January 30, 2007
HWA Project No. 2006-172

Art O'Neal & Associates
127 17th Avenue SW
Olympia, WA 98501

Attention: Art O'Neal

Subject: **MASON COUNTY**
WATER QUALITY PROJECT PLANNING
POTLATCH "BUBBLE" PLANNING AREA
MASON COUNTY, WASHINGTON

Dear Mr. O'Neal:

HWA GeoSciences Inc. (HWA) is pleased to submit this draft report of our soils and hydrogeologic evaluation at the Potlatch "bubble" planning area, Mason County, Washington, in support of the Mason County Water Quality Project Planning.

EXECUTIVE SUMMARY

HWA GeoSciences Inc. was contracted by Mason County to evaluate areas within the Potlatch "Bubble" area for soil septic treatment capability and infiltration potential based on geologic, soils, and physiographic criteria.

Soils in the Potlatch Bubble area include mostly Hoodsport and Grove series soils. Hoodsport soils are well-drained upland soils developed over glacial till. Grove soils are excessively drained, and formed on glacial outwash. The geology of the project area consists of glacial till and advance outwash. Glacial till generally consist of a compact unsorted mixture of clay to boulder-size particles, deposited at the base of a glacier. Till is usually very dense, with low permeability, but may be suitable for septic drainfields if sufficient depth of soils and weathered till are present. Glacial outwash consists mostly of permeable sand and gravel (with some clay and silt) deposited by glacial rivers and streams, both during glacial advance (advance outwash) and retreat (recessional outwash).

Criteria for establishing areas requiring a higher level septic treatment include soils, geology, slopes, distance to surface water, depth to ground water, and presence of sensitive receptors (e.g., shallow water wells, wetlands, recharge areas, etc.) Several of these criteria overlap, for example slopes, distance to surface water, and permeable outwash soils all occur at drainages in the planning area. Soils suggesting the need for enhanced treatment include those that are excessively drained and soils on steep slopes or near surface water.

INTRODUCTION

HWA GeoSciences Inc. was contracted by Mason County to evaluate areas within the Potlatch "bubble" for soil septic treatment capability and infiltration potential, based on geologic, soils, and physiographic criteria. HWA reviewed published soils, geologic and other data, in addition to the 1994 HWA *Preliminary Hydrogeologic Evaluation,* prepared for the KCM *Skokomish Wastewater Facility Report* (HWA, 1994).

SOILS

Soils in the Potlatch Bubble area include mostly Hoodsport and Grove series soils (Ness, 1960). Figure 1 shows the mapped soil units in the Potlatch planning area.

Hoodsport series (Hd, He, Hf) soils consists of well-drained upland soils developed over glacial till. The characteristic reddish color is derived from iron staining of granitic, metamorphic, and basic igneous gravel and stone. The Hoodsport soils are shallower, stonier, and more acid than other typical soils formed over till like the Alderwood series. In addition, they developed under heavier rainfall. Flatter, upland areas of the Potlatch Bubble are mapped as Hoodsport gravelly sandy loam, 5 to 15 percent slopes (Hd). The drainages and slopes present at the north, south, and east portions of the planning area are mapped as Hoodsport gravelly sandy loam, 30 to 45 percent slopes (Hf). These steeper soils have developed more slowly, have shallower profiles, are less vegetated, and may be altered by slips, slides, and soil creep (Ness, 1960).

The soil survey report lists Hd soils as having a "very limited" rating for septic tank absorption fields, due to slow water movement and shallow depth to saturated zone. Hf soils are also listed as having a "very limited" rating for septic tank absorption fields, due to slow water movement, shallow depth to saturated zone, and slope (Ness, 1960).

Grove series (Gk) soils consist of somewhat excessively drained, reddish-brown gravelly soils, formed on glacial outwash plains. The Grove soils have developed over Vashon glacial drift, modified considerably by inclusions of local basaltic rock and mixed material from the Olympic Mountain glaciers. The soil survey report (Ness, 1960) lists Grove gravelly sandy loam, 5 to 15 percent slopes (Gk), as having a “very limited” rating for septic tank absorption fields, due to “bottom layer seepage” (i.e., soils are too permeable).

Made land (Ma) consists of soils that have been modified through dredging, grading, or industrial operations. Although rated as “not limited” for septic tank absorption fields (Ness, 1960), artificial or fill soils are generally not considered suitable for septic drainfields per Chapter 246-272 and 272A WAC, On-site Sewage Systems, which typically require “original, undisturbed soil” for drainfields.

The soils and geologic maps reviewed are not entirely consistent with regard to correlation of mapped glacial deposits with mapped overlying soils. For example, the soil maps shows Grove soils (described as forming over outwash) in some areas mapped as till on the geologic map, and Hoodsport soils (described as forming over till) over mapped outwash. Some differences in geologic mapping based on different references also occurs, which is not uncommon, as geologic mapping is highly interpretive in nature. Field verification of soils and geology is therefore recommended prior to design or siting of any facility.

GENERAL GEOLOGIC CONDITIONS

The geology of the project area has been mapped in detail by Carson (1976) Shannon and Wilson (1978), and Logan (2003). Ground water resources are described in Molenaar & Cummins (1973). In general, upland areas are covered by Pleistocene (0.01 to 1.6 million years ago) glacial drift consisting of Vashon Glacial Till and Vashon Advance Outwash. The Vashon Glaciation covered the project area most recently (approximately 12,000 years ago) and extended as far south as Olympia. The compact, lower permeability till typically overlies the sandy, higher permeability outwash except along the bluffs and in stream canyons where the outwash has been exposed. Beneath the Vashon Advance Outwash older, Pre-Vashon glacial drift and interglacial deposits occur with fine grained Pre-Vashon till and outwash well exposed along the lower bluff immediately adjacent to Highway 101. Lowland areas are mapped as Recessional outwash.

Planning Area Geology

Figure 2 shows the mapped geology in the Potlatch “bubble” planning area according to the Logan (2003). Figure 3 shows the mapped geology per Carson (1976). Unconsolidated sediments mapped in the Potlatch planning area include the following:

Qgt - Till, late Wisconsinan (Pleistocene). Glacial till deposits generally consist of a compact unsorted mixture of clay, silt, sand, gravel, and boulders, deposited at the base of the Puget lobe of the Cordilleran ice sheet during the latest glaciation. Occasional sand and gravel lenses may be present. Till is commonly referred to as “hardpan” due to its cement-like texture. Till does not provide a favorable infiltration medium, but may be suitable for septic drainfields if sufficient depth of soils and weathered till are present. Till acts as an aquitard that inhibits the flow of ground water, perches water on top of it where overlain by recessional outwash, and also confines water below it in the advance outwash. In general, the permeability of till ranges from low in weathered surficial deposits to relatively impermeable in very dense non-weathered materials (Logan, 2003).

Qga - Advance outwash, late Wisconsinan (Pleistocene). Advance outwash consists mostly of glaciofluvial sand and gravel, with some and lacustrine clay, silt, and sand deposited during the advance of glaciers. Sandy units are commonly thick, well sorted, and fine grained, with interlayered coarser sand, gravel, cobbles and silt (Logan, 2003). Advance outwash is typically denser than recessional outwash, having been overriden by glacial ice, and is commonly overlain by till.

Qgo - Proglacial and recessional outwash, late Wisconsinan (Pleistocene). Recessional outwash typically includes poorly to moderately sorted, rounded gravel and sand with localized coarser- and finer-grained constituents. Some fine sand, silt, and clay form local overbank sediments may also occur. Recessional outwash thickness varies and is not well known. It most commonly occupies outwash channels scoured into or through till (Logan, 2003). Recessional outwash was not glacially overridden, and is generally poorly consolidated to loose. Typically outwash deposits exhibit moderate to high permeabilities and infiltration rates depending on silt content.

Qapo - Alpine outwash, pre–late Wisconsinan (Pleistocene). Alpine outwash consists of stratified sand, gravel, and cobbles, may include peat, silt, and clay, and may be capped by weathered loess. Clasts are generally more rounded than those in till and lack facets and striations.

SOIL TREATMENT CAPACITY

Our scope of work includes identifying areas likely to require more than traditional on-site septic treatment. Criteria for establishing areas requiring a higher level septic treatment include:

- Soils/geology
- Slopes
- Distance to surface water

- Depth to ground water
- Presence of sensitive receptors (shallow water wells, wetlands, recharge areas, etc.)

Several of the criteria are overlapping, for example slopes, distance to surface water, and permeable outwash soils all occur in the east-west drainages north and south of the planning area.

The Mason County Soil Survey (Ness, 1960) lists all soil types present in the planning area (except Made Land) as having “very limited” suitability for septic drainfields. Similarly, figures prepared by Latourell Associates show soil limitations for use of septic tanks over the entire Potlatch bubble planning area as either moderate or very severe (reproduced in HWA, 1994).

Soils with lower septic treatment capabilities include those that are excessively drained, such as Grove gravelly sandy loam, 5 to 15 percent slopes (Gk), and soils formed on steep slopes, such as Hoodsport gravelly sandy loam, 30 to 45 percent slopes (Hf). These soil types would provide less treatment than slower draining soils due to higher permeability, resulting lower effluent residence times, and lower organic content.

HWA’s opinion is that of the three main soil types encountered (Hd, Hf and Gk), the Hd soils have the best septic treatment potential and least off site septic contaminant transport risk. Hf and Gk soils are both associated with surface water or drainages, and have a higher potential for off site septic contaminant transport, due to steep slopes and excessive permeability, respectively. Artificially placed or fill soils are also likely unsuitable.

Other planning criteria for enhanced treatment include distance to surface water, as it relates to potential for septic contaminant transport (e.g., BOD, nutrients, bacteria, etc.) to surface water bodies, particularly Hood Canal. Surface water for the purpose of this discussion includes creeks, intermittent drainages, tide flats, and Hood Canal. The planning area does not appear to contain isolated upland wetlands. Figure 4 shows mapped wetlands and surface water features that are likely to convey septic drainfield effluent rapidly and without much treatment to Hood Canal. Enhanced septic treatment (above conventional residential systems) may be considered for areas near surface water or drainages. For reference, Chapter 246-272A WAC, On-Site Sewage Systems specifies a setback of 100 feet for drainfields from surface water, and 30 feet from any downgradient site feature that may allow effluent to surface.

INFILTRATION POTENTIAL - CORE RESERVATION AREA

Of the geologic units found in the planning area, glacial till is expected to have poor to negligible infiltration potential, whereas outwash (both recessional and advance) is likely have moderate to high infiltration potential. Recessional outwash may be limited by lateral extent or thickness, as it typically overlies the till. Infiltrating water will generally perch on the till surface, and flow down the slope of the till surface, which often follows topography. Recessional outwash may contain ground water in some areas, which would limit infiltration potential depending on the depth to water. Advance outwash may be also limited by lateral extent or depth to ground water. Advance outwash deposits at the surface in the project area are generally located in drainages, which have been incised through the till to expose the underlying outwash.

The Ecology 2005 *Stormwater Management Manual for Western Washington* provides general infiltration rates based on grain size distribution and soil classifications. This guidance document is intended primarily for stormwater, but can be used to estimate infiltration rates from other sources (e.g., treated waste water effluent). Table 3.7 (reproduced from the Ecology Manual) shows estimated infiltration rates for USDA soil types.

Table 3.7 -- Recommended Infiltration Rates based on USDA Soil Textural Classification.

	*Short-Term Infiltration Rate (in./hr)	Correction Factor, CF	Estimated Long-Term (Design) Infiltration Rate (in./hr)
Clean sandy gravels and gravelly sands (i.e., 90% of the total soil sample is retained in the #10 sieve)	20	2	10**
Sand	8	4	2***
Loamy Sand	2	4	0.5
Sandy Loam	1	4	0.25
Loam	0.5	4	0.13

HWA also reviewed infiltration potential in the northern portion of the Core Reservation planning area, to evaluate suitability for rapid infiltration of treated effluent from a proposed membrane bioreactor wastewater treatment plant. Geology of the proposed treatment plant site is mapped as Qgo, Proglacial and

Recessional Outwash (Logan, 2003). Recessional outwash typically is associated with high permeability and favorable infiltration potential. Soils at the treatment plant site are mapped as Mg, Mukilteo peat, 0 to 2 percent slopes (Ness, 1960). These soils are formed in peat bogs and are very poorly drained. Although not entirely consistent with the geologic map, the Mg soils have formed in peat bogs over outwash at this location due to drainage patterns (e.g., low lying area with shallow ground water). Two test pits conducted in this area by HWA in 1994 indicate the presence of clean and silty sands to depths of six feet, suggesting the presence of outwash, not peat (HWA, 1994).

An intermittent drainage located northwest of the proposed treatment plant site is known locally as Dry Bed Creek. The drainage is mapped as Qapo, Alpine Outwash, with Qga, Advance Outwash mapped further upstream (Logan, 2003). Another reference shows this area as Recessional Outwash, Glacial Drift, and Advance Outwash mapped further upstream (Carson, 1976). For site suitability purposes, differentiation of outwash as alpine, advance, or recessional is not critical.

HWA visited the Dry Bed Creek area on December 6, 2006, and observed bank exposures in the steeply incised (dry) channel consisting of stratified clean sands and gravels, with some thin layers of silty sand, consistent with the mapped designation of glacial outwash. Local residents report the channel rarely contains any water; even after heavy precipitation events, it flows for a few days, then dries out. HWA observed glacial till in an excavation just north and outside the edge of the channel, more consistent with Carson (1976) than the Logan (2003) map, and suggesting the outwash may only crop out at and near the channel in this area.

HWA recommends explorations in this area to establish actual soil types and ground water depths, to determine suitable areas for infiltration and allow estimation of infiltration rates. The geologic investigation would likely consist of test pit explorations and/or soil borings followed by classification and laboratory grain size distribution analysis of potential receptor soils. This evaluation (along with other criteria such as steep slopes, property availability, distance to wastewater infrastructure, elevation, presence of receptors, etc.) would allow selection of the most appropriate site and estimation of infiltration capacities. Once a site is selected, ground water monitoring and pilot infiltration testing would be needed to size the facility for design flows. The pilot infiltration test typically entails a 17-24 hour period of infiltration at rates scaled to design flows, into an approximately 100 square-foot pit (Ecology, 2005). Discharge and water levels are monitored and long term infiltration rates can be approximated.

REFERENCES

Carson, R. J., 1976. *Geologic Map of North Central Mason County, Washington*, 1 sheet, scale 1:62,500, Washington Division of Geology and Earth Resources, Open File Report 76-2.

Ecology, Washington State Department of, 2005. *Stormwater Management Manual for Western Washington*, Publications Numbers 05-10-029 through 05-10-033, Water Quality Program, Washington State Department of Ecology

HWA GeoSciences, Inc., September 19, 1994. *Preliminary Hydrogeologic Evaluation, Skokomish Wastewater Facility Report*, prepared for KCM Portland.

Logan, R. L., 2003. *Geologic Map of the Shelton 1:100,000 Quadrangle, Washington.* 45 x 36 in. color sheet, scale 1:100,000, Washington Division of Geology and Earth Resources, Open File Report 2003-15 http://www.dnr.wa.gov/geology/pdf/ofr03-15.pdf

Molenaar, Dee, and Cummans, J.E., 1973. *Water Resources of the Skokomish Indian Reservation, Washington*, USGS Open File Report, 55p.

Ness, A. 0., and Fowler, R. H., 1960. *Soil Survey Of Mason County, Washington,* Soil Conservation Service, United States Department of Agriculture, Washington Agricultural Experiment Stations. http://www.or.nrcs.usda.gov/pnw_soil/wa_reports.html

Shannon & Wilson, Inc. 1978. *Generalized Geologic Map, Skokomish Indian Reservation, Mason County, Washington*, Report #W-3302-01.

LIMITATIONS

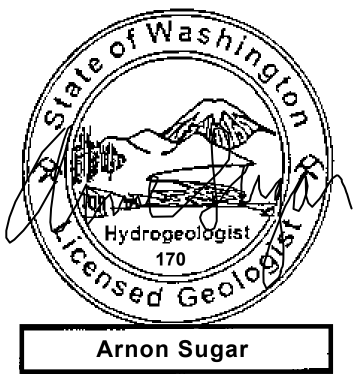
The conclusions expressed by HWA are based solely on material referenced in this report. Observations were made under the conditions stated. Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the area at the time the report was prepared. No warranty, express or implied, is made. HWA's findings and conclusions must not be considered as scientific or engineering certainties, but rather as our professional opinion concerning the significance of the limited data gathered and interpreted during the course of the assessment.

This study and report have been prepared on behalf of Mason County for the specific application to the subject property. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, nor the use of segregated portions of this report.

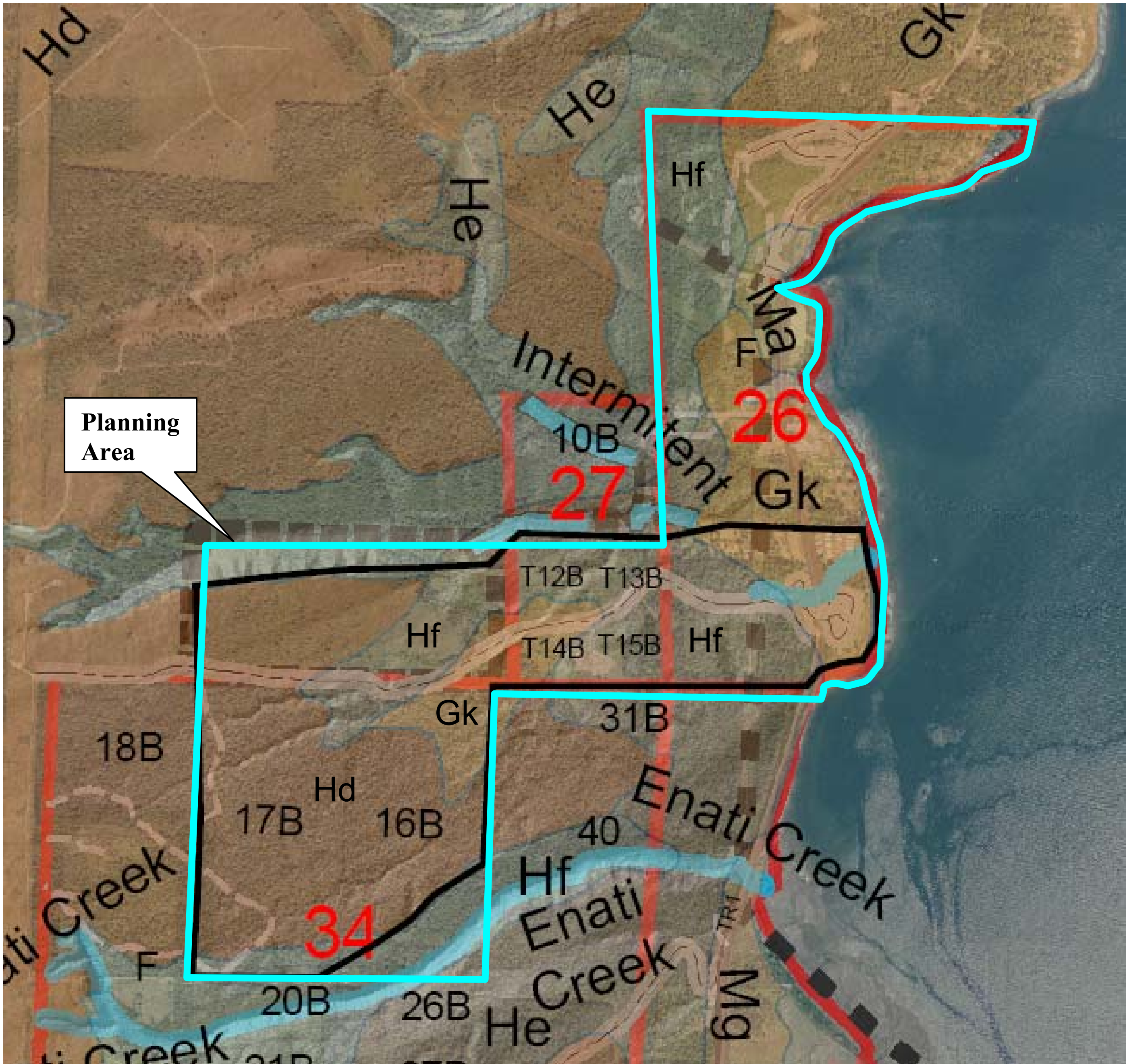
We appreciate the opportunity to provide our services. Please feel free to call us if you have any questions or need more information.

Sincerely,

HWA GEOSCIENCES INC.



Arnie Sugar, LG, LHG
Vice President



NORTH

From: Ness, A. 0., and Fowler, R. H., 1960. *Soil Survey Of Mason County, Washington,* Soil Conservation Service, United States Department of Agriculture, Washington Agricultural Experiment Stations.
http://www.or.nrcs.usda.gov/pnw_soil/wa_reports.html

Soils key:

Hd: Hoodsport gravelly sandy loam, 5 to 15 % slopes
He: Hoodsport gravelly sandy loam, 15 to 30 % slopes
Hf: Hoodsport gravelly sandy loam, 30 to 45 % slopes
Gh: Grove gravelly sandy loam, 0 to 5 % slopes
Gk: Grove gravelly sandy loam, 5 to 15 % slopes
Ma - Made land

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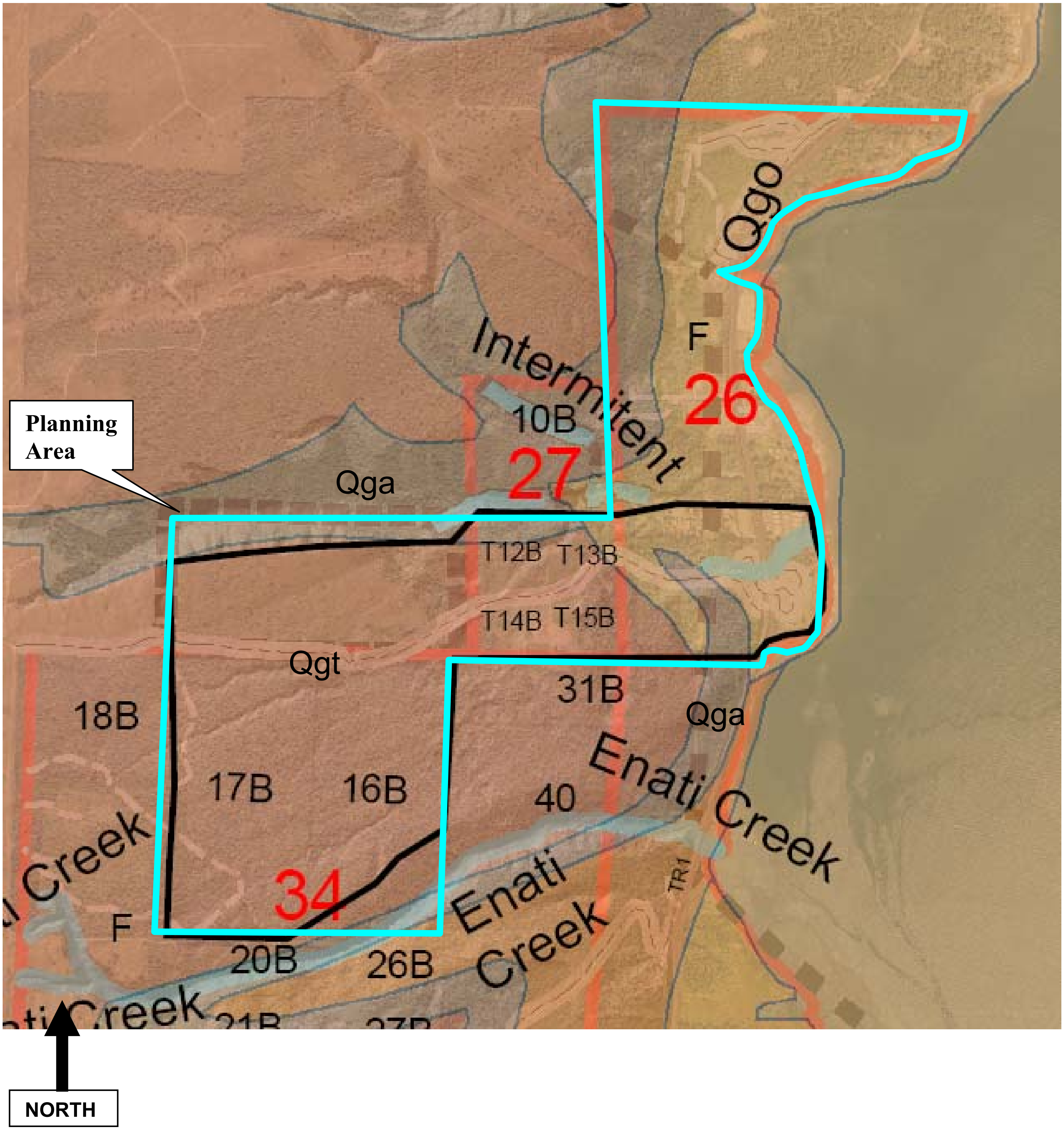
SOILS MAP

MASON COUNTY
WATER QUALITY PROJECT PLANNING
POTLATCH BUBBLE AREA

FIGURE NO.
1

PROJECT NO.
2006-172



From: Logan, R. L., 2003. *Geologic Map of the Shelton 1:100,000 Quadrangle, Washington.* 45 x 36 in. color sheet, scale 1:100,000, Washington Division of Geology and Earth Resources, Open File Report 2003-15 http://www.dnr.wa.gov/geology/pdf/ofr03-15.pdf

Geology key:

Qgt - Till, late Wisconsinan (Pleistocene)
Qga - Advance outwash, late Wisconsinan (Pleistocene)
Qgo - Proglacial and recessional outwash, late Wisconsinan (Pleistocene)

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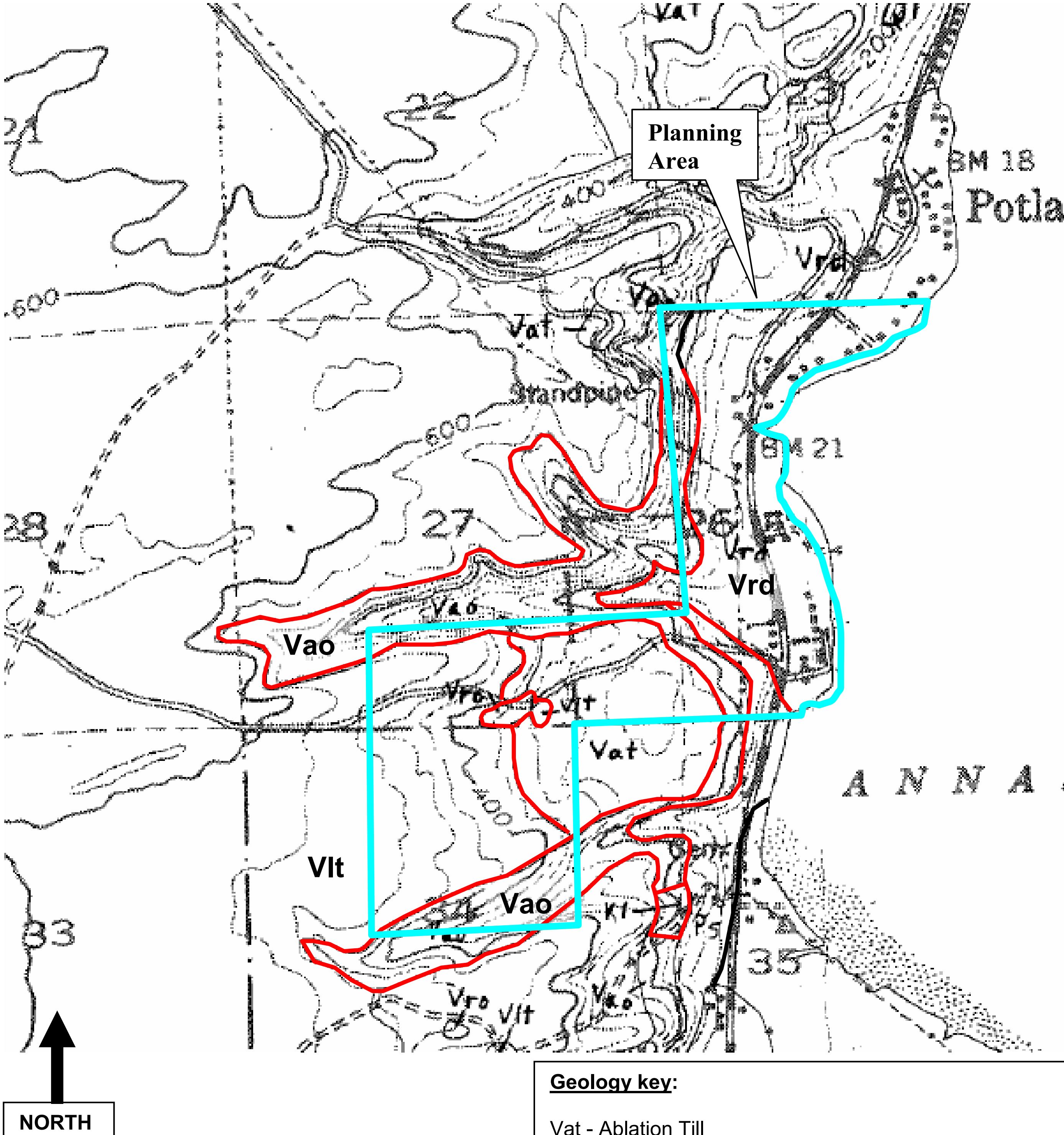
GEOLOGIC MAP (Logan, 2003)

MASON COUNTY
WATER QUALITY PROJECT PLANNING
POTLATCH BUBBLE AREA

FIGURE NO.
2

PROJECT NO.
2006-172



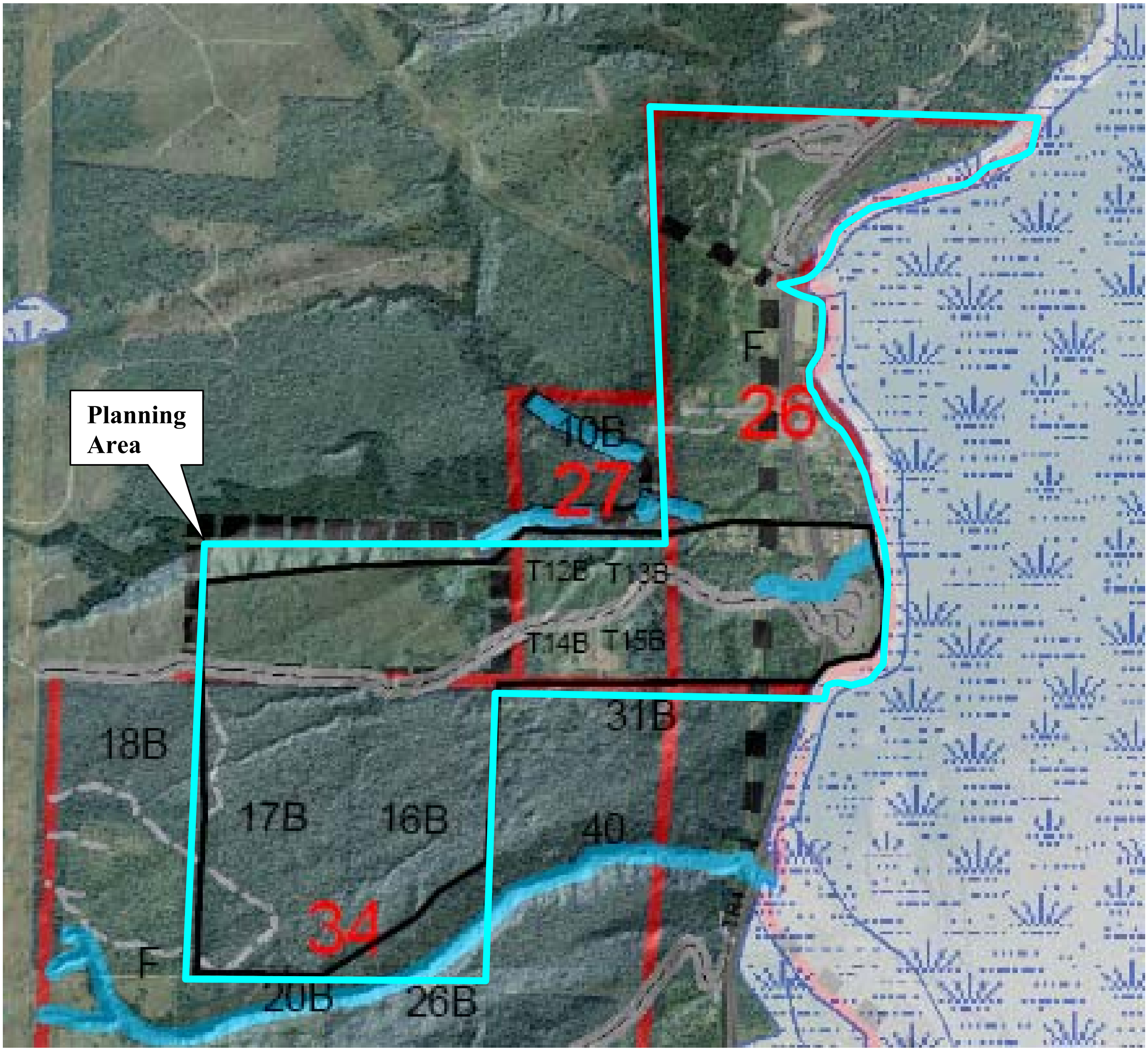
From: Carson, R. J., OFR 76-2. Geologic Map of North Central Mason County, Washington, 1 sheet, scale 1:62,500, Washington Division of Geology and Earth Resources, Open File Report 76-2.

Geology key:

Vat - Ablation Till
Vlt - Lodgment till
Vro - Recessional outwash
Vrd - Recessional outwash - deltas/alluvial fans
Vl - Lacustrine sediments
Ps - Salmon Springs Drift

HWA GEOSCIENCES INC.

GEOLOGIC MAP (Carson, 1976)	FIGURE NO. 3
MASON COUNTY WATER QUALITY PROJECT PLANNING POTLATCH BUBBLE AREA	PROJECT NO. 2006-172



NORTH

From: Skokomish Tribe GIS Services

HWA GEOSCIENCES INC.

WETLANDS

MASON COUNTY
WATER QUALITY PROJECT PLANNING
POTLATCH BUBBLE AREA

FIGURE NO.
4

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