Preliminary Geotechnical Report
Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

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SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

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PRELIMINARY GEOTECHNICAL REPORT
THORNDYKE RESOURCE OPERATIONS COMPLEX
SINGLE CONVEYOR AND PIER
JEFFERSON COUNTY, WASHINGTON

1.0 INTRODUCTION

This report presents the results of our evaluation of the proposed Thorndyke Resource Operations Complex (T-ROC) Single Conveyor and Pier. *Note: This report is subject to modification as a result of the completion of the SEPA analysis (Environmental Impact Statement) being undertaken as a part of the governmental permitting process.*

The purpose of our work was to identify areas of potential slope instability and potential geologic and geotechnical issues related to the Single Conveyor and Pier (and zone of probable alignments) and the proposed construction. Our work for this task was limited to the area along the Single Conveyor and the proposed Pier to be constructed in Hood Canal.

Our scope of services consisted of:

1. Review of selected existing geologic, geotechnical, development, and environmental records related to the potentially affected properties and nearby properties.
2. Review of topographic, bathymetric, and other information available from the Client; U.S. Geological Survey (USGS) topographic and geologic maps; Washington State Department of Ecology (WSDOE) *Coastal Zone Atlas*; Critical Areas – Landslide Hazard map for Eastern Jefferson County; and information in our files for nearby properties.
3. Review of May 2001 aerial photograph stereo pairs of the proposed site and vicinity.
4. Reconnaissance of the slope and beach on property(ies) that the proposed Single Conveyor may cross performed by Mr. Ted Hopkins, an engineering geologist with Shannon & Wilson, Inc.
5. Observation of site conditions by Mr. Stan Boyle, Shannon & Wilson project manager and project geotechnical engineer.
6. Presentations of our findings at progress meetings.
7. Preparation of this report summarizing our opinions, conclusions, and recommendations.

No subsurface explorations were performed for this study. Our scope of services did not include reconnaissance along the proposed Twin Conveyors or the Shine Pit.

Our services were provided in general accordance with our August 28, 2001, proposal, as authorized by Ms. Lyn Keenan of Reid Middleton on August 28, 2001, via e-mail.

2.0 SITE AND PROJECT DESCRIPTION

A detailed T-ROC conveyor and pier project description and fact sheet are provided in Appendix A of this report. An abbreviated project description is presented below.

The proposed Single Conveyor and Pier site is located on the west side of Hood Canal approximately five miles southwest of the Hood Canal Bridge and approximately one mile northeast of Thorndyke Bay, as shown on the Vicinity Map, Figure 1. The site is near the edge of a broad upland plateau area that is dissected by valleys extending northwesterly from Hood Canal, Figure 2. The T-ROC sand and gravel transport system would consist of Twin Conveyors, a Single Conveyor, and Pier, which are proposed to be constructed along the approximate alignments and at the approximate locations indicated in Figures 1 and 2. The Twin Conveyors would consist of twin 48-inch conveyors originating at Shine Pit. Shine Pit is located approximately four miles south of Port Ludlow. These conveyors would transfer the sand and gravel to the Single Conveyor where the two conveyors meet (see Figure 1). The Single Conveyor would be 60 inches wide and convey the sand and gravel to the end of the Pier in Hood Canal where the materials would be loaded onto a vessel for transport.

The Single Conveyor would cross Thorndyke Road on a covered bridge, extend toward the beach across a narrow triangular-shaped point formed by two valleys that cut into the upland, and drop to the beach by crossing a steep, southeast-facing bluff (see Figure 2). The conveyor would be constructed through an approximately 400-foot-long cut proposed at the top of the bluff. The Single Conveyor would be about 3,800 feet long. Geologic and geotechnical review for design and construction of the Twin Conveyors was not part of our scope of services and is not discussed in this report.

The upland area slopes gently to moderately toward Hood Canal. At the edge of this upland area, the slopes become steep toward valleys located to the northeast and southwest of the proposed Single Conveyor and toward Hood Canal where the slope forms a bluff along the beach. This bluff is approximately 80 to 100 feet high. The combined height above Hood Canal of the bluff and steep slope above it is about 190 feet. The steep slopes are interrupted by a midslope bench along the east and southeast sides of the triangular upland area that this conveyor would cross. The upland area at the site and much of the adjacent valleys have been recently logged. Vegetation in these areas generally consists of fir trees less than about 6 feet high and thick understory brush. The base of the broad valley to the northeast and the lower portions of the valley to the southwest remain heavily wooded.

3.0 DOCUMENT REVIEW

As part of our study, we reviewed numerous documents relating to the geologic and geotechnical aspects of the subject property and vicinity. We reviewed published geologic maps, including the *Coastal Zone Atlas of Washington, Jefferson County* (WSDOE, 1979); *Geologic Map of East-Central Jefferson County*, Washington; (Birdseye, 1976a); and *Relative Slope Stability in East-Central Jefferson County*, Washington; (Birdseye, 1976b). We also reviewed the *Critical Areas Maps for Jefferson County* (Jefferson 1995) and Jefferson County's Resolution #37-83, Thorndyke Slide Area. Unpublished work we reviewed included several geotechnical reports that we previously prepared for nearby residential properties and two reports prepared by others (Krazan, 2001, and Golder, 2001) for the subject property and T-ROC project.

We analyzed May 2001 aerial photograph stereo pairs of the area. We also reviewed oblique aerial photographs of the site available on WSDOE and Jefferson County websites.

4.0 SITE CONDITIONS

Our description and analyses of the conditions at the site is based on a reconnaissance of the site and our review of published and unpublished documents. Reconnaissance of the site between the upland area near Single Conveyor Station 200+00 and the beach was performed on August 30, September 5, and October 9, 2001. During our reconnaissance, we noted features such as topography, soil exposures, springs, vegetational clues to geologic conditions and stability, and evidence of past landsliding.

4.1 Alignment Topography

Northwest of Thorndyke Road, the Single Conveyor crosses an upland plateau that generally slopes south and southwest at approximately 5 degrees. Between Stations 205+50 and 211+50, the conveyor skirts the top west edge of a ravine that has side slopes of about 35 degrees, although the slopes are steeper and flatter locally. Thorndyke Road lies in a 60- to 70-foot-deep cut where the conveyor crosses the road near Station 212+75. Just southeast of Thorndyke Road, the ground surface is between elevations 325 and 350 feet and slopes to the southeast, generally increasing in steepness as it approaches the beach. A ground surface and geologic profile along the Single Conveyor is presented in Figure 4.

At the southeast edge of the upland area, i.e., southeast of Station 221+00, there are two zones of relatively steep ground separated by a relatively gently sloped bench. The upper steep slope, from about Station 223+50 to Station 224+75, is between 50 and 75 feet high and slopes between 25 and 40 degrees. The bench is between about Station 224+75 and Station 225+60, is approximately 70 to 100 feet wide, and in the vicinity of the proposed conveyor lies between elevations 120 and 150 feet. The ground surface here has an approximate slope of 15 degrees. Between about Station 225+60 and Station 227+00, the conveyor spans an approximately 80 to 100 feet high bluff at the back of the beach. The uppermost portion of the bluff has a slope face inclination between approximately 60 and 70 degrees from the horizontal. The slope inclination decreases to approximately 40 to 45 degrees farther downslope and flattens more in the landslide debris that was observed along the toe of the slope, just above the beach. These areas are delineated in Figure 4.

4.2 Geology

Based on our observations of exposed soils and on reviewed geologic maps, the upland area is capped by a thin veneer of glacial till that overlies stratified outwash consisting of sand and gravelly sand with layers of sandy gravel. The outwash appears to extend down to the base of the bench (to approximately elevation 100 feet to 120 feet) near the face of the bluff. Both of these soil units were likely deposited during the last glacial advance into central Puget Sound.

Soils are well exposed along the bluff, where we observed layers of clayey silt and silt interbedded with layers of sand and gravelly sand. The uppermost layer of clayey silt outcrops near the top of the steepest portion of the bluff. This layer is likely perching water as we observed seepage near the top of this unit. The clayey silt appears to be lacustrine in origin and was likely deposited during the most recent glaciation. Below this layer, the soils are likely nonglacial sediments deposited during the interglacial period prior to the last glaciation. Thin or localized layers of silt in these soils may also perch water and are the likely cause of seepage that we observed on lower portions of the bluff face.

Although not observed, a low permeability layer is suspected to be present at an elevation of about 200 feet, approximately 800 feet northwest from the bluff face. Seepage and associated wetlands, likely indicating the presence of this perching layer, were observed in the valley west of the proposed Single Conveyor below an approximate elevation of 200 feet. Based on the log of a water well installed approximately 3,000 feet to the southwest, this layer could be continuous, with the uppermost layer of clayey silt exposed on the bluff. The log of this water well also indicates the presence of sandy or gravelly clay below an elevation of approximately 45 feet, extending downward to approximately 35 feet. This material is likely to be glaciomarine sediments deposited during the second to last glaciation. These sediments were not observed along the beach or in the bluff face but are indicated on geologic maps as being exposed just above beach level several thousand feet northeast of the site.

4.3 Landslide Mapping

The steep, southeast-facing slope along Hood Canal, including the site and areas southwest and northeast of the site, is mapped as "Unstable" in the *Coastal Zone Atlas of Washington* (WSDOE, 1979). During our reconnaissance, we observed numerous landslide scars and indicators of marginally stable and unstable slopes in the vicinity of the project and along the proposed conveyor. The landslides observed or inferred from aerial photographs and topography are shown in Figure 2. Although the proposed conveyor alignment does not cross and would not be affected by Landslide Areas A or B, we included these areas in our geologic review because doing so helps us to better understand the historical and ongoing geologic processes at and near the site. Review of these landslides also helps us to better understand and interpret geology below the conveyor alignment and Landslide Areas C and D.

Between Thorndyke Road and the beach, the proposed Single Conveyor crosses a narrow, triangular-shaped point formed by two valleys that cut into the upland. The upland area between the two valleys that define this point narrows from about 800 feet wide at Thorndyke Road to about 150 feet wide at proposed conveyor Station 224+00. This triangular point and the valleys that define its limits are located between two large, active landslide areas, portions of which are designated Landslide Areas A and B in Figures 2 and 3.

Landslide Area A, northeast of the site, is a bowl-shaped feature that appears to be a large, deep-seated, rotational landslide extending southeastward to about 500 feet northeast of the proposed conveyor alignment. Landslide Area A is about 1/2 to 3/4 mile long, parallel to the shore. This landslide appears to be relatively active; we observed offsets in Thorndyke Road where it crosses the slide and patched asphalt where Thorndyke Road crosses the landslide margins. We also observed blocks of clayey soils that appear to have been pushed upward through the landward edge of the beach. If these blocks have been pushed up, they would confirm our opinion that this is a deep-seated, rotational landslide. It is our understanding, based on previous work we performed in the area, that the most recent movement of this landslide occurred in the winter of 1999 or spring of 2000. This landslide area is mapped as “Unstable” in the *Coastal Zone Atlas of Washington* (WSDOE 1979). In our opinion, based on our observations of upturned beds on the beach and offsets and patching of Thorndyke Road, Landslide Area A would be better classified as an “Unstable Recent Slide” (Urs). According to the definition presented in the *Coastal Zone Atlas of Washington*: “Map symbol Urs identifies recent or historically active landslide areas.” Landslide Area A includes areas designated “Risk Factor 1 and 2” on the *Critical Areas – Landslide Hazard, Eastern Jefferson County* map (Jefferson 1995). The Risk Factor ranges from 1 to 3, with 1 representing low potential for landsliding and 3 representing the highest risk for landsliding.

Landslide Area B, the area to the southwest of the site, is about one mile long parallel to the shore and appears to consist of a series of large rotational landslides and smaller translational landslides along the steep slope above the water. Large rotational landslides have developed in the thick section of sand and gravel above the interbedded clay, silt, and sand soils that are exposed in the bluff at the back of the beach. Much of this large landslide area is mapped as "Unstable Recent Slide" and is designated as a "Very Critical Area" in the *Coastal Zone Atlas of Washington*. Following landsliding in the winter of 1982/1983, Jefferson County passed Resolution No. 37-83, which designated this area as the "Thorndyke Bay Slide Area" and limited development within it. Extending northeasterly from the northeast side of Landslide Area B to the northeast side of the point upon which the conveyor alignment is to be located, the slopes are designated as "Critical Area" and are also included in the regulated "Thorndyke Bay Slide Area" (see Figures 2 and 3). Landslide Area B includes areas designated "Risk Factor 2 and 3" on the *Critical Areas – Landslide Hazard, Eastern Jefferson County* map (Jefferson 1995).

Landsliding has also occurred on the point that the Single Conveyor is proposed to cross. However, these instabilities are relatively small in comparison to those that occur in Landslide Areas A and B. These landslide areas, designated C and D in Figures 2 and 3, include the bench above the bluff, the upper steep slope just above the bench, and the extension of these two features around the point into the ravine southwest of the proposed conveyor. The instability expressed on the bench is indistinct but includes fallen and leaning trees, localized grabens and holes in the ground surface, and abrupt changes in the ground surface. The landslide activity is also represented by the accumulation of landslide debris at the base of the bluff (see Figures 3 and 4).

Slope movement in Landslide Areas C and D appears to occur as an episodic but progressive combination of rotational and translational failure in the areas of steeper ground upslope and south of the bench. Ground movement along the bench appears translational in nature. High water levels perched by the less permeable soils below likely cause both types of failure. High groundwater levels within the soils along the bench cause ground movement toward the bluff. As these soils move, support for the steeper slopes above is reduced. The reduction in support at the toe of the steeper slope combined with high groundwater levels within the steeper portion of the slope causes rotational failure of soil onto the bench.

In the area designated Landslide Area C, which the Single Conveyor is proposed to cross, the upper steep slope upslope of the bench represents the headscarp area of the broad zone of landsliding. Little of the landslide mass remains on this upper steep slope, having moved downslope to form and occupy the bench area. The thickness of the landslide mass that underlies the bench is unknown but may range from 10 to 50 feet (See Figure 4). A less advanced stage of landsliding was observed in Landslide Area D where the landslide mass still occupies steeper ground and has not completely failed. Ground instability in Landslide Areas C and D appears to be largely controlled by groundwater perched on the clayey silt layer that occurs at an elevation of about 100 feet.

Landslide Area D is on the northeast slope of the large ravine that bounds the southwest and south side of the proposed Single Conveyor. This landslide appears to move generally southwest toward the ravine. A relatively fresh set down with a near-vertical scarp as high as 12 feet exists at the top of the landslide area (see Figure 3.). Several benches, set downs, and setdown scarps were observed within this landslide area and jack-strawed trees exist along the lower portion of the landslide near its toe (above the bluff). At the mouth of the ravine, southwest of the proposed conveyor, the width of the bench diminishes and failure extends to the creek. In addition to instability caused by water pressures developed above a perching layer, stream erosion at the toe of the landslide mass removes support and reactivates landsliding or progression of landsliding upslope. The proposed Single Conveyor is located just northeast of the top of the Landslide Area D headscarp.

Besides the landsliding in Areas A through D discussed above, some indications of less significant instability were observed along the upland portion of the conveyor. Northwest of Thorndyke Road, the conveyor alignment lies close to the southwest edge of a deep ravine. We observed bowed 8- to 10-inch-diameter trees on the southwest slope of this ravine, which are indicative of soil creep. (This area is designated "area of creep" on Figure 2.) We did not observe evidence of active or past landsliding on this slope.

4.4 Faulting

The site is located along the west side of the Puget Lowland, which has several known and inferred west- to northwest-trending crustal faults. North- to northeast-trending faults are also known or inferred along the east and west margins of the Puget Lowland. One such fault is the Hood Canal Fault, approximately 4 miles west of the project site at its closest point (Figure 1). The Hood Canal Fault is inferred to trend northeasterly along Hood Canal in the southern half of Puget Sound and to diverge and extend northward along Dabob Bay west of Toandos Peninsula (Gower et al., 1985) (Johnson et al., 1994). No seismicity or Holocene activity (i.e., within the past 10,000 years) has been associated with this fault.

Based on recent seismic reflection work and on previous aeromagnetic studies, Brocher et al. (2001) infer an east-west-trending fault zone, informally named the Lofall fault zone, that is about one mile north of the proposed Pier at its closest point. The fault location was inferred from linear, steep, geophysical gradients; it is uncertain whether the structure is actually a fault, and no paleoseismic evidence attests to its earthquake history.

4.5 Geologic Hazardous Areas

In Landslide Areas C and D, Figure 3, the proposed Single Conveyor crosses several geologically hazardous areas regulated by Jefferson County Unified Development Code. Based on *Jefferson County Critical Areas* maps, designated erosion, seismic, and landslide hazard areas are present where the conveyor transitions from the upland plateau, crosses Landslide Area C, and extends down the bluff to the beach. Based on our discussions with the owners, our interpretation of the site geology, and our experience, the potential for and frequency of landsliding within Landslide Areas C and D near the proposed Single Conveyor can be reduced to a degree generally acceptable for protection and operation of facilities of this type, i.e., where the operators have control over maintenance and operation facilities and can make adjustments or suspend operations if necessary. Potential stability improvement measures are discussed below. Improving stability of the landslide zone above the bluff will also reduce the potential for landslide, seismic ground motion, and erosion hazards to contribute to burial or disturbance of wetland areas on the beach near the conveyor alignment.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Slope Stability

5.1.1 General

Near the Single Conveyor alignment, the steep slopes along the margins of the upland plateau and the valleys and drainages dissecting the plateau are subject to landsliding. Many of these slopes show active landsliding or evidence of recent landsliding. To reach the beach from the upland plateau, the crossing of unstable slopes appears unavoidable. However, in our opinion, based on our observations and experience, the degree and significance of potential ground movement along the proposed Single Conveyor (Landslide Areas C and D) is significantly less than for the slopes northeast and southwest of the alignment (Landslide Areas A and B, respectively).

The proposed conveyor crosses an active landslide zone at the top of the bluff (Figures 3 and 4). The frequency and magnitude of landslide movement in this zone are unknown; however, movement appears to occur with relative frequency as tilted, downed, and jack-strawed trees were observed. Relatively fresh setdown scarps were also observed on the ravine slope southwest of conveyor Stations 222+00 to 226+00. Additionally, a portion of the wetland area at the toe of the bluff appears to have been recently impacted by deposition of landslide debris that likely originated from the bench at the top of the bluff.

Water is a major contributor to the occurrence and reactivation of landslides at this site. Instability of landslides observed at the site is likely associated with infiltration of rain, snowmelt, and runoff and with groundwater perched in sandy soils near the top of the bluff above less permeable soil layers. Based on our experience, reducing the quantity of water that infiltrates landslide-prone ground and draining groundwater from landslide-prone ground will reduce the frequency and magnitude of ground movement (see also, Turner and Schuster, 1996 and Abramson, et al, 1996). Recommendations for using drainage to improve stability of the landslide zone at the top of the bluff are presented below. In our opinion, based on our experience with the use of subsurface drainage systems to improve slope stability, implementation of the proposed drainage measures will reduce landslide, seismic, and erosion hazards to the natural environment and constructed facilities in the areas where the drainage measures are installed.

In our opinion, slope stability improvement measures more extensive than installation of surface and subsurface drainage are not required to improve stability of the slope to a level acceptable for conveyor operation. This opinion is based on (1) our observations at the site; (2) review of geologic information for the site; (3) our understanding that the proposed conveyor would be designed to tolerate occasional movement; (4) discussions with the owners regarding acceptable operations levels, maintenance, and ground movement; and (5) our experience. Other stability improvement alternatives, such as retaining walls and tiebacks, could be pursued should operational considerations so warrant.

5.1.2 Surface Drainage Improvements

We recommend that surface runoff be intercepted and directed away from Landslide Areas C and D to reduce infiltration in these areas. Decreasing infiltration into landslide-prone ground would improve stability of this ground. Runoff from upland areas should be intercepted and directed away from the proposed cut. In accordance with common practice, water that would not naturally flow onto adjacent property under the existing conditions should not be diverted onto adjacent property (unless authorized) or potentially unstable ground.

Interception and redirection of surface water may be accomplished using berms, diversion ditches, and storm drains. One proposed arrangement for surface drainage diversion berms, ditches, and catch basins is shown in Figure 5. Culverts should be installed where forestry service roads cross natural drainages. Storm drain pipes from the area above the bluff should be tightlined to the stream or beach, or discharged to an existing drainage swale or other location where the water would not increase the likelihood of a landslide or pose a hazard to the natural or developed environment. Water dispersion, energy dissipation, and erosion protection measures should be installed at tightline pipe outlets (see Figures 6 and 7). A schematic of a tightline pipe is presented in Figure 7.

5.1.3 Subsurface Drainage Improvements

Slope and landslide stability may be improved by removing water from and lowering the groundwater level in landslide-susceptible soils. Based on our preliminary geologic and geotechnical review of the site, site geometry, proposed conveyor alignment, and wetland locations, we recommend that trench drains be constructed near the Single Conveyor in Landslide Areas C and D to improve slope stability. A trench drain is used to intercept groundwater and is constructed by excavating a trench and backfilling the trench with drainage gravel. Trench drains are generally constructible to depths of 10 to 15 feet and have a maximum practical depth of about 25 feet. Drains proposed for this project would be about 5 to 15 feet deep near the top of the bluff and increase in depth with increasing distance from the bluff face. Perforated pipe may be buried in the gravel to collect and remove intercepted water (see Figures 7 and 8). Cleanouts should be provided for pipes installed in trench drains. Water collected in trench drains should be tightlined to the beach (see Figure 5). Water dispersion, energy dissipation, and erosion protection measures should be installed at tightline pipe outlets (see Figures 6 and 7).

Multiple trench drains are recommended for this project to improve ground stability along and to either side of the conveyor where it crosses Landslide Area C. Preliminary recommended trench drain locations are shown in Figure 5. Our preliminary recommendations include a central trench drain below the bottom of the cut along the conveyor and laterals that extend northeast and southwest from the central trench drain. Near the top of the bluff, at the south end of the cut (approximately Station 225+75), we propose that the trench drain system pipes discharge into a vault. The surface water collection system pipes could also discharge into this vault. A tightline drainpipe should be used to deliver water from the vault to the toe of the bluff. Energy dissipation and erosion protection measures should be installed at tightline pipe outlets. Depending on the ground conditions encountered in explorations that would be performed during the design phase of this project, additional trench drains or extension of the proposed trench drains (see Figure 5) may be appropriate to increase groundwater collection and sufficiently improve slope stability to protect the proposed facility. Trench drain depths and alignments would be determined after completion of explorations, during final design. If ground conditions encountered during trench drain installation differ from those interpreted from the design phase explorations, additional trench drains or extensions of the proposed trench drains may be necessary.

Other subsurface drainage measures may also be appropriate for this project. In our opinion, horizontal drains may be appropriate if it is determined through subsurface explorations and stability analyses that groundwater must be drained from a larger area or from depths unreachable by trench drains, or if less surface disruption is required. The need for and extent of alternative subsurface drainage systems would be determined during final design. Horizontal drains would be constructed by drilling 4-inch-diameter holes into the ground and installing a 1.5-inch-diameter slotted drainpipe in each hole. The holes would be drilled at a slight upward inclination so that water collected in the pipes will drain under the influence of gravity toward the pipe outlet. The drainpipes should connect to tightlines that discharge water at the beach. Energy dissipation and erosion protection measures should be installed at tightline pipe outlets.

5.2 Seismic Hazards

Two faults are inferred to be located within 4 miles of the project area: the Hood Canal Fault and the Lofall fault zone, respectively. The T-ROC conveyor system will cross the Lofall fault zone near the Twin Conveyor to Single Conveyor transfer location. Although these faults are not known to be active, the Puget Sound region is known to experience seismic events. Based on the *Seismic Zone Map of the United States* in the 1997 *Uniform Building Code*, the project is in Seismic Zone 3. The corresponding Seismic Zone Factor, Z, equals 0.30 (ICBO 1997). Soil explorations have not been conducted along the Single Conveyor alignment. However, based on our observations and experience, potentially liquefiable soils are likely present on the beach and below the waters of Hood Canal in the proposed Pier area. Liquefiable soils may also be present on the bench above the bluff, depending on the groundwater level and the effectiveness of proposed subsurface drainage measures on lowering the groundwater. The foundation systems for those portions of the facility that cross liquefiable soils should be designed to support the structures and resist forces associated with lateral spread of the ground should liquefaction occur. Candidate foundation systems are discussed below. Foundation design would be based on subsurface explorations and soil laboratory tests conducted during the project final design phase.

5.3 Foundation Systems

Preliminary geotechnical recommendations for foundation systems are presented below. These recommendations are based on our observations and review of geologic information and our understanding of the conveyor and pier design. Subsurface explorations have not been completed for this project; they would be performed prior to design of the conveyor and pier foundations.

5.3.1 Single Conveyor Station 200+00 to Station 224+75

Based on our understanding of the project, proposed conveyor construction, and foundation loads, it is likely that the conveyor could be supported on spread footings where it is constructed across the upland plateau from Station 200+00 to about Station 224+75, i.e., upland of Landslide Areas C and D. Spread footings or pile foundations would be appropriate for conveyor pier supports founded near the toe of the Thorndyke Road cut slopes. Spread footings that support the conveyor bridge over Thorndyke Road would be founded near or below the ditch elevation. Excavations into the existing roadway cut slopes would be necessary to construct spread footings. If spread footing construction is pursued, the slope should be reconstructed to its existing configuration after footing construction. Construction of drilled piers would not require significant excavation into the slope. Although the existing Thorndyke Road cut slopes are steep, in our opinion, conveyor foundations could be installed at the slope toes without causing slope instability.

5.3.2 Single Conveyor Station 224+75 to Station 225+60

Based on our understanding of the project, proposed conveyor construction, and foundation loads, it is likely that the conveyor could be supported on spread footings or piles where it passes through the proposed cut and crosses Landslide Area C between Station 224+75 and Station 225+60. In our opinion and based on our experience, the potential for and frequency and magnitude of landslide-associated ground movement would be decreased by installing the surface and subsurface drainage improvements described in Section 5.1. The potential for loose colluvium on the bench to liquefy during a seismic event would also be reduced through installation of these drainage improvements because the groundwater elevation would be lowered.

In our opinion, spread footing foundations and conveyor supports constructed on landslide-susceptible terrain could be designed to accommodate occasional ground movement from a few inches to a couple of feet without damaging the conveyor, provided the conveyor is also designed to accommodate these movements. Leveling, realigning, or other adjustments to the conveyor or footings could be made when ground movement exceeds some operational threshold.

Pile foundations could be used in lieu of footings where the conveyor crosses the landslide zone. Pile lengths would, in general, increase toward the center of the slide area. Piles could be required near the top of the bluff to support the conveyor where it extends over the top of the bluff and down the bluff face. Piles would pass through soils that have moved, or are likely to move, and would be embedded in stiff to hard or dense to very dense underlying soils. Piles could be designed to resist lateral forces associated with potential ground movement.

5.3.3 Single Conveyor Beach Area and Pier

We understand that the conveyor and pier would be supported across the beach and in Hood Canal by driven, steel pipe piles assembled in multiple-pile bents. Bent spacing would be selected based on foundation conditions, loads, and other factors. A preliminary bent spacing of 100 feet has been proposed for the conveyor in this area with the exception of a proposed 200- to 250-foot span where the conveyor extends from the top of the bluff to the beach. We understand that vertical and batter piles would be incorporated in each bent, as appropriate, to accommodate vertical and lateral loads, including conveyor, seismic, and docking loads. We understand that driven steel piles are also proposed for construction of breasting dolphins at the Pier. Based on our observations, review of geologic information for the site, and the proposed general facility plan, it is our opinion that the proposed driven pile foundation system would likely be appropriate for support of the conveyor, pier, and construction of breasting dolphins. Driven piles are commonly used for pier and dolphin applications and equipment to install piles of this type is locally available. Steel piles also have high vertical and lateral capacity and can be relatively easily increased in length to accommodate variations in bearing depth and channel bathymetry.

Drilled shafts may be applicable for bents constructed across the beach or in the landslide zone above the bluff. Drilled shafts would be appropriate if it is determined that steel piles could not be driven to adequate depth to obtain sufficient embedment for lateral loads and scour protection or if environmental or other considerations necessitated a particular foundation footprint. Small, mobile equipment is readily available and could be used to install drilled shafts on the bench above the bluff. Drilled shafts may be easier to install than driven piles in the bench area because small, mobile equipment could be used for their installation. Soil exploration, liquefaction potential analyses, and lateral load determination are recommended prior to final design and foundation type selection.

We understand that the conveyor will span from the top of the bluff (approximate Station 225+60) to the water side of Wetland Area B (approximate Station 228+00). The conveyor foundation near Station 225+60 can be designed as a spread footing, drilled shaft, or driven pile founded in stiff to dense, in situ native soil. Drilled shaft and driven pile foundations could be designed to directly resist lateral loads that might act on the top of bluff foundation or on the conveyor. Tiebacks could be installed through a spread footing located at the top of the bluff to resist lateral loads. In our opinion and based on our observation of soil deposits at the toe of the bluff, a bent located near Station 228+00 would be far enough from the bluff that it would be unlikely to be impacted by soil or other debris that might slide off the top of the bluff should ground movement continue. Erosion and scour protection may be necessary for structures on or near the beach or bluff toe and in Hood Canal.

5.4 Construction Considerations

In our opinion, conventional construction equipment, such as bulldozers, excavators, and dump trucks, could be used to excavate the proposed cut, and to construct surface and subsurface drainage systems, spread footing foundations, and forestry service roads for the proposed Single Conveyor and Pier. Blasting is not anticipated to be necessary. Track-mounted, pile-driving or shaft-drilling equipment would probably be applicable for pile installation above the bluff and on the beach. Pile-driving equipment working from a barge could be used to install offshore piles.

Erosion protection measures, including installation of silt fences, and scheduling of on land work during drier periods are recommended. A temporary erosion control plan is required. Permanent erosion control measures, such as surface drainage systems, application of erosion control mats, and seeding of disturbed areas, should also be installed upon completion of the conveyor and pier. Erosion control fabrics, gravel-filled geocells, erosion control vegetation, quarry spalls, or other erosion control system should be applied to the bluff face and slope at the base of the bluff to minimize erosion by rain, minor runoff that is not intercepted by upland catch basins, and water that drips from the conveyor.

Cut slopes should be constructed with maximum inclinations of 2H:1V (horizontal to vertical). Flatter slopes may be required depending on soil and groundwater conditions. Cut slopes and other areas disturbed by construction should be vegetated or otherwise protected from erosion.

5.5 Summary

The steep slopes along the northwest side of Hood Canal in the vicinity of the proposed project are generally unstable. From a geologic hazard avoidance perspective, in our opinion, the selected conveyor alignment and location where the Single Conveyor is proposed to descend from the upland plateau to the beach is a preferred location along Hood Canal in this area. Mitigation for landslide hazards to a risk level acceptable to the T-ROC operators is likely more manageable and less costly in Landslide Areas C and D than in Landslide Areas A and B. It is up to the Complex operators to determine the level of risk that they are willing to accept and to evaluate the cost tradeoffs associated with different risks.

The proposed Single Conveyor and Pier would cross or be constructed in areas classified as "Critical Areas," based on erosion, landslide, and seismic hazards. In our opinion, based on our observations and experience, the proposed facility could be constructed along the proposed alignment, and landslide, erosion, and seismic hazards that could affect the project could be mitigated to a risk level acceptable to the facility operators and regulatory agencies and with no increase in risk to adjacent properties above the current condition. These hazards could be reduced by construction of surface and subsurface drainage systems, appropriate foundation and facility designs, and construction of retaining walls or debris catchment systems. Mitigation for landslide hazards to protect the proposed facility would reduce the landslide, erosion, and seismic hazards below their existing condition. Erosion hazards associated with construction and operation of the facility could be addressed using best management practices.

The pattern of erosion on the beach may be modified by construction of the facility across the beach and in Hood Canal. In our opinion, mitigation for landslide hazards on the top of the bluff near the conveyor should reduce the frequency and magnitude of landslide events that bury wetlands at the bluff toe in this area, which have apparently occurred at this location in the past. Reducing the frequency and magnitude of landslides may also modify the bench environment by decreasing the volume of soil delivered to the beach. We understand that, if necessary, a study of these potential effects on the beach environment would be performed by others for this project.

6.0 LIMITATIONS

The analyses, conclusions, and preliminary recommendations presented in this report are based on the site and subsurface conditions as observed in the field and as represented in reviewed documents prepared by others. As for any site located on or near a slope, there is the potential for slope instability. Instability that could affect structures on or near a slope is a risk that owners must be prepared to accept. In addition to natural factors (heavy precipitation, steep topography, soil, and surface and groundwater conditions), other risks include water leaks, pipe breaks, improper or inappropriately directed drainage, lack of maintenance for drains or vegetative cover, filling or saturation at the top of the slope, excavating at the bottom of the slope, unwise acts by adjacent property owners, or similar events or unknown conditions which could cause slope instability.

The scope of our services did not include any subsurface explorations. Subsurface explorations should be completed prior to design or construction of the drainage improvements and foundation systems preliminarily recommended in this report. This report should not be used as a warranty of subsurface conditions. Unanticipated soil conditions commonly exist which may not be revealed by subsurface explorations or surface soil exposures.

The scope of our services did not include any environmental assessment or evaluation regarding the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air at the project site. Shannon & Wilson has prepared the document, *Important Information About Your Geotechnical Report,* included in Appendix B, to assist you and others in understanding the use and limitations of our report.

SHANNON & WILSON, INC.

State of Washington Engineering Geologist 362 Licensed Geologist — 2/24/03

Theodor W. Hopkins

Stanley R. Boyle State of Washington 35805 Registered Professional Engineer — 2/24/03

EXPIRES 12/30/03

Theodor W. Hopkins
Senior Principal Engineering Geologist

Stanley R. Boyle, Ph.D., P.E.
Associate

TWH:SRB/lkd

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8.0 GLOSSARY

bench A raised, narrow strip of relatively level earth. A small terrace or comparatively level area breaking the continuity of a sloping ground surface.

graben A block of earth, generally long compared to its width, which has been set down along faults or slide planes relative to earth on either side of it.

headscarp A steep slope that develops at the head (i.e., upland limit) of a landslide as a result of downward movement of the landslide mass.

interbedded Alternating or random thin layers of different soils lying in beds parallel to other soil beds. For example, interbedded layers of clay, silt, and sand, could create a unit consisting of layers of clay, silt, and/or sand that occur in any sequence in the overall soil unit created by the accumulation of the individual soil beds.

jack-strawed trees Trees tilted or leaning in multiple, seemingly arbitrary directions. This condition is often caused by non-uniform movement of ground after trees have grown on the ground.

lateral spread Lateral movement of ground resulting from seismically-induced soil shear-strength reduction or liquefaction and gravity-induced downslope movement of those soils and soils overlying them.

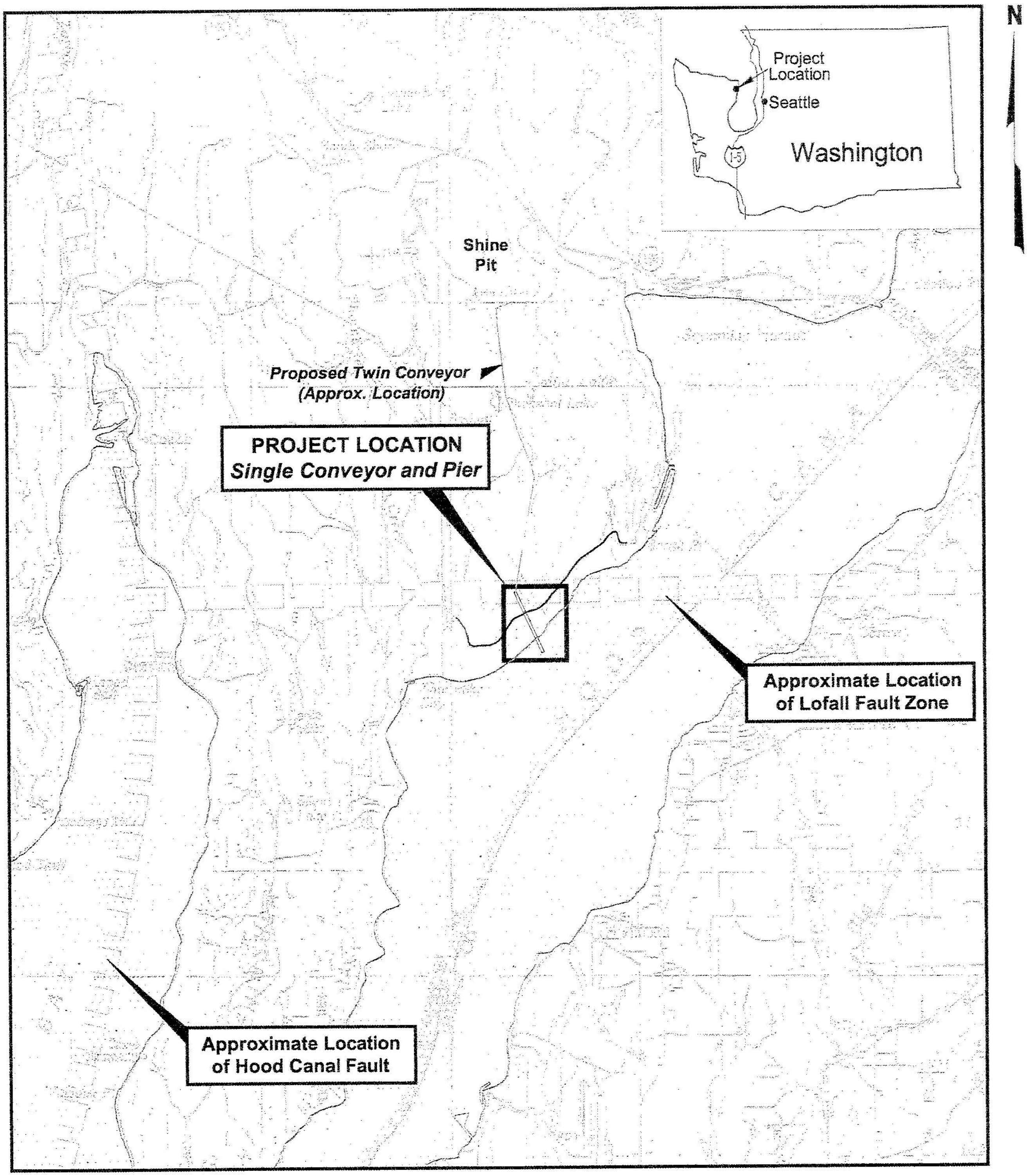
liquefaction The conversion of saturated loose, cohesionless soils (silts, sands, and gravels) to a liquid state as a result of seismic ground shaking and a resulting increase in porewater pressure (i.e., water pressure between the soil particles). Liquefaction reduces the shear strength and load resisting capacity of soil relative to its non-liquefied condition. Ground movement, settlement, and lateral spread commonly result following soil liquefaction.

perched groundwater Groundwater separated from an underlying body of groundwater by low permeability soil. This groundwater is said to be "perched" above the low permeability soil.

rotational failure / rotational ground movement / rotational landslide Ground movement along a generally circular surface as if the ground mass is rotating about an axis that is oriented parallel to a horizontal line crossing the ground mass. Rotational movement generally results in downward movement of the head (upslope end) of the ground mass and upward movement of the toe (downslope end) of the ground mass.

Seismic Zone Factor, Z (ICBO, 1997) A variable used to define the general level of ground shaking that structures to be constructed at a particular location are to be designed for, as specified in the Uniform Building Code, Chapter 16.

translational failure / translational ground movement / translational landslide Downslope ground movement along a generally planar surface, as if the ground mass is translating horizontally and downslope. Movement is generally parallel to the ground surface inclination.



0 2 4

Scale in Miles

NOTE

Map adapted from 1:100,000 USGS topographic map of Seattle, WA quadrangle, dated 1975.

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

VICINITY AND FAULT LOCATION MAP

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FIG. 1

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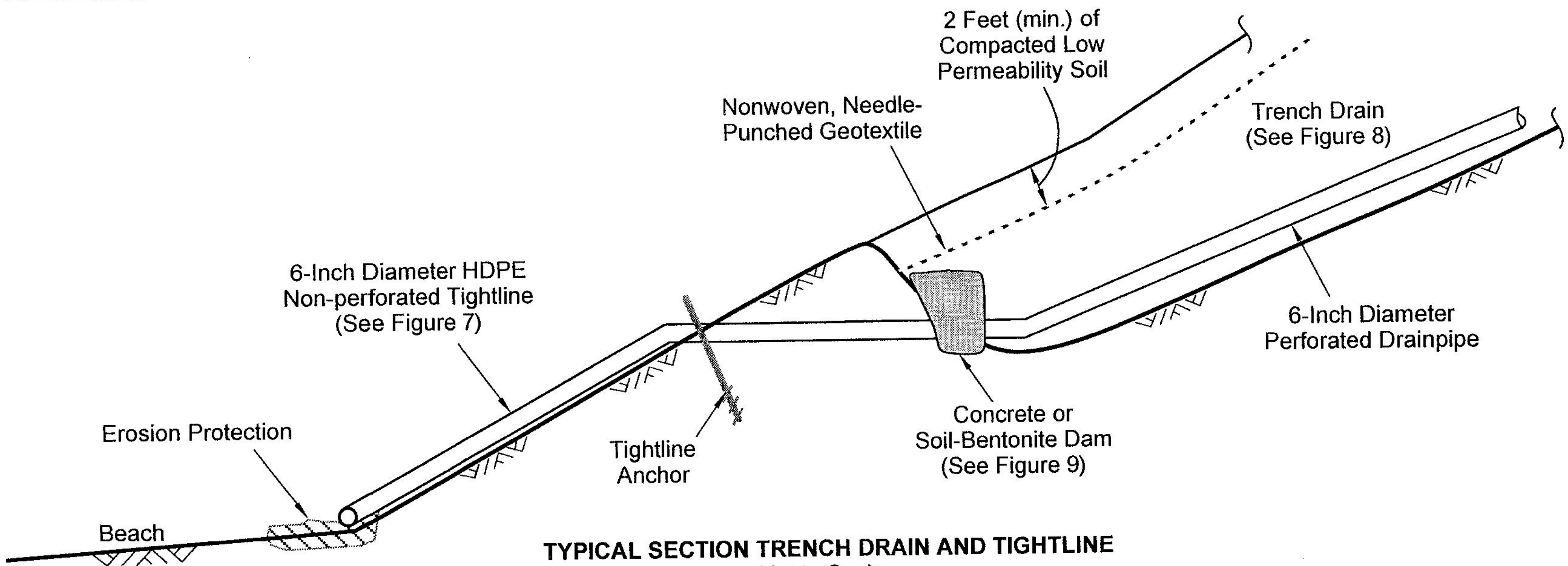
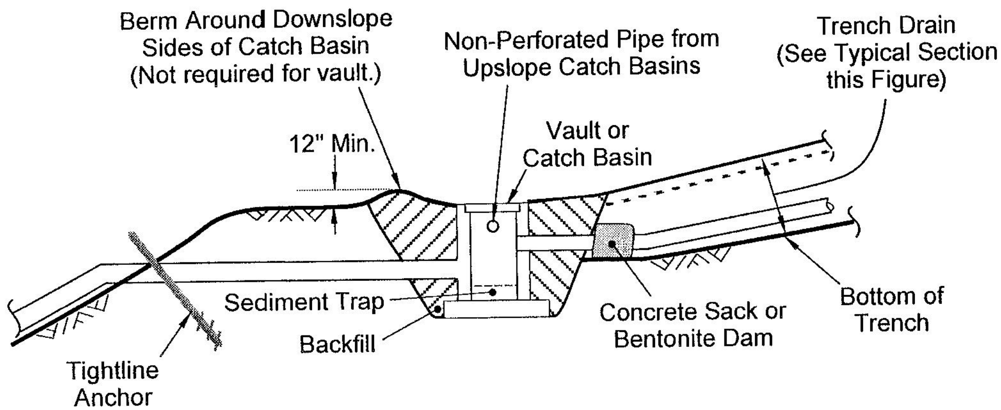


TYPICAL SECTION TRENCH DRAIN AND TIGHTLINE
Not to Scale



TYPICAL SECTION TRENCH DRAIN CONNECTION TO VAULT OR CATCH BASIN
Not to Scale

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

TRENCH DRAIN AND TIGHTLINE SECTION

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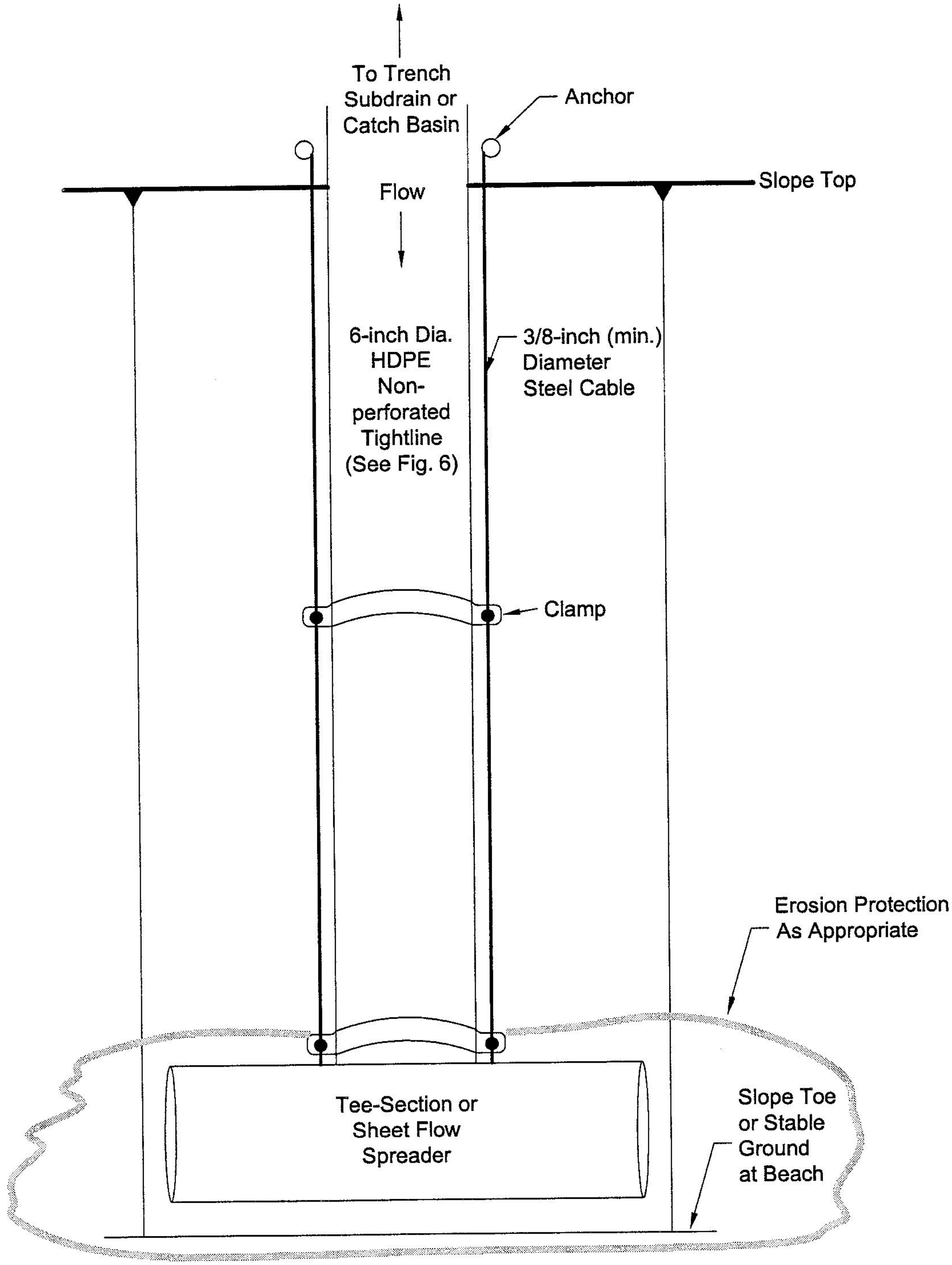
FIG. 6

FIG. 6



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Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

DRAINAGE TIGHTLINE DETAIL

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FIG. 7

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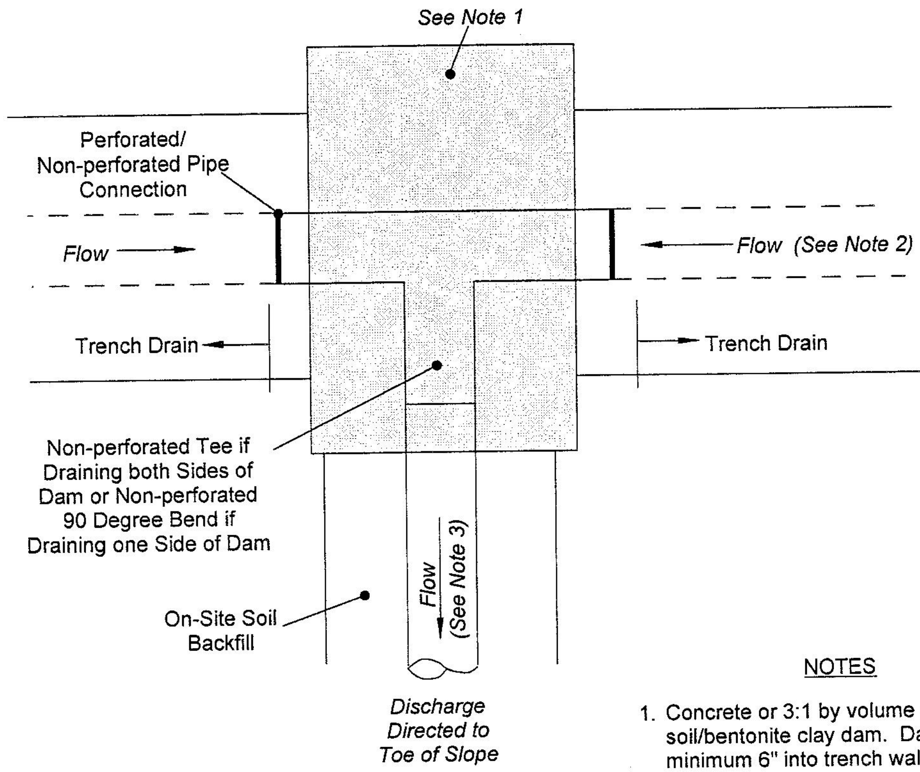
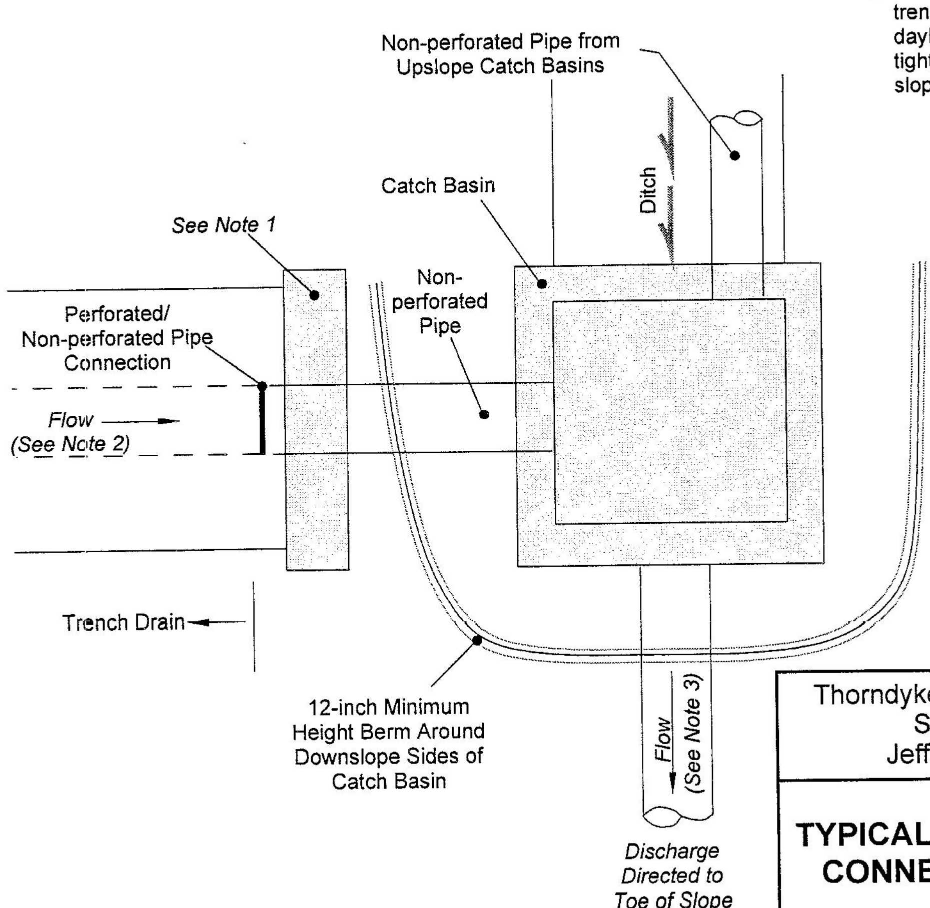


NOTES

1. Concrete or 3:1 by volume ratio soil/bentonite clay dam. Dam keyed minimum 6" into trench walls and invert.
2. 6" diameter flexible ADS perforated drain pipe, sloped at minimum 0.5 percent.
3. Non-perforated HDPE tightline pipe in trench sloped at minimum 0.5 percent; daylight pipe at break in slope; anchor tightline at slope top and extend down slope face (See Figure 7).



Not to Scale

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

TYPICAL TRENCH DRAIN DAM AND CONNECTION TO CATCH BASIN

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FIG. 9

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APPENDIX A

CENTRAL CONVEYOR AND PIER PROJECT DESCRIPTION AND FACT SHEET

CENTRAL CONVEYOR AND PIER
PROJECT DESCRIPTION

Purpose

This application is for a permit to build a Central Conveyor and Pier to move sand and gravel from the T-ROC Operations Hub to Hood Canal for marine transport by barges and ships.

Introduction

Fred Hill Materials, Inc. (FHM) conducts its primary sand and gravel mining and processing operations in Jefferson County at the existing Shine Pit, which is the Operations Hub for the Thorndyke Resource Operations Complex (T-ROC). T-ROC encompasses both existing and proposed expanded operations in and around the Shine Pit.

FHM has undertaken a planning and development process to identify and then pursue its business objectives into the mid-21st century. As a result of this planning process, including analysis of the geologic resources and critical environmental areas within the Thorndyke Management Area (Thorndyke Block), FHM has established a series of proposals, which, if approved, would result in:

- Continued growth of existing activities (Shine Pit), including opening of new extraction areas approximately one mile west and south of the Shine Pit (Wahl and Meridian)
- Development of a marine transportation system for the delivery of sand and gravel (Central Conveyor and Pier)

General Location

T-ROC is located within the approximately 21,000-acre Thorndyke Block, which is a portion of the Pope Resources 72,000-acre Hood Canal Tree Farm. The Thorndyke Block is located in Jefferson County on the Toandos Peninsula, which is south and west of the Hood Canal Bridge. The area is locally known as the Upper Coyle Peninsula.

General Description of Central Conveyor and Pier

The proposed four-mile Central Conveyor originates at the southwest corner of the Shine Pit, travels south through the Thorndyke Block (within an approximately 34-acre easement), bridges over Thorndyke Road (just south of mile post 3), crosses a 14.7-acre parcel of waterfront property (owned by Hood Canal Sand and Gravel, LLC) and terminates at the end of the proposed 1,000-foot Pier on Hood Canal.

The Pier will originate at Hood Canal Sand and Gravel's waterfront property approximately five miles southwest of the Hood Canal Bridge, one mile northeast of Thorndyke Bay, and 1.25 miles southwest of South Point.

The Central Conveyor's route was specifically selected to avoid and/or minimize impacts to environmentally sensitive areas (steep slopes, wetlands, streams, and their associated buffers). An Environmental Impact Statement (EIS) will be prepared that will examine any identifiable probable significant adverse environmental impacts of the proposal and, if required, will propose and evaluate possible mitigating measures that could become conditions of approval if accepted by Jefferson County.

The Pier is designed for ships and barges of various sizes and displacements to transport sand and gravel. Only ships will require opening of the Hood Canal Bridge. Only U.S. flagged ships will call at the Pier. At this time, the particular ships required for transport of sand and gravel at the proposed Pier are not available on the West Coast. It is anticipated that these ships will become available in approximately eight to 12 years after the Pier's construction and will be used subject to market demand.

Proposed Pier Operations

Initially, only barges will call at the Pier. Typical barge capacity is 5,000 dead-weight U.S. short tons (dwt).

In Year 1 of Pier operations, it is anticipated that the volume of sand and gravel transported by barge will be 2 million U.S. short tons (tons).

By Year 10, the volume of sand and gravel transported by barge is expected to reach 4 million tons annually.

In the first year that U.S. flagged ships become available (Year 8 to 12 of Pier operations), it is anticipated that 600,000 tons of sand and gravel will be transported by ship.

By Year 25, the volume of sand and gravel transported by ship is expected to reach 2.75 million tons annually.

By Year 25, it is anticipated that the combined volume of sand and gravel transported by ship and barge will reach 6.75 million tons annually (i.e. 4 million tons via barge and 2.75 million tons via ship), subject to market demand.

(For further details, see *Central Conveyor and Pier Facts Sheet.*)

History

The Thorndyke Block was logged in the early 1900s, with most of the logging having taken place in the 1930s. After a significant forest fire in 1939, much of the forest re-seeded naturally.

Currently, the area is managed as commercial forestland with periodic logging of small acreage units and predominant replanting of Douglas fir. Much of the commercial forestland crossed by the proposed Central Conveyor was logged within the past 10 years. Old tree stumps, small Douglas firs, forest brush, and shrubs dominate the landscape. In areas that were recently logged, second growth Douglas fir and stands of alder dominate.

Mining of sand and gravel in the general area of the Shine Pit began in 1959 to supply materials for the building of the Hood Canal Bridge revetment on the Jefferson County side. Since that time, various operators have mined sand and gravel in the same vicinity and provided truck delivery of materials.

In December 1979, FHM took over operation of the Shine Pit and obtained a Surface Mine Reclamation Permit (No. 70-011936) issued by the Washington State Department of Natural Resources (WSDNR). Since then, FHM has continuously operated the pit.

In addition to the WSDNR surface mining reclamation permit, FHM operates under a Washington State Department of Ecology (WSDOE) Sand and Gravel General Permit (No. WAG 50-1120), which regulates the treatment and control of stormwater. All stormwater that falls on the existing 144-acre Shine Pit is prevented from leaving the site through application of infiltration techniques.

In June 1999, Ace Paving obtained a Jefferson County Conditional Use Permit (No. ZON98-0041) to operate a portable asphalt batch plant located on five acres within the 144-acre Operations Hub/Shine Pit. Ace Paving operates under its own Washington State Department of Ecology (WSDOE) Sand and Gravel General Permit (No. WAG 50-1237). The stormwater that runs off the asphalt batch plant site goes directly into FHM's central stormwater treatment and control system.

In March 2001, to prepare for the impending depletion of sand and gravel supplies at the existing Shine Pit, FHM submitted to WSDNR a preliminary application for the 156-acre Wahl Extraction Area as an expansion of the existing Shine Pit

In April 2002, FHM submitted a Mineral Resource Lands Overlay (MRL) application to Jefferson County. The submission complied with the new requirements (effective January 2001) of the Jefferson County Unified Development Code (UDC).

In September 2002, WSDNR determined that the March 2001 FHM application for the Wahl Extraction Area would need to be resubmitted as a new permit, independent of the existing permit. In addition, Jefferson County UDC requirements will be applicable.

In December 2002, Jefferson County approved a modified application for MLA-02-235, a Mineral Resource Land Overlay (MRL) designation for 690 acres, located approximately a mile west and south of FHM's existing T-ROC Operations Hub. This MRL designation formally recognizes the existence of commercially viable deposits of sand and gravel; provides for appropriate notification of adjacent landowners regarding likely future mineral resource activities in this designated area; and allows FHM to apply for specific excavation permits greater than 10 acres in size under the requirements of the Jefferson County UDC. The MRL designation alone does not authorize specific mining activities within the MRL.

Existing T-ROC Operations

T-ROC *currently* consists of five major activity components at the existing 144-acre Shine Pit:

1. Sand and gravel extraction area
2. Operations Hub, including
    - portable crushing, washing, and sorting equipment for sand and gravel
    - portable equipment for recycling of concrete waste
    - stockpile areas
    - trucks and loaders
    - scale house, maintenance building, caretaker home, well, and outbuildings
    - Rock-To-Go access road (forestry service road T-3100) to Hwy. 104
3. Portable conveyors used to move sand and gravel from the extraction area to the Hub
4. Asphalt batch plant (operated by Ace Paving)
5. Mined acreage in various stages of reclamation

In 2003, it is anticipated that the volume of sand and gravel transported by truck will be 500,000 tons, including sand and gravel used in asphalt mix. In approximately 10-15 years, the annual volumes of sand and gravel transported by truck are projected to reach 750,000 tons and remain constant due to the saturation of the local market.

Current and future volumes of sand and gravel transported by truck will be supported by the existing configuration of the T-ROC Operations Hub.

Continued Growth of Existing Activities

Current truck-based operations are expected to deplete the sand and gravel extraction area at the existing Shine Pit by 2004, requiring the opening of a new extraction area.

The analysis of geological resources within the Thorndyke Block, combined with the public concern with the visual impacts of existing mining operations, led FHM to propose a new extraction area approximately a mile west and south of the existing Shine Pit. This new extraction area (Wahl) is outside the public's general view shed.

The proposed 156-acre Wahl Extraction Area is located west of Wahl Lake and is anticipated to have sufficient volumes of sand and gravel to supply truck-based operations for 20 years. After the Wahl Area is depleted, new permits would be sought to mine in the Meridian Extraction Area (a portion of MLA-02-0235).

Sand and gravel will be transported from the proposed Wahl and prospective Meridian Extraction Areas to the T-ROC Operations Hub via a 1.25-mile conveyor (located in an easement of approximately nine acres) referred to as the Wahl Conveyor. This conveyor will be built adjacent to an approved forestry service road. Much of the commercial forestland crossed by the proposed Wahl Conveyor has been logged within the past 10 years.

Since the extraction area located in the existing Shine Pit is nearing exhaustion, FHM reiterates that the proposed Wahl Extraction Area and Conveyor (a portion of MLA-02-235) are necessary to provide a continued supply for *existing* FHM truck-based operations.

Application for the Wahl Extraction Area and Wahl Conveyor has been initiated and will be considered in parallel to this application for the Central Conveyor and Pier.

In addition, FHM has initiated the process of gaining permission to accept concrete rubble from outside sources.

Development of Marine Transportation System

Should FHM receive necessary approvals for the proposed Central Conveyor and Pier, the extraction rates from the Wahl Extraction Area will accelerate due to the added marine delivery. This acceleration would advance the time frame for application for excavation permits in some or all of the remaining MRL area (Meridian Extraction Area).

The prospective 525-acre Meridian Extraction Area is located generally south of Wahl Lake, and contains the remainder of MLA-02-235. FHM expects that as excavation is completed in the Wahl Extraction Area, permits for expansion of mining into some or all of the Meridian Extraction Area will be submitted. The exact timing of a prospective application for the Meridian Extraction Area will be a function of numerous variables, including but not limited to future market demand and successful development of marine transport capabilities (i.e. the Central Conveyor and Pier).

Upon construction of the Central Conveyor and Pier, reconfiguration of the T-ROC Operations Hub will be needed to accommodate the processing of increased volumes of sand and gravel. The reconfigured Operations Hub will be located on a 100-acre area within the existing 144-acre Shine Pit.

Summary

Under currently planned proposals, if approved, T-ROC would include:

- a 100-acre **Operations Hub** located within the existing Shine Pit, where up to 7.5 million tons of sand, gravel and recycled concrete will be processed annually and transported by trucks (750,000 tons), barges (4 million tons), and ships (2.75 million tons)
- a proposed 156-acre extraction area **(Wahl Extraction Area)**, where sand and gravel would be mined to supply truck-based operations and initial years of marine operations
- a prospective 525-acre extraction area (**Meridian Extraction Area**), where up to 40 years of sand and gravel would be mined
- a proposed 1.25-mile conveyor (**Wahl Conveyor**) connecting the Wahl Extraction Area and subsequent Meridian Extraction Area to the Operations Hub
- a proposed 4-mile conveyor (**Central Conveyor**) connecting the Operations Hub to a 1,000-foot Pier located on Hood Canal, where ships and barges would be loaded up to 300 days a year, up to 24 hours a day

CENTRAL CONVEYOR AND PIER
FACTS SHEET

1.0 CENTRAL CONVEYOR

The proposed Central Conveyor will move sand and gravel from the T-ROC Operations Hub (at the existing Shine Pit) to a Pier on Hood Canal for marine transport by barges and ships. The Central Conveyor will be approximately four miles long and is made up of the Twin Conveyors and Single Conveyor. The Twin Conveyors are located at the northern portion of the Central Conveyor originating at Shine Pit. The Single Conveyor is located at the southern portion of the Central Conveyor, originating at the end of the Twin Conveyors and terminating at the end of the Pier.

Central Conveyor belts travel on self-lubricating rollers forming a U-shaped trough that carries sand and gravel. Failsafe sensors on each head pulley motor automatically shut down operation along the entire conveyor system in case of belt failure. Covers are installed over the Central Conveyor's belts to keep out rain and wind, preventing fugitive dust, sand, or gravel from escaping. Pans are installed under the Central Conveyor's return belt over all stream crossings. Conveyor enclosures are at the Thorndyke Road crossing and from the shoreline to the end of the Pier. Enclosures include a roof, painted metal siding and solid floor (or a grated walkway with a pan under the return belt).

Each of the six segments of the Central Conveyor terminates at a transfer point, where sand and gravel on the incoming conveyor segment will drop into a hopper and funnel onto the next conveyor segment. The Central Conveyor shifts direction slightly at Transfer Points 2, 3, 4, and 5. A utility shed at each transfer point will enclose the conveyor and hopper to protect electrical equipment, contain fugitive dust, and minimize noise. This shed will include a head pulley and electric motor, unpowered tail pulley, hopper, and the return belt cleaning equipment.

Twin Conveyors		
	Location:	Station 25+23.69 to 200+00
	Easement:	60 feet
	Length:	3.3 miles long
	Width (each conveyor)	5 feet wide
	Gap between conveyors:	4 feet
	Segments between transfer pts:	4 of varying lengths
Single Conveyor		
	Location:	Station 200+00 to 237+90
	Easement:	60 feet north of Thorndyke Road; 300 feet south of Thorndyke Road
	Length:	0.7 miles long
	Width:	6 feet
	Segments between transfer points:	2 of varying lengths
Color	Scheme:	Natural to blend into environment

Belts	Power:	Electric motor at head pulley (tail pulley unpowered)
	Rollers:	Self-lubricating
	Material:	Composite
	Speed (approx):	6 miles per hour
Assembly	Frame:	Steel channel, open box
	Height (approx.):	5 feet
	Vertical support:	Pair of steel channel, open box legs at 20-foot intervals
	Color(s):	Natural to blend into existing environment
Cover	Material:	Light metal
	Shape:	Half-moon
	Height above belt:	2 feet 6 inches
	Height above ground:	7 to 8 feet
	Location:	Station 25+23.69 to 211+50 (to Thorndyke Road) Station 214+00 to 228+00 (beginning of Pier)
Pan	Location:	Station 144+00 to 165+00 (at stream crossings)
	Ground clearance:	Approximately 2 feet
	Location:	Station 226+00 to 228+00 (bluff to Pier)
	Ground clearance:	Approximately 5 to 60 feet
Enclosures	Location:	Thorndyke Road (Station 211+50 to 214+00)
	Components:	Metal roof/siding, solid floor
	Dimensions:	12 feet high by 13 feet wide
	Location:	Shoreline (Station 228+00 to 234+35)
	Components:	Metal roof/siding, pan under return belt, grated walkway
	Dimensions:	10-12 feet high by 13 feet wide
	Location:	Pier Loadout (Station 234+35 to 237+90)
	Components:	Metal roof/siding, solid floor
	Dimensions:	15 feet high by 15-18 feet wide
Transfer Point	Transfer Point 1:	Station 25+23.69
	Transfer Point 2:	Station 39+27.09
	Transfer Point 3:	Station 87+16.4
	Transfer Point 4:	Station 134+44.87
	Transfer Point 5:	Station 200+00
	Transfer Point 6:	Station 221+55
Utility Shed	Size:	12 feet by 16 feet
	Material:	Wood and metal
	Lighting:	Interior only
	Location:	Transfer Points 1, 2, 3, 4, 5, and 6
Wiring	Electrical Power:	Underground
	Control Lines:	Underground
Wildlife Crossings		
	Typical clearance:	2 feet below return belt
	Large mammal crossings:	4-6 feet clearance below return belt every 300 feet (approx.)

2.0 PIER

The proposed Pier consists of a stationary and retractable load-out conveyor supported on pilings spaced at 100-foot intervals and two support structures. Perpendicular to the Pier in deep water are eight dolphins (six breasting and two mooring dolphins) connected by a grated catwalk. The Pier will be painted to blend into the existing environment and constructed in a manner that will minimize visual intrusion and glare. While the conveyor supported by the Pier will be enclosed, the Pier will be constructed largely of open steel girders to minimize shading effects. The Pier begins at approximately the Ordinary High Water (OHW) mark. Pilings will support the trusses (and enclosed conveyor), support structures, and breasting and mooring dolphins.

Two open steel structures will support the conveyor near the end of the Pier. The first structure is located approximately 650 feet from the shoreline. It supports the conveyor and has an overall height of 91 feet above MLLW (85 feet MSL). The second structure supports both the conveyor and the retractable (load-out) conveyor. The load-out conveyor will have an overall height of 76 feet above MLLW (70 feet MSL).

Two maintenance/storage buildings will be located on dolphins. An enclosed control room with access stairways, storage area, restroom, and holding tank is located within the second support structure. These facilities will not increase the area of over-water coverage.

Lighting of the intertidal and subtidal portions of the Central Conveyor and Pier will be kept to the minimum required for safe operation. Lighting of the water surface will be minimized with location, color, shielded and/or directional fixtures. During non-operation hours, lights will be turned off except as needed for maritime safety requirements.

Pier	Location:	5 miles southwest of Hood Canal Bridge; 1 mile northeast of Thorndyke Bay; 2 miles southwest of the community of Shine; 1.25 miles southwest of Southpoint
	Total Length:	990 feet, measured at Ordinary High Water (OHW) mark
	Stationary Conveyor:	Station 228+00 to 236+75
	Length:	875 feet
Station 228+00 to 233+00		Station 228+00 is supported by pilings, marks the beginning of the Pier at approximately the OHW mark.
	Length:	500 feet
	Truss Height:	10 feet
	Truss Width:	13 feet
	Top Elevation:	32 feet above MLLW (26 feet MSL)
	Invert Elevation:	22 feet above MLLW (16 feet MSL)
	Clearance (Water):	11 feet MHHW (16 feet MSL)
	Clearance (Beach):	25 feet above MLLW (19+ feet MSL)
Station 233+00 to 234+35		Station 233+0 begins the incline toward the first support structure.
	Length:	135 feet
	Truss Height:	12 feet
	Truss Width:	13 feet

	Top Elevation:	Slopes from 32 feet MLLW to 91 feet MLLW (26 feet MSL to 85 feet MSL)
	Invert of Conveyor:	Slopes from 22 feet MLLW to 76 feet MLLW (16 feet MSL to 70 feet MSL)
Station 234+35 to 236+75		Station 234+35 is supported by the first steel support structure. Station 236+75 is supported by the second steel support structure.
	Length:	240 feet
	Truss Height:	15 feet
	Truss Width:	18 feet
	Top Elevation:	91 feet above MLLW (85 feet MSL)
	Invert of Conveyor:	76 feet above MLLW (70 feet MSL)
Station 236+75 to 237+90		This modular enclosed distribution (load-out) conveyor pivots and retracts to conform to various vessel loading configurations.
	Length:	180 feet (extended)
	Truss Height:	15 feet
	Truss Width:	15 feet
	Top Elevation:	76 feet above MLLW (70 feet MSL)
	Invert of Conveyor:	61 feet above MLLW (55 feet MSL)
	Channel Elevation at end of Pier:	-79 feet MLLW (-73 feet MSL)
Color	Scheme:	Blend into existing environment
Pilings	Material:	Hollow steel round
	Diameter:	18-inch (truss supports) 30-inch (support structures) 30-inch (dolphins) 18-inch (catwalk supports)
	Spacing:	100-foot (truss supports) 50 feet (catwalk supports)
	Number:	4 each (truss supports) 16 each (support structures) 12 each (dolphins) 3 each (catwalk supports)
Support Structures		
	Support No. 1:	Station 234+35 to 234+65 (approximately 650 feet from shoreline, as measured from center)
	Materials:	Steel
	Dimensions:	30 feet by 30 feet
	Top Elevation:	76 feet above MLLW (70 feet MSL)
	Overall Height (including conveyor):	91 feet above MLLW (85 feet MSL)
	Channel Elevation (measured at center of support):	-13 feet MLLW (-7 feet MSL)

	Support No. 2:	Station 236+55 to 236+95
	Materials:	Steel
	Dimensions:	40 feet by 40 feet
	Top Elevation:	61 feet MLLW (55 feet MSL)
	Overall Height (at conveyor):	91 feet MLLW (85 feet MSL)
	(at load-out conveyor):	76 feet above MLLW (70 feet MSL)
	Channel Elevation (measured at center of support):	-52 feet MLLW (-46 feet MSL)
Control Room	Location:	Support Structure No. 2
	Dimensions:	20 feet by 40 feet by 20 feet
	Material:	Metal
Maintenance and Storage Buildings		
	Location:	Two innermost breasting dolphins
	Dimensions:	10 feet by 10 feet
	Material:	Metal roof/siding, solid floor
Breasting and Mooring Dolphins		
	Water depth range:	-37 feet to -64 feet MLLW (-43 feet to –58 feet MSL)
	Typical depth:	-50 feet MLLW (-42 feet MSL)
	Shallowest depth:	-37 feet MLLW (-31 feet MSL)
	Pilecap dimensions:	20 feet by 20 feet, 7-feet thick
	Pilecap material:	Concrete
	Pilecap invert elevation:	15 feet MLLW (9 feet MSL)
Maintenance Catwalk		
	Material:	Galvanized aluminum or steel
	Width:	5 feet
	Length:	710 feet
	Railings:	36 to 42 inches high
	Elevation:	22 feet MLLW (16 feet MSL)

3.0 ROADS AND PARKING

A gravel forestry service road will provide access for forest firefighting, logging, and Central Conveyor maintenance. It will parallel the Central Conveyor and connect to the network of existing forestry service roads in the Thorndyke Block. The majority of the route realigns an existing forestry service road; abandoned routes will be re-graded and reforested. A turnout/parking area for a maintenance vehicle will be provided at each transfer point.

Access to the Central Conveyor south of the Thorndyke Road will be via an existing gravel road that leads to a parking area for employees working at the Pier. The southernmost portion of the road/walkway will be constructed of concrete for greater erosion protection.

Gravel Road	Location:	Central Conveyor (Station 25+23.69 to 211+50, 214+00 to 217+50)
	Width:	14 feet
	Length:	3.6 miles
Concrete Road	Location:	Single Conveyor (Station 217+50 to 222+00)
	Width:	24 feet
	Length:	450 feet
Concrete Walkway	Location:	Single Conveyor (Station 222+00 to 226+00)
	Width:	12 feet
	Length:	400 feet
Parking	Location:	Employee Pier Parking (Station 214+50 to 215+50)
	Number of stalls:	10
	Surface:	Gravel
Parking/Turnout	Location:	Transfer Points 2, 3, 4, and 5
	Surface:	Gravel
	Location:	Transfer Point 6
	Surface:	Concrete
Roads, Walkways And Parking	New:	7.3 acres
	Abandoned roads:	6.3 acres
	Net increase:	1.0 acres

4.0 VESSEL DESCRIPTIONS

The Pier is designed for ships and barges of varying sizes and displacements to transport sand and gravel. Only ships will require opening of the Hood Canal Bridge. It is anticipated that the first ships will call at the Pier 8 to 12 years after the Pier's construction.

	Barge	Typical Barge	Ship
Maximum Length (feet)	400	240	745
Maximum Width (feet)	100	60	110
Maximum Draft (feet)	25	16	45
Volume Range (dwt's)	2,500 to 20,000	5,000 to 7,000	20,000 to 65,000
Estimated Loading Time (hrs.)	1 to 8	2 to 3	8 to 24

5.0 PROJECTED VOLUMES*

In U.S. Short Tons (tons)

Individual Year of Operation	Barge	Ship	Combined
Year 1 of Pier Operation	2,000,000	0	2,000,000
Year 10 of Pier Operation	4,000,000	**600,000	4,600,000
Year 25 of Pier Operation	4,000,000	2,750,000	6,750,000

* Subject to market demand.

** First year shipping volume. U.S. flagged ships are projected to become available in Years 8 to 12 of Pier operation and not specifically in Year 10.

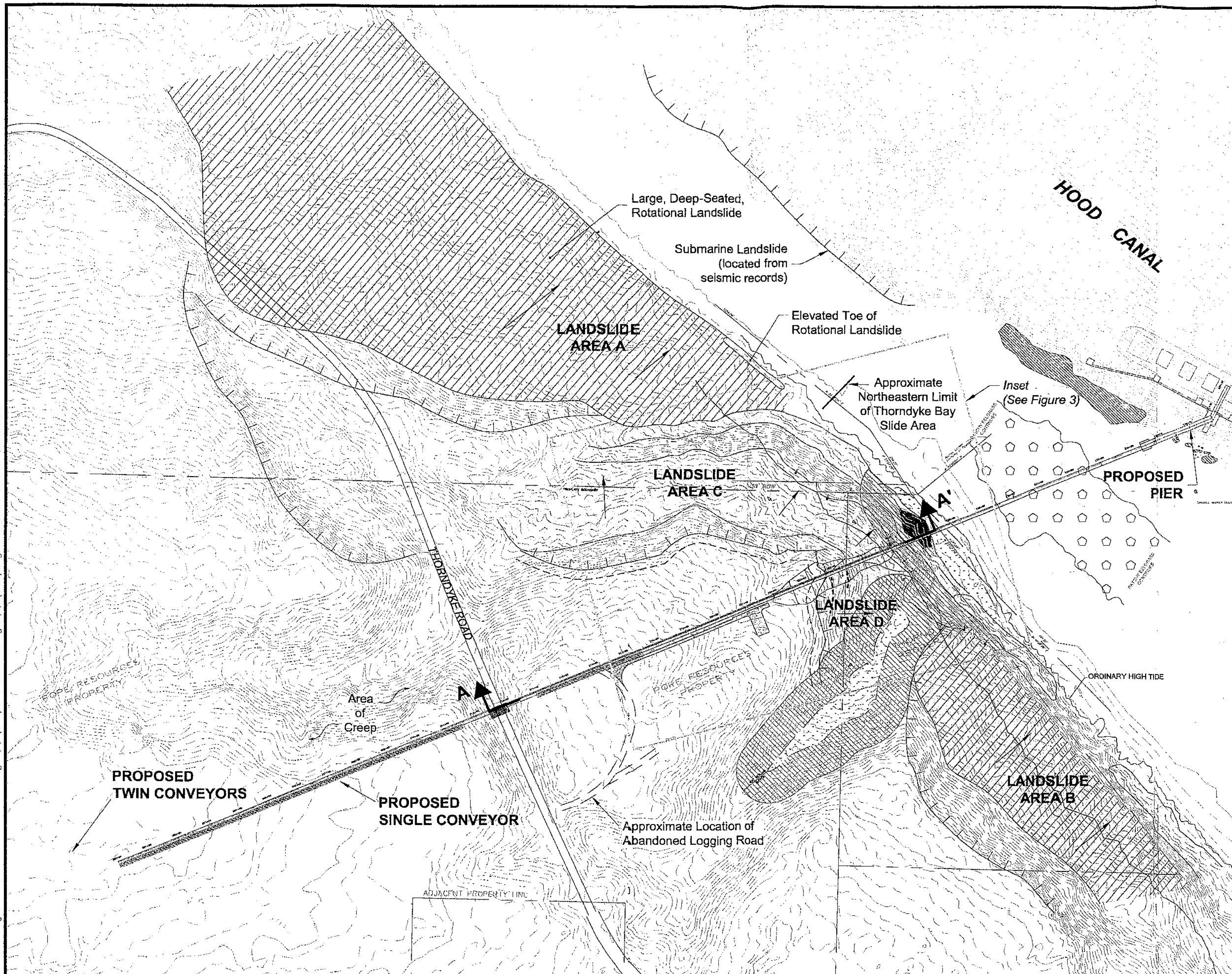
6.0 OPERATION

The Pier will be used up to 300 days a year, which excludes 65 days annually for holidays, tribal fishing, inclement weather, and periods of non-use.

Frequencies	Barge	Ship
Avg. Berthings Per Day	3	---
Avg. Berthings Per Month	---	0 to 6
Max. Berthings Per Day (either/or)	6	1
Max. Number of Vessels Berthed At Any Given Time (either/or)	2	1

APPENDIX B

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT



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0 300 600

Scale in Feet
Contour Interval = 5 Feet

LEGEND

- Headscarp of Landslide Area
- Ground Setdowns
- Approximate Boundary of Landslide Buffer
- Approximate Location of Seepage
- Approximate Direction of Slope Movement
- Approximate Area of Landslide Deposit
- Approximate Area of Deep-Seated, Rotational Landsliding
- Approximate Limits of Wetland Disturbed by Recent Landslide Deposits
- Wetland Area
- Wetland Buffer Area
- Eelgrass (Zoster Marina)
- Patchy Eelgrass
- A Generalized Subsurface Profile (See Figure 4)

NOTES

1. Figure adapted from plans provided by Reid Middleton, dated 11-13-01, 1-3-02, and 5-15-02.
2. Landslide features shown are located based on observations, stereo photographs, and topographic contours and should be considered approximate.

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

SITE PLAN AND GEOLOGIC CRITICAL AREAS MAP

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FIG. 2

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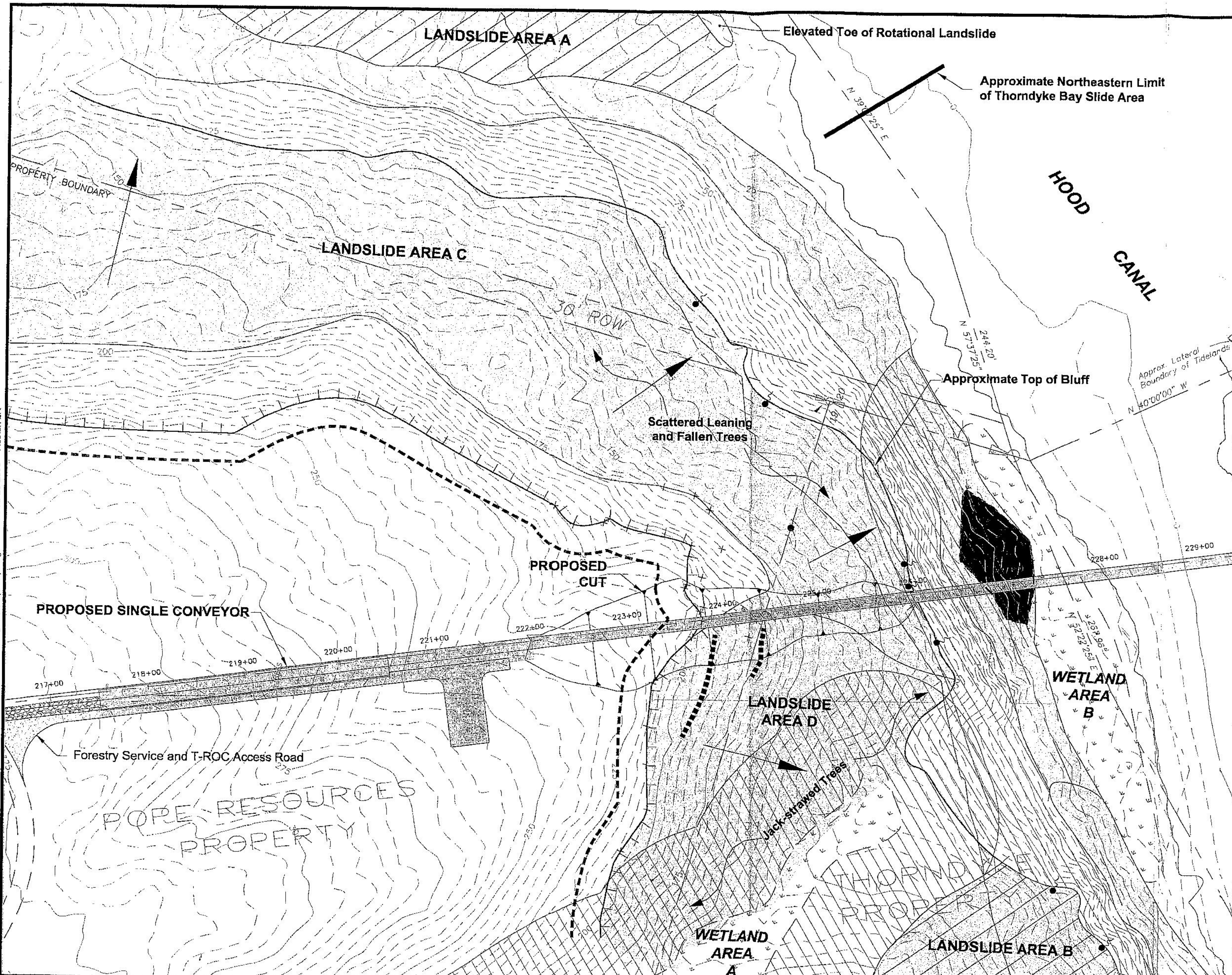

LEGEND

- Headscarp of Landslide Area
- Ground Setdowns
- Approximate Boundary of Landslide Buffer
- Approximate Location of Seepage
- Approximate Direction of Slope Movement
- Approximate Area of Landslide Deposit
- Approximate Area of Deep-Seated, Rotational Landsliding
- Approximate Limits of Wetland Disturbed by Recent Landslide Deposits
- Wetland Area
- Wetland Buffer Area

NOTES

1. Figure adapted from plans provided by Reid Middleton, dated 11-13-01, 1-3-02, and 5-15-02.
2. Landslide features shown are located based on observations, stereo photographs, and topographic contours and should be considered approximate.

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

GEOLOGIC CRITICAL AREAS
SINGLE CONVEYOR
STATIONS 217+00 TO 230+00

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FIG. 3

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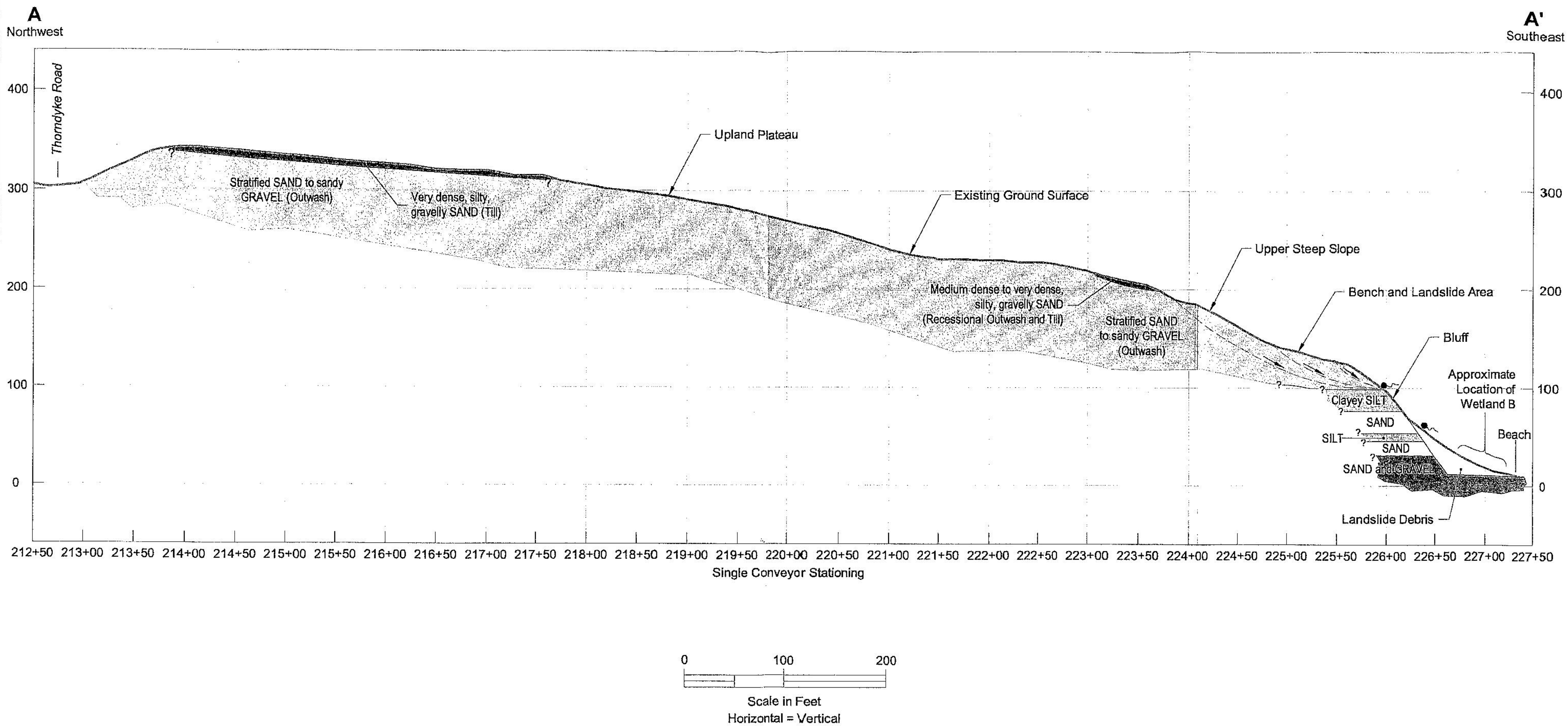

NOTES

1. Profile provided by Reid Middleton and based on topographic plan, dated 11-13-01.

2. This subsurface profile is generalized from materials observed in soil exposures. Variations between the profile and actual conditions may exist.

LEGEND

●~ Approximate Location of Seepage

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

GENERALIZED SUBSURFACE PROFILE A-A'

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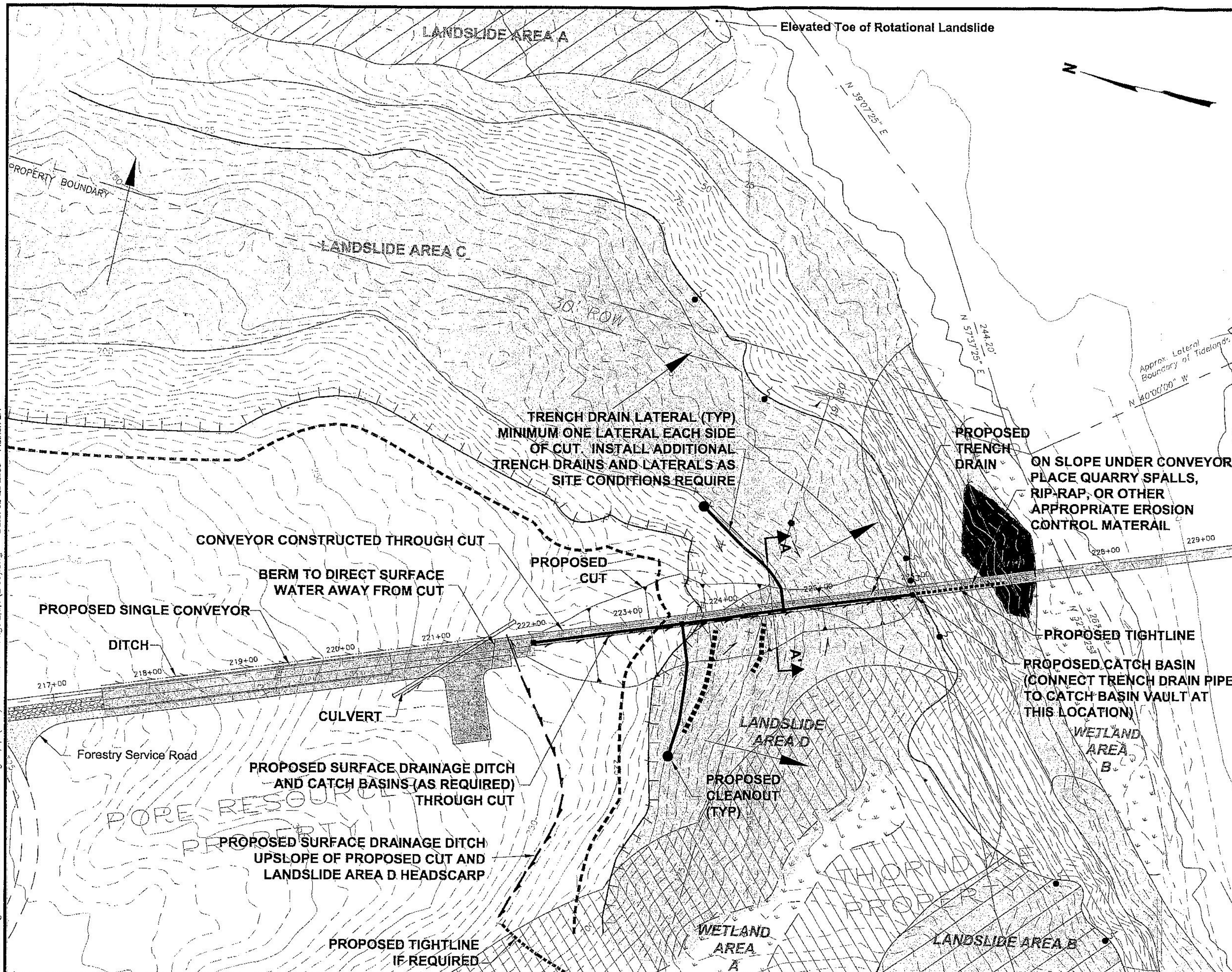
FIG. 4

File: I:\Drafting\211\09475-001\21-1-09475-001 Figs 2,3,5 (2-03)\21-1-09475-001 figs 2,3,5 (2-03).dwg Date: 02-25-2003 Author: LR



0 100 200

Scale in Feet
Contour Interval = 5 Feet

LEGEND

- Headscarp of Landslide Area
- Ground Setdowns
- Approximate Boundary of Landslide Buffer
- Approximate Location of Seepage
- Approximate Direction of Slope Movement
- Approximate Area of Landslide Deposit
- Approximate Area of Deep-Seated, Rotational Landsliding
- Approximate Limits of Wetland Disturbed by Recent Landslide Deposits
- Wetland Area
- Wetland Buffer Area
- Trench Drain and Direction of Flow
- Surface Ditch and Direction of Flow
- Tightline
- Cleanout
- A Trench Drain Section (See Figures 6 and 8)

NOTES

1. Figure adapted from plans provided by Reid Middleton, dated 11-13-01, 1-3-02, 5-15-02, and 10-4-02.
2. Landslide features shown are located based on observations, stereo photographs, and topographic contours and should be considered approximate.

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

PROPOSED DRAINAGE IMPROVEMENTS SINGLE CONVEYOR STATIONS 217+00 TO 230+00

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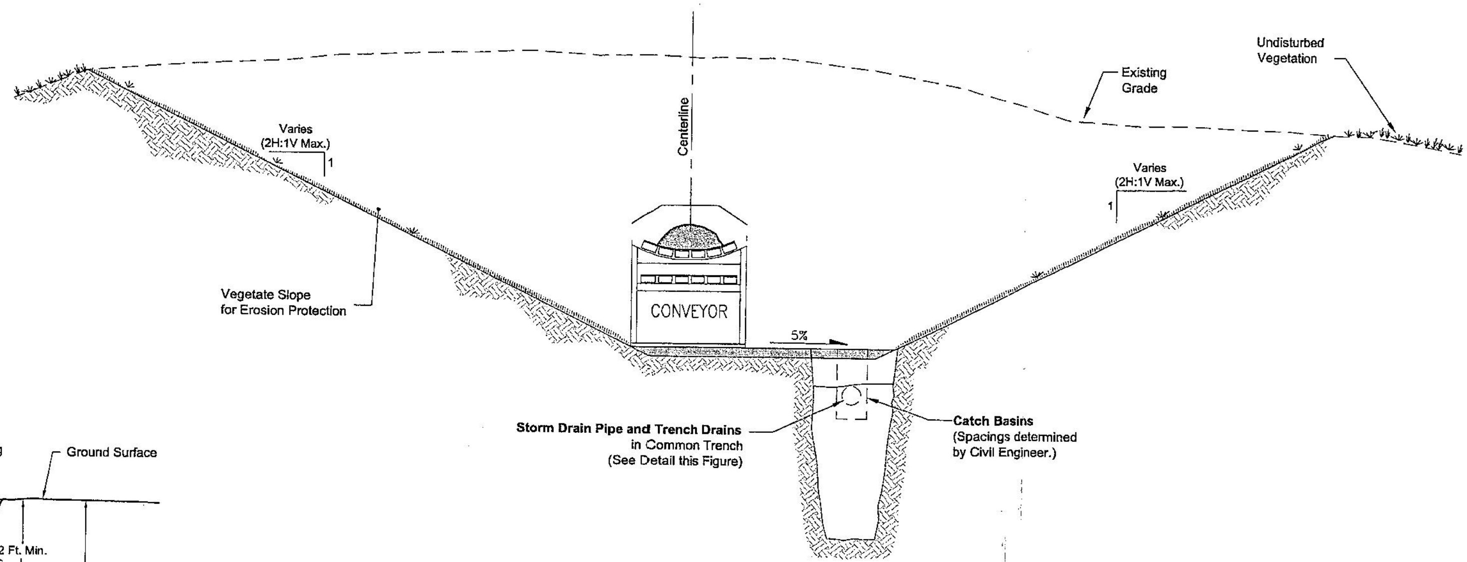
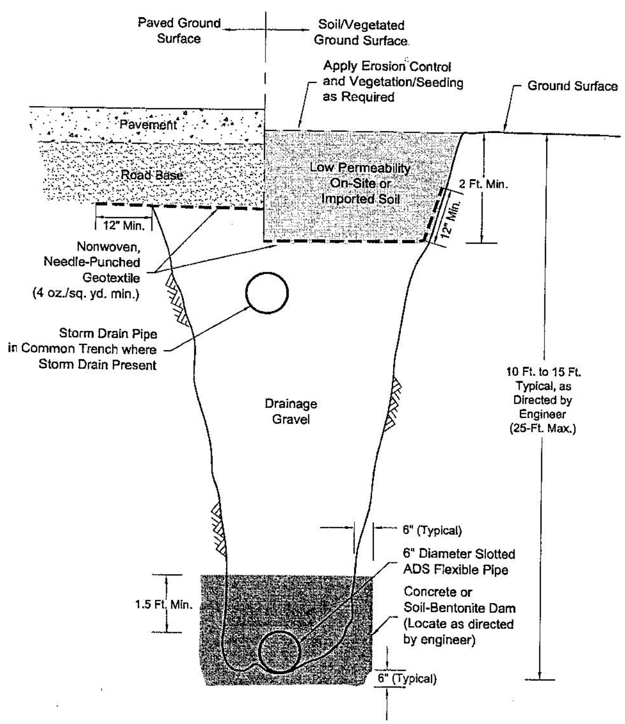
FIG. 5



SECTION A-A' - SUBSURFACE AND SURFACE DRAINAGE THROUGH CUT

Stations 222+00 to 226+00



DETAIL - TRENCH DRAIN

Not to Scale

Thorndyke Resource Operations Complex Single Conveyor and Pier Jefferson County, Washington	
TRENCH DRAIN **SECTION A-A' AND DETAIL**	
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SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	**FIG. 8**