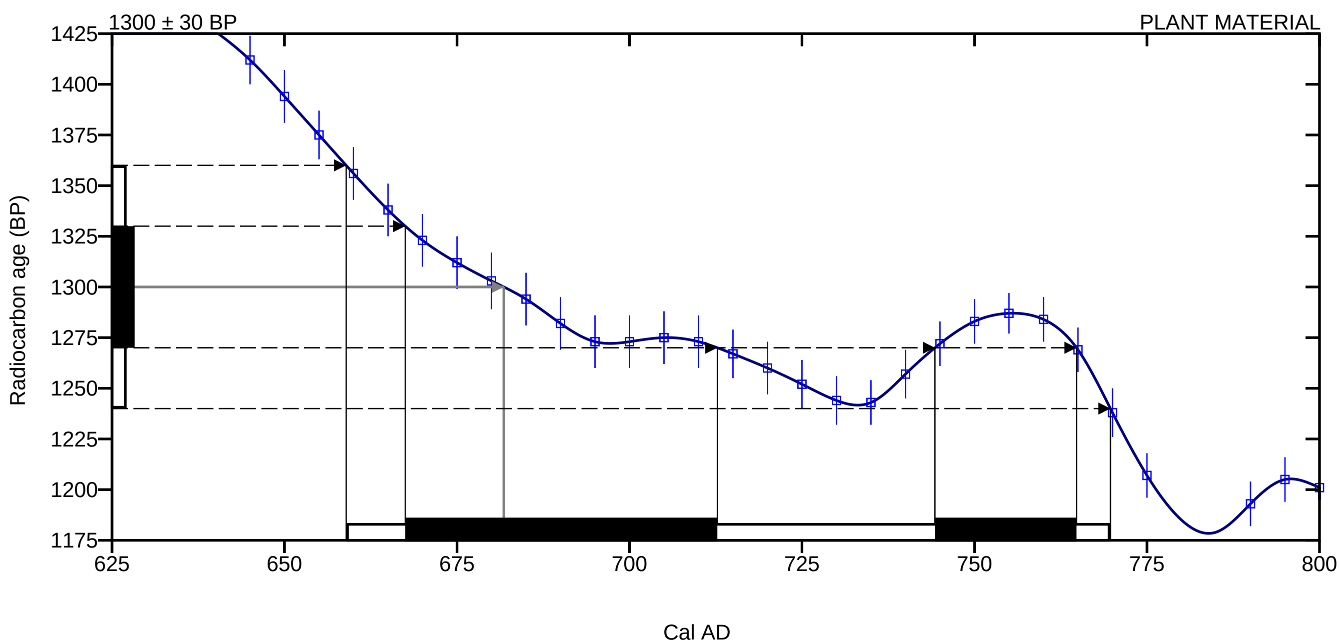
Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -27.5 o/oo : lab. mult = 1)

Laboratory number	**Beta-400235**
Conventional radiocarbon age	**1300 ± 30 BP**
2 Sigma calibrated result 95% probability	**Cal AD 660 to 770 (Cal BP 1290 to 1180)**
Intercept of radiocarbon age with calibration curve	Cal AD 680 (Cal BP 1270)
1 Sigma calibrated results 68% probability	Cal AD 670 to 715 (Cal BP 1280 to 1235) Cal AD 745 to 765 (Cal BP 1205 to 1185)



Database used

INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0– 50,000 years cal BP. Radiocarbon 55(4):1869– 1887., 2013.

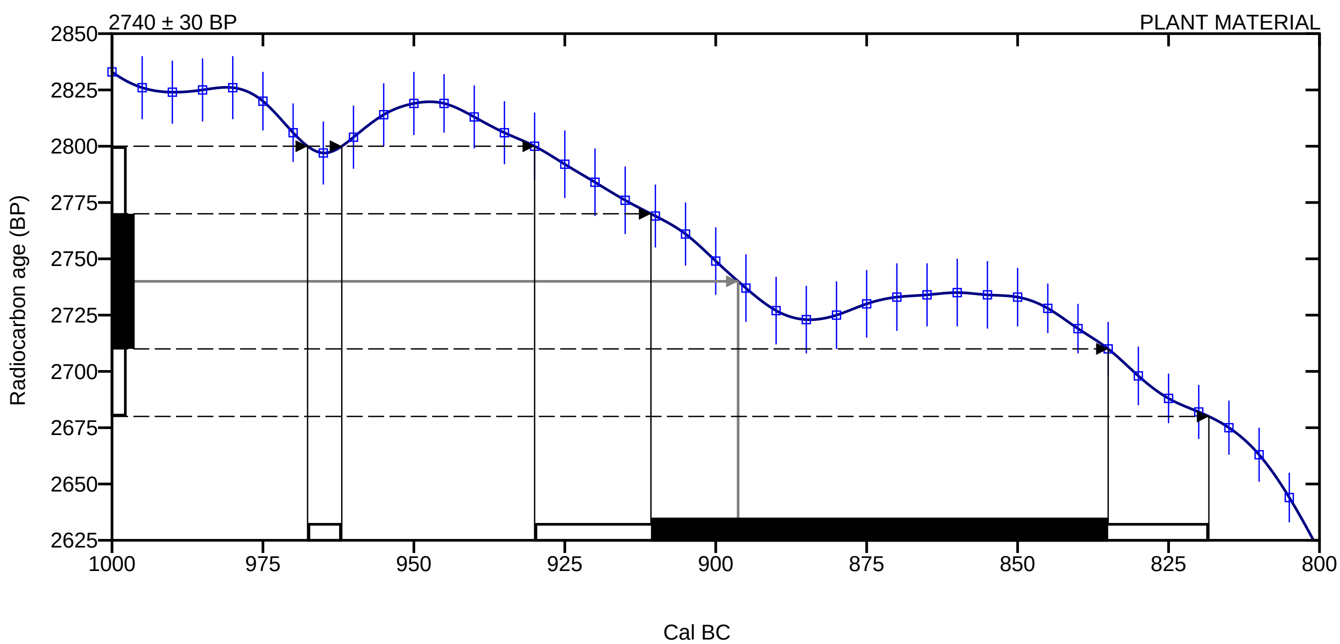
Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • Email: beta@radiocarbon.com

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -29.3 o/oo : lab. mult = 1)

Laboratory number	**Beta-400236**
Conventional radiocarbon age	**2740 ± 30 BP**
2 Sigma calibrated result 95% probability	**Cal BC 970 to 960 (Cal BP 2920 to 2910)** **Cal BC 930 to 820 (Cal BP 2880 to 2770)**
Intercept of radiocarbon age with calibration curve	Cal BC 895 (Cal BP 2845)
1 Sigma calibrated results 68% probability	Cal BC 910 to 835 (Cal BP 2860 to 2785)



Database used

INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

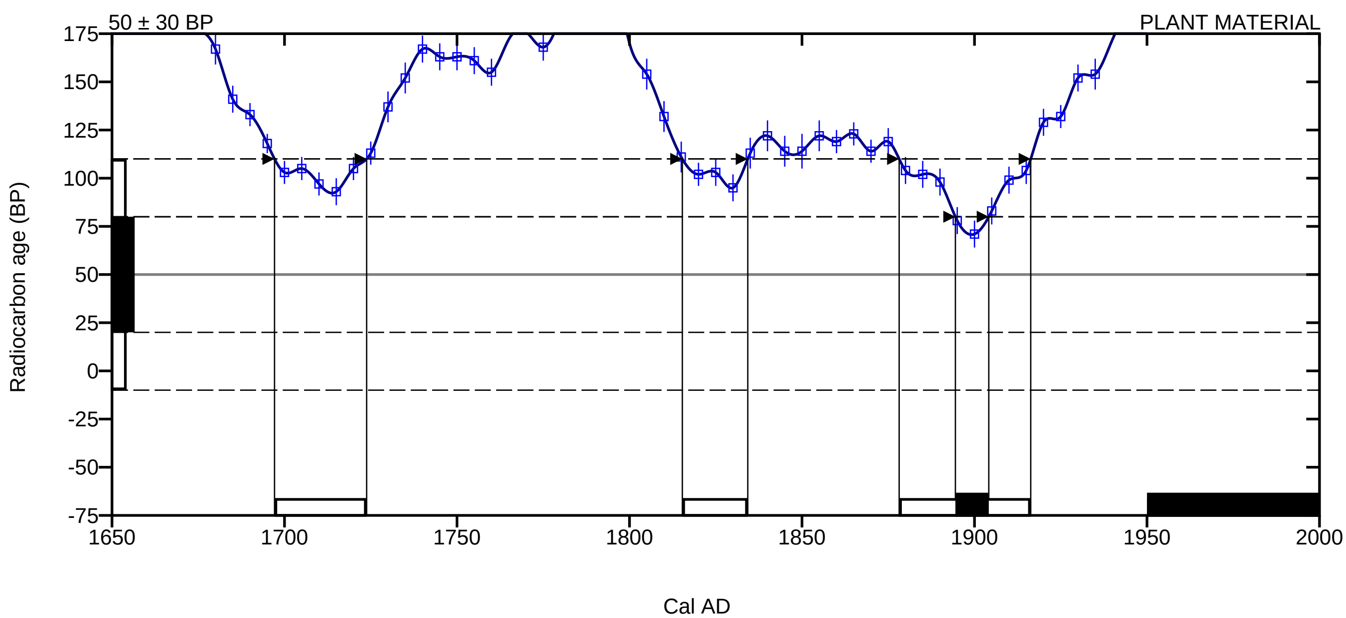
References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887., 2013.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -29.7 o/oo : lab. mult = 1)

Laboratory number	**Beta-400237**
Conventional radiocarbon age	**50 ± 30 BP**
2 Sigma calibrated result **95% probability**	**Cal AD 1695 to 1725 (Cal BP 255 to 225)** **Cal AD 1815 to 1835 (Cal BP 135 to 115)** **Cal AD 1880 to 1915 (Cal BP 70 to 35)** **Post AD 1950 (Post BP 0)**
Intercept of radiocarbon age with calibration curve	Post AD 1950 (Post BP 0)
1 Sigma calibrated results 68% probability	Cal AD 1895 to 1905 (Cal BP 55 to 45) Post AD 1950 (Post BP 0)



Database used

INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

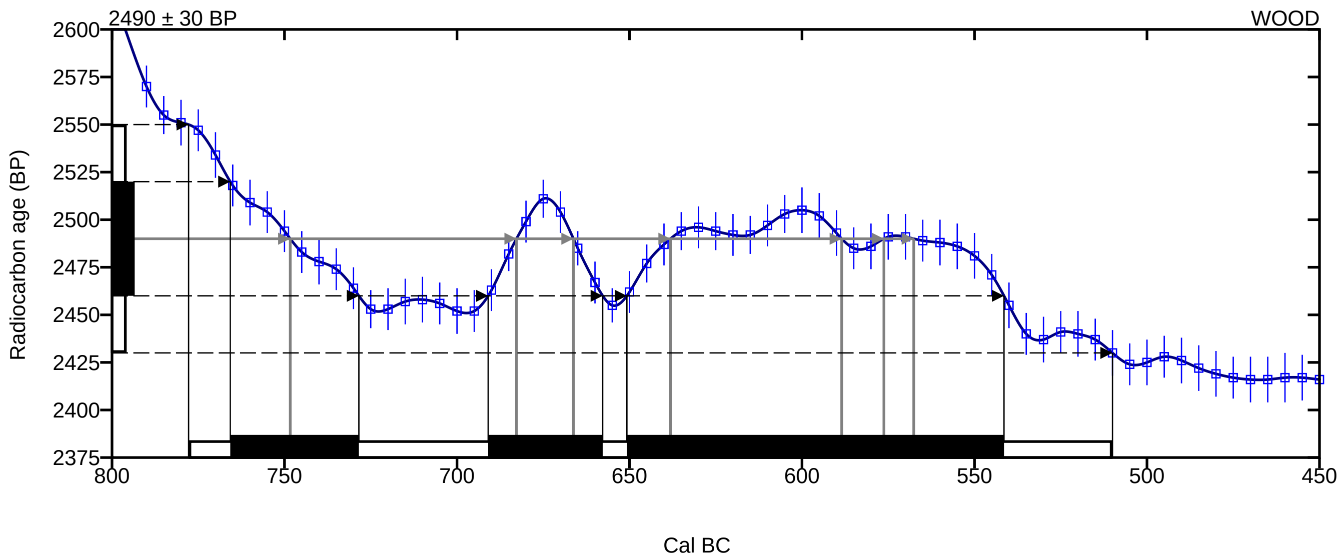
References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887., 2013.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -23.5 o/oo : lab. mult = 1)

Laboratory number	**Beta-400238**
Conventional radiocarbon age	**2490 ± 30 BP**
2 Sigma calibrated result 95% probability	**Cal BC 780 to 510 (Cal BP 2730 to 2460)**
Intercept of radiocarbon age with calibration curve	Cal BC 750 (Cal BP 2700) Cal BC 685 (Cal BP 2635) Cal BC 665 (Cal BP 2615) Cal BC 640 (Cal BP 2590) Cal BC 590 (Cal BP 2540) Cal BC 575 (Cal BP 2525) Cal BC 570 (Cal BP 2520)
1 Sigma calibrated results 68% probability	Cal BC 765 to 730 (Cal BP 2715 to 2680) Cal BC 690 to 660 (Cal BP 2640 to 2610) Cal BC 650 to 540 (Cal BP 2600 to 2490)



Database used
INTCAL13

References

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322
References to INTCAL13 database
Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55(4):1869–1887., 2013.

Appendix C
Washington State University Tephra Analysis Report

WASHINGTON STATE UNIVERSITY

School of the Environment

Eva Hulse
Archaeological Investigations NW
3510 NE 122nd Ave.
Portland, OR
97230-1500

Dear Ms. Hulse:

I have enclosed the glass analytical results for the three tephra samples (33-01, 98-01 and 100-01) you provided our laboratory. Two of the samples (33-01, 98-01) appear to mixtures of tephras. The bulk composition of the glass in both of these tephras (Table 1) have high standard deviations of the oxide weight percents (compare to those for 100-01) which is usually indicative of a mixture of tephras from different sources. Sample 33-01 appears to be a mixture of Mazama Climactic tephra (SC =0.99) and Mount St Helens Ye (SC=0.98) or possibly MSH Sg (SC=0.97).

The bulk glass composition of sample 98-01 is a very good match (SC=0.98) to Rock Mesa tephra from South Sister volcano in the southern Oregon Cascades but Rock Mesa tephra glass normally is not so variable in composition. Upon further examination of the data there appears to be a minor amount (2 shards) of glass (glass 1) with an excellent compositional match (SC = 0.99) to Mazama climactic tephra. The remaining glass (glass 2) is an equally good match (SC=0.95) to Rock Mesa and Glacier Peak Dusty Creek. Without any location information on these samples it is hard to pick one over the other.

The composition of the glass in sample 100-01 is a very good match (SC= 0.98) to glass found in MSH Ye tephra.

Thank you for using our service. If you have any questions regarding these analyses please feel free to call (509-335-3093) or email (fffoit@gmail.com) me.

Sincerely,

Nick

Franklin F. (Nick) Foit, Jr.
Professor Emeritus

TABLE 1. GLASS COMPOSITION OF THE ARCHAEOLOGICAL INVESTIGATIONS NORTHWEST TEPHRAS

Oxide	AINW 33-01			AINW 98-01			AINW 100-01
	bulk composition	glass 1	glass 2	bulk composition	glass 1	glass 2	
SiO_2	74.77(1.47)	73.06(0.22)	75.96(0.17)	76.75(1.48)	73.15(0.17)	77.22(0.85)	75.98(0.31)
Al_2O_3	14.46(0.32)	14.82(0.09)	14.22(0.11)	13.01(0.82)	14.78(0.14)	12.74(0.52)	13.76(0.17)
Fe_2O_3	1.66(0.40)	2.12(0.05)	1.34(0.06)	1.28(0.30)	2.12(0.07)	1.18(0.09)	1.42().07)
TiO_2	0.26(0.14)	0.43(0.02)	0.15(0.03)	0.22(0.08)	0.42(0.01)	0.20(0.04)	0.22(0.03)
Na_2O	4.25(0.30)	4.57(0.13)	4.03(0.14)	3.73(0.47)	4.58(0.04)	3.60(0.38)	4.32(0.09)
K_2O	2.39(0.31)	2.75(0.07)	2.14(0.07)	3.75(0.56)	2.72(0.05)	3.96(0.25)	2.31(0.07)
MgO	0.38(0.06)	0.44(0.05)	0.34(0.03)	0.18(0.12)	0.45(0.03)	0.13(0.04)	0.32(0.04)
CaO	1.66(0.05)	1.64(0.05)	1.67(0.05)	0.97(0.32)	1.61(0.04)	0.86(0.19)	1.59(0.11)
Cl	0.15(0.05)	0.18(0.02)	0.13(0.06)	0.12(0.03)	0.18(0.01)	0.12(0.02)	0.10(0.01)
Total**	100	100	100	100	100	100	100
Number of shards analyzed	24	9	13	20	2	17	17
Probable Source/Age		Mazama 6850 ^{14}C BP	MSH Ye 3450^{14}C BP MSH Sg ~ 13,000 ^{14}C BP	Rock Mesa 2150-2740 ^{14}C BP	Mazama 6850 BP	GP Dusty Creek 5780-5830 Cal Yr BP Rock Mesa 2150-2740 ^{14}C BP	MSH Ye 3450^{14}C BP
Similarity Coefficient***		0.99	0.98 0.97	0.98	0.99	0.95	0.98

* Standard deviations of the analyses given in parentheses
** Analyses normalized to 100 weight percent
*** Borchardt et al. (1972) J. Sed. Petrol., 42, 301-306

Sample: **AINW 33-01 bulk composition**

number of records searched: 1716

Glass composition of sample:

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
74.79	0.26	14.46	0.38	1.66	0.00	0.00	1.66	4.25	2.39	0.15	100.00

weighting factor (only for oxides in bold type)

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O
1	0.25	1	0.25	1			1	1	1

Similiarity Coefficients for 15 closet matches

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
0.990	0.963	0.960	0.842	0.946	0.971	0.991	0.987	0.969	1156			OR	MSH We 1482 AD	Sample 1, Stratum5, TU-1, 35JE455; Metolius River Terrace below "outlet into Billy Chinook Reservoir, UTM Zone 10, Easting: 622220, Northing: 494111
0.996	0.885	0.979	0.842	0.994	0.902	0.986	0.992	0.966	205			WA	SH Wn ?	Burton Creek Rock Shelter #3, 5 mi E of Randle, WA, C. Miss, NW Archaeological Assoc.
1.000	0.962	0.980	0.842	0.994	0.927	0.973	0.948	0.965	535			WA	MSH Wn ???	#98 (bulk composition) from site 45CH425 near Lk Wenatchee State Park, V. Morgan, Archaeological & Historical Services
0.999	0.923	0.973	0.947	0.988	0.874	0.962	0.996	0.963	208			WA	SH Wn ?	CR05-07-31 #9, location unknown, B. Onat, BOAS Inc
0.994	0.731	0.976	0.816	1.000	0.960	0.970	0.971	0.963	1304			WA	MSH Wn	Sample Pitt #10, from 16 cm b.s., core B-03, drive 1 from Castor Lake north of Omak, WA; Mark Abbott, Department of Earth & Planetary Sciences, Unive
0.995	1.000	0.997	0.921	0.994	0.838	0.953	0.987	0.961	213			WA	SH Wn ?	CF-658, Tephra A, Okanogan Co., WA, (NE NW NW T33, R20E, S25), C. Fulkerson, WSU Anthro
0.992	0.769	0.981	0.842	0.982	0.949	0.969	0.958	0.959	1380	s		BC	MSH Wn 488 cal yrs BP	Sample CYI 50.8 from a depth of 50.8 cm in Cooley Lake (49 deg. 29.5' N; 117 deg 38.7'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (2004)
0.982	0.929	0.930	0.842	0.904	0.994	0.988	0.992	0.959	1384			BC	MSH P ?	Sample CYI 168.5 from a depth of 168.5 cm in Cooley Lake (49 deg. 29.5' N; 117 deg 38.7'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (20(
0.986	0.923	0.930	0.947	0.988	0.928	0.979	0.948	0.958	1010			WA	MSH M: 19,200-20,350 BP ???	Sample D (1003-6) depth ~ 2.5m, Saddle Mts., WA, NW SW NE Sec 11, T16N, R21E, Boylston 7.5' Quad; Stan Gough, Archaeological and Historical Se
0.992	0.731	0.986	0.842	0.982	0.960	0.955	0.958	0.958	376	s		WA	MSH Wn; 450	Sarna-Wojcicki et al., (1980) p 667-681 in Lipman and Mullineau eds. "The 1980 Eruptions of MSH, WA" USGS PP 1250
0.996	1.000	0.983	0.947	0.988	0.851	0.922	0.992	0.957	536			WA	MSH Wn ???	#98 (glass 1) from site 45CH425 near Lk Wenatchee State Park, V. Morgan, Archaeological & Historical Services
0.984	0.929	0.930	0.868	0.904	0.964	1.000	0.968	0.954	1385			BC	MSH P	Sample RSII 93.5 from a depth of 93.5 cm in Rockslide Lake (49 deg. 30.0' N; 117 deg 31.3'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (2
0.996	0.769	0.974	0.789	1.000	0.938	0.936	0.958	0.953	1026			WA	MSH W 513 BP ???	Sample 45KT1014 TR1.1, Kachess Reservoir approximately 16 mi east southeast at an elevation of 666m, Stan Gough, Archaeological & Historical Servi
0.981	0.769	0.926	0.895	0.976	0.898	0.991	0.996	0.951	253	s		WA	MSH M/	STD, DM8471-10, from B. Cochran, collected by D. Mullineaux, data by EW & DJ in file 123
0.996	0.769	0.972	0.868	1.000	0.878	0.966	0.958	0.951	238	s		WA	MSH Wn/	STD, DM92565-19, from B. Cochran, collected by D. Mullineaux, data by EW, DJ, SC in file 124

Sample: AINW 33-01 glass 1

number of records searched: 1716

Glass composition of sample:

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
73.06	0.42	14.82	0.44	1.64	0.00	0.00	2.12	4.57	2.75	0.18	100.00

weighting factor (only for oxides in bold type)

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O
1	0.25	1	0.25	1	1	1	1

Similiarity Coefficients for 15 closet matches

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
0.996	1.000	0.983	0.936	1.000	0.991	0.987	0.993	0.990	225			WA	Mazama	Rola 69 229-2, Tephra C, North Cascades National Park, B. Mierendorf
0.996	1.000	0.976	0.898	0.994	0.991	0.998	0.996	0.988	1237			OR	Mazama O 6850 BP	BRE Corral #2; tephra buried in colluvial fan deposit of small basin, exposed by arroyo cutting; 117 deg 01' 33", 44 deg 44'21", Sturgill Creek 7.5 Quad.; R
0.994	0.977	0.977	0.978	1.000	1.000	0.978	0.985	0.988	1338			WA	Mazama Climactic	Sample MW1B from a core (45-48.5 cm b.s.) in a forest hollow in Marckworth Experimental Forest at ~ 500 m elevation near Carnation, WA Shelly Causb
0.995	0.977	0.978	0.957	0.994	0.995	0.982	0.989	0.987	1339			WA	Mazama Climactic	Sample C11D from a core (61-63.5 cm b.s.) in a forest hollow in Moran State Park on Orcas Island, WA, Shelly Causbay, College of Forest Resources, Ur
0.999	0.929	0.986	1.000	0.982	0.995	0.970	0.996	0.986	1310			CA	Mazama Climactic	Sample 110601-8 from Lower Truckee/Pyramid Lake area; Kyle House, Nevada Bureau of Mines & Geology, University of Nevada, Reno, NV 89557
0.995	0.977	0.994	1.000	1.000	0.976	0.967	0.982	0.986	1349			WA	Mazama Climactic	Sample SRASH-2 from Rattlesnake Mountain portion of the Hanford Reach National Monument; Steve Reidel, Pacific Northwest National Laboratory, 902
0.994	0.955	0.976	0.957	0.994	0.991	0.985	0.978	0.984	1510			WA	Mazama Climactic	Sample NWAA T-1, 220 cm bs, left bank of Sammamish River near outlet of Lake Sammamish, Redmond, WA; Charlie Hodges, Norewest Archaeologica
0.995	0.977	0.984	0.957	0.957	0.995	0.987	0.993	0.984	1193			WA	Mazama O 6850 BP	Sample Little Twin Lake, 76.3-76.7cm (Core B, Drive 3) near Winthrop, WA; Jon Riedel, North Cascades Natl. Park, 7280 Ranger Station Road, Marblem
0.999	1.000	0.984	1.000	0.988	0.995	0.946	0.982	0.984	980			?	Mazama Climactic 6850 BP	Sample BB-6-1, Alan Busacca, Dept of Crop and Soil Science, WSU, Pullman, WA
0.994	1.000	0.979	0.978	0.963	0.991	0.972	1.000	0.984	1353			ID	Mazama Climactic	Sample 2001-2 from 87 cm b.s. near Latah Mammoth Site approximately 1 mile nw of Latah, WA in Section 30, T21N, R45E; Charles Luttrell, Archaeologi
0.998	1.000	0.976	0.898	1.000	0.972	0.996	0.975	0.983	906			MT	Mazama Climactic 6850 BP	Sample S-2, depth =55cm, Unit: 3S/1E, Site 24LN1478, Yaak River, NE 1/4, Sec 32, Bonnet Top 7.5' Quad., Montana, Matthew Zweifel, District Archaeolc
0.996	0.977	0.973	1.000	0.976	0.981	0.976	0.993	0.983	1360			WA	Mazama Climactic	Sample Tephra 7 from sand dune on west side of Eureka Flat (11T 382777E 5139203 N); Mark Sweeney, Department of Geology, Washington State Uni
0.996	0.977	0.977	0.917	0.994	0.968	0.991	0.989	0.983	1320			NV/CA	Mazama Climactic	Sample KDA120402-T1 from Lahontan back barrier playette (Z11 300200E 4464600N); Ken Adams, Desert Research Institute, 2215 Raggio Parkway, R
0.995	0.929	0.982	1.000	0.962	0.976	0.985	0.986	0.983	1289			MT	Mazama	Sample FL-03 16K II, depth 138 cm Flathead Lake, Montana, Michael Hofmann (Marc Hendricks), Department of Geology, University of montana, Missoul
0.994	0.998	0.976	0.978	0.963	0.991	0.991	0.975	0.982	1369			WA	Mazama Climactic	Sample KRF 99-111 from the Pasco Basin, WA; Karl Fecht, Environmental Technologies, Bechtel Hanford Inc., 3550 George Washington Way, Richland,

Sample: AINW 33-01 glass 2

number of records searched: 1716

Glass composition of sample:

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
75.98	0.15	14.22	0.34	1.67	0.00	0.00	1.34	4.03	2.14	0.13	100.00

weighting factor (only for oxides in bold type)

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O
1	0.25	1	0.25	1	1	1	1

Similiarity Coefficients for 15 closet matches

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
0.995	0.938	0.979	0.971	0.976	0.970	0.993	0.977	0.979	1536			OR	MSH Sg	Sample Miller Cave tephra, Miller Caves, 5 miles north of Rock Creek ranch house, Catlow Valley, OR; Pete Mehringer, Dept of Anthropology, WSU
1.000	0.933	0.993	1.000	0.988	0.933	0.971	0.995	0.979	1279 s			WA	MSH Ye	Carp Ash-2 (major) (lab number: T281-3), from core 90 (depth = 2.29-2.31m) in Carp Lake, OR; Whitlock et al., 2000, Environmental History and Tephrost
0.999	0.933	0.993	1.000	0.988	0.933	0.971	0.995	0.979	1487 s			WA	MSH Ye 3450+-420, cal = 3690	Sample Carp Ash-2, T281-3, 2.29-2.31m in Carp Lake, Washington; Whitlock, C., Sarna-Wojcicki, A.M., Bartlein, P. J., Nickmann, R.J. (2000) Environmer
0.999	0.833	0.985	0.971	1.000	1.000	0.924	0.995	0.978	1278 s			WA	MSH Ye	MSH Ye Std Ye713721 (lab number: T3,4) Whitlock et al., 2000, Environmental History and Tephrostratigraphy at Carp lake, southwestern Columbia Basi
0.999	0.833	0.985	0.971	1.000	1.000	0.924	0.995	0.978	1486 s				o MSH Ye	Sample MSH Ye 713721 (T3,4); Whitlock, C., Sarna-Wojcicki, A.M., Bartlein, P. J., Nickmann, R.J. (2000) Environmental history and tephrostratigraphy at
0.992	0.980	0.960	0.958	1.000	0.981	0.964	0.970	0.977	587			WA		Sample CLY-1A, Clyde, WA, Harsha Quad, Busacca et al. (1992) Quat. Res., 37, 281-303
0.996	0.867	0.979	1.000	0.994	0.985	0.969	0.963	0.977	1275 s			WA	MSH Ye	MSH Ye Std (10/70) c (lab number: T5-3); Whitlock et al., 2000, Environmental History and Tephrostratigraphy at Carp lake, southwestern Columbia Basi
0.996	0.867	0.979	1.000	0.994	0.985	0.969	0.963	0.977	1488 s				o MSH Ye	Sample MSH Ye (10/70) (T3-3); Whitlock, C., Sarna-Wojcicki, A.M., Bartlein, P. J., Nickmann, R.J. (2000) Environmental history and tephrostratigraphy at
0.996	0.938	0.994	1.000	0.988	0.903	0.988	0.991	0.976	18			OR	SH Ye ?	Twin Lakes 1.445m, Wallowa-Whitman NF, OR, Marden-Mehringer
0.998	0.933	0.994	1.000	0.982	0.955	0.926	0.995	0.975	447			WA	MSH Ye ?	USFS-5 Tephra from a section in S1/2 Steamboat Mtn 3405, approx 15 mi NW of Trout Lake WA, C. Mack, Mt Adams Ranger Dist.
0.993	0.938	0.970	0.941	0.952	0.963	0.981	1.000	0.974	1404 s			WA	MSH Sg	MSH Sg Standard analysis performed by F. F. Foit, Jr. in WSU Microprobe lab on sample provided by Andre Sarna-Wojcicki, USGS, Menlo Park, CA
0.992	1.000	0.963	1.000	0.970	0.993	0.963	0.943	0.973	1363			WA	MSH Sg	Sample Tephra Bab 6 below L1 loess along Smith Springs Road (11T 390841E 5140690 N); Mark Sweeney, Department of Geology, Washington State
0.998	0.938	0.988	1.000	0.971	0.940	0.955	0.986	0.973	1489 s				o MSH Ye	Sample MSH Ye (8/93) (T5-3); Whitlock, C., Sarna-Wojcicki, A.M., Bartlein, P. J., Nickmann, R.J. (2000) Environmental history and tephrostratigraphy at C
0.995	0.938	0.976	0.971	0.940	0.978	0.988	0.968	0.973	1322			OR	MSH set S or set Y	Sample PM-FG from cut bank near French Glen, OR, Pete Mehringer, Department of Anthropology, WSU
0.991	0.933	0.968	0.882	0.976	0.940	0.995	0.995	0.972	1520			WA	MSH Sg 12500-13600 BP	Sample T-3, Section 2, 1.8m interval; Bishop Sloth Locality; SW1/4,Section 5, T19N, R23E Bishop Ridge Quad, WA; Stan Gough, Archaeological & Histor

Sample: **AINW 98-01 bulk composition**

number of records searched: 1716

Glass composition of sample:

SiO_2	TiO_2	Al_2O_3	MgO	CaO	BaO	MnO	Fe_2O_3	Na_2O	K_2O	Cl	Total
76.74	0.22	13.01	0.18	0.97	0.00	0.00	1.28	3.73	3.75	0.12	100.00

weighting factor (only for oxides in bold type)

SiO_2	TiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	Na_2O	K_2O
1	0.25	1	0.25	1	1	1	1

Similiarity Coefficients for 15 closet matches

SiO_2	TiO_2	Al_2O_3	MgO	CaO	Fe_2O_3	Na_2O	K_2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
1.000	0.864	0.989	1.000	0.969	0.992	0.956	0.995	0.980	17			OR	????	Twin Lakes 0.955m, Wallowa-Whitman NF, OR, Marden-Mehringer
1.000	0.955	0.982	0.947	1.000	0.962	0.944	0.997	0.979	915 s			OR	Rock Mesa 2150-2740 BP	ROCKM-1, lapilli from surface 0.5km S of Rock Mesa flow next to Moraine Lakes-Wickiup Trail, South Sister 7.5' Quad, s 33, T 17N, R 8E, Craig Skinner,
0.999	0.955	0.992	0.889	0.969	1.000	0.935	0.992	0.977	1068			OR	Rock Mesa 2150-2740 BP ??	Sample Twin Lakes 0.935m, tephra from core of Twin Lakes, OR at 0.935m depth by Peter Mehringer, Department of Anthropology, Washington State Un
0.995	0.917	0.963	0.857	0.942	0.970	1.000	0.981	0.968	626			OR	Glacier Peak, 11,200 BP ?	Sample 324-1, glass 2, Oregon Archaeological Site 35-UM-154, just SW of Bucks Corners, Hermiston 7.5' Quad, OR; Infotec, Craig Skinner
0.994	0.957	0.957	0.857	0.990	0.962	0.960	0.974	0.968	1118			WA	Rock Mesa	Sample 45KT326 Tephra 2 (glass 2, 6 shards), depth 2.5m along a tributary to Washout Gulch (SW1/4, SE1/4 of Sec 33, Badger Gap 7.5 Quad, Yakima F
0.988	1.000	0.952	1.000	0.990	0.875	0.995	0.963	0.963	534			WA	Glacier Peak ???	#69 (glass 2) from site 45CH425 near Lk Wenatchee State Park, V. Morgan, Archaeological & Historical Services
0.999	0.864	0.988	0.944	0.938	0.889	0.987	0.982	0.959	260			NV	Mono Craters ??	1.99m, Blue Lake, Pine Ridge Forest, NV, P. Mehringer
0.993	0.818	0.985	0.944	0.959	0.970	0.906	0.966	0.957	8 s			OR	Rock Mesa 2150-2740 BP	ROCKM-4, 5km S of South Sister Volcano, OR, Craig Skinner, Infotec, Pers. Comm.
0.986	0.880	0.941	0.889	1.000	0.914	0.944	0.992	0.957	537			WA	Glacier Peak ???	#98 (glass 2) from site 45CH425 near Lk Wenatchee State Park, V. Morgan, Archaeological & Historical Services
0.999	0.665	0.988	0.957	0.988	0.942	0.939	0.947	0.955	618			WA		Sample SJE-1D, St. John-Endicott Road, St. John 7.5 Quad, Busacca et al. (1992) Quat. Res., 37, 281-303
0.996	0.957	0.958	0.900	0.948	0.883	0.971	0.971	0.952	551			WA	????	Sample 45FR52-02A, Glass 2 Palouse Canyons, B. Hicks, BOAS, Inc., Seattle
0.987	0.957	0.935	0.889	0.959	0.945	0.933	0.957	0.950	214			WA	Glacier Peak ?	CF-658, Tephra B, Okanogan Co., WA, (NE NW NW T33, R20E, S25), C. Fulkerson, WSU Anthro
0.998	0.846	0.998	0.947	0.938	0.871	0.912	0.995	0.948	9 s			OR	Rock Mesa 2150-2740 BP	ROCKM-1, 5km S of South Sister Volcano, OR, Craig Skinner, Infotec, Pers. Comm.
0.989	0.864	0.963	1.000	0.951	0.844	0.960	0.987	0.948	681			WA	GP Irving (below G) ?	Sample YR/SPR3/IF1-3 (lower ash), depth 2.3m, Yakima Ridge, Yakima Training Center, K. Boreson, Archaeological & Historical Services, EWU
0.997	1.000	0.964	0.900	0.907	0.930	0.976	0.907	0.947	1462 s			CA	Nomlaki-like & related tuffs, ~3.4 Ma	Sample TSN-1, Nomlaki Tuff, Tuscan Formation, Tuscan Springs, CA; Knott, J.R., Sarna-Wojcicki, A.M., Meyer, C.E., Tinsley III, J.C., Wells, S.G., and W

Sample: AINW 98-1 glass 1

number of records searched: 1716

Glass composition of sample:

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
73.14	0.42	14.78	0.45	1.61	0.00	0.00	2.12	4.58	2.72	0.18	100.00

weighting factor (only for oxides in bold type)

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
1	0.25	1	0.25	1			1	1	1		

Similiarity Coefficients for 15 closet matches

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
0.995	0.998	0.979	1.000	0.981	0.991	0.993	0.985	0.988	1369			WA	Mazama Climactic	Sample KRF 99-111 from the Pasco Basin, WA; Karl Fecht, Environmental Technologies, Bechtel Hanford Inc., 3550 George Washington Way, Richland,
0.996	0.977	0.986	0.978	0.975	0.995	0.985	0.996	0.988	1193			WA	Mazama O 6850 BP	Sample Little Twin Lake, 76.3-76.7cm (Core B, Drive 3) near Winthrop, WA; Jon Riedel, North Cascades Natl. Park, 7280 Ranger Station Road, Marblem
0.995	0.977	0.980	1.000	0.982	1.000	0.976	0.996	0.988	1338			WA	Mazama Climactic	Sample MW1B from a core (45-48.5 cm b.s.) in a forest hollow in Marckworth Experimental Forest at ~ 500 m elevation near Carnation, WA Shelly Causb
0.997	1.000	0.978	0.918	0.988	0.991	1.000	0.986	0.988	1237			OR	Mazama O 6850 BP	BRE Corral #2; tephra buried in colluvial fan deposit of small basin, exposed by arroyo cutting; 117 deg 01' 33", 44 deg 44'21", Sturgill Creek 7.5 Quad.; R
0.996	0.977	0.981	0.978	0.976	0.995	0.980	1.000	0.987	1339			WA	Mazama Climactic	Sample C11D from a core (61-63.5 cm b.s.) in a forest hollow in Moran State Park on Orcas Island, WA, Shelly Causbay, College of Forest Resources, Ur
0.995	1.000	0.978	0.978	0.988	0.991	0.985	0.982	0.987	1325			ID	Mazama Climactic	Sample 2 from Site 10BR092 along Pend Oreille River in northern Idaho; Leslie Norman, Northwest Archaeological Associates Inc., 5416 20th Avenue N\
0.997	0.977	0.976	0.978	0.994	0.981	0.979	0.996	0.986	1360			WA	Mazama Climactic	Sample Tephra 7 from sand dune on west side of Eureka Flat (11T 382777E 5139203 N); Mark Sweeney, Department of Geology, Washington State Uni
0.997	1.000	0.986	0.957	0.982	0.991	0.985	0.982	0.986	225			WA	Mazama	Rola 89 229-2, Tephra C, North Cascades National Park, B. Mierendorf
0.998	1.000	0.988	1.000	0.988	0.995	0.968	0.971	0.986	1313			NV/CA	Mazama Climactic	Sample PR4-, from cutbank along Powder River 0.6 mile downstream from Mason Dam (W117.98194 deg. N44.67278 deg.) in eastrem OR, Ralph Klinge
0.998	0.933	0.976	0.957	1.000	0.991	0.979	0.993	0.986	1342			WA	Mazama Climactic	Sample PPBIIG from a core (6.80-6.82 m b.s.) in Panther Potholes, Fourth of July Pass (4 miles from Colonial Campground) North Cascades National Pa
0.995	1.000	0.982	1.000	0.981	0.991	0.969	0.989	0.986	1353			ID	Mazama Climactic	Sample 2001-2 from 87 cm b.s. near Latah Mammoth Site approximately 1 mile nw of Latah, WA in Section 30, T21N, R45E; Charles Luttrell, Archaeologi
0.995	0.955	0.979	0.978	0.988	0.991	0.983	0.989	0.986	1510			WA	Mazama Climactic	Sample NWAA T-1, 220 cm bs, left bank of Sammamish River near outlet of Lake Sammamish, Redmond, WA; Charlie Hodges, Norewest Archaeologica
0.998	0.977	0.978	0.938	0.994	1.000	0.972	0.985	0.985	1206				0 Mazama O 6850 BP	Sample Pine Creek; Pat Spencer, Dept. of Geology, Whitman College, Walla Walla, WA 99362
0.998	0.977	0.976	0.957	1.000	1.000	0.956	0.989	0.985	1393 s			BC	Mazama Climactic	Sample CYl 382.0 from a depth of 382.0 cm in Cooley Lake (49 deg. 29.5' N; 117 deg 38.7'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (20(
0.997	0.977	0.995	0.978	0.994	0.986	0.952	0.989	0.985	1231			ID	Mazama O 6850 BP	Sample #83, Bank Face C, Strata IV, taken from profile, Pend Oreille River, northern Idaho; Leslie Norman, NW Archaeological Assoc., Inc, 5416 1/2 20th

Sample: AINW 98-01 glass 2

number of records searched: 1716

Glass composition of sample:

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
77.21	0.20	12.74	0.13	0.86	0.00	0.00	1.18	3.60	3.96	0.12	100.00

weighting factor (only for oxides in bold type)

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O
1	0.25	1	0.25	1			1	1	1

Similiarity Coefficients for 15 closet matches

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
0.993	0.870	0.954	0.813	0.925	0.975	0.967	0.990	0.958	214			WA	Glacier Peak ?	CF-658, Tephra B, Okanogan Co., WA, (NE NW NW T33, R20E, S25), C. Fulkerson, WSU Anthro
0.995	0.769	0.956	0.867	0.935	0.967	0.969	0.978	0.955	1075			WA	Rock Mesa 2150-2740 BP ??	Sample 45-WA-B1-A (Glass 2, 4 shards); tephra layer beneath rotting log on terrace above Skagit River near Newhalem, WA; Meg Nelson, NW Archaeolc
0.986	0.950	0.948	0.765	0.988	0.890	0.992	0.924	0.947	1389 s			BC	Glacier Peak Dusty Creek 5780-5830 cal years BP	Sample CYI 319.5 from a depth of 319.5 cm in Cooley Lake (49 deg. 29.5' N; 117 deg 38.7'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (20(
0.985	0.900	0.940	0.813	1.000	0.873	0.994	0.932	0.946	1391 s			BC	Glacier Peak Dusty Creek 5780-5830 cal years BP	Sample CYI 329.0 from a depth of 329.0 cm in Cooley Lake (49 deg. 29.5' N; 117 deg 38.7'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (20(
0.992	0.800	0.961	0.813	0.887	0.992	0.978	0.939	0.946	537			WA	Glacier Peak ???	#98 (glass 2) from site 45CH425 near Lk Wenatchee State Park, V. Morgan, Archaeological & Historical Services
0.986	0.950	0.946	0.813	1.000	0.873	0.936	0.967	0.946	1194			WA		Sample Little Twin Lake, 58.5-59.5cm (Core A, Drive 6) near Winthrop, WA; Jon Riedel, North Cascades Natl. Park, 7280 Ranger Station Road, Marblem
0.999	0.900	0.995	0.765	0.925	0.894	0.939	0.980	0.946	8 s			OR	Rock Mesa 2150-2740 BP	ROCKM-4, 5km S of South Sister Volcano, OR, Craig Skinner, Infotec, Pers. Comm.
0.987	0.850	0.958	0.929	0.977	0.873	0.917	0.987	0.945	222			WA	Glacier Peak ???	Rola 89 229-1, Tephra B, North Cascades National Park, B. Mierendorf
0.988	0.667	0.947	0.867	0.965	0.992	0.881	0.988	0.945	1192			WA		Sample Little Twin Lake, two of two, 55-56cm (Core A, Drive 2) near Winthrop, WA; Jon Riedel, North Cascades Natl. Park, 7280 Ranger Station Road, I
0.988	0.850	0.979	0.813	1.000	0.856	0.969	0.929	0.944	836 s			UT	Nomlaki Ash Bed 3.29 Ma	T-4-86K, data from Sarna-Wojcicki & Meyer (pers. comm., 1992) in S.K. Williams (1994) Late Cenozoic tephrostratigraphy of deep sediment cores from th
0.995	0.950	0.991	0.765	0.945	0.819	0.978	0.965	0.942	260			NV	Mono Craters ??	1.99m, Blue Lake, Pine Ridge Forest, NV, P. Mehringer
0.980	1.000	0.919	0.591	0.965	0.992	0.950	0.917	0.941	176			CA		Ash in Searles Lake sediments, A. Sarna-Wojcicki et al. (1964) USGS PP 1293
0.992	0.952	0.987	0.813	0.915	0.922	0.902	0.955	0.941	1068			OR	Rock Mesa 2150-2740 BP ??	Sample Twin Lakes 0.935m, tephra from core of Twin Lakes, OR at 0.935m depth by Peter Mehringer, Department of Anthropology, Washington State Un
0.984	0.900	0.946	0.813	1.000	0.856	0.983	0.914	0.940	1390 s			BC	Glacier Peak Dusty Creek 5780-5830 cal years BP	Sample CYI 321.0 from a depth of 321.0 cm in Cooley Lake (49 deg. 29.5' N; 117 deg 38.7'W), B.C. Canada, Foit, Jr., F.F., Gavin, D.G., and Hu, F.S. (20(
0.987	1.000	0.976	0.765	0.977	0.873	0.908	0.947	0.940	833			UT	Nomlaki Ash Bed 3.29 Ma	BUR-989.4, Core from Bonneville Basin, Utah, S.K. Williams (1994) Late Cenozoic tephrostratigraphy of deep sediment cores from the Bonneville Basin, r

Sample: AINW 100-01

number of records searched: 1716

Glass composition of sample:

SiO2	TiO2	Al2O3	MgO	CaO	BaO	MnO	Fe2O3	Na2O	K2O	Cl	Total
75.96	0.22	13.76	0.32	1.59	0.00	0.00	1.42	4.32	2.31	0.10	100.00
weighting factor (only for oxides in bold type)											
1	0.25	1	0.25	1			1	1	1		

Similiarity Coefficients for 15 closet matches

SiO2	TiO2	Al2O3	MgO	CaO	Fe2O3	Na2O	K2O	sim coef weighted avg	rec#	Std	Date	State	Source/Age	Notes
0.997	0.957	0.975	0.941	0.988	0.958	1.000	0.970	0.979	1277			WA	MSH Ye	Carp Ash-1 (major) (lab number: T-279-1), from core 90 (depth = 2.15-2.16m) in Carp Lake, OR; Whitlock et al., 2000, Environmental History and Tephro
0.997	0.957	0.975	0.933	0.988	0.958	1.000	0.970	0.978	1485 s			WA	MSH Ye 3450+-420, cal = 3630	Sample Carp Ash-1, T279-1, 2.15-2.16m in Carp Lake, Washington; Whitlock, C., Sarna-Wojcicki, A.M., Bartlein, P. J., Nickmann, R.J. (2000) Environmer
0.999	0.864	0.993	0.938	0.962	0.973	0.986	0.987	0.977	439			WA	MSH Jy or Ye ?	USFS-1 Tephra from a section in S1/2 Steamboat Mtn 3405, approx 15 mi NW of Trout Lake WA, C. Mack, Mt Adams Ranger Dist.
0.998	0.955	0.999	0.941	0.952	0.951	0.956	0.991	0.972	1024			WA	MSH M 19,200-20,350 BP ???	Sample #3 (Stratum VI) Archaeological Site 45 SA 338, Unit C, Indian Heaven Wilderness (35 km SE of MSH), Gifford Pinchot National Forest, Rick McCl
0.996	1.000	0.992	0.941	0.925	0.986	0.925	0.996	0.970	1276			WA	MSH Ye	Carp Ash-1 (hi Fe, lo Ca) (lab number: T279-1) , from core 90 (depth = 2.15-2.16m) in Carp Lake, OR; Whitlock et al., 2000, Environmental History and T
0.997	0.909	0.973	0.941	0.981	0.953	0.975	0.963	0.970	253 s			WA	MSH M/	STD, DM8471-10, from B. Cochran, collected by D. Mullineaux, data by EW & DJ in file 123
0.996	0.727	0.998	0.938	0.994	0.979	0.965	0.952	0.969	381 s			WA	MSH So, 13,000	Sarna-Wojcicki et al., (1980) p 667-681 in Lipman and Mullineau eds. "The 1980 Eruptions of MSH, WA" USGS PP 1250
0.997	0.727	0.997	0.906	0.994	0.979	0.972	0.952	0.969	258 s			WA	MSH Sg^12120-13650	SHSO, Mt. St. Helens Tephras Set S, Davis (1985), Quat. Res., 23, 38-54
0.991	0.864	0.969	0.969	0.950	0.993	0.951	0.983	0.969	476			WA	MSH J or MSH M ?	Trout Creek Site (45SA222) T4N R7E Sec 21, G. Cauk, USDA Wind River Ranger District
0.997	0.932	0.989	0.899	0.991	0.988	0.899	0.973	0.968	584 s			WA	MSH Mc 19,200-20,350 BP	Sample MSH Mc Std, Busacca et al. (1992) Quat. Res., 37, 281-303
0.995	0.773	0.996	1.000	0.994	0.951	0.963	0.948	0.968	772 s			WA	MSH S 12,900	Sample Mabton-1, from outcrop of rythmites on south side of Yakima River just north of Mabton 46 deg 14'N, 120.00 deg W; Dan Levish, Bur of reclamatic
0.998	0.955	0.975	0.780	0.988	0.966	0.975	0.951	0.967	408 s			BC	Dufferin Hill ~34,000	Sample UA 333 from south-central BC, Westgate & Fulton (1975) Ca. J. Earth Sci., 12, 489-502
0.999	0.773	0.999	1.000	0.994	0.934	0.982	0.931	0.967	249 s			WA	MSH Sg/	STD, DM82477-2, collected by D. Mullineaux, data by DJ & EW file 123
0.994	0.842	0.987	0.932	0.912	0.986	0.976	0.980	0.966	581 s			WA	MSH Jy 10,700 BP	Sample MSH Jy Std, Busacca et al. (1992) Quat. Res., 37, 281-303
0.999	0.955	0.995	1.000	0.899	0.958	0.988	0.951	0.966	1050			WA	MSH J 11000 BP ??	Sample NOCA2, from well-stratified fluvial deposit inCirque basin on top of Copper Ridge 1.25km NE of Copper Mtn in NW corner of NCNP, 9 km S of Ca