Unconsolidated Deposits

Subsequent to the formation of the basalt bedrock, sediments were deposited throughout the Puget Lowland during several glacial and nonglacial intervals over the last 2.4 million years. Sediments from the most recent glacial episode, the Fraser Glaciation, are widely exposed at the surface in the Puget Lowland. Exposures of older glacial and nonglacial deposits are typically limited to bluffs and river valley walls. The Fraser Glaciation consists of multiple stades (episodes of glacial deposition). These sediments are present over a majority of the ground surface in the Mats Mats area (refer to Appendix I for detail on area geology).

The presence of mapped outcrops of the Crescent Formation basalt in the Chimacum Valley indicates that basalt is located beneath the glacial deposits. The unconsolidated glacial/nonglacial deposits are relatively thin north of the quarry where the Crescent Formation basalt is present at or near ground surface. North and northwest of Mats Mats Bay the thickness of the unconsolidated deposits is variable, ranging from approximately 20 to 80 feet. The major units of unconsolidated deposits in the Mats Mats area include Undifferentated Pre-Fraser Deposits (Qpfu), Vashon Advance Outwash (Qva), Vashon Lodgement Till (Qvt) and Vashon Drift Over Basalt (Cd) (refer to *Appendix I* for additional detail).

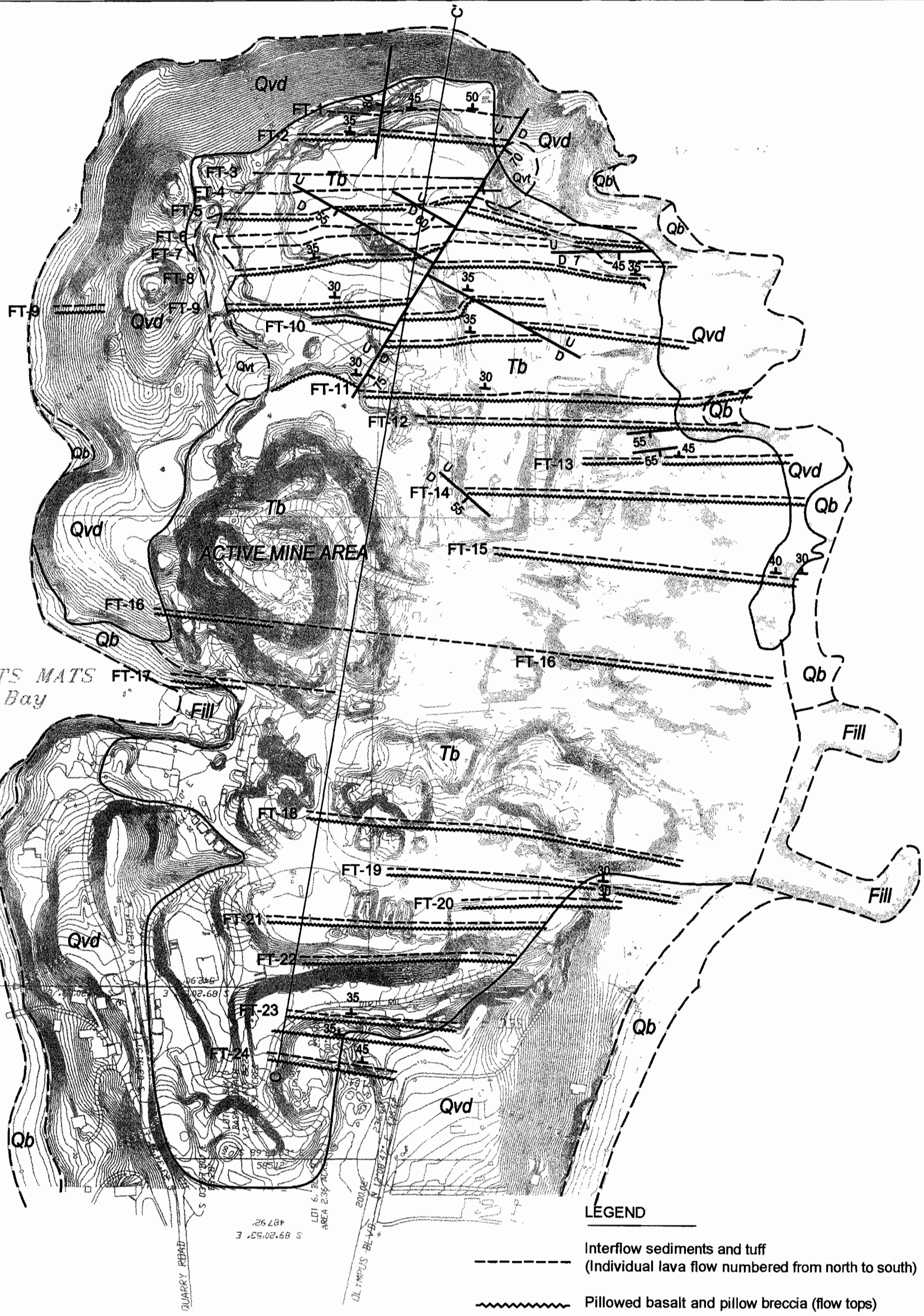
Site Geology

As for the region, geologic units at the Mats Mats Quarry include basalt (Cresent Formation), and unconsolidated deposits consisting of Vashon lodgement till, and Vashon Drift (see Figure 3.1-4). Beach sand and fill are also present. A geologic cross section summarizing surface and subsurface geology at the site is presented in Figure 3.1-5.

For the basalt bedrock, four distinct layers are present:

1) At the base of a flow is an approximately one foot thick zone consisting of aphanitic (microcrystalline) basalt. This zone commonly has good rock quality and is rather impermeable.

2) Above the aphanitic zone is massive columnar jointed basalt that can be up to several tens of feet thick. This zone cooled more slowly but is still fine grained and is characterized by interlocking polygonal cooling fractures that run perpendicular to the cooling surface creating a series of parallel columns. This zone is also characterized by relatively good rock quality and is relatively impermeable.



LEGEND

- Interflow sediments and tuff (Individual lava flow numbered from north to south)
- Pillowed basalt and pillow breccia (flow tops)
- 35 — Strike and dip of flow and interflow sediment
- U / D 55 — Fault with relative displacement and dip
- *Qb* — Beach sand
- *Qvd* — Vashon glacial drift
- *Qvt* — Vashon lodgement till
- *Tb* — Basalt - Crescent Formation (where bedrock is exposed) Some areas include stockpiles of fill soils and processed mine aggregate stockpiles

REFERENCE: BASE MAP BY NIES MAPPING GROUP, INC. FOR "MATS MATS QUARRY", DATED 6/30/95.

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc.
HWA

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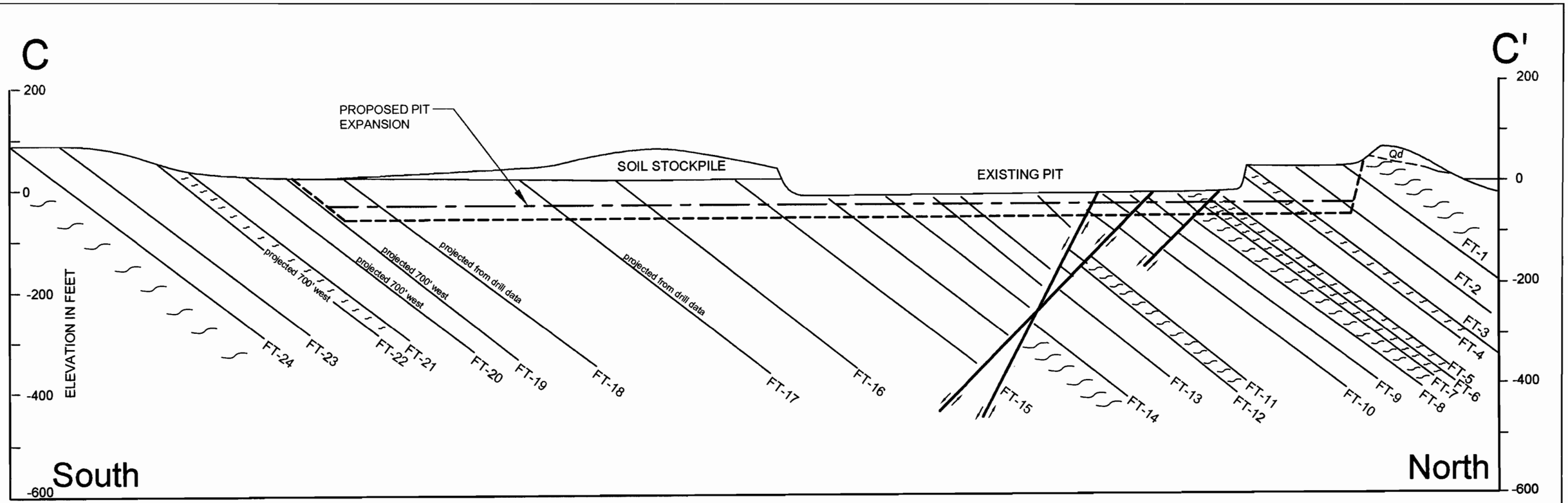
Figure 3.1-4

Site Geology



LEGEND

- Limited Mining Alternative mine base (-30 MLLW)
- Proposed Action mine base (-60 MLLW)
- Basalt flow top
- Columnar jointed basalt
- Fault with relative displacement
- *Qd* Vashon drift (undifferentiated)

HORIZONTAL SCALE IN FEET
0 200 400
0 200 400
VERTICAL SCALE IN FEET

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc.
HWA

Mats Mats Quarry
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Figure 3.1-5

Geologic Cross Section C-C'

3) Overlying the columnar jointed section is a layer of pillow lavas and pillow breccias (broken pillows) that are bulbous shaped to cobble-like. This zone can be up to about 15 feet thick at the site and represents the top of an individual lava flow which has reacted significantly with sea water. The pillow shape is caused by sea water cooling. This zone has reacted the most with sea water and therefore contains an abundance of secondary minerals. Solidified gas cavities, or vesicles, are also abundant in this upper zone and the cavities have generally been filled with whitish minerals such as calcite, aragonite, and quartz. The abundance of soft secondary minerals gives this zone poor rock quality. The brecciated character could also facilitate groundwater seepage.

4) As the basalt flow cooled, small fragments of rock debris and volcanic glass (now altered to soft chlorite) settled atop the pillowed zone. The sedimentation continued uninterrupted until the next lava flow covered this sedimentary "break" (layer of sediment deposited between lava flows). The thickness of a sedimentary break is a measure of the length of time between lava flows. Thick sedimentary breaks indicate a long time between lava flows. Thin to nonexistent breaks indicate that the flow of lava continued relatively uninterrupted from one flow to the next. When a sedimentary break became covered with next lava flow, the heat of the overlying flow baked the underlying sediments creating shale. The shale "breaks" are typically friable, with poor rock quality and the potential for allowing groundwater seepage.

After a period of several million years, the lava flows and sediments were tilted to their present 35-degree northward dip with the uplift of the Olympic Mountains. During the uplift the basalt flows were offset by a number of relatively small-scale faults that cut across the basalt flows at relatively high angles.

Unconsolidated sediments that historically covered portions of the basalt within the "active" mine area have been removed during past mining operations.

Fill soils at the site consist of native soils that have been removed from the active mine area and imported soils (prior to placement on the site for reclamation, all imported soils were tested to confirm that the soils were clean – see Appendix VI for the Clean Soil Acceptance Policy). Fill soils consisting of stripped native soil at the mine were encountered in several borings completed in the buffer zone. Fill soils were likely placed in the buffer zone during past mining operations at the site, as no mining or reclamation activities are currently occurring in the buffer zone. Fill soils are also present in the vicinity of the abandoned Mats Mats Bay slip, the Admiralty Inlet barge loading dock, and in multiple stockpiles throughout the active mine area. Stockpiles consisting of imported fill soils are present at several locations within the active mine area.

Groundwater movement in the vicinity of the quarry is restricted for the most part to the flow tops and interflow sediments of the basalt. The direction of groundwater flow is therefore strongly controlled by the east-west fabric of the individual basalt flows. Some groundwater movement could also occur along the high angle faults, but these zones are relatively narrow. Very little groundwater moves in a north-south direction across the site, as the groundwater would have to flow through several relatively thick layers of nearly impermeable columnar basalt. Based on the site geology, flows and sediments, taken as a collective unit, have very low permeabilities and are considered an aquiclude (barrier to groundwater flow). Please refer

to the *Water* Section for additional detail on groundwater.

Geologic Hazards

Existing geologic hazards identified within the project vicinity include potential landslides and erosion hazards. Landslide and erosion hazards were assessed through visual geologic reconnaissance, subsurface explorations, and review of existing geologic literature. The existing geologic hazards on-site and in the immediate vicinity of the site are discussed below.

Landslide Hazards

A site reconnaissance revealed no evidence of landslide activity was noted within the quarry. With the exception of areas actively being mined, the bedrock typically has a low risk of slope instability.

An off-site reconnaissance of private properties on the west side of the inlet to Mats Mats Bay was completed during September 1999 to evaluate reported landslide activity. Several landslides were identified on the west side of the inlet leading to Mats Mats Bay. This slope is composed of Vashon Drift sediments and is approximately 30 feet high. Where observed, slope gradients were estimated at 80 to 100 percent. Three slides were noted in this vicinity during the site reconnaissance. All three slides showed evidence of recent activity. In several areas, bank retreat from 10 to 20 feet was observed. Erosion from wave action was also noted at the toe of the slopes. Based on conversations with one of the property owners, landslide movement along this slope occurred sometime between 1996 and 1999.

The Washington State Department of Ecology's Coastal Zone Atlas (DOE, 1978) identifies relative slope stability categories on coastal lands of the state. According to the Atlas, the majority of the site is designated as "Stable Slopes" (including areas of low groundwater concentration or competent bedrock). The shoreline slope areas outside of the mining area are designated as "Intermediate Slopes" (slopes over 15 percent with thin soils over bedrock). The barge loading area is designated as "Modified Slopes" (areas highly modified by human activity).

Erosion Hazards

No recent evidence of erosion was observed in the Mats Mats Quarry at the time of fieldwork. The bedrock is relatively competent and resistant to erosion from concentrated and sheet flow. Fine-grained sediment was observed to have accumulated within the Mats Mats Bay slip. Silt fencing had been placed around the perimeter of this area. The silt fencing was observed to be in disrepair at several locations. It is understood that the silt fence was installed by the previous property owner when the back portion of the Mats Mats Bay slip, in the southwest portion of the property, was used as a sediment trap. Glacier Northwest discontinued the use of the back portion of the slip as a sediment trap in 1995 and the silt fence is no longer required to trap sediments. Glacier Northwest has not proposed to remove or repair the silt fence.

3.1.2 Impacts of the Proposed Action

The primary impact of the *Proposed Action* is the depletion of a portion of the remaining bedrock reserves at the site. Approximately 9 million tons of rock would be mined from the site over a projected mine life of approximately 18 years. Issues associated with resource extraction