Reconnaissance Investigation of Sand, Gravel, and Quarried Bedrock Resources in the Snoqualmie Pass 1:100,000 Quadrangle, Washington

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INTRODUCTION

Background

During its 1998 session, the Washington State Legislature, acting on a recommendation from the Governor's Land Use Study Commission, asked the Washington Department of Natural Resources (WADNR) to map gravel and bedrock resources that are used for maintenance and construction of homes and infrastructure. The Study Commission sought information to assess the need to protect these resources from urban sprawl and other intensive land uses. These data would, in turn, result in better long-range planning and possible legislation to aid in designating mineral resource lands under the Growth Management Act (Revised Code of Washington [RCW] 36.70A; Lingley and Jazdzewski, 1994).

Although the data are presented here in the traditional text and map format, this report is part of a project to prepare a geographic information systems (GIS) database that delineates the locations of some of the significant construction aggregate resources (sand, gravel, and quarried bedrock) of Washington State. The digital version of this report, including ArcInfo© coverages, is available through the Washington Division of Geology and Earth Resources (see back of title page for address).

The Snoqualmie Pass 1:100,000-scale quadrangle straddles the Cascade crest in west-central Washington from 47 to 47.5 degrees north latitude and 121 to 122 degrees west longitude (Fig. 1). Approximately one-half of the quadrangle is in King County, the remainder in Kittitas, Pierce, and Yakima Counties. As of the 2000 federal census, the population of the quadrangle was approximately 50,000, with the largest population centers at Enumclaw (population ~11,100) and North Bend (population ~4,746) (Dwyer and Dwyer, 2001).

Intended Readership

This inventory was created primarily for use by local government planners to help refine comprehensive plans and other zoning determinations. It will also aid legislators and other policy makers to assess the importance of largely nonrenewable sand, gravel, and quarried bedrock resources. The study should also benefit engineers, transportation departments, and industry.

Primary Products

This inventory consists of the following products:

- A map showing the probable extent of bedrock and gravel resources (in pink and yellow, respectively, on Plate 1). Thickness contours (isopachs) are shown within those sand and gravel deposits for which we have sufficient data.
- A map showing the location of active mines, borrow pits, some depleted mines, and large proposed mines (Plate 1).
- A glossary of terms used in this report (Appendix 1).
- A complete discussion of the methods used in this study (Appendix 2).

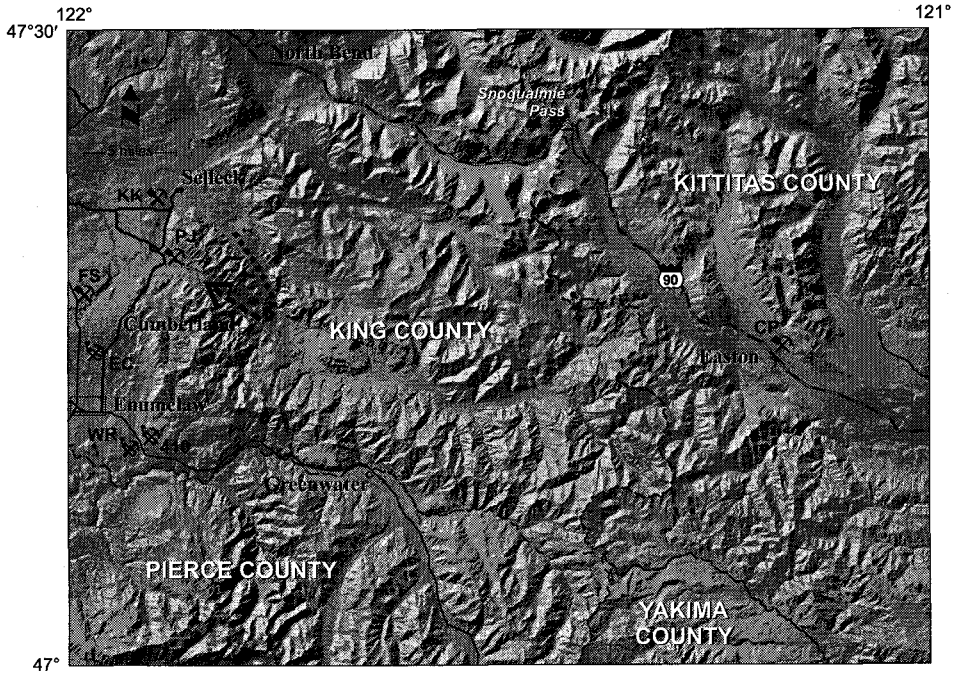

Figure 1. Index map of the Snoqualmie Pass quadrangle showing selected geographic locations and some important sand and gravel pits (pick and shovel) and quarries (pick and dynamite). Mines shown: WR, White River pit and quarry; EC, Enumclaw quarry; 410, 410 quarry; FS, eastern portions of the Flintstone pit; PJ, Palmer Junction pit; KK, Kangley pit; and CP, Cresto pit. The arrow indicates the direction of flow in a late Pleistocene outwash channel, which reversed the flow of Taylor Creek (dotted portion), crossed the pass at its headwaters, and flowed down the Green River drainage (dashed portion) to a proglacial lake near the Palmer Junction pit. The lake formed as a result of ice-damming by the Puget lobe of the Cordilleran ice sheet. Today, Taylor Creek flows northwestward. Shaded relief is derived from a U.S. Geological Survey 30-meter digital elevation model (DEM).

- Databases containing the location, thickness, quality, and volume of some sand, gravel, and bedrock resources (Appendices 3–4).
- Brief descriptions of geologic units known to contain aggregate resources (Appendix 5).
- A description of the geology and mining history of construction aggregates in the Snoqualmie Pass quadrangle (see text).

Accuracy of Estimates

We emphasize that this report almost certainly overestimates the volume of construction aggregate within the Snoqualmie Pass quadrangle that is available under current market conditions. Overestimation results from factors such as shallow bedrock under surficial gravels, diminishing rock quality with depth, unmapped areas of thick overburden, and lateral geologic variation. Furthermore, history indicates that future drilling and mining are more likely to yield disappointing results than to add significantly to hypothetical aggregate reserves.

Threshold of Significant Resources

Because this study is primarily designed as an aid to land-use planning, we inventoried only those resources deemed as significant to the long-term economic health of the region. Therefore, we restricted our investigation to those resources that exceed the following threshold criteria:

- The thickness of the sand and gravel or bedrock deposit appears to be in excess of 25 feet (7.5 m).
- The 'stripping ratio' (ratio of overburden to gravel or overburden to bedrock) is less than one to three (1:3).
- The strength and durability of the rock meet the Washington State Department of Transportation (1999) (WSDOT) minimum specifications for asphalt-treated base, a rock product used to construct some lower layers of asphalt roads (Table 1).
- The area of the deposit exposed at the surface exceeds 160 acres and measures at least 1,500 feet across the minimum dimension of the deposit.
- Estimated reserves within the deposit exceed 10 million cubic yards.

A few unusually thick deposits or resources of special local importance are included although they do not meet the threshold criteria. More information on the threshold criteria can be found in Appendix 2.

In some markets, a lack of high-quality gravel and bedrock has forced producers to mine lower-quality deposits. Homes and infrastructure constructed with weak gravel or bedrock generally have relatively short life cycles. We have not inventoried these lower-quality deposits because they do not meet the criteria of this study. However, Appendices 3 and 4 will serve as guides to the locations of some of the poorer-quality deposits as well as resources buried under thick overburden layers that may become more attractive under future market conditions.

Scope of Deposits Inventoried

In order to produce an objective analysis, we have inventoried all deposits meeting the threshold criteria, without consideration of environmental impacts or land-use conflicts that may be involved in permitting or extracting these resources. The only exceptions are those deposits that lie within the Clearwater, Norse Peak, and Alpine Lakes Wilderness areas. For example, the Yakima River flood plain has historically been a major gravel resource, and numerous mines are still operating beside the river. Future mining operations in flood plains will likely have more difficulty obtaining permits because alluvial mining can cause adverse impacts to aquatic and riparian habitat (Norman and others, 1998). Nevertheless, all Yakima River sand and gravel deposits meeting the threshold criteria are depicted in this report. Therefore, this inventory must be used with maps of environmentally sensitive areas and land-use status in order to obtain a complete picture of available aggregate within the quadrangle.

Previous Aggregate Reserve Studies

Gence (1934) and Kroft (1972) mapped gravel reserves exposed at the surface in parts of King and Pierce Counties, but did not assess the engineering properties of the rock or the subsurface extent of these deposits. General aspects of the sand and gravel industry in the Puget Sound region were discussed by Huntting (1982), who listed reserves of major sand and gravel producers. White and others (1990) presented the results of a regional market study of the western Washington sand and gravel industry. The geology and hydrogeology of the Snoqualmie Pass quadrangle have been mapped by Vine (1962), Rosengreen (1965), Richardson and others (1968), Luzier (1969), Fischer (1970), Evans and Jensen (1996), Hellwig (1997), and Tabor and others (2000).

The locations of most commercial mines in Washington are given in Lingley and Manson (1992), who also summarized the market conditions at that time, and McKay and others (2001). Specific data for most active and some terminated mines are archived in Washington Division of Geology and Earth Resources Reclamation Permit files, Washington State Department of Transportation records, and U.S. Forest Service files and reports (Cook, 1992, 1993). Environmental assessments of larger mines, for example Huckell/Weinman Associates (1996), Huckell/Weinman Associates and others (1995, 1996), King

Table 1. Some specifications for construction aggregate products *(after Washington Department of Transportation, 1999)*. Los Angeles Abrasion and Percent Passing U.S. No. 200 Sieve measurements are in weight percent. Los Angeles Abrasion and Degradation specifications for coarse portland cement concrete aggregate are not rigorous because the gravel is rarely exposed on the outside of concrete structures such as foundations or sidewalks

	Product			
Laboratory test	**Asphalt-treated base**	**Crushed (road) surfacing, top course**	**Coarse aggregate for portland cement concrete**	**Ballast (road subgrade)**
Los Angeles Abrasion	≤30%	≤35%	≤35%	≤40%
Washington Degradation	≥15	≥25	not used	≥15
Sand Equivalent	≥30%	≥35%	not used	≥30%
Percent Passing U.S. No. 200 Sieve (<0.0025 in.)	2–9%	0–7.5%	0–0.5%	0–9%

County (1987, 1996, 1997), and McLucas and Associates (1986) provide details of stratigraphy and reserve estimates. Hydrologic information is included in various types of environmental documentation, wellhead-protection studies, and water-resource reports. Water-well logs and some logs of geotechnical boreholes are archived by the Washington Departments of Ecology and Transportation, respectively and the Weyerhaeuser Company.

Other reports in this series of reconnaissance investigations of sand, gravel, and bedrock resources include Loen and others (2001), Weberling and others (2001), Dunn (2001), and Norman and others (2001).

Table 2. Large sand and gravel pits in the Snoqualmie Pass quadrangle

Mine name	Current operator	Location	Approximate reserves remaining (million tons)	Approximate annual production rate (million tons)
Western Washington:				
Flintstone pit	Cadman, Inc.	Black Diamond (1.5 mi southeast)	10	~1.5
Palmer Junction pit	Watson Asphalt, Inc.	Kanaskat (0.3 mi east)	24	0.5
Kangley pit	Stoneway Rock & Recycling	Kangley (1.0 mi west)	38	0.5
Enumclaw pit	Tim Corliss and Son, Inc.	Enumclaw	14	~0.5
		Total	86	3.0
Eastern Washington:				
Cresto pit	Ellensburg Cement Products, Inc.	Easton (5.0 mi northwest)	5	0.10
Bullfrog pit	Trendwest Resorts, Inc.	Cle Elum (3.0 mi northwest)	3	0.00
Ellison pit	Ellensburg Cement Products, Inc.	Easton (5.0 mi northwest)	0.6	0.04
		Total	8.6	0.14

GEOLOGY OF CONSTRUCTION AGGREGATES IN THE SNOQUALMIE PASS QUADRANGLE

Numerous igneous intrusions, volcanic activity, and glacial processes resulted in remarkably large volumes of sand, gravel, and bedrock in the Snoqualmie Pass quadrangle. Much of this material has good to excellent characteristics for construction aggregate. Large gravel mines in the quadrangle were developed to supply aggregate to the eastern Puget Sound area for portland cement concrete or asphaltic cement concrete. Most small mines in the quadrangle were developed for forestry purposes in the Cascade Range and produce from the andesitic or basaltic volcanic rocks that are common in the mountainous areas. Table 2 lists larger sand and gravel mines in the quadrangle, and Table 3 lists larger bedrock quarries. Intrusive igneous rocks such as granodiorite have not been extensively developed, but they have potential to yield enormous volumes of aggregate.

Sand and Gravel Geology

Sand and gravel deposits cover less than 20 percent of the Snoqualmie Pass quadrangle. Large areas of the lowlands are covered with fine sediments (clay, silt, very fine sand) that are unsuitable for construction aggregate because they tend to flow under pressure and will not support weight. In the flat areas at the edge of the foothills, landslide deposits and soil wedges commonly cover or interfinger with otherwise commercial gravel resources. About 5,700 years ago, the giant Osceola Mudflow from Mount Rainier inundated the entire lowland near Enumclaw to depths in excess of 40 feet (Dragovich and others, 1994), covering otherwise commercial gravel deposits with a thick overburden of ash and mud.

Large gravel deposits are present only at lower elevations. Gravel does not accumulate in mountains and their foothills because currents in steep-gradient streams are too rapid to allow permanent deposition; gravel in mountainous streams can be thought of as being temporarily delayed in its inevitable transport to low elevation. Moreover, the bottoms of most V-shaped mountain stream valleys or U-shaped glacial valleys do not provide sufficient flat area for large gravel deposits to accumulate.

In general, the quality of gravel in the Snoqualmie Pass quadrangle is a function of the bedrock geology and distance of sediment transport. West of the Cascade crest, accumulations of exceptionally strong and durable gravel formed because only stronger clasts survived the long transport from the northern Cascade Range or Canada. These strong clasts are mostly composed of granitic rocks and metamorphosed volcanic rocks. These clasts were carried by the Puget lobe of the late Pleistocene Cordilleran ice sheet or by meltwater streams that formed at the snout or margins of the lobe (Fig. 2). Some of the high-quality gravel between North Bend and Cumberland (Fig. 3) has been reworked by ice-marginal streams that winnowed the remaining weak fragments. East of the Cascade crest, the Cle Elum River drainage contains strong and durable gravel mostly derived from granitic or metamorphosed volcanic bedrock in the central Cascade Range. Farther south, gravels in the main stems of the Naches and Yakima Rivers are derived from the Miocene Columbia River Basalt Group and Quaternary volcanic units and have varied quality. Gravel that consistently meets the threshold criteria is present only in the lower reaches of these rivers because miles of fluvial transport pulverized the weaker clasts.

Table 3. Large quarries in the Snoqualmie Pass quadrangle

Mine name	Current operator	Location	Reserves (million tons)	Approximate annual production rate (million tons)
White River quarry	Glacier Northwest, Inc.	Enumclaw (2.0 mi southeast)	25	0.4
Enumclaw quarry	Richard Pierotti	Enumclaw (1.0 mi northeast)	10	0.2
410 quarry	Laramie Joubert	Enumclaw (2.5 mi southeast)	5	0.1
		Total	40	0.7

Gravel eroded from weak volcanic rocks of the southern Cascade Range commonly fails to meet our threshold criteria for strength and durability. Gravel derived from certain volcanic rocks of the Cascade Range is chemically reactive, resulting in less-durable portland cement concrete. Tributary channels of the Naches and Yakima Rivers contain some of these chemically reactive gravels.

Three major types of sand and gravel deposits are exposed in the lowlands of the study area: outwash deposits, kame deposits, and alluvial deposits. In each type, the gravel was deposited directly from streams and rivers that slowed abruptly beyond the snouts of glaciers or as they reached flat ground at lower elevations.

OUTWASH DEPOSITS

Outwash deposits are the braided-stream sedoments laid down next to the continental ice sheet on the margins of the Puget Lowland (Fig. 2) or by streams associated with younger alpine glaciers that issued from both sides of the Cascade Range. These deposits are characterized by groups of concave-upward layering (trough cross-bedding); each layer is typically 20 feet wide and 3 feet high.

Sediment in the Snoqualmie Pass quadrangle is dominated by outwash composed of coarse gravel, cobbles, and boulders deposited by streams close to the snouts of the ice-age glaciers. Close to the ice, streams had swifter currents and therefore could carry larger clasts. For example, sediment in the giant Kangley pit ranges from coarse gravel to boulders, with no sand or clay. The large size of the trough cross-beds in this pit indicate that torrential rivers issued from the nearby ice. This deposit also contains numerous large boulders, some of which are more than 25 feet in diameter, that must have rolled directly off the front of the ice and dropped into the adjacent outwash plain. In contrast, miles downstream from the glacier, current slowed and braided channels coalesced to form rivers that could transport only finer gravel and sand.

Most commercial gravel pits in western Washington produce from outwash associated with ice recession (melting back) following the most recent glacial advance (the Vashon Stade of the Fraser Glaciation). Recessional outwash is generally separated from underlying advance outwash by a layer of till, which was laid down directly by the ice. Till is an unsorted mixture of clay, gravel, and boulders that cannot be used as construction aggregate and is typically about 35 feet thick in the Snoqualmie Pass quadrangle.

Outwash deposited during the advancing phase of the Fraser Glaciation and outwash from earlier glaciations are rarely exposed at the surface, so few Washington mines produce from

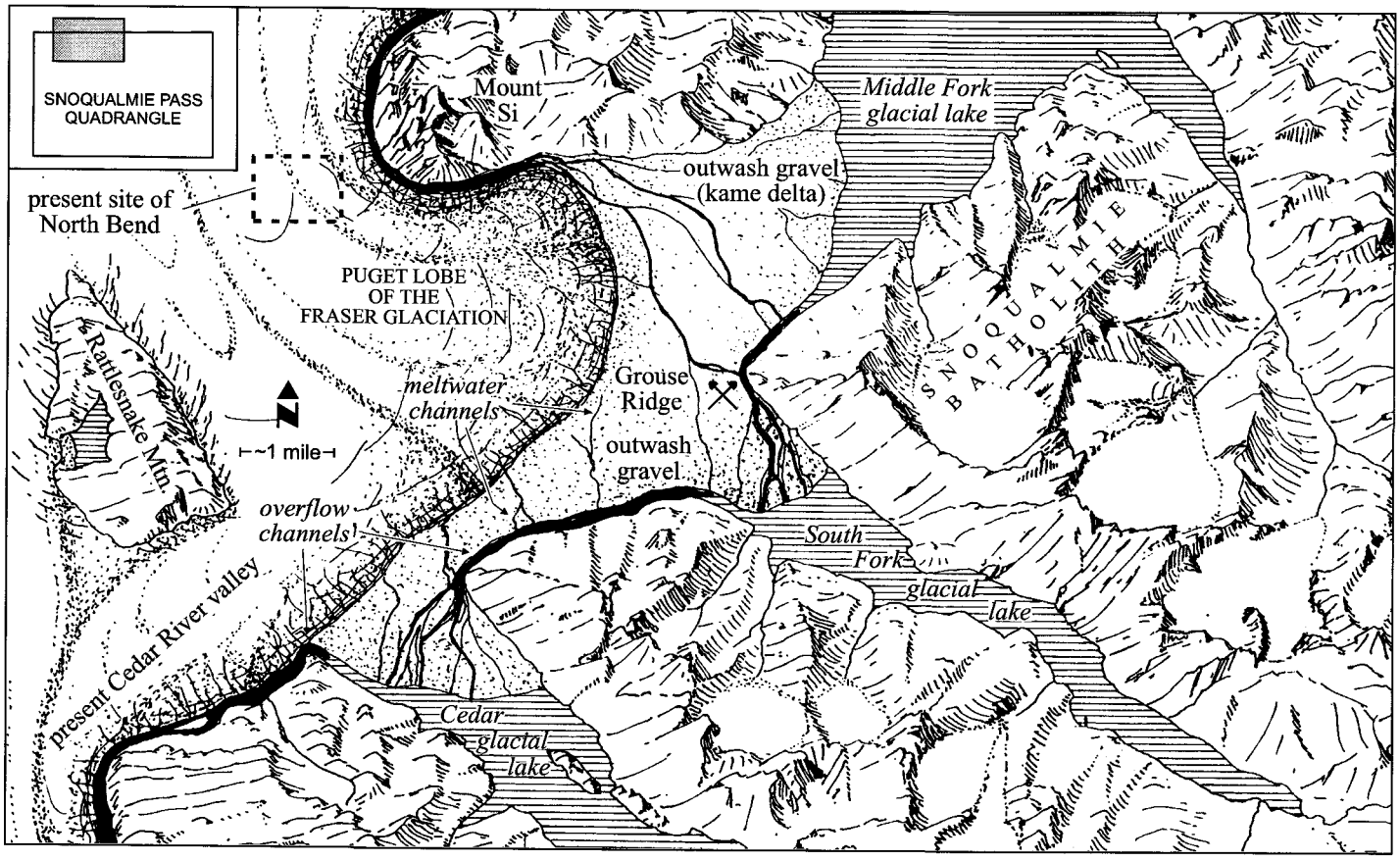

Figure 2. Paleogeographic map of part of the Snoqualmie Pass quadrangle as it appeared near the end of the last advance of Cordilleran ice about 15,000 years ago (modified from Cary, 1966, and Mackin, 1941). (Note that alpine glacial ice from the Cascade Range did not extend far enough down valley to coalesce with the Puget lobe of the continental ice sheet.) As the Puget lobe flowed southeastward, meltwater streams from the continental ice were trapped against the foothills of the Cascade Range. At the same time, rivers flowing westward out of the mountains were dammed by the continental ice forming glacial lakes along the Middle and South Forks of the Snoqualmie River and the Cedar River. Meltwater and entrained sediment from the continental ice poured into these lakes forming thick gravel deltas, such as the Grouse Ridge deposit. Overflow channels from these lakes coalesced and deposited outwash gravel in intervening areas. Together the outwash and deltaic deposits form a remarkably large sand and gravel resource. Also shown is the western portion of the Snoqualmie batholith, a large granitic body that contains large reserves of hard and durable bedrock.

these deposits. Large volumes of gravel are probably contained in these deeply buried outwash deposits. Although the stripping ratio for these deposits generally exceeds 1 to 3, increases in the price of aggregate might make some older outwash deposits commercially attractive. However, we believe that, in the future, quarried bedrock generally will prove to be a more profitable source of aggregate than older outwash deposits. In addition, bedrock generally can be quarried with fewer adverse environmental impacts than mining most advance outwash gravel deposits.

KAME DEPOSITS

Kames in the Snoqualmie Pass quadrangle are sand and gravel ridges or hummocks that formed on or beside the Cordilleran ice sheet. Most of these kames were deposited in trough-like hollows between the sides of the continental ice sheet and adjacent foothills when the ice sheet impinged on the foothills of the Cascade Range during the late Vashon Stade about 13,000 years ago (Mackin, 1941; Cary, 1966).

At the time the Puget lobe impinged on the foothills, the valleys of the Middle Fork Snoqualmie, South Fork Snoqualmie, Cedar, and Green Rivers and Taylor Creek were not occupied by ice flowing downvalley from local alpine glaciers. When the Cordilleran ice sheet flowed into the ends of these valleys, rivers flowing in the valleys were blocked, creating lakes (Fig. 2). In the Snoqualmie Pass quadrangle, the thickest kame deposits were laid down as gravel deltas and outwash plains that grew out into these glacial lakes.

Kame deposits in the study area, such as in the Palmer Junction pit (Fig. 4), are among the largest gravel deposits in Washington. Similar kames form a series of exceptionally thick gravel deposits along the mountain front northwest of the Snoqualmie Pass quadrangle (Booth, 1990).

ALLUVIAL DEPOSITS

Alluvial gravels were laid down relatively recently along the flood plains of major rivers. Currently, alluvium is mined only on the upper flood plain of the Yakima River southwest of the town of Ronald (Plate 1). Older alluvial gravels are also present in the Snoqualmie Pass quadrangle. These range from high-quality gravel in the ancestral Green River channel north of Cumberland to cemented gravel in the Yakima

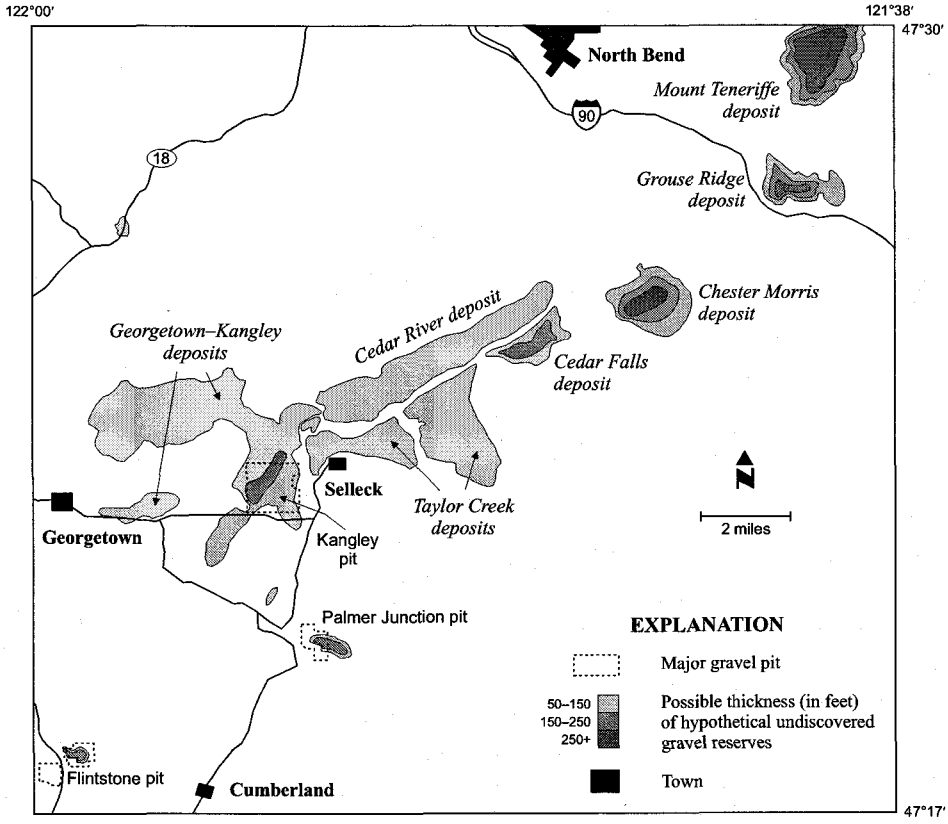

Figure 3. Large gravel mines and the possible distribution and thickness of some hypothetical undiscovered gravel resources in the northwestern Snoqualmie Pass quadrangle. The contours are based on discontinuous outcrop data and poor-quality borehole information. Compare this figure with present-day topography shown on Figure 1 and paleogeography shown on Figure 2.

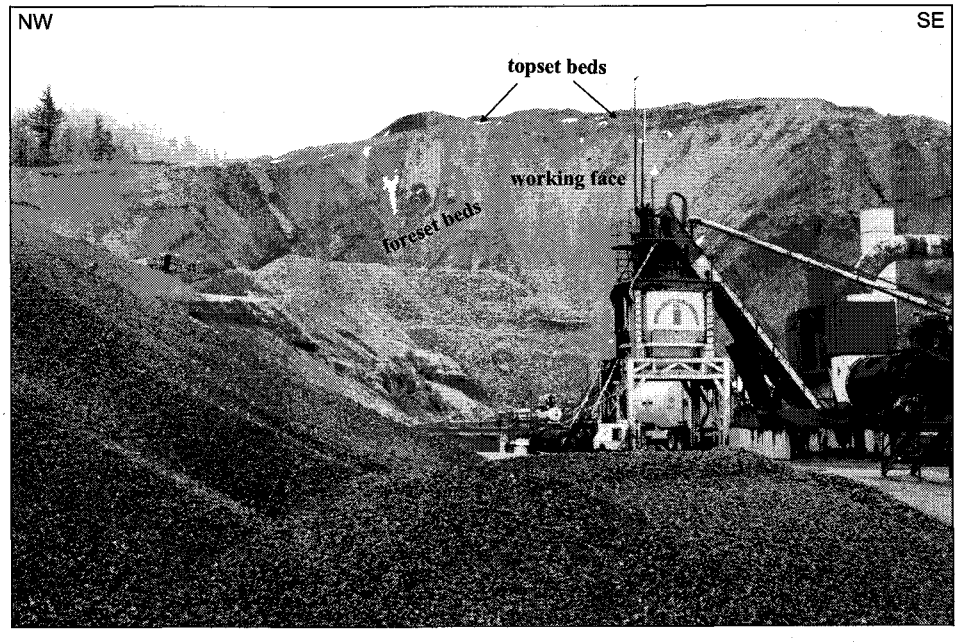

Figure 4. View northeast into the Palmer Junction pit. Product stockpiles and an asphalt batch plant are in the foreground. The white spots are snow. The working face is more than 120 feet high and composed of kame delta gravels deposited in a late Pleistocene glacial lake that formed where the valley of the Green River was dammed by continental ice. The paleo–Green River together with water and sediment from the Taylor Creek drainage (see Fig. 1) flowed across the top of the delta, depositing topset beds. Foreset beds were laid down deeper in the lake as gravel rolled down the face of the delta.

River valley. The cemented gravels can be costly to excavate and in some places contain oxides that diminish the quality of the gravel.

Bedrock Geology

In the Snoqualmie Pass quadrangle, abundant hard and durable bedrock is the result of two types of igneous processes: lava flows that formed volcanic rocks and underground intrusions of magma that formed intrusive igneous rocks.

VOLCANIC ROCKS

During the last 50 million years, lava flows from eruptions in the central Cascade Range spread over large areas of the ground surface and cooled quickly to form finely crystalline volcanic rocks. Unlike in southwestern Washington, where most lava erupted on the sea floor and was rapidly altered to weaker materials, volcanic rocks in the Snoqualmie Pass quadrangle were extruded on land, preserving their natural hardness. Each flow formed a distinct layer that is generally less than 150 feet thick except where the lava ponded in topographic lows. The strongest and most durable flows commonly contain columnar jointing, or vertical palisades that have characteristic hexagonal cross sections. Hard and durable volcanic flows commonly crop out as flat-topped cliffs, hence the term 'ledge rock'.

However, lava flows constitute a minor percentage of most volcanic units. Layers of fragmented volcanic rock or ash-rich strata (conglomerates, breccias, and tuffs, collectively known as volcaniclastic rock) generally separate the flows. Commercial operators attempt to locate ancient lava flows that are not covered by a thick overburden of weaker volcaniclastic rock. However, lower-quality volcaniclastic rocks are occasionally used for logging road surfacing, even though these rarely meet specifications for strength and durability.

The 410, Enumclaw, and White River quarries, all near Enumclaw, are important mines producing construction aggregate from flows of the Fifes Peak Formation of Miocene age. However, most of the Fifes Peak Formation consists of soft rock types that are unsuitable for construction aggregate. Older volcanic rocks of the Tukwila Formation are locally acceptable sources of quarried bedrock. Both of these units, and rocks of similar age and composition, crop out throughout the central Cascade Range, where large quarries might be developed with relatively low environmental impact. These hypothetical resources are not commercial at the present time due to the long mine-to-market distance.

Exceptionally strong and durable flows of the Grande Ronde Basalt of the Columbia River Basalt Group are present in the southeastern part of the quadrangle. These flows, which are typically 140 feet thick, are the most important quarried rock resource in eastern Washington (Weberling and others, 2001; Dunn, 2001), but in the Snoqualmie Pass quadrangle, long haul distances currently preclude development of this basalt.

INTRUSIVE IGNEOUS ROCKS

Intrusive units, composed mostly of coarsely crystalline igneous rock, formed from magma that cooled slowly at great depth and are generally exposed as areally extensive units. Intrusive units have more uniform quality and are much thicker than volcanic units. Most of these bodies are hundreds to thousands of feet thick, so the depth of aggregate mining is primarily limited by excavation technology and slope stability at the working face.

In the Snoqualmie Pass quadrangle, intrusive igneous rocks used for construction aggregates are generally granitic rocks (granodiorite, quartz monzonite, or tonalite), but intrusive dacite and andesite are used for forest road construction. Although no large mines currently produce aggregate from intrusive igneous rocks in the study area, these rock types are likely to become a major source of construction aggregate after lowland gravel deposits have been depleted. Rocks of the Snoqualmie batholith, which crop out east of North Bend (Fig. 2), may become an especially important resource.

AGGREGATE MINING AND SIGNIFICANT DEPOSITS

As of May 2001, there were at least 657 pits, quarries, and designated borrow sites, including 51 known abandoned mines, in the Snoqualmie Pass quadrangle (Appendix 3). (The number of mines cannot be precisely determined because government and timber industry records seldom discriminate between small mines and sites that have been designated for mining but are not yet developed. Moreover, the records do not indicate whether a mine is active or abandoned.) At least 80 large construction aggregate mines have been developed in the quadrangle, but at least 30 of these are depleted and others are almost exhausted. An additional 577 small mines, generally less than 3 acres, are used intermittently for forest road construction or borrow.

Because hard and durable bedrock and gravel are abundant in the study area, most mines have been located solely on the basis of proximity to the end use. This practice reduces the expense of transporting the rock. (Transporting aggregate generally costs about $0.25 per ton-mile of haul radius.) Many larger mines opened prior to 1970 were developed to support construction of Interstate Highway 90 (I-90). (See Plate 1.) Highway construction and repair continue to consume enormous amounts of aggregate.

More recently, emphasis has shifted toward the urban market in eastern King County. During the past decade, several giant pits west of the study area, including those near Issaquah, Redmond, and Auburn, have been largely depleted, and suburban development has covered other deposits nearer to the market than those in the Snoqualmie Pass quadrangle. These factors have resulted in development or expansion of several giant deposits in the Snoqualmie Pass quadrangle during the past 15 years.

Another trend is the diminishing role of small-scale mining in King County. Borrow pits and smaller commercial mines have difficulty competing in the current market because they do not enjoy the economies of volume that characterize most large mines. In addition, many small operations do not generate sufficient cash flow to maintain appropriate permits.

Sand and Gravel Resources

Many gravel-producing areas in the state can be grouped into mining complexes that share common geologic and geographic characteristics. In the Snoqualmie Pass quadrangle, two such complexes are present: the North Bend–Cumberland complex and the Bullfrog complex.

NORTH BEND–CUMBERLAND COMPLEX

Most undeveloped gravel resources in the Snoqualmie Pass quadrangle are contained in six giant deposits trending from the Middle Fork Snoqualmie River near North Bend southwestward to the village of Cumberland (Fig. 3). These six kame terraces or

deltas form the North Bend–Cumberland complex and consist of the Mount Teneriffe (or Salal), Grouse Ridge, Chester Morris, Cedar Falls, and Taylor Creek deposits and parts of the Georgetown–Kangley deposits. Each appears to contain several million tons of high-quality sand and gravel, although the Cedar Falls and Taylor Creek deposits have large percentages of sand and other fine aggregate. Glacial sediments in the North Bend–Cumberland complex were deposited in two environments: (1) deltas that built out eastward into lakes dammed by the continental ice and (2) west-to-east sequences of till that grades laterally into kame terrace gravels that in turn grade eastward into lacustrine and alluvial deposits of ancestral river drainages. During deposition, the Mount Teneriffe and Grouse Ridge deposits were parts of a continuous delta that has eastward-dipping foreset beds and a flat upper surface formed of topset beds at the paleo-lake level. (Typical foreset and topset beds are shown on Figure 4.) This upper surface is currently preserved on both deposits at an elevation of 1,600 feet. Following deglaciation, the Middle Fork Snoqualmie River cut down through the delta, isolating the two deposits from each other (George Bennett, Sub Terra, Inc., oral commun., 2002). Farther southwest, ice-damming forced the Cedar River to reverse its flow direction; water moved southeastward into the Cascade Range through Taylor Creek, across a small pass to the south, and then westward through the Green River drainage (Fig. 1). Sediments in this system were ultimately deposited as westward-dipping, deltaic foreset beds in a glacial lake beside the Palmer Junction deposit (Fig. 4).

Gravel in the North Bend–Cumberland complex is produced from the giant Kangley, Flintstone, and Palmer Junction pits. The Palmer Junction pit currently manufactures much of the asphalt aggregate for south-central King County. Farther northwest, gravel has been produced from a small pit on the southern end of Grouse Ridge near I-90. A much larger mine at Grouse Ridge has been proposed in the same deposit.

The kame terraces of the North Bend–Cumberland complex were connected by overflow and outwash channels that carried melt water southwest along the margins of the continental ice sheet (Fig. 2). A major outwash channel flowed along the present-day course of the Cedar River westward past Georgetown and a second followed the ancestral Green River valley (Rosengreen, 1965). These outwash channels contain the Kangley pit and several depleted mines near North Bend.

BULLFROG COMPLEX

East of the Cascades, post-ice-age alpine glaciers periodically advanced down the Yakima and Cle Elum Rivers, depositing outwash that was subsequently incised and formed terraces south and west of Ronald in Kittitas County. A thicker, genetically linked kame terrace is developed against an alpine terminal moraine directly east of the village of Nelson on the northeast side of the Yakima River. These deposits, which compose the Bullfrog complex and are typically in excess of 50 feet thick, constitute the only major gravel resource east of the Cascade crest within the Snoqualmie Pass quadrangle.

Bedrock Resources

Quarried bedrock is becoming more competitive with gravel in some parts of Washington, but only three quarries currently produce large volumes of construction aggregate in the Snoqualmie Pass quadrangle (Table 3). These quarries are located within a four-mile radius of Enumclaw, where topography and proximity to market favor development. Because gravel is not deposited in hilly or mountainous areas, most of the aggregate for forest road construction and repair comes from numerous small bedrock quarries.

VOLUME OF AGGREGATE

Table 2 lists major existing sand and gravel pits in the study area and the proposed mine at Grouse Ridge. The total volume of construction aggregate that has been extracted or is contained in existing mines is approximately 177 million tons from at least 657 mines (Appendix 3). Of these, 60 small mines ultimately will produce about 3 million tons of pit run, 141 mines and small pits will ultimately produce about 104 million tons of gravel, and 456 quarries will produce 70 million tons of bedrock products (Table 2, 3; Appendix 3). The Kangley, Palmer Junction, Flintstone, and Enumclaw pits together have remaining reserves of about 86 million tons of high-quality sand and gravel, forming one of the largest permitted reserves in Washington. Approximate production rates for these giant gravel pits is about 3 million tons per year (Table 2). During late 2001, however, production rates dropped well below those shown on Table 2 (Grant Newport, Weyerhaeuser Co., oral commun., 2002). The total remaining reserves for all gravel mines are 104 million tons (Appendix 3). The Grouse Ridge deposit is entering the final stages of environmental review. If permitted, this mine would add about 60 million tons of high-quality sand and gravel to the market as planned. Note that total reserves at the site may be as much as 200 million tons (Grant Newport, Weyerhaeuser Co., oral commun., 2002).

No mines with high production rates are currently operating east of the Cascade crest owing to the small size of the local market. Only 14 million tons of gravel has been permitted, and the cumulative annual production rate is approximately 0.27 million tons per year.

The volume of undeveloped sand and gravel in the study area can be estimated using formline contours that show thickness of hypothetical undiscovered reserves (Plate 1). These contours were generated using data from water wells and geotechnical boreholes (Appendix 4) and a few measured sections (Plate 1), but they have low reliability owing to the poor quality of the water-well information. Perusal of these contours suggests that many millions of tons of hypothetical sand and gravel are present in the Snoqualmie Pass quadrangle. These large volumes of sand and gravel compare favorably with reserves elsewhere in Washington and much of the conterminous United States. In Washington, only outburst-flood deposits that now form the Spokane–Rathdrum Prairie aquifer (Spokane County) and glacial deltaic or outwash-channel deposits of the south Puget Sound–Hood Canal region contain comparable hypothetical undiscovered reserves.

Effective undeveloped sand and gravel reserves, however, are much less. For reasons discussed in Appendix 2, our inventory methods result in overestimation of reserves. Calculation of effective reserves must include factors for sand and gravel lost in the excavation and processing operations and the percentage of any given deposit that is subcommercial owing to inherent clast weakness or clay-size material. Typically, the recovery factor is about 80 percent of the total volume of any given deposit. Meaningful estimation of effective reserves must also take into account resources that cannot be excavated owing to environmental and land-use considerations. Key considerations in the Snoqualmie Pass quadrangle include the municipal watersheds, the Mountains to Sound Greenway reserve, salmonid/riparian habitat, and high-density residential development.

The average area of the 20 largest quarries in the quadrangle is 17.4 acres, but the average area of the remaining 436 quarries is only 0.4 acres, and none of these is larger than 3 acres.

Table 3 lists major existing bedrock quarries in the study area. The total bedrock production to date and remaining permitted resources from all large and small quarries are 70 million tons. The approximate quarried bedrock reserves and production rates for the three largest quarries in the quadrangle are 40 million tons and 0.7 million tons per year, respectively. Again note that late 2001 production rates are substantially lower.

Undiscovered bedrock reserves suitable for quarrying are more difficult to quantify than sand and gravel reserves Overburden and topography commonly render some deposits inaccessible, and the thickness of individual deposits is rarely known. Unlike gravel-bearing units, which are commonly penetrated by water wells, ancient lava flows and intrusive igneous units are almost never drilled. However, speculative undiscovered bedrock reserves within igneous intrusive rocks such as the Snoqualmie batholith may be essentially inexhaustible, because these bodies are likely to be very thick (on the order of miles) and of uniform quality.

MARKET ASSESSMENT

At the present time, the construction aggregate industry in the study area is intensely competitive owing to a large volume of high-quality sand and gravel under permit. As of the 2000 federal census, the population of the Snoqualmie Pass quadrangle was only 50,000 persons (Dwyer and Dwyer, 2001), but demand is high because produced rock is shipped west to serve markets in north-central Pierce and west-central King Counties. The population of the west-central King County market (east of Lake Washington and the Green River) is approximately 750,000 persons, who typically consume about 9 million tons (8 million metric tons) of sand, gravel, and crushed stone per year. Current reserves of sand, gravel, and bedrock suitable for construction aggregate will provide consumers with relatively low-cost construction aggregates for about 20 years. Addition of the Grouse Ridge deposit would prolong this period at least five years. In addition to these reserves, several large gravel mines located north and west of the Snoqualmie Pass quadrangle service the same market. Efforts to alleviate traffic congestion in and around Seattle will likely require enormous volumes of aggregate and many new mines.

East of the Cascade crest, gravel resources are not abundant, and most lie within flood plains of major rivers. Urban sprawl and concern for salmonid habitat limit the area available for gravel extraction in these areas. A proposed project to rebuild I-90 east of Snoqualmie Pass would consume essentially all permitted gravel resources in western Kittitas County (Dexter Derain, consulting engineer, Pasco, Wash., oral commun., 2000). However, abundant hard and durable bedrock is readily available directly east of the quadrangle.

During the last 20 years, demand has increased significantly in response to increasing population, low-density housing, and better construction standards. Low-density zoning (that is, rural five-acre or R5 zoning) results in greater per-capita consumption than concentrated development. Improving construction standards generally increases short-term consumption (e.g., better roads are thicker), but ultimately it reduces total aggregate consumption because the life cycle of bridges, roads, and buildings increases substantially. In the past, mines in the Snoqualmie Pass quadrangle served to maintain infrastructure, support new construction (especially I-90), and build forest roads for the timber industry. Over time, this mix has shifted, and new construction in north-central Pierce and west-central King Counties dominates demand, while forestry uses have been reduced to negligible levels. Because demand correlates closely with population, increased usage has been spurred by rapid growth in Bellevue, Issaquah, North Bend, Kent, Bonney Lake, and Puyallup.

Most companies currently replace depleted mines by acquiring existing mines instead of developing new deposits. Up-front costs of the environmental impact statements necessary to permit new deposits or to expand existing mines are commonly on the order of several million dollars per mine. These permitting costs cannot be recovered in a competitive market unless the deposit contains gigantic reserves and the proponent is well capitalized. A trend in ownership has evolved partly as a result of permitting costs—multinational companies, including Irish, German, and Japanese firms, now own much of Washington's construction aggregate resources. When considering the process of opening a new mine, proponents must weigh the considerable risk that, following costly environmental review, a determination will be made that land-use conflicts are too great to allow mining to proceed.

Sand and gravel are finite, nonrenewable resources. Eventually, gravel mining will cease when the remaining resources cannot be tapped because of environmental damage, suburban expansion, and other factors. We anticipate that two major changes will then occur. First, the supply will shift to more reliance on abundant quarried bedrock reserves. This trend would mimic that in Europe and the eastern United States where the construction industry is mainly supplied by quarried bedrock, chiefly crushed granite or limestone. Mining bedrock resources has the advantage of low environmental impact relative to gravel mining because a unit area of land at the surface disturbed by quarrying yields a far greater volume of aggregate than gravel mining. (A cubic yard of bedrock in outcrop yields almost two cubic yards of crushed aggregate due to fluffing.) However, the construction industry will have to undertake an expensive retooling effort in order to substitute abrasive crushed bedrock for smooth gravel in applications such as portland cement concrete. Second, the aggregate itself will become more expensive for consumers as haul radii increase and the number of mining companies decreases. This situation could be modified if rail transport costs were reduced. Currently rail transport, which is characterized by low real cost and low environmental impact, is regulated and operated so that costs are several times greater than those for truck transport.

DISCUSSION

Our work indicates that the northwest part of the Snoqualmie Pass quadrangle contains remarkably large volumes of high-quality sand and gravel and hard and durable bedrock. However, much of this resource-rich area may be unavailable for development. For example, parts of this area lie within the Seattle and Tacoma municipal watersheds, and some is adjacent to salmon-bearing waters, in restricted view corridors, or under residential developments. Farther south, near Enumclaw, gravel deposits are covered by thick volcanic mudflows from Mount Rainier that are too costly to strip from the underlying gravel under current market conditions.

Exceptionally large sand and gravel deposits accumulated in the area between North Bend and Cumberland when ice-age continental glaciers impinged against the Cascade Range. These accumulations, in places more than 300 feet thick, were depos-

ited where southeast flowing ice trapped sand and gravel from glacial meltwater streams against the foothills of the Cascade Range. For the most part, these resources have not been exploited. Sand and gravel are relatively scarce east of the Cascade crest. The best gravel resources east of the Cascade Range are within outwash terraces deposited from alpine glaciers that flowed down the valleys of the Yakima River and its tributaries, especially in the area south and southwest of the town of Ronald.

Undeveloped bedrock resources suitable for crushed stone and larger rock products are also abundant in the Snoqualmie Pass quadrangle. The Snoqualmie batholith and other igneous intrusive units within the quadrangle contain enormous volumes of hard and durable bedrock, far in excess of the volume of available gravel. Ancient subaerial lava flows are also excellent sources of crushed stone in the central parts of the study area. However, these flows are commonly separated by thick sequences of weak volcanic conglomerates and ash-rich layers that are unsuitable for aggregate use.

More than 80 large construction aggregate mines have been developed in the quadrangle, but 30 of these are depleted and others are nearly depleted. Many of the active larger mines are located along the I-90 corridor where highway construction and repair serve as a reliable large-scale market. Government, the timber industry, and mining companies have developed or identified an additional 577 small pits, quarries, and potential barrow sites. This large number of small mines results from an abundance of quality gravel and rock resources throughout the quadrangle, which allowed operators to minimize haul distances to low-volume end uses, chiefly logging road construction.

Currently about 177 million tons of construction aggregate have been extracted or are contained in larger permitted mines, borrow pits, and small quarries in the Snoqualmie Pass quadrangle. This large volume of high-quality construction aggregate available will mitigate eventual shortages elsewhere in King, Pierce, and Kittitas Counties.

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Appendix 1. Glossary of mining-related terms

The terms defined below are modified from Jackson (1997), American Geological Institute (1997), and Washington State Department of Transportation (1999).

Aggregate, construction aggregate – A mixture of sand and gravel or sand and crushed rock used in portland cement concrete, asphaltic concrete, mortar, plaster, or graded fill. Gravel and crushed stone that are in grain-to-grain contact in the aggregate are strong enough to support the weight of roads, buildings, or other infrastructure. The sand keeps the coarse aggregate in grain-to-grain contact by limiting the ability of the larger particles to shift laterally.

Alluvium – Unconsolidated boulders, cobbles, pebbles, sand, silt, and (or) clay deposited relatively recently from a stream or river and sorted by the current velocity.

Andesite – Gray volcanic rock composed of a finely crystalline groundmass, commonly surrounding a few visible crystals (phenocrysts) of feldspar and one or more black minerals such as biotite, amphibole, or pyroxene. Andesite forms much of the Cascade Range and forms most of the edifices of Mount Rainier, Baker, St. Helens, and Adams. Most andesitic lava results from subduction processes. If andesitic magma cools deep underground, the resultant rock type is granodiorite, a coarsely crystalline igneous rock.

Asphalt – Heavy oil (tar) produced from oil wells that is used to make asphalt roads.

Asphaltic concrete – Concrete made of asphalt and crushed aggregate.

Asphalt-treated base – A specific construction aggregate used to prepare the base of an asphaltic concrete road.

Basalt – A black volcanic rock that is finely crystalline. Basalt is the most common rock in the earth's crust and forms the floor of almost all of the oceans. In Washington, basalt covers the entire Columbia Basin and much of the Cascade Range and high Olympic Mountains. Basalt that erupted on land (for example, the Columbia River Basalt Group) is hard and makes excellent crushed aggregate, whereas basalt that erupted on the sea floor is commonly weak (for example, much of the Crescent Formation basalts).

Batching, batch plant – A concrete manufacturing process or plant that mixes aggregate and portland cement or aggregate and asphaltic cement to manufacture concrete. Basically, a batch plant functions like a gigantic eggbeater and bowl.

Blend(ing) sand – Sand that is combined with coarse aggregate in order to achieve the appropriate grading for an end product. The sand must be clean and hard with a Sand Equivalent of at least 27.

Boulder – A rock fragment larger than 10 inches (256 mm) in diameter that has been somewhat rounded by abrasion in the course of transport.

Cement – (1) baked limestone dust and water that glues aggregate particles together to form concrete; (2) minerals, usually precipitated from hydrothermal fluids, that naturally glue the grains of a rock together creating a hard sediment or harder rock.

Clast – A rock fragment of any size, initially broken off bedrock by the force of water freezing in cracks or by impact from another rock. Clasts become smaller as they roll off a hillside and (or) down a stream.

Clay – Sediment composed of particles that are plastic, consolidated when dry, and are smaller than 0.000079 inch (0.002 mm) in diameter. Clay will not support weight (it behaves as a paste) because it is composed primarily of platy clay minerals. Clay is unsuitable for use in construction aggregates, and even small amounts must be washed off coarser aggregate.

Coarse aggregate – Gravel or crushed stone that is larger than ¼ inch (4.76 mm) in diameter. All clasts in coarse aggregate are larger than pea gravel (pebbles, cobbles, and boulders).

Cobble – A rock fragment larger than a pebble, but smaller than a boulder, having a diameter in the range of 2½ to 10 inches (64–256 mm) that has been somewhat rounded by abrasion in the course of transport.

Construction aggregate – *see Aggregate*

Cross-bed – A bed inclined at an angle to the main plane of stratification. Usually indicates deposition in a delta.

Crushed stone – Bedrock, cobbles, or boulders that have been crushed with a mechanical crusher to gravel-size rock fragments with at least three freshly broken faces. Crushed stone makes an excellent base course for road construction because the rock fragments tend to form an interlocking matrix. It is the only material suitable for asphaltic concrete because asphalt sticks only to freshly broken surfaces.

Dacite – Light gray igneous rock composed of a finely crystalline groundmass, commonly surrounding a few visible crystals (phenocrysts) of feldspar, quartz, and one or more black minerals such as biotite or amphibole.

Degradation Test – A laboratory test designed to test the durability of rock under wet conditions. The degradation number indicates the percentage of rock remaining intact after tumbling with steel balls in a wet chamber. Large numbers indicate favorable rock.

Dike – A tabular intrusive rock that cuts across the bedding or foliation of the country rock.

Fine aggregate – Sand and gravel or crushed stone that will pass through a ¼-inch (4.76 mm) sieve, but will be trapped in a 200 mesh (ultrafine) sieve.

Granite – A light gray or pink, coarsely crystalline (typically ⅛-inch crystals) intrusive igneous rock composed of the hard minerals quartz and feldspar with minor amounts of black mica and black iron-magnesium-rich minerals. Granite and closely related rocks can make excellent construction aggregate.

Gravel – An unconsolidated natural accumulation of typically rounded rock fragments resulting from erosion and consisting predominantly of particles larger than sand, such as boulders, cobbles, and pebbles, in any combination.

Intrusive rock – Igneous rock that was emplaced below the earth's surface as a magma that cooled very slowly to form a coarsely crystalline rock.

Kame – A hummock, terrace, or short ridge composed of stratified sand and gravel deposited at the margin of a glacier as a delta or fan. In Washington, the term is generally applied to landforms created by deposition in the low area between the margin of a glacial ice sheet and the confining hills. After the ice has melted away, a high-quality sand and gravel deposit frequently remains.

Limestone – A rock composed of the mineral calcite. Normally, these are rocks deposited in the ocean from materials that are by-products or remnants of shells. Limestone is an important source of construction aggregate in much of the nation.

Loess – Silt and fine sand that is produced by the erosion of glacial outwash and transported by wind.

Los Angeles Abrasion Test – A laboratory test to assess the strength of aggregate under dry conditions. A 100-pound sample is placed in a tumbler resembling a washing machine with a tungsten carbide ball weighing about five pounds. The tumbler is revolved 500 times and then the sample is passed through a U.S. Standard No. 4 sieve. The larger the percent of the sample that passes through the sieve, the weaker the sample. The Los Angeles Abrasion number indicates the percent of the sample that has passed through the sieve.

Outwash – Sand, gravel, and coarser round rock deposited from streams and rivers issuing from alpine or continental (ice-age) glaciers. Proximal outwash was deposited relatively close to the snout of a glacier and is poorly sorted and has a large fraction of cobbles and boulders. Distal outwash was deposited miles from the edge of the glacier and is relatively well sorted and dominated by sand.

Overburden – The material that overlies an aggregate or mineral resource and must be removed before mining the underlying material.

Pebble – A stone, usually rounded by water transport, 1/6 to 2½ inches in diameter—the size of a small pea to that of a tennis ball.

Pebble imbrication – A sedimentary fabric characterized by disk-shaped or elongate pebbles dipping in a preferred direction at an angle to the bedding. It is commonly displayed by pebbles on a stream bed, where flowing water tips the pebbles so that their flat surfaces dip upstream.

Pit – This term is restricted herein to sand and gravel mines, regardless of size. A borrow pit is a small (<3 acre) mine that periodically produces unprocessed gravel and other sediment, generally for use as fill.

Pit run – Unprocessed material taken directly from the undisturbed geologic formation.

Plug – A vertical, pipe-like body of magma that represents the conduit to a former volcanic vent.

Portland cement – Cement made by heating limestone to about 2,700°F (calcining) to form lime. This lime is mixed with small amounts of water and dries to a hard adhesive that can glue aggregate together to form portland cement concrete. Portland cement by itself does not have great compressive strength, and it is costly because of the heat used in its manufacture. For these reasons, aggregate is added to form concrete. The gravel in portland cement concrete has great compressive strength and adds inexpensive filler to the mix.

Quarry – Used exclusively herein for mines that produce aggregate by blasting bedrock.

Round rock, round rock aggregate – Coarse aggregate that has been rounded by the process of stream or glacial transport. It generally has greater value than crushed aggregate because it is less expensive to mine, easy to mix in batch plants, and easy to finish to a smooth surface with trowels or other tools when used in concrete. Asphalt does not adhere effectively to round rock aggregate.

Sand Equivalent Test – A laboratory test that measures the cleanness of a sample in terms of the relative proportion of fine-grained dust or clay. High numbers indicate less dust and (or) clay, whereas low numbers indicate greater plasticity. Favorable samples have values greater than 30.

Sill – A tabular intrusion that parallels the bedding or foliation of the sedimentary or metamorphic country rock and is substantially wider than it is thick. Sills form within a few miles of the Earth's surface.

Silt – Sediment composed of particles that are unconsolidated or poorly consolidated when dry and will pass a U.S. Standard No. 200 sieve (0.0025 in.) but are larger than clay (0.000079 in.). Silt has little or no cohesive strength because it contains a small proportion of clay minerals. Abundant silt can render a gravel deposit unsuitable for use in construction aggregates.

Specific gravity – The specific gravity of a sample is the weight of the substance relative to the weight of an equal volume of water. The specific gravities of water, weak aggregate, granite, limestone, and basalt are 1.0, 1.95, 2.65, 2.72, and 3.2 grams per cubic centimeter, respectively.

Stabilometer R Value Test – A laboratory test that measures horizontal deformation when a vertical weight is applied. High numbers indicate stronger materials. Favorable samples have values greater than 70.

Till – Very poorly sorted clay, silt, sand, gravel, cobbles, and boulders deposited directly from glacial ice in the form of a moraine or a compact blanket of sediment under the ice. Generally, till is unsuitable for construction aggregate.

Appendix 2. Methods

INVENTORY PHILOSOPHY

Two end-member philosophies for resource inventory have been employed in Washington: (1) strictly factual reporting showing only those sand, gravel, and bedrock resources that have been proven to exist because they are part of active mines, and (2) a speculative approach that reports all of the potential aggregate deposits that might exist, as determined from surficial geologic or soils mapping. Both approaches have shortcomings. The first philosophy results in underestimation of available aggregate in any given area by ignoring high-quality deposits that have not been mined. The second philosophy results in overestimation of the resource because this method cannot adequately account for the heterogeneous nature of aggregate-bearing geologic units. In this study, we attempt to achieve a balance between these two philosophies using a method that includes the geologic and engineering criteria described below.

The accuracy of any assessment of undiscovered gravel or bedrock resources, whether performed as a proprietary exploration project or as a governmental or academic research study, is largely controlled by the quantity and quality of available subsurface data. As a general rule, subsurface information is not readily available for undeveloped deposits. Consequently, mineral economists categorize resources based on degree of certainty that any given deposit actually exists, mainly as determined from subsurface and other data.

The most commonly used categories are identified and undiscovered reserves, which are further subdivided as shown on Table 4. In order to demonstrate that an identified (or commercially viable) resource exists, the geology of the deposit must be very well known and (or) the deposit must have been defined by closely spaced exploratory drilling. Such costly work is beyond the scope of this study. Conversely, studies that rely solely on surficial information in order to delineate speculative undiscovered reserves are of little value to industry and have led to poor land-use decisions.

In this study, we mapped hypothetical (and some speculative) undiscovered reserves throughout the state as defined in Table 4 and shown on Plate 1. The most widely available source of subsurface geological data for mapping hypothetical reserves is water-well logs, but the accuracy of information on these logs is generally very poor or even misleading. To reduce the inherent uncertainty introduced by use of these logs, we depict hypothetical reserves only where the average of data from several water wells, together with other information such as landform analysis (geomorphology), geotechnical bores, outcrop descriptions, hydrologic data, and mine data allow reasonable extrapolation of surficial data into the subsurface. These hypothetical reserves are shown on Plate 1 with isopachs (thickness contours) for the gravel deposits. Elsewhere, speculative undiscovered reserves are mapped, but only where several data sets strongly suggest the presence of a deposit meeting the threshold criteria. These speculative reserves are shown on Plate 1 as simple polygons showing the extent of high-quality sand, gravel, or bedrock at the surface.

DEFINITION OF SIGNIFICANT RESOURCES

This study is limited to assessing significant aggregate resources. Significant aggregate resources are defined herein as those hard and durable sand and gravel or bedrock deposits that are likely to yield at least 10 million cubic yards of recoverable aggregate. Ten million cubic yards is the approximate volume necessary to maintain existing infrastructure in a 100,000-person market during the 20-year period mandated by the Growth Management Act, calculated as follows. Lingley and Manson (1992) estimated that the total annual per capita demand for sand, gravel, and crushed rock products in Washington is approximately 12 cubic yards. An informal rule of thumb used in industry and government is that about half of the demand for construction aggregates in any market will be used to repave roads, rebuild bridges, and remodel existing buildings, and half is used for new construction. Therefore, a hypothetical maintenance level of production for a 100,000-person market can be approximated as follows:

100,000 persons x 12 cubic yards/year x 20 years x 50%
= ~10 million cubic yards

Local governments might want to designate at least double this volume for every 100,000 people in order to ensure adequate resources to implement a 20-year comprehensive plan and to meet other goals of the Growth Management Act (Lingley and Jazdzewski, 1994).

THRESHOLD CRITERIA USED IN PREPARING THIS INVENTORY

Inherent weaknesses in many common rock types in the earth's crust, such as claystone or layered sedimentary and metamorphic rocks, coupled with unfavorable alteration and weathering processes render much of the outcropping bedrock and gravel unsuitable for construction aggregates. Furthermore, extraction or development costs may exceed expected return under current market conditions. In order to reduce the probability of including weak or insignificant resources, we have developed the following threshold criteria to determine which resources should be included in our inventory.

Table 4. Classification of gravel and bedrock resources *(modified from U.S. Bureau of Mines and U.S. Geological Survey, 1976)*

IDENTIFIED RESERVES			UNDISCOVERED RESERVES	
Measured	**Indicated**	**Inferred**	**Hypothetical**	**Speculative**
Deposit whose engineering properties, reserves in tons or cubic yards, and grain sizes are measured with a margin of error <20% (that is, a mine or a well-drilled prospect)	Deposit whose measurements, together with reasonable geologic projections, can be used to compute reserves in tons or cubic yards	Reasonable extension of indicated or measured deposit (generally <0.50 miles); thickness contours can be drawn with confidence	Undiscovered resources that may reasonably be expected to exist; applicable where landforms, water wells, proximal mines, or geophysical data justify such extension	Unexplored surficial deposit with no subsurface data
Active mine	Densely drilled deposit	Deposit with good subsurface control	Possible deposit defined only by poor subsurface control	Possible deposit; surficial data only

THICKNESS—Only those deposits that are known or likely to exceed 25 feet in the thickest portions are depicted. Thin gravel deposits rarely contain significant reserves. For example, a 20-foot-thick deposit covering 20 acres would yield only about 500,000 cubic yards of sand and gravel, and the value of the gravel might not exceed proceeds from selling the land in its undisturbed state for its real estate value. Moreover, current mining technology does not allow efficient excavation of thin veneers of sediment or bedrock. Thin deposits must spread over a large area in order to contain a significant volume of gravel, but relatively inexpensive excavating equipment (that is, front-end wheel loaders) cannot be used to carry pit run long distances within the mine. Finally, thinner deposits require greater surface disturbance per unit of aggregate produced, and damage to the plant/soil ecosystem increases in proportion to the surface area of mining. Therefore, permitting costs per unit of resource generally increase as a function of decreasing thickness.

SURFACE AREA AND DIMENSIONS OF THE DEPOSIT—Few gravel deposits are more than 100 feet thick and, consequently, the deposit must cover a large area to contain significant volumes of construction aggregate. The smallest geologic polygons inventoried as significant gravel resources cover at least 0.25 square mile (160 acres). The volume of a 50-foot-thick gravel unit of this size would be about 10 million cubic yards. Additionally, we map only those deposits that have minimum widths of 1,500 feet. As noted above, deposits with long, narrow map patterns are generally inefficient to operate. Although environmental issues are not considered herein, long narrow deposits are generally associated with rivers or streams where mining cannot take place owing to environmental considerations.

The surface area of each deposit was initially estimated using 1:100,000-scale geologic maps compiled by the Washington Division of Geology and Earth Resources (Washington Division of Geology and Earth Resources, 2001) and other geologic maps (Bentley and others, 1980, 1993). The resulting polygons were modified where the portion of the deposit meeting the threshold criteria is less extensive than the mapped surface area of the deposit. Most of the geologic polygons depicted on this compilation contain mines or outcrops with engineering tests that prove at least some of the rock or sediment meets the threshold criteria. This approach, taken to expedite the inventory process, probably results in omission of a few significant resources.

OVERBURDEN—Only those deposits that have stripping ratios (ratios of overburden to gravel or overburden to rock) of less than 1 to 3 are included in this inventory. Overburden can cost from $0.35 to more than $1.50 per ton to remove. Typically, miners try to achieve a net profit of $1.00 per ton, and landowner royalties are typically $0.50 to $1.00 per ton. Therefore, the overburden volume must be much less than the volume of underlying aggregate if the mine is to be commercially viable. The stripping ratio can be larger where supply restrictions, favorable topography, or other considerations allow the overburden to be removed profitably. The largest known stripping ratio for a profitable mine in Washington was 1 to 2, or 0.50.

The practice of topsoil sales and (or) synthesis is one method of profitably disposing of thicker organic or clay-rich overburden, but as a general rule, most overburden must be saved for reclamation (Norman and others, 1998; Norman and Lingley, 1992). Historically, few gravel deposits with more than 10 feet of overburden have been mined.

STRENGTH AND DURABILITY—In order to perform adequately as construction aggregate, gravel or bedrock must have high compressive strength and resist degradation when wet. Without these characteristics, the aggregate cannot support the weight of roads or buildings. Much of the vertical compressive strength, or load-bearing capacity, comes from grain-to-grain contact among individual pebbles that are effectively stacked up and prevented from shifting by cement and fine aggregate. Stronger aggregate commands a higher price, but weak rock is of no use. Minimum specifications for strength and durability of various rock products are published by the Washington State Department of Transportation in the Standard Specifications for Road, Bridge, and Municipal Construction, 2000 (Washington State Department of Transportation, 1999), a key reference book for the industry that is updated periodically. Specifications for gravel and bedrock are determined with laboratory tests including Los Angeles Abrasion, Degradation, Sand Equivalent, Specific Gravity, and Stabilometer tests (Appendix 1). Table 1 identifies some of the specifications required for certain uses of aggregate.

For this study, we inventory gravel and bedrock that meet WSDOT specifications for asphalt-treated base (Table 1). Asphalt-treated base is a compacted layer of aggregate treated with asphalt for stability and weatherproofing and placed directly on bulldozed earth or rock of the subgrade. The minimum acceptable test results are: Los Angeles Abrasion ≤30%, Degradation ≥15, Sand Equivalent ≥30%, specific gravity >1.95 grams per cubic centimeter, and weight percent passing a U.S. Standard No. 200 sieve <9%. If most of the deposit appears to meet these specifications, then we depict the entire deposit as meeting the strength and durability threshold criteria (Plate 1; Appendices 3 and 4).

OTHER CONSIDERATIONS—Typically, sand and gravel deposits should have a sand-to-gravel ratio of 40:60 and be free of weak or deleterious materials such as foliated metamorphic rock, poorly indurated clasts, clay, iron oxides, sulfides, glassy volcanic rock, and organic matter (Kroft, 1972; Washington State Department of Transportation, 1999).

SOURCES OF DATA

The locations of most mines in Washington are given in McKay and others (2001). Data for existing and terminated mines are archived in Washington Department of Natural Resources permit files, Washington State Department of Transportation pit site files, and U.S. Forest Service mine files. The thicknesses of mined units, for example, are taken from Washington Department of Natural Resources Form SM-2 or from other permit-related documentation such as Environmental Impact Statements. The surface extent of geologic units is depicted on Washington Division of Geology and Earth Resources geologic maps (Washington Division of Geology and Earth Resources, 2001; Phillips, 1984; Walsh, 1984) and U.S. Geological Survey maps (Booth, 1990; Tabor and others, 2000). Hydrology studies are particularly useful in assessing the stratigraphy of gravel deposits. Such reports are included in various types of environmental documentation, wellhead protection studies, and water-resource reports. Many logs of geotechnical bores (for example, bores for foundation engineering studies) are useful. Water-well logs and some logs of geotechnical borings are archived by the Washington Department of Ecology and the Washington State Department of Transportation, respectively.

Appendix 3. Mine and outcrop database

This database contains information about most small active and terminated borrow pits or quarries and large active, terminated, and proposed mines in the Snoqualmie Pass 1:100,000 quadrangle. It also includes data from important outcrops, such as sites that have been identified as probable aggregate resources on the basis of laboratory tests and geologic work. All of the borrow pits, quarries, gravel pits, and outcrops in this database are plotted on Plate 1. The information contained herein is available digitally as part of the geographic information system (GIS) files for the Snoqualmie Pass quadrangle. References to "notes" mean that the data were taken from field notes generated by the authors during this study. The columns that are not self-explanatory are defined as follows:

WADNR unique number – The Washington Department of Natural Resources (WADNR) unique number used by the geographic information system (GIS) to relate a feature on Plate 1 to a row in the database. The first four digits of the number identify the 7.5-minute quadrangle map in which the mine is located. The last four digits are a unique number in each 7.5-minute quadrangle.

WADNR data type code – The code number that indicates the type and size of the mine, as follows: 13= outcrop; 15 = small borrow pit or quarry (point); 16 = small terminated/depleted borrow pit or quarry (point); 18 = large active mine (polygon); 21 = large terminated/depleted mine (polygon); 22 = large proposed mine (polygon).

WADNR permit number – The five-digit number on Washington Department of Natural Resources form SM-2, *Application for Surface Mining Reclamation Permit* (for a permitted mine).

WSDOT/USFS site number – A pit or quarry number assigned by the Washington State Department of Transportation (WSDOT) or a number that has been arbitrarily assigned by the authors for mines owned by the U.S. Forest Service (USFS). These numbers link results of strength and durability testing or other data to a particular mine. WSDOT numbers consist of a letter that identifies the county the site is in, followed by a sequentially assigned number; USFS numbers begin with 'FS'.

¼ ¼ section, ¼ section, Section, Township, Range, Meridian – Legal description of the mine with reference to the Government Land Office grid. Townships and ranges are shown on Plate 1.

Product – The material being mined: rock, sand, or gravel.

Rock type – The type of rock that is being quarried at the site, if the mine is a quarry.

Geologic unit – The short label that identifies a particular unit on a geologic map. This field indicates the unit in which the mine is located. See Appendix 5 for some geologic unit descriptions; descriptions of geologic units not in Appendix 5 can be found in Tabor and others (2000). (OB) refers to a geologic unit mapped as bedrock but producing sand and gravel from the overburden, whereas (BR) indicates a unit mapped as unconsolidated sediment, such as glacial outwash, that is producing quarry in an unmapped, mis-mapped, or small bedrock exposure.

Qualifier – Indicates either that the thickness shown in the adjacent column is exact because the mine penetrates all the way through the resource (blank) or that the actual resource thickness is greater than the thickness reported because the bottom of the resource was not identified (>).

Resource thickness (feet) – The thickness, in feet, of the sand, gravel, or bedrock that is being mined.

Million cubic yards – The estimated volume (in millions of cubic yards) of aggregate resource present within the permitted boundary of a mine as of May 2000.

Million tons – Reserve weight calculation based on reserve volume estimates. Conversion factors are 1.5 yd^3/ton for sand and gravel; 2.4 yd^3/ton for basalt and gabbro; and 2.2 yd^3/ton for siliceous igneous rock.

Acres – Typically the number of acres permitted on the Washington Department of Natural Resources form SM-2, *Application for Surface Mining Reclamation Permit.* For unpermitted mines, indicates the estimated area of the mine. Includes not only areas of aggregate extraction, but also all operations associated with the mine (stockpiling, crushing, screening, scales, etc.).

Percent depletion – The percentage by which the resource within the mine boundary has been depleted by mining, determined by communication with the mine operators or by field investigations.

Overburden thickness (feet) – The thickness, in feet, of soil, clay, or non-commercial aggregate that must be removed in order to reach the aggregate resource.

Stripping ratio – The overburden thickness divided by the resource thickness. A value of less than 0.33 (ratio of less than 1:3) is preferred.

Los Angeles Abrasion, Degradation, Specific Gravity, Sand Equivalent, and Stabilometer R Value tests – Results of laboratory tests, conducted mainly by the WSDOT, that reflect the quality of the deposit. See the glossary (Appendix 1) for explanation of tests.

Percent >2½ inches, Percent ¼–2½ inches, Percent <¼ inch, Percent <U.S. No. 200 sieve – Results of laboratory grain-size analysis of samples. Values are given in weight percent. The first three fields divide the whole sample, and the fourth field refers to the amount of silt and clay in the entire sample.

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit number	WSDOT/USFS site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridan	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2½ inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
16270028	18		FS-35	Flip-O-Way quarry		SW	SW	7	18	7	E	Pierce	crushed rock	breccia	Tfci									37	20.9							
16250011	15		FS-1	Pit 3, South Prairie	U.S. Forest Service	NE	NE	8	18	7	E	Pierce	rock	volcanic rock	Tf									19								
16250014	15		FS-2		U.S. Forest Service	SW	NE	10	18	7	E	Pierce	crushed rock	andesite	Tf	>	15			0.2		2	0.13	38		2.51						
16250013	15		FS-3			SE	SE	10	18	7	E	Pierce	rock	volcanic rock	Tf									20.2								
16250012	15		FS-4		Weyerhaeuser	NW	NE	15	18	7	E	Pierce	crushed rock	volcanic rock	Tf									17.1	36	2.54						
16250009	15		FS-5		WSDOT	E/2	SW	17	18	7	E	Pierce	rock	granitic rock	Tf									33.8								
16250010	15		FS-6			NW	NW	18	18	7	E	Pierce	crushed rock	andesite	Tfcr			0.10	0.160	0.2		10		19.6	21	2.52						
16250008	15		FS-7	Carbon River Blow Down pit		NE	NE	20	18	7	E	Pierce	crushed rock	volcanic rock	Tfcr	>	20	0.04	0.064	0.1				20	29	2.36						
16250007	15		FS-8			SW	SW	20	18	7	E	Pierce	rock	volcanic rock	Tfcr																	
16260005	15		FS-9			SW	SW	25	18	7	E	Pierce	rock	granitic rock	Tcr	>	160		0.006	0.1		2	0.01									
16250005	15		FS-10			NE	NE	30	18	7	E	Pierce	pit run	andesite	Tfcr				0.002					16	77	2.67						
16250001	15	11265	FS-11			SW	SE	33	18	7	E	Pierce	rock	andesite	Tcr	>	100	0.01	0.010	0.03		5	0.05	77.5								
16250002	15		FS-12			NW	SE	34	18	7	E	Pierce	rock	granitic rock	Tcr	>	50		0.003	0.1		8	0.16									
16260001	15		FS-13			NE	SW	36	18	7	E	Pierce	crushed rock	granitic rock	Tcr		10	0.01	0.016	0.05		0	0.00									
16260010	15		FS-14			NW	SE	14	18	8	E	Pierce	rock	andesite	Tfci		20	0.01	0.016	0.8		0	0.00	15.3	70	2.4						
16250011	15		FS-15			SE	NE	14	18	8	E	Pierce	rock	talus	Tfci									15.9						97	3	
16260007	15		FS-16			SE	NE	19	18	8	E	Pierce	rock	grano-diorite	Tcr	>	25		0.002			0	0.00									
16260008	15		FS-17			SW	NW	20	18	8	E	Pierce	rock	grano-diorite	Tcr		400			0.05		0	0.00	14								
16260009	15		FS-18			SW	NW	20	18	8	E	Pierce	rock	grano-diorite	Tf	>	25		0.005			0	0.00									
16270012	15		FS-22			NE	SW	24	18	8	E	Pierce	gravel		Tfci (OB)	>	30	0.01	0.010	0.3		3	0.10									
16270008	15		FS-20	Viola Ridge pit		SE	SE	24	18	8	E	Pierce	rock	dacite	Tfci									17.1								
16270013	15		FS-21	Pit 18		SE	NE	24	18	8	E	Pierce	rock	rhyolite	Tfci									14								
16270017	13		FS-19	Viola Creek pit		NW	NE	24	18	8	E	Pierce	rock	andesite	Tfci	>	100					4	0.04	18.1								
16270007	15		FS-23			NW	NE	25	18	8	E	Pierce	rock	rhyolite	Tfci									19.2								

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit number	WSDOT/USFS site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridan	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2½ inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
16260006	15		FS-24			NE	SW	30	18	8	E	Pierce	crushed rock	talus	Tcr	>	50	0.10	0.160			0	0.00									
16260002	15		FS-25			NW	SW	33	18	8	E	Pierce	rock	talus	Tf	>	45		0.002	0.07		0	0.00									
16260004	15		FS-27			SE	NE	34	18	8	E	Pierce	crushed rock	andesite	Tfci	>	30	0.01	0.016	2.3		0	0.00									
16260003	15		FS-26			NW	NE	34	18	8	E	Pierce	pit run	andesite	Tfci	>	10		0.008	0.1		10	1.00									
16280047	13		FS-28			SW	NE	1	18	9	E	Pierce	rock	talus	To									21.5								
16270038	18		FS-29	Dickman Slope quarry		E/2	NE	2	18	9	E	Pierce	crushed rock	andesite	Tf	>	200	0.50	0.800	3		2	0.01	20.2		2.51						
16280046	18		FS-29	Dickman Slope quarry		E/2	NE	2	18	9	E	Pierce	crushed rock	andesite	Tf	>	200	0.50	0.800	3		2	0.01	20.2		2.51						
16270037	15		FS-30			W/2	NW	2	18	9	E	Pierce	rock	talus	To									20.2								
16270036	15		FS-32			SE	NW	3	18	9	E	Pierce	crushed rock	andesite	To				0.008	0.2		2		20								
16270031	15		FS-31	Thirsty Creek pit		SW	SW	3	18	9	E	Pierce	rock	andesite	Tf	>	50	0.03	0.048	0.2		0	0.00									
16270035	15		FS-33			SW	SE	5	18	9	E	Pierce	rock	andesite	To	>	30		0.005	0.07		3	0.10	42.6								
16270034	15		FS-34				E/2	6	18	9	E	Pierce	crushed rock	andesite	Tfst	>	15			0.25		2	0.13	17.4	33	2.41						
16270030	15		FS-36	Hank Creek pit		SE	NE	9	18	9	E	Pierce	rock	andesite	Tf											2.38						
16270032	15		FS-38			NW	NW	11	18	9	E	Pierce	crushed rock	andesite	Tip																	
16270033	15		FS-37			NE	NE	11	18	9	E	Pierce	rock	volcani-clastic rock	To												73					
16280033	15		FS-43		U.S. Forest Service	NW	SW	12	18	9	E	Pierce	crushed rock	andesite	To																	
16280034	15		FS-44			NE	SW	12	18	9	E	Pierce	crushed rock	andesite	To									40.4								
16280039	15		FS-42		U.S. Forest Service	NE	NE	12	18	9	E	Pierce	crushed rock	andesite	To				0.005	1.3		4		21	74	2.39						
16280036	15		FS-41		U.S. Forest Service	SW	NE	12	18	9	E	Pierce	crushed rock	volcani-clastic rock	To							1		36.4					47	33	17	3
16280037	15		FS-40			SE	NE	12	18	9	E	Pierce	crushed rock	volcani-clastic rock	To																	
16280035	13		FS-39			NW	SE	12	18	9	E	Pierce	sand	alluvium	Qa																	
16280025	13		FS-45			SE	SW	13	18	9	E	Pierce	rock	andesite	To									20.7					0	70	26	4
16270021	15		FS-46		U.S. Forest Service	NW	SE	14	18	9	E	Pierce	gravel		To (OB)					0.7		3		19.6								
16280024	15		FS-47		U.S. Forest Service	SE	SE	14	18	9	E	Pierce	rock	andesite	To		6		0.006	0.1				16		2.46						

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit number	WSDOT/USFS site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridan	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2½ inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
16280029	15		FS-48		U.S. Forest Service	NE	NE	14	18	9	E	Pierce	rock	volcanic rock	To																	
16270019	15		FS-50		U.S. Forest Service	SW	SE	16	18	9	E	Pierce	rock	andesite	To			0.02	0.024	0.2		4		21	44	2.34						
16270026	15		FS-51		U.S. Forest Service	SE	NW	16	18	9	E	Pierce	rock	andesite	To	>	15	0.02	0.032	0.25		3	0.20									
16270025	18		FS-49	Sell's Knob	U.S. Forest Service	NW	NW	16	18	9	E	Pierce	rock	andesite	To	>	150	0.25	0.400	14.6		3	0.02	14.6	56	2.62			0	88	11	1
16270024	15		FS-52		U.S. Forest Service	SE	NE	17	18	9	E	Pierce	rock	volcani-clastic rock	Qag (BR)	<	20		0.003			0	0.00	26	32	2.43						
16270027	15		FS-54		U.S. Forest Service	NE	NE	18	18	9	E	Pierce	crushed rock	andesite	To				0.008			3										
16270022	18		FS-55	Pinochle Creek quarry		SE	NW	18	18	9	E	Pierce	rock	andesite	Tfci	>	40	0.04	0.064	2		3	0.08	15.5	49	2.42						
16270023	15		FS-53			NE	SW	18	18	9	E	Pierce	rock	dacite	Tfci					1.8				19.7								
16270010	15		FS-57		U.S. Forest Service	NW	SW	19	18	9	E	Pierce	rock	andesite	Tfci	>	40	0.02	0.032	0.2		3	0.08	23								
16270014	15		FS-59			NW	SE	19	18	9	E	Pierce	rock	andesite	Tfci										33							
16270009	15		FS-58		U.S. Forest Service	SW	SW	19	18	9	E	Pierce	rock	rhyolite	Tfci	>	20		0.005	0.02		3	0.15									
16270018	15		FS-56			NW	NE	19	18	9	E	Pierce	rock	rhyolite	Tfci										61	2.52	57					
16270011	15		FS-60	Mule Creek	U.S. Forest Service	NE	SW	21	18	9	E	Pierce	gravel		To (OB)	>	20	0.01	0.010	0.7		0	0.00	23.6	38	2.35						
16270015	18		FS-62		U.S. Forest Service	SE	SE	21	18	9	E	Pierce	rock	andesite	To	>	25	0.01	0.016	1				16.8	66	2.44						
16270020	15		FS-61			NW	NE	22	18	9	E	Pierce	rock	volcanic rock	To									14	78	2.51	56					
16270016	15		FS-63		U.S. Forest Service	SE	SW	23	18	9	E	Pierce	rock	grano-diorite	Qra				0.002			2										
16280022	15		FS-65		U.S. Forest Service	NE	NE	24	18	9	E	Pierce	ballast	volcani-clastic rock	Tfst	>	40	0.01	0.016			2	0.05	33.9	33	2.35						
16280021	15		FS-64		U.S. Forest Service	NW	SE	24	18	9	E	Pierce	gravel		Tfst (OB)	>	15		0.002													
16280011	15		FS-67		U.S. Forest Service	SW	SW	25	18	9	E	Pierce	riprap	andesite	To	>	50	0.01	0.013			1	0.02									
16280019	15		FS-66		U.S. Forest Service	NE	NW	25	18	9	E	Pierce	rock	volcani-clastic rock	To	>	60		0.003	0.3		3	0.05									
16280018	15		FS-68		U.S. Forest Service	SE	NE	26	18	9	E	Pierce	crushed rock	volcani-clastic rock	To	>	60	0.01	0.013			2	0.03									
16270005	15		FS-71			NE	SW	27	18	9	E	Pierce	crushed rock	andesite	Qra			0.07	0.112	1												

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16270004	15		FS-70		U.S. Forest Service	SE	SE	27	18	9	E	Pierce	crushed rock	tuff	Qra	>	6		0.008	0.4		0	0.00	20.1								
16270006	15		FS-72	Lonesome Slide Road		SW	NE	28	18	9	E	Pierce	crushed rock	andesite	To		40	0.01	0.021			3	0.08	16	46	2.69						
16270001	15		FS-73	Clearwest pit	U.S. Forest Service	NW	SW	29	18	9	E	Pierce	crushed rock	andesite	Tfci	>	100	0.50	0.800	4		1	0.01	13.6		2.47						
16270002	15		FS-74		U.S. Forest Service	NE	SW	29	18	9	E	Pierce	crushed rock	landslide	Ql	>	30	0.05	0.080			3	0.10	14	93	2.53						
16270003	15		FS-75		U.S. Forest Service	NE	NE	34	18	9	E	Pierce	riprap	andesite	Qra	>	45	0.02	0.032			1	0.02									
16280001	15		FS-77		U.S. Forest Service	SW	NE	36	18	9	E	Pierce	crushed rock	andesite	To	>	10	0.02	0.032			0	0.00									
16280010	15		FS-76		U.S. Forest Service	NE	NW	36	18	9	E	Pierce	crushed rock	granitic rock	To	>	27		0.006	0.15		6	0.22									
16290006	15		FS-78		U.S. Forest Service	NE	SE	1	18	10	E	Pierce	crushed rock	volcani-clastic rock	Tf									19.1								
16280052	15		FS-79		U.S. Forest Service	NW	NW	2	18	10	E	Pierce	crushed rock	rhyolite	Tf									21.5								
16280045	15		FS-80	Upper 28 Mile Creek pit	U.S. Forest Service	SE	SE	3	18	10	E	Pierce	rock	andesite	Tf			0.50	0.800	5		1		16.6	6	2.58						
16280051	15		FS-81		U.S. Forest Service	NE	NE	4	18	10	E	Pierce	riprap	andesite	Tbd	>	36		0.006			0	0.00									
16280050	15		FS-82			NE	SE	4	18	10	E	Pierce	rock	andesite	Tf																	
16280043	15		FS-87		U.S. Forest Service	SW	SW	5	18	10	E	Pierce	crushed rock	volcani-clastic rock	Tfst	>	100	0.01	0.016			2	0.02	36.8								
16280044	15		FS-86		U.S. Forest Service	SW	SE	5	18	10	E	Pierce	crushed rock	volcani-clastic rock	Tfst	>	35	0.01	0.016	0.16		1	0.03									
16280048	15		FS-85		U.S. Forest Service	NE	SW	5	18	10	E	Pierce	crushed rock	volcani-clastic rock	Tfst	>	40	0.01	0.016			1	0.02									
16280049	15		FS-84		U.S. Forest Service	SE	NW	5	18	10	E	Pierce	crushed rock	volcani-clastic rock	Tfst	>	35	0.01	0.016			1	0.03									
16280040	18		FS-88	Cow Flat pit	U.S. Forest Service	SE	SE	6	18	10	E	Pierce	gravel	alluvium	Qa	>	50	0.50	0.800	2.9		3	0.06	24.4	51	2.65			39	43	17	1
16280038	15		FS-89		U.S. Forest Service	SW	SE	7	18	10	E	Pierce	rock	volcani-clastic rock	Tfst					0.9		0										
16280032	13		B-44			SW	SW	8	18	10	E	Pierce	quarried rock	andesite	Tfst	>	70					0	0.00	15.7								
16280042	15		FS-90		U.S. Forest Service	NE	SW	10	18	10	E	Pierce	rock	andesite	Tf	>	50	0.02	0.032			0	0.00	19.1		2.48						

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16280031	18		B-45		U.S. Forest Service	NW	NW	17	18	10	E	Pierce	gravel	alluvium	Qa									13					41	45	14	
16280030	15		FS-91			NE	NW	17	18	10	E	Pierce	quarried rock	volcanic rock	Tfst									17		2.71						
16280027	13		B-259			NE	SW	17	18	10	E	Pierce	gravel	alluvium	Qa		10					0	0.00	27.8	67	2.59	96	72	36	38	6	2
16280026	13		B-250			SW	SW	17	18	10	E	Pierce	gravel	lahar	Qlh																	
16280028	15		FS-92		U.S. Forest Service	SW	NE	18	18	10	E	Pierce	rock	volcani-clastic rock	Tfst	>	20		0.002	0.06		5	0.25	17.4								
16280023	13		B-251			NE	SW	21	18	10	E	Pierce	rock	andesite	To																	
16290005	15		FS-94		U.S. Forest Service	SE	SE	25	18	10	E	Pierce	crushed rock	andesite	Tf	>	31	0.02	0.032			1	0.03									
16290004	15		FS-93		U.S. Forest Service	SW	SE	25	18	10	E	Pierce	pit run	landslide	Ql	>	5		0.008			4	0.80									
16280020	13		B-47			NW	SW	27	18	10	E	Pierce	gravel	alluvium	Qa														0	67	33	
16280013	15		FS-98		U.S. Forest Service	SE	SW	28	18	10	E	Pierce	crushed rock	andesite	To		6															
16280014	15		FS-96		U.S. Forest Service	SW	SE	28	18	10	E	Pierce	crushed rock	andesite	To	>	31	0.01	0.011			1	0.03	20.1								
16280015	15		FS-95	Buck Creek rip rap	U.S. Forest Service	SW	NE	28	18	10	E	Pierce	crushed rock	andesite	Qlh	>	20	0.10	0.160	3		2	0.10	15		2.72						
16280016	15		FS-97	Pinochie Creek	U.S. Forest Service	SW	SW	28	18	10	E	Pierce	crushed rock	andesite	Qlh		12					2	0.17	18.4		2.59						
16280017	13		B-46			SE	NW	28	18	10	E	Pierce	gravel	dacite	Qlh																	
16280012	15		FS-99		U.S. Forest Service	NE	NW	32	18	10	E	Pierce	crushed rock	andesite	To					3.6		0		24.7								
16280006	15		FS-100		U.S. Forest Service	NE	SW	34	18	10	E	Pierce	gravel	alluvium	Qa				0.002			0		35		2.68			12	51.5	35.5	1
16280002	13		B297?	Weyerhaeuser		SE	NW	34	18	10	E	Pierce	quarried rock	andesite	To							0										
16280003	13		B-297	U.S. Forest Service		SW	SW	34	18	10	E	Pierce	gravel	alluvium	Qa							0		39.8	82	2.59			28	58	14	
16280004	13			Weyerhaeuser		SW	SW	34	18	10	E	Pierce	sand	alluvium	Qa	>	10					6	0.60						0	0	0	3
16280005	13		B-296			SE	NW	34	18	10	E	Pierce	quarried rock	andesite	To																	
16280008	13		B-16			NW	NW	34	18	10	E	Pierce	gravel	lahar	Qlh																	
16280007	15		FS-101		U.S. Forest Service	SE	NW	35	18	10	E	Pierce	crushed rock	volcani-clastic rock	To	>	15		0.002			3	0.20									
16290001	15		FS-102		U.S. Forest Service	NE	NE	35	18	10	E	Pierce	crushed rock	volcani-clastic rock	Tf	>	11		0.005			3	0.27									
16290002	15		FS-103		U.S. Forest Service	SW	NW	36	18	10	E	Pierce	crushed rock	andesite	Tf	>	11		0.008	1		1	0.09									

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16290003	15		FS-104		U.S. Forest Service	NE	NW	36	18	10	E	Pierce	rock	andesite	Tf	>	12	0.02	0.024	0.2		3	0.25	20.6	78	2.42						
16290007	15		FS-105	Try Again pit	U.S. Forest Service	SW	NE	6	18	11	E	Pierce	rock	diorite	Tf	>	15	0.50	0.800	27.5		0	0.00	19		2.69						
16320007	15		FS-510	South Mole alternate	U.S. Forest Service	SW	NW	1	18	14	E	Kittitas	rock	basalt	Tbfb			0.03	0.048													
16320006	15		FS-509	South Mole rock pit	U.S. Forest Service	NW	NE	2	18	14	E	Kittitas	rock	basalt	Tbf		50	0.02	0.028													
16320008	15		FS-511	South Mole alternate	U.S. Forest Service	SE	NE	2	18	14	E	Kittitas	rock	basalt	Tbf			0.02	0.040													
16310002	15		E-342		U.S. Forest Service	NE	NW	30	18	14	E	Yakima	gravel	alluvium	Qa					45.9		0		17	66	2.69						
16320009	15		FS-512	South Mole alternate	U.S. Forest Service	NW	SE	6	18	15	E	Kittitas	rock	basalt	Tbf			0.05	0.080													
16320005	15		FS-536			NW	SE	7	18	15	E	Kittitas	pit run	landslide	Ql		6	0.01	0.016	0.7												
16320004	15		FS-537	Frosty	U.S. Forest Service	NE	SE	18	18	15	E	Kittitas	rock	basalt	Tta				0.005					17	66		73					
15250008	13		A-92	Pete Blaschick		SW	NE	1	19	6	E	King	quarried rock		Qa (BR)							1										
15250005	13		B-73	M. W. Klink		NW	NE	11	19	6	E	Pierce	gravel	lahar	Qlh		30					6	0.20	18.4			80	65	15	34	51	6
16250003	13		B-341			SE	SW	26	19	6	E	Pierce	gravel	Vashon drift	Qvu																	
16250004	13		B-342	Plum Creek - Truax pit		SW	NE	26	19	6	E	Pierce	quarried rock		Qvu (BR)									17	66	2.69						
15260002	15		FS-106	Denny–Renton quarry	Weyerhaeuser	SE	NW	1	19	7	E	King	riprap	andesite	Tfce																	
15250012	18	11269		Nelson pit	Jensen's Sand and Gravel, Inc.	NE	NE	6	19	7	E	King	gravel	landslide	Ql		100	0.20	0.320	26												
15250006	13		A-88	Griffith Hughes pit		SE	SW	6	19	7	E	King	gravel	alluvium	Qa		5					0	0.00	23.3					62	19	19	
15250009	13		A-93	L. F. Lowe		SW	NW	6	19	7	E	King	gravel and quarried rock	basalt	Qa (BR)									36.7								
15250010	13		A-94	Weyerhaeuser		SE	NW	6	19	7	E	King	quarried rock	basalt	Tf		7					2	0.29	33.5					31	39	30	
15250011	13		A-483	Bart Jensen, Enumclaw		SE	NE	6	19	7	E	King	gravel	landslide	Ql	>	12												2	63	35	6.7
16250015	15		FS-107		Weyerhaeuser	SW	SW	35	19	7	E	Pierce	rock	andesite	Tf									41.6								
15270005	13		B-301	Weyerhaeuser		SW	SW	1	19	8	E	Pierce	gravel	alluvium	Qa		10					0	0.00	33.8	54	2.59		75	13	34	53	13
15260006	13		A-485	King		NE	NW	2	19	8	E	King	gravel	alluvium	Qa																	
15260005	18		A-419			NE	NE	3	19	8	E	King	gravel	alluvium	Qa		5			6.9				38.8		2.59			23	43	34	2
15260001	13		A-50			NW	NW	7	19	8	E	King	quarried rock	rhyolite	Tfce																	

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15270004	18		B-260		Weyerhaeuser		N/2	12	19	8	E	Pierce	gravel		Tf (OB)		10					0	0.00						72	2	98	
15270009	18		A-405			SW	SW	3	19	9	E	King	gravel	alluvium	Qa		15							32.1	78	2.57			13	58	29	16
15270010	15		FS-108		Weyerhaeuser	SW	SW	3	19	9	E	King	rock	andesite	To		45	0.03	0.054			8	0.18	30.8		2.49						
15270007	15		A-48		W. S. Stout, et al.	SW	SE	4	19	9	E	King	quarried rock	diorite	To		65			0.2		2	0.03	20.2								
15270012	15		FS-110		Weyerhaeuser	SW	SE	5	19	9	E	King	crushed rock	andesite	Tf	>	30	0.01	0.014			3	0.10		40	2.43						
15270016	15		FS-111		Weyerhaeuser	NW	NE	5	19	9	E	King	crushed rock	andesite	Tidp	>	70	0.04	0.056	0.2		1	0.01			2.36						
15270017	15		FS-113	East Twin Ridge pit	Weyerhaeuser	NE	NE	5	19	9	E	King	crushed rock	andesite	Tidp			0.02	0.038					26.6								
15270013	15		FS-109		Weyerhaeuser	SW	NE	5	19	9	E	King	pit run	andesite	To	>	45	0.01	0.013	0.03		2	0.04	18.2	21	2.34						
15270011	15		FS-112		Weyerhaeuser	NE	SW	6	19	9	E	King	crushed rock	andesite	Tf		20	0.04	0.058			5	0.25	26.5		2.45						
15270006	18		A-47		Washington State	NW	NW	9	19	9	E	King	pit run	alluvium	Qa					1		0										
15270008	13		B-43			NW	NW	10	19	9	E	Pierce	gravel	alluvium	Qa														45	40	15	
15280002	15		FS-114	Gold Hill	Weyerhaeuser	NE	SW	13	19	9	E	King	crushed rock	andesite	To	>	70	0.50	0.800			1	0.01	17	48	2.59						
15280001	15		B-42		White River Lumber Co.	SE	SE	14	19	9	E	Pierce	gravel	alluvium	Qa														44	56		
16280076	18		B-154		WSDOT	NW	SW	24	19	9	E	Pierce	gravel	lahar	Qlh		10			5.5		1.5	0.15	28.1					63	24	13	6
16280070	21		B-166		White River Lumber Co.	SE	NW	25	19	9	E	Pierce	gravel	alluvium	Qa		10			3.7	100	1.5	0.15	25.9					33	44	23	
16280065	13		B-40	White River bar		SE	SE	25	19	9	E	Pierce	gravel	alluvium	Qa														24	52	24	
16280071	13		B-41			NW	NE	25	19	9	E	Pierce	gravel	alluvium	Qa														28	48	26	
16270048	15		FS-115		Weyerhaeuser?	SE	SE	27	19	9	E	Pierce	crushed rock	andesite	To	>	20	0.10	0.160			1	0.05	20		2.49						
16270040	15		FS-116	Road No. 191 riprap pit	Weyerhaeuser	SE	NE	33	19	9	E	Pierce	crushed rock	andesite	Tit			0.01	0.016					24		2.82						
16270041	15		FS-117		Weyerhaeuser	SW	NW	35	19	9	E	Pierce	crushed rock	andesite	Tip	>	100	0.50	0.800			5	0.05									
15280012	15		FS-118		U.S. Forest Service	SW	SW	4	19	10	E	King	rock	andesite	To									33.7		2.4						
15280014	15		FS-120		Burlington Northern	NW	SE	5	19	10	E	King	crushed rock	andesite	To	>	40	0.02	0.024	0.9		0	0.00	20.7	71	2.66						
15280011	15		FS-119		Burlington Northern	SE	SE	5	19	10	E	King	crushed rock	breccia	To	>	45	0.10	0.160			4	0.09	42.9	40	2.33						
15280013	15		FS-121			NE	SE	6	19	10	E	King	rock	andesite	To					0.3		2										
15280015	15		FS-122			N/2	NE	6	19	10	E	King	rock	andesite	To									25.8	24							
15280010	15		FS-123		U.S. Forest Service	NE	NW	8	19	10	E	King	rock	andesite	To	>	20	0.02	0.032			1	0.05	24.4		2.62						

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15280009	15		FS-124		Burlington Northern	NW	NW	9	19	10	E	King	crushed rock	andesite	To					1		0		15		2.6						
15290003	15		FS-125		Weyerhaeuser	SW	SE	11	19	10	E	King	rock	breccia	To									16.4		2.62						
15290001	15		FS-126	Whistler Creek pit	Weyerhaeuser	SW	SE	13	19	10	E	King	rock	andesite	To			0.04	0.064					23.6								
15280007	15		FS-127	Midnight Creek pit		SW	NE	17	19	10	E	King	crushed rock	volcani-clastic rock	To									31.6	34	2.26						
15280005	15		FS-129			SE	NW	17	19	10	E	King	pit run	andesite	To									17.5	48	2.58						
15280006	15		FS-128			SE	NW	17	19	10	E	King	rock	andesite	To									15	61							
16280075	15		FS-141		Weyerhaeuser	SW	NW	17	19	10	E	Pierce	pit run	landslide	Ql	>	100	0.10	0.160													
15280003	15		FS-130	Miller quarry		S/2	S	18	19	10	E	King	rock	rhyolite	To				0.002	0.25		5										
15280078	15		FS-131			SW	NE	19	19	10	E	King	rock	andesite	To									15.1	62	2.54						
15280004	15		FS-132	Midnight Creek pit	U.S. Forest Service	NW	NW	20	19	10	E	King	rock	andesite	To	>	25	0.08	0.120					25.5	27	2.49						
15280079	15		FS-133		Weyerhaeuser	E/2	E	21	19	10	E	King	pit run	landslide	Ql									27.7								
15280080	15		FS-134	Lower 28 Mile Creek pit	U.S. Forest Service	SW	NW	22	19	10	E	King	pit run	landslide	Ql	>	40	0.50	0.800	5.6		8	0.20	33	40	2.33						
16290015	15		FS-135		Weyerhaeuser	SW	SE	23	19	10	E	Pierce	pit run	landslide	Ql	>	20					0	0.00	32	23				0	51	46	3
16290020	15		FS-136		U.S. Forest Service	SE	NW	24	19	10	E	King	crushed rock	andesite	To	>	30	0.01	0.016			1	0.03									
16290018	15		FS-137		U.S. Forest Service	NE	NW	25	19	10	E	King	crushed rock	andesite	Tf			0.04	0.064	0.3				28								
16290017	15		FS-138		U.S. Forest Service	NW	SE	25	19	10	E	Pierce	crushed rock	volcani-clastic rock	Tf	>	100	0.05	0.080			4	0.04									
16290016	15		FS-139			S/2	NE	26	19	10	E	Pierce	pit run	landslide	Ql									18	82	2.68						
16280068	15		FS-140		Weyerhaeuser	SE	SW	27	19	10	E	Pierce	crushed rock	landslide	Ql	>	40	0.50	0.800			0	0.00	28.6								
16280072	15		FS-142		U.S. Forest Service	NW	NW	28	19	10	E	Pierce	crushed rock	andesite	Tfst									32	8	1.99						
16280069	15		FS-145		U.S. Forest Service	NW	SW	28	19	10	E	Pierce	rock	volcanic rock	Tfst									23.1								
16280073	15		FS-144		U.S. Forest Service	NW	NW	28	19	10	E	Pierce	rock	volcanic rock	Tfst									19								
16280074	15		FS-143		U.S. Forest Service	SE	NE	28	19	10	E	Pierce	pit run	landslide	Ql									27.3								
16280061	15		FS-152		Weyerhaeuser	SE	NE	31	19	10	E	Pierce	crushed rock	andesite	To	>	20		0.003	0.7		5	0.25									
16280062	15		FS-154		Weyerhaeuser	NE	NE	31	19	10	E	Pierce	crushed rock	andesite	To	>	50	0.02	0.040	0.3		2	0.04									
16280063	15		FS-155		Weyerhaeuser	NE	NE	31	19	10	E	Pierce	crushed rock	andesite	To		20	0.02	0.032	0.3		2	0.10									

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16280067	15		FS-150		Weyerhaeuser	NE	SE	31	19	10	E	Pierce	crushed rock	volcani-clastic	To	>	23		0.003			5	0.22									
16280055	15		FS-149		Weyerhaeuser	NE	SE	31	19	10	E	Pierce	crushed rock	volcani-clastic rock	To	>	15		0.003			3	0.20									
16280057	15		FS-150		Weyerhaeuser	NE	SE	31	19	10	E	Pierce	crushed rock	volcani-clastic rock	To	>	23		0.003			5	0.22									
16280058	15		FS-151		Weyerhaeuser	SW	NE	31	19	10	E	Pierce	crushed rock	volcani-clastic rock	To	>	20		0.002			2	0.10									
16280054	15		FS-148		Weyerhaeuser	NW	SE	31	19	10	E	Pierce	pit run	volcani-clastic rock	To	>	10		0.002			3	0.30									
16280053	15		FS-147		Weyerhaeuser	SE	SE	31	19	10	E	Pierce	rock	andesite	To	>	18		0.002			5	0.28									
16280059	15		FS-157		U.S. Forest Service	NW	SW	32	19	10	E	Pierce	crushed rock	volcani-clastic rock	Tfst									15.3		2.47						
16280056	15		FS-156		U.S. Forest Service	NE	SW	32	19	10	E	Pierce	pit run	landslide	Ql			0.01	0.016					23.2		2.8						
16280060	15		FS-158		Weyerhaeuser	SW	NW	33	19	10	E	Pierce	crushed rock	andesite	Tfst	>	175	0.25	0.400	0.1		0	0.00	27	79	2.76						
16280064	15		FS-159		U.S. Forest Service	NW	NW	34	19	10	E	Pierce	pit run	landslide	Ql							2		22		2.31						
16290009	15		FS-160			SW	NE	35	19	10	E	Pierce	pit run	landslide	Ql	>	30	0.02	0.032	0.02		0	0.00									
15300004	15		FS-161		Burlington Northern	NW	SW	1	19	11	E	King	rock	andesite	To	>	20	0.05	0.080	3.4		4	0.20	27.3		2.42						
15290007	15		FS-162		U.S. Forest Service	SW	SW	2	19	11	E	King	crushed rock	andesite	To					2.8												
15290004	15		FS-163	Sawmill Ridge pit	U.S. Forest Service	NE	SW	8	19	11	E	King	crushed rock	andesite	Tiap		50	0.02	0.024					17.3		2.44						
15290005	15		FS-164		U.S. Forest Service	SW	NE	10	19	11	E	King	crushed rock	volcani-clastic rock	To																	
15290006	15		FS-165		Burlington Northern	NW	NW	11	19	11	E	King	rock	breccia	To	>	60	0.02	0.032	0.4		3	0.05									
15290002	15		FS-167		U.S. Forest Service	NE	NE	20	19	11	E	King	rock	andesite	To					3.2					34	14.4						
16290021	15		FS-166	East Colquhoun Peak pit	U.S. Forest Service	NE	SW	20	19	11	E	King	gravel	breccia	To		20	0.02	0.032			1	0.05	19.9	29	2.51						
16290022	15		FS-168		Weyerhaeuser	NW	SW	21	19	11	E	King	crushed rock	volcani-clastic rock	To	>	25			0.1		0	0.00			22.2						
16290019	15		FS-169	Pyramid Creek pit	U.S. Forest Service	NE	NW	30	19	11	E	King	crushed rock	andesite	To					0.6		2				16.5						

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16290010	15		FS-170			SW	NW	31	19	11	E	Pierce	riprap	andesite	Tf	>	20					0	0.00									
16290008	15		FS-171		U.S. Forest Service	SW	SW	31	19	11	E	Pierce	rock	andesite	Tf			0.01	0.016			0										
16290011	15		FS-172		U.S. Forest Service	NW	NW	32	19	11	E	King	crushed rock	andesite	Tf			0.05	0.080	0.25		0										
16290013	15		FS-174		Weyerhaeuser	NE	SE	33	19	11	E	Pierce	crushed rock	andesite	Tf	>	30	0.02	0.024			2	0.07	18.1	31	2.43						
16290012	15		FS-173		Weyerhaeuser	NE	SW	33	19	11	E	King	pit run	landslide	Ql	>	25	0.10	0.160			0	0.00	22		2.54						
16290014	15		FS-175		U.S. Forest Service	NW	SW	34	19	11	E	King	grid-roll	andesite	Tf			0.01	0.016													
15300008	15		FS-183		Burlington Northern	NE	SW	1	19	12	E	Kittitas	crushed rock	andesite	Tns			0.03	0.045	0.6												
15300012	15		FS-180	Windy T.S. rock pit		SW	NE	1	19	12	E	Kittitas	crushed rock	andesite	Tns		30	0.10	0.160	2.8												
15300011	15		FS-181	Windy pit	Burlington Northern	SE	NE	1	19	12	E	Kittitas	crushed rock	diabase	Tn			0.08	0.120	1.5												
15300009	15		FS-179		Burlington Northern?	NE	SE	1	19	12	E	Kittitas	riprap	diabase	Tn		15	0.01	0.016	1.5												
15300006	15		FS-178	Log Creek riprap pit	Burlington Northern	NE	SW	1	19	12	E	Kittitas	riprap	volcanic rock	Tns	>	9	0.01	0.016	0.7												
15300007	15		FS-538	Log Creek riprap pit	Burlington Northern	NE	SW	1	19	12	E	Kittitas	rock	basalt	Tns		9	0.01	0.010	1												
15300010	15		FS-177		Burlington Northern	NE	SE	1	19	12	E	Kittitas	rock	volcani-clastic rock	Tn		10	0.01	0.016	0.05		0	0.00									
15300005	15		FS-176		Burlington Northern	NW	SW	3	19	12	E	King	crushed rock	volcani-clastic rock	To	>	30	0.02	0.032			0	0.00	26.1								
15310005	15		FS-184		Burlington Northern	SW	SE	3	19	13	E	Kittitas	crushed rock	rhyolite	Tn		30	0.02	0.040	1												
15310009	15		FS-186		U.S. Forest Service	NW	SE	3	19	13	E	Kittitas	crushed rock	rhyolite	Tn			0.02	0.040	1.2												
15310004	15		FS-187		U.S. Forest Service	SE	SE	4	19	13	E	Kittitas	crushed rock	volcanic rock	Tn	>	25	0.02	0.032	2.3												
15310008	15		FS-185	Big Creek rhyolite pit	U.S. Forest Service	NE	SE	4	19	13	E	Kittitas	rock	rhyolite	Tnr			0.01	0.016	0.5												
15310007	15		FS-539		U.S. Forest Service	NE	SW	4	19	13	E	Kittitas	rock	rhyolite	Tnr			0.02	0.040	1.2												
15310003	15		FS-513			SE	SW	4	19	13	E	Kittitas	rock	rhyolite	Tnr									26								
15310006	15		FS-188	Cole Butte rhyolite pit		NE	SW	5	19	13	E	Kittitas	pit run	rhyolite	Tnr			0.01	0.016	1.4				27.6	70							
15300003	15		FS-182A		U.S. Forest Service	SW	SW	6	19	13	E	Kittitas	rock	andesite	Tit																	
15300002	15		FS-189		U.S. Forest Service	NW	NW	8	19	13	E	Kittitas	crushed rock	andesite	Tns			0.02	0.035	1.4												

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15310002	15		FS-190		U.S. Forest Service	NE	SW	8	19	13	E	Kittitas	crushed rock	volcanic rock	Tnb			0.02	0.032	1.7											
15310001	15		FS-191			NW	NW	15	19	13	E	Kittitas	crushed rock	basalt	Tnb		30	0.02	0.040	0.5											
15320005	15		FS-514	Granite Creek rock pit	Burlington Northern	NE	SW	3	19	14	E	Kittitas	rock	gneiss	Qa (BR)		15	0.02	0.024			3	0.20	31	56	2.86			36.3	31.6	23.1	8.52
15320004	15		FS-540		U.S. Forest Service	SW	NE	10	19	14	E	Kittitas	rock	gneiss	Khb			0.01	0.011	2												
15320001	15		FS-541		Burlington Northern	SE	SE	17	19	14	E	Kittitas	crushed rock	diabase	Tbfb			0.02	0.040	0.8												
15320002	15		FS-542		Burlington Northern	NW	NE	21	19	14	E	Kittitas	crushed rock	andesite	Tbf			0.02	0.024	0.4		25										
16320011	15		FS-543		Burlington Northern	SW	NE	21	19	14	E	Kittitas	crushed rock	diabase	Tbf			0.02	0.029	0.9		25										
16320001	15		FS-544		Burlington Northern	NW	NE	22	19	14	E	Kittitas	crushed rock	tuff	Tm			0.02	0.024	0.6		25										
16320003	15		FS-545		U.S. Forest Service		NE	24	19	14	E	Kittitas	rock	gneiss	Khb		25	0.02	0.024	0.7		2	0.08									
16320002	15		FS-546		U.S. Forest Service	SW	SW	24	19	14	E	Kittitas	rock	tuff	Tta			0.05	0.077	0.6												
15320006	15		S-117			NW	SW	6	19	15	E	Kittitas	gravel	alpine drift	Qag		15			2		0	0.00	38.7		2.78			0	63	37	6
16320010	15		FS-515	Fishtail Rock pit	U.S. Forest Service	SE	SE	30	19	15	E	Kittitas	rock	basalt	Tta		15	0.10	0.160	4.1		9	0.60	24	58		46					
15250035	18	11178	A-322	Enumclaw quarry	Kennedy and Muth	NE	NE	13	20	6	E	King	quarried rock	basalt	Tip				10.00					21	58	2.67						
15250033	21		A-200		Orval Garner	SW	SE	14	20	6	E	King	gravel	lahar	Qlh		10			0.5	100	1.5	0.15									2
15250022	15		A-101		C.A. Pope, Enumclaw	NW	NW	36	20	6	E	King	quarried rock	basalt	Tf							0		20.6								
14250001	18	12506		Veasey quarry (Fell Hill)	Meridian Minerals Inc.	SW	NW	5	20	7	E	King	rock	andesite	Tip																	
15250041	21	10839		Veasey quarry	Glacier Park	SW	SW	5	20	7	E	King	rock	gabbro	Tip		370			15		0	0.00									
15250042	15	12506		Fell Hill quarry	Meridian Minerals	SW	NW	5	20	7	E	King	rock	gabbro	Tip		380					4	0.01									
14250011	13		A-154			SW	NW	5	20	7	E	King	gravel	Vashon outwash	Qvr_3																	
15250038	18		A-296		Joe Anicich, Enumclaw	E/2	NE	8	20	7	E	King	gravel	Vashon outwash	Qvr_3	>	40			5				13	76	2.74			5	65	30	4
15250028	21	10800	A-276	Enumclaw	Tyman Fiske	SE	SE	19	20	7	E	King	gravel	ice contact	Qvi_1						100								1	41	58	3
15250029	21	11542			Corliss Reddi Mix	NE	SE	19	20	7	E	King	gravel	ice contact	Qvi_1					13	100			16.5	37				0	59	41	
15250027	18	10597	A-44		Tim Corliss and Sons	NW	NW	29	20	7	E	King	gravel, rock	Vashon outwash	Qvr_1		50		14.00					14	74	2.7			3	53	44	5.1

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15250025	13		A-76	White River Lumber Co.		SE	NW	29	20	7	E	King	quarried rock	Vashon outwash	Tf																	
15250026	13		A-86			SW	NE	29	20	7	E	King	gravel		Tf (OB)														0	68	32	
15250030	13		A-44	Tim Corliss and Sons (10597)		NW	NW	29	20	7	E	King	gravel, quarried rock	Vashon outwash	Qvr_1		50							14	74	2.7			3	53	44	5.1
15250024	13		A-40	King County		NW	NE	30	20	7	E	King	gravel	lahar	Qlh		30					1.5	0.05						0	53	47	8
15250014	18	12865	A-487	White River quarry and pit	Glacier Northwest		W/2	33	20	7	E	King	gravel, rock	andesite, gravel	Tf, Qvr		110		25.00	80						2.73						
15250021	18	12576		410 quarry	Laramie Joubert	SW	NE	33	20	7	E	King	quarried rock	basalt	Tf		100		5.000	40												
15250016	13		A-401			SE	SE	33	20	7	E	King	gravel	Vashon outwash	Qvr_6		40					1	0.02	24.3	57	2.69			12	55	33	27
15250017	13		A-49			NW	SE	33	20	7	E	King	quarried rock	basalt	Tf																	
15250018	13		A-45	410 quarry		SW	NE	33	20	7	E	King	quarried rock	basalt	Tf		100							19	61	2.73						
15250019	13		A-89	White River quarry (12865)			W/2	33	20	7	E	King	quarried rock, gravel	andesite	Tf		110					10	0.09	16	57	2.71			0	52	43	5
15260008	15		FS-192		WSDOT	NE	NE	36	20	7	E	King	gravel	alpine drift	Qag				0.002					23	71	2.45						
15260011	15		FS-193			S/2	SW	22	20	8	E	King	crushed rock	breccia	Teg									22.3	31	2.51						
15260013	18	12120		Canton Creek quarry	Weyerhaeuser	SW	SW	22	20	8	E	King	rock	volcanic rock	Teg		225					2	0.01									
15260012	18	12130				S/2	SW	22	20	8	E	King	rock	volcanic rock	Teg																	
15260020	16		FS-194		U.S. Forest Service	NE	NW	23	20	8	E	King	crushed rock	andesite	Teg						100			21	50	2.57						
15260014	15		FS-195			NW	NW	23	20	8	E	King	rock	volcanic rock	Teg									14	40	2.64						
15260007	18	11412			Associated Sand and Gravel, Inc.	NE	SE	33	20	8	E	King	gravel	alluvium	Qa		20			3												
15260003	15		FS-196	Bridge Camp pit	Weyerhaeuser	SE	SE	33	20	8	E	Pierce	riprap	lahar	Qlh																	
15260018	13		A-473	Weyerhaeuser		SE	SE	33	20	8	E	King	gravel	alluvium	Qa		3					3	1.00	25.3	55	2.6			33	33	34	4
15260004	13		A-46			S/2	SE	34	20	8	E	King	quarried rock	andesite	Tfce																	
15290022	15		FS-212		Weyerhaeuser	SW	SE	1	20	9	E	King	pit run	landslide	Ql	>	20	0.01	0.016			0	0.00	30.5	23	2.15						
15270029	15		FS-197		Burlington Northern	SW	NE	3	20	9	E	King	crushed rock	andesite	Teg	>	40					1	0.02	26.7								
15280024	15		FS-199		Burlington Northern	NE	SW	13	20	9	E	King	crushed rock	andesite	Teg	>	120		0.008			3	0.02									

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15280025	15		FS-200		City of Tacoma	NE	SE	13	20	9	E	King	rock	andesite	Teg	>	25	0.03	0.048	0.1		1	0.04	17.1								
15270027	15		FS-201		City of Tacoma	NW	NW	14	20	9	E	King	rock	diorite	Teg					0.6												
15270026	15		FS-202		U.S. Forest Service	NW	NE	16	20	9	E	King	crushed rock	landslide	Ql	>	70	0.01	0.010			4	0.06									
15270024	15		FS-203		Burlington Northern	NE	SW	17	20	9	E	King	crushed rock	basalt	Teg	>	50	0.10	0.160			0	0.00	22	71	2.53						
15270021	15		FS-205		Burlington Northern	SW	SW	21	20	9	E	King	crushed rock	andesite	To	>	5		0.008			6	1.20	45	21	2.26						
15270022	15		FS-206		Burlington Northern	NE	SE	21	20	9	E	King	crushed rock	andesite	To			0.01	0.011			2		55	11	2.05						
15270025	15		FS-207		U.S. Forest Service	NE	NE	22	20	9	E	King	crushed rock	andesite	Teg	>	15		0.008	0.07				20.9		2.45						
15280020	15		FS-208		Burlington Northern	NE	NE	23	20	9	E	King	crushed rock	basalt	Teg																	
15270020	15		FS-209		Weyerhaeuser	NW	NE	33	20	9	E	King	crushed rock	andesite	To			0.01	0.013					14.1		2.71						
15270019	15		FS-210			SE	NE	33	20	9	E	King	rock	andesite	To									18.1	58	2.5						
15290021	15		FS-213		Burlington Northern	NE	SW	1	20	10	E	King	crushed rock	breccia	To	>	45	0.01	0.010	0.2		3	0.07								
14290001	15		FS-214			NW	NE	2	20	10	E	King	rock	volcanic rock	Tf									24.1								
14280006	15		FS-217		Weyerhaeuser	SE	NW	3	20	10	E	King	crushed rock	andesite	To			0.02	0.032					28.3		2.65						
14280007	15		FS-215		Weyerhaeuser	NE	NW	3	20	10	E	King	pit run	volcani-clastic rock	To	>	45	0.02	0.032	0.2				26.1	33	2.42						
15280028	15		FS-216		Weyerhaeuser	SE	SW	3	20	10	E	King	rock	andesite	To																	
15280027	15		FS-217		Weyerhaeuser	SE	SE	5	20	10	E	King	crushed rock	andesite	To			0.02	0.032					28.3		2.65						
15280027	16		FS-218		Weyerhaeuser	SE	SE	5	20	10	E	King	rock	andesite	Tip						100			21	27	2.36						
15280026	15		FS-219		City of Tacoma	N/2	SW	18	20	10	E	King	crushed rock	basalt	Teg	>	100	0.50	0.800	0.5		3	0.03								
15280019	15		FS-221		Burlington Northern	NE	SE	19	20	10	E	King	crushed rock	green-stone	To	>	40	0.02	0.024			2	0.05								
15280018	15		FS-220		Burlington Northern	SW	SW	19	20	10	E	King	rock	andesite	To	>	40	0.10	0.160	0.2		2	0.05								
15280021	15		FS-222		City of Tacoma	SW	NW	21	20	10	E	King	crushed rock	andesite	To			0.05	0.080													
15280022	15		FS-223	McCain Creek pit	U.S. Forest Service	SW	NW	22	20	10	E	King	rock	grano-diorite	To	>	20	0.02	0.032			2	0.10								
15280023	15		FS-224		City of Tacoma	SW	NW	23	20	10	E	King	crushed rock	grano-diorite	Qa (BR)	>	60	0.05	0.080	3.2		3	0.05								
15280016	15		FS-226		City of Tacoma	NW	SE	32	20	10	E	King	crushed rock	volcani-clastic rock	To				0.002													

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15280017	15		FS-225		City of Tacoma	SW	NE	32	20	10	E	King	crushed rock	volcani-clastic rock	To	>	60	0.02	0.032	0.2				36.7		2.25						
15290019	15		FS-227		U.S. Forest Service	SW	SW	2	20	11	E	King	pit run	landslide	Ql	>	50	0.02	0.032	2.8		0	0.00									
14290002	15		FS-231		Burlington Northern	NW	NW	5	20	11	E	King	crushed rock	rhyolite	To				0.002	0.3		4		20.5					0	97	3	
14290004	15		FS-228		Burlington Northern	N/2	SW	5	20	11	E	King	crushed rock	rhyolite	To	>	30	0.10	0.160	10.3		0	0.00	22.3		2.47						
14290003	15		FS-230		Burlington Northern	SE	NE	5	20	11	E	King	pit run	volcani-clastic rock	To				0.008														
14290005	15		FS-229		Burlington Northern	NE	NE	5	20	11	E	King	pit run	volcani-clastic rock	To	>	40	0.02	0.024	0.28		4	0.10									
15290016	15		FS-233			SE	NE	7	20	11	E	King	rock	andesite?	To									35.3								
15290015	15		FS-232			NW	NE	7	20	11	E	King	rock	volcanic rock	To									27	63	2.5						
15290017	15		FS-236		Burlington Northern	SE	NE	9	20	11	E	King	crushed rock	andesite	To	>	40		0.002	0.1												
15290012	15		FS-234		Burlington Northern	SE	SW	9	20	11	E	King	pit run	volcani-clastic rock	To	>	60	0.02	0.040	0.3		0	0.00									
15290013	15		FS-235		Burlington Northern	E/2	SE	9	20	11	E	King	pit run	volcani-clastic rock	To	>	30		0.008														
15290018	15		FS-237		U.S. Forest Service	NE	NE	10	20	11	E	King	pit run	landslide	Ql	>	50	0.02	0.032	0.3				28.5	27	2.5						
15300042	15		FS-240		Burlington Northern	NW	NE	11	20	11	E	King	crushed rock	andesite	To	>	100	0.02	0.032	0.5		0	0.00									
15300043	15		FS-239		Burlington Northern	NE	NE	11	20	11	E	King	crushed rock	andesite	To	>	40	0.01	0.016			0	0.00									
15300032	15		FS-238		Burlington Northern	SW	SE	11	20	11	E	King	pit run	landslide	Ql	>	35		0.008	0.1		6	0.17	29.9	41	2.35						
15300031	15		FS-241		U.S. Forest Service	NE	NW	14	20	11	E	King	rock	andesite	To	>	20	0.01	0.013			3	0.15	23.2								
15290014	15		FS-242		Burlington Northern	NW	SE	15	20	11	E	King	rock	rhyolite	To	>	150	0.50	0.800	0.4		4	0.03									
15290011	15		FS-243		City of Tacoma	SW	NW	17	20	11	E	King	rock	volcanic rock	Qa (BR)																	
15290010	15		FS-244		Burlington Northern	SW	SW	23	20	11	E	King	rock	andesite	To	>	60	0.02	0.032	0.2		0	0.00									
15300021	15		FS-245		Burlington Northern	NE	SW	23	20	11	E	King	rock	grano-diorite	To	>	60	0.05	0.080	0.2		0	0.00			21.7						
15300023	15		FS-246		U.S. Forest Service	SE	SW	24	20	11	E	King	rock	andesite	To	>	100	0.20	0.320	0.5		4	0.04									

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15300026	15		FS-248		U.S. Forest Service	NW	NW	24	20	11	E	King	rock	andesite	To	>	15		0.008	0.1		2	0.13	18		2.59						
15300022	15		FS-247		U.S. Forest Service	SW	SW	24	20	11	E	King	rock	volcani-clastic rock	To									16	77	2.55						
15300017	15		FS-250		Burlington Northern	NW	SW	25	20	11	E	King	riprap	breccia	To	>	35	0.05	0.080			0	0.00									
15300016	18		FS-249		U.S. Forest Service	NE	SW	26	20	11	E	King	crushed rock	andesite	To	>	120	0.20	0.320	2.2		2	0.02	21.6		2.72						
15290009	15		FS-251		Burlington Northern	SW	SW	27	20	11	E	King	ballast	sand-stone	To	>	130	0.10	0.160	0.6		4	0.03	35.4	82	2.66						
15290008	15		FS-252		Burlington Northern	NE	SW	33	20	11	E	King	rock	andesite?	To?										50	2.47						
15300013	15		FS-253		Burlington Northern	NW	NE	35	20	11	E	King	rock	conglom-erate	To		120	0.10	0.160	0.6				26.4		2.26						
15300039	15		FS-261	Bearpaw Overlook pit	U.S. Forest Service	SW	SE	10	20	12	E	Kittitas	crushed rock	basalt, tuff	To		20	0.01	0.016	0.5		2	0.10	23.9	29							
15300045	15		FS-263		Burlington Northern	SW	NE	11	20	12	E	Kittitas	crushed rock	gabbro	Tn			0.01	0.011	0.9		0										
15300046	15		FS-262		Burlington Northern	NE	NE	11	20	12	E	Kittitas	pit run	tuff	Tn				0.002	0.07		0										
15300047	15		FS-264		U.S. Forest Service	NW	NW	12	20	12	E	Kittitas	pit run	tuff	Tn				0.002	0.07		0										
15300041	15		FS-265	West Cabin Mountain pit	U.S. Forest Service	SE	SE	12	20	12	E	Kittitas	pit run	volcanic rock	Tn				0.005	0.1		0		23.2			35					
15300036	15		FS-267	Cabin Creek Knob	U.S. Forest Service	NE	SW	14	20	12	E	Kittitas	crushed rock	andesite	Tn		75	0.06	0.096	1.2		0	0.00	13.8	67							
15300040	15		FS-266		U.S. Forest Service	NE	NE	14	20	12	E	Kittitas	grid roll	basalt	Tn				0.002	0.9		0										
15300037	15		FS-547		U.S. Forest Service	SW	NW	14	20	12	E	Kittitas	rock	tuff, basalt	Tn				0.008	0.1		0										
15300035	15		FS-268		U.S. Forest Service	SW	NW	14	20	12	E	Kittitas	pit run	landslide	Ql				0.008													
15300034	15		FS-256		Burlington Northern	NW	NE	23	20	12	E	Kittitas	crushed rock	tuff	Tn			0.02	0.040	1.8		2		49.7								
15300019	15		FS-269		Burlington Northern	SW	SW	25	20	12	E	Kittitas	grid roll	basalt	Tn			0.01	0.014	2.4		0										
15300025	15		FS-270		U.S. Forest Service	NE	NE	26	20	12	E	Kittitas	crushed rock	gabbro	Tn			0.11	0.176	9.2		2										
15300024	15		FS-258		Burlington Northern	N/2	NW	27	20	12	E	Kittitas	crushed rock	diorite	Tit	>	70	0.20	0.320	0.7		2	0.03	19.6		2.59						
15300020	15		FS-257		Burlington Northern	SE	SE	27	20	12	E	Kittitas	crushed rock	gabbro	Tit	>	80	0.03	0.048	0.4		3	0.04	26.2	30	2.49						

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15300014	15		FS-259		U.S. Forest Service	NE	SE	34	20	12	E	Kittitas	pit run	volcani-clastic rock	To									30.5		2.16						
15300018	15		FS-260		Burlington Northern	NW	NW	35	20	12	E	Kittitas	rock	tuff	To									30		2.46						
15300015	15		FS-271		U.S. Forest Service	NW	SE	36	20	12	E	Kittitas	crushed rock	tuff	Tn			0.07	0.112	2.8		0										
14310007	15		FS-273	Easton Ridge rhyolite pit	Burlington Northern	NE	SW	1	20	13	E	Kittitas	crushed rock	rhyolite	Tssp			0.05	0.080	1.4		0										
14310005	18		S-141		Northern Pacific Railroad	NW	SW	1	20	13	E	Kittitas	quarried rock	dacite	Tssp					4.1				16	38	2.7						
14310006	15		S-40	Swauk Creek/ Silver Creek pit	Burlington Northern	SW	NW	1	20	13	E	Kittitas	pit run	alluvium	Qa		20			2		0	0.00									
14310004	13		S-4	Easton Lake—U.S. Forest Service		SW	NE	2	20	13	E	Kittitas	gravel	alpine drift	Qag											2.66			11	51	38	0.1
14310002	13		S-114			SE	NE	3	20	13	E	Kittitas	gravel	alluvium	Qa		40					0	0.00	15.9		2,71			7	54	39	0.1
14310003	13		S-147			SE	NE	3	20	13	E	Kittitas	gravel	alpine drift	Qag		40					0	0.00							51	49	12
14310001	13		S-115			E/2	SW	4	20	13	E	Kittitas	gravel	alluvium	Qa	>	8					1	0.12	11.8		2.66			7	63	30	5
14300003	15		S-264			NW	NW	5	20	13	E	Kittitas	quarried rock	rhyolite?	Tnr							0		19.8	36	2.52						
15310033	15		FS-274	Hut County Road pit	U.S. Forest Service	SW	NE	10	20	13	E	Kittitas	crushed rock	tuff	Tns			0.06	0.096	1.9		0										
15310031	15		FS-275		Burlington Northern	SE	SW	11	20	13	E	Kittitas	crushed rock	rhyolite	Tnr			0.04	0.064	0.5		0										
15310026	13		S-8			NW	SE	11	20	13	E	Kittitas	gravel	alluvium	Qa														7	57	36	0.1
15310035	13		S-6		Mr. Jones, Easton, WA	NE	SE	11	20	13	E	Kittitas	gravel	alpine drift	Qag	>	15					2	0.13	14.4					25	43	32	0.5
15310036	13		S-5			SW	NE	11	20	13	E	Kittitas	gravel	alpine drift	Qag														8	62	30	0.2
15310029	18	11260	S-262	Cresto pit	Ellensburg Cement Products	SW	NE	12	20	13	E	Kittitas	gravel	alluvium	Qa		45		5.000	98.6		2	0.04	16	28	2.7			8	42	40	3
15310027	18		S-101		WSDOT	SE	SW	12	20	13	E	Kittitas	gravel	alluvium	Qa	>	10			12.5		2	0.20	20.5	11	2.7			17	59	24	2
15310028	18		S-295		Cresto and Lanphere Inc.	SE	SW	12	20	13	E	Kittitas	gravel	alluvium	Qa		30			5.7		2	0.07	17.6	40	2.7						
15310025	21		S-249		Mr. and Mrs. Hages, Easton	SW	SW	12	20	13	E	Kittitas	gravel	alluvium	Qa	>	5			3.4	100	0.5	0.10	17.5	29	2.68			10	49	41	10
15310030	13			Cresto-Lanphere Inc.		SE	SW	12	20	13	E	Kittitas	gravel	alluvium	Qa									16	28	2.73						
15310023	21		S-143		Anthony Burzenski		NE	13	20	13	E	Kittitas	gravel	alluvium	Qa		12.5			39	100	2	0.16	16.3	33	2.7			4	71	25	0
15310015	15		FS-276		Boise Cascade		SE	16	20	13	E	Kittitas	gravel	alluvium	Qa			0.10	0.160	31		0										
15310021	13		FS-516			SW	NE	16	20	13	E	Kittitas	gravel	alluvium	Qa																	

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15300029	15		FS-277	Log Creek rhyolite pit	Burlington Northern	NW	SW	19	20	13	E	Kittitas	crushed rock	rhyolite	Tnr			0.01	0.016	0.7		0		17.2	44							
15300030	15		FS-517	Log Creek rhyolite pit	Plum Creek Timber Co.	NE	SE	19	20	13	E	Kittitas	rock	rhyolite	Tnr			0.02	0.030													
15310011	13		FS-507				S/2	20	20	13	E	King	pit run	breccia	Ql																	
15310014	15		FS-272	Cabin Creek pit	Burlington Northern	NE	NW	21	20	13	E	Kittitas	crushed rock	rhyolite	Tn			0.08	0.128	0.3		0		19.9			35					
15320041	18	12663			Cresto & Lanphere Inc.	SW	SE	11	20	14	E	Kittitas	gravel	alpine drift	Qag		200	0.88	1.400	15		0	0.00									
15320044	13		S-65	Northwest Improvement Co.		NE	NE	11	20	14	E	Kittitas	gravel	alpine drift	Qag	>	10					3	0.30						26	43	31	
15320042	15	11830		Port Quendall pit	Port Quendall Development Co.	SW	SW	12	20	14	E	Kittitas	gravel	alpine drift	Qag		75	0.75	1.200	19		2	0.03									
15320043	18		S-281		Alpine Veneer	NW	SW	12	20	14	E	Kittitas	pit run	alpine drift	Qag		35			4.1												
15310022	18		S-184		Fred Handley, Monroe	SW	NW	13	20	14	E	Kittitas	gravel	alpine drift	Qag		12					2.5	0.21	18.4	27	2.65			24	54	22	4
15320040	13		S-289	Bud Carlson		SE	SE	13	20	14	E	Kittitas	gravel	alluvium	Qa		10					2	0.20		8							
15310019	13		S-183	H. D. Maxwell, Easton		SW	SE	18	20	14	E	Kittitas	gravel	alluvium	Qa	>	13					2	0.15	16.4	34	2.65			20	66	12	0.2
15310020	13		S-181	H. D. Maxwell, Easton		NW	SW	18	20	14	E	Kittitas	gravel	alluvium	Qa		12					2	0.17						17	57	26	1
15310024	13		S-66	WSDOT		SW	NE	18	20	14	E	Kittitas	gravel	alluvium	Qa	>	10					4	0.40						14	57	29	0.2
15310016	13		S-49			NW	NW	19	20	14	E	Kittitas	gravel	alluvium	Qa																	
15310017	13		S-87			NW	NE	19	20	14	E	Kittitas	gravel	alluvium	Qa														13	62	25	6
15320025	18		S-298		Ellensburg Cement Products		SE	20	20	14	E	Kittitas	gravel	alluvium	Qa	>	20			151		3	0.15	25	43	2.7						
15310018	13		S-50	WSDOT		NW	NW	20	20	14	E	Kittitas	gravel	alluvium	Qa	>	11					2	0.18	12.8		2.66			16	59	25	4
15320035	13		S-50	WSDOT		NW	NW	20	20	14	E	Kittitas	gravel	alluvium	Qa	>	11					2	0.18	12.8		2.66			16	59	25	4
15320036	13		S-88				NE	20	20	14	E	Kittitas	gravel	alluvium	Qa														11	65	24	5
15320026	15		FS-506	Cook's Gravel pit		N/2	SW	21	20	14	E	Kittitas	gravel	alluvium	Qa																	
15320037	21		S-86		Dom Venera, Cle Elum	SW	NW	21	20	14	E	Kittitas	gravel	alluvium	Qa	>	7			18.3	100	1.5	0.21						14	53	33	9
15320038	13		S-25			NW	NW	21	20	14	E	Kittitas	gravel	alluvium	Qa											2.66			4	42	54	0.2
15320027	21		S-144		WSDOT	SE	SW	22	20	14	E	Kittitas	gravel	alluvium	Qa		10			12.6	100	2	0.20	14.2	69	2.74			18	53	29	3
15320028	21		S-189		William Hoffner, Seattle	SW	SE	22	20	14	E	Kittitas	gravel	alluvium	Qa	>	13			1.72	100	1.5	0.12						4	76	20	5
15320029	13		S-51	Branchetto		SE	SE	22	20	14	E	Kittitas	gravel	alluvium	Qa														3	59	38	
15320019	13		S-85	Mrs. Huntley		SW	SW	25	20	14	E	Kittitas	gravel	alluvium	Qa	>	20					0	0.00	15.8	82	2.7			0	50	50	4
15320022	16		S-162		Mary Huntley, Cle Elum	SW	NE	26	20	14	E	Kittitas	gravel	alluvium	Qa		11			28.7	100	5	0.45	19	59	2.73			6	55	39	0

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15320021	21		S-260		Mary Huntley, Cle Elum	NW	NW	26	20	14	E	Kittitas	gravel	alluvium	Qa						100			20.4	50	2.69			6	60	34	8
15320020	13		S-102	O. C. Spenser, Easton		E/2	NW	26	20	14	E	Kittitas	gravel	alluvium	Qa		4					1.5	0.38	15.7		2.64			7	62	31	0.1
15310010	15		FS-518	Little Creek pit	U.S. Forest Service	SW	NW	32	20	14	E	Kittitas	rock	schist	Kes			0.10	0.160			0		33	44	2.98				53	41	6
15320015	13		S-119	WADNR		NE	SE	36	20	14	E	Kittitas	sand	alluvium	Qa		4					0.7	0.17						0	0	100	6
15320016	13		S-145	WADNR		NE	SW	36	20	14	E	Kittitas	gravel	alluvium	Qa		11					2	0.18	19.8	33	2.72			15	52	33	0
15320031	18	10149		Bullfrog pit	Trendwest Resorts, Inc.	N/2	SW	19	20	15	E	Kittitas	gravel	alpine drift	Qag		40		1.000	30												
15320033	13		S-263	Burlington Northern		SW	SE	19	20	15	E	Kittitas	gravel	alpine drift	Qag		50							20.7	30	2.66			12	41	47	17.5
15320034	13		S-150	Northern Pacific Railroad		N/2	SW	19	20	15	E	Kittitas	gravel	alpine drift	Qag		200					3	0.02		14.5	2.71			1	32	67	2
15320039	13		S-24			NW	NW	19	20	15	E	Kittitas	gravel	alluvium	Qa																	
15320018	13			Northwest Improvement Co.		SW	SE	30	20	15	E	Kittitas	gravel	alluvium	Qa											2.67			13	62	25	0
15320024	13		S-23			SE	NW	30	20	15	E	Kittitas	gravel	alluvium	Qa														11	49	40	0.2
15320032	13		S-44	J. S. Candless		NE	NW	30	20	15	E	Kittitas	gravel	alpine drift	Qag	>	10					1	0.10			2.66			35	44	21	0
15320009	18		S-195		WSDOT	SE	NE	31	20	15	E	Kittitas	gravel	alluvium	Qa		12					1	0.08	14.3	63	2.71			25	44	31	5
15320013	18		S-97		Northwest Improvement Co.		NE	31	20	15	E	Kittitas	gravel	alluvium	Qa	>	12			114.8		2	0.17	16.2	48	2.72			21	53	26	10
15320014	18		S-45		Northwest Improvement Co.	NE	SW	31	20	15	E	Kittitas	gravel	alluvium	Qa	>	10			1		1.5	0.15	14.5					10	58	32	3
15320017	13		S-43	J. S. Candless		NE	NW	31	20	15	E	Kittitas	gravel, quarried rock	alpine drift	Qag		150					2	0.01									
15320010	18		S-47		Northern Pacific Railroad	NW	SW	32	20	15	E	Kittitas	gravel	alluvium	Qa		12					0	0.00						0	53	47	1
15320011	18		S-46		WSDOT	NW	SW	32	20	15	E	Kittitas	gravel	alluvium	Qa	>	12								78	2.69			17	44	39	10
15320012	18		S-160		Heston and Mary Walsh	SW	NW	32	20	15	E	Kittitas	gravel	alluvium	Qa		8			8.3		0	0.00	21	61	2.7			16	53	31	1.8
15290020	15		FS-211		Burlington Northern	SW	SW	1	20	10	E	King	pit run	volcanic rock	To	>	20		0.005	0.07		0	0.00									
15270023	15		FS-204		Burlington Northern	NE	NE	19	20	9	E	King	crushed rock	andesite	To			0.02	0.032													
14250005	18	11543	A-511	Black Diamond pit	Cadman Sand & Gravel, Inc.		S/2	24	21	6	E	King	gravel	Vashon outwash	Qvr_4		60		10.00	140		3	0.05	16	64	2.72						
14250003	13		A-153	Flintstone, Cadman (11543)		SW	SW	24	21	6	E	King	gravel	Vashon outwash	Qvr_4		15					1	0.07									
14250006	13		A-455	Cadman, Inc.		NW	NE	25	21	6	E	King	gravel	alluvium	Qa									16	68	2.73			0	71	29	2.1

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14250007	13		A-162	Gladding–McBean and Co.		NW	NW	25	21	6	E	King	gravel	Vashon outwash	Qvr_4		50					2	0.04	11.5					7	72	21	
14250002	13		A-174	WSDOT		SW	NE	36	21	6	E	King	gravel	Vashon outwash	Qvr_4		14					1	0.07	11.9					5	81	14	10
14250110	14			Lingley notes: WSL12-99-4		NE	SE	4	21	7	E	King	gravel	Vashon outwash	Qvi_3		33												5	55	35	5
14250008	15		A-332		Northern Pacific Railroad	SE	NE	7	21	7	E	King	gravel	Vashon outwash	Qvr_4		30			11.5		1	0.03						0	58	42	9
14250009	18	11956	A-309	Palmer Junction/ Kanaskat pit	Shrod-Mar Inc.	NE	SW	11	21	7	E	King	gravel	Vashon outwash	Qvr_2	>	400		24.00	40		2	0.00	12.4		2.68			0	48	45	
14250192	15		A-309		Northern Pacific Railroad	NW	SE	11	21	7	E	King	gravel	Vashon outwash	Qvr_2									16	77	2.82			14	38	48	3.8
14250004	18	12688			Wheeler Construction	NE	SW	30	21	7	E	King	gravel	Vashon outwash	Qvr_4		60	0.20	0.320	8												
14270015	15		FS-281	Eagle Lake pit	Weyerhaeuser	SE	SE	13	21	8	E	King	gravel		To (OB)			0.05	0.080	0.2				21.8						29.5	37.6	32.9
14260010	15		FS-282		City of Tacoma	NE	NE	22	21	8	E	King	crushed rock	andesite	To																	
14260005	15		FS-283	Piling Creek pit	City of Tacoma	NE	SW	26	21	8	E	King	pit run	Vashon outwash	Qvr_2	>	30	0.03	0.048					20						78	22	
14270026	15		FS-284		City of Seattle	N/2	NW	3	21	9	E	King	crushed rock	andesite	Tf	>	60					2	0.03	34.9	20	2.17						
14270016	15		FS-286		U.S. Forest Service	NE	SW	8	21	9	E	King	crushed rock	andesite	Tf	>	60	0.01	0.013			0	0.00									
14270017	15		FS-285		U.S. Forest Service	E/2	SE	8	21	9	E	King	crushed rock	andesite	Tf	>	75	0.02	0.032	0.2		1	0.01	19.4	53	2.71						
14270018	15		FS-287		City of Seattle	SW	SW	9	21	9	E	King	crushed rock	andesite	Tf	>	30		0.008			1	0.03	23.1		2.68	73					
14270019	15		FS-288		U.S. Forest Service	SE	SW	10	21	9	E	King	pit run	andesite	Tf	>	15		0.002	0.06		0	0.00									
14280032	15		FS-289		City of Seattle	SE	SE	11	21	9	E	King	crushed rock	breccia	Teg	>	50	0.25	0.400			2	0.04	24.1	22	2.09						
14270021	15		FS-290		City of Seattle	SE	SW	11	21	9	E	King	rock	breccia	Teg	>	20	0.04	0.064	0.2		0	0.00									
14280022	15		FS-291		City of Seattle	SE	SW	13	21	9	E	King	crushed rock	andesite	Tf	>	40	0.02	0.032			1	0.02	27.1								
14280031	15		FS-293		City of Seattle	NE	NW	13	21	9	E	King	crushed rock	volcanic rock	Tf	>	20			0.6		0	0.00	21.5	47	2.61						
14280023	15		FS-292		City of Seattle	SE	SE	13	21	9	E	King	rock	andesite	Tf	>	20	0.05	0.080	0.2		0	0.00	19	47	2.43						
14280030	15		FS-294		U.S. Forest Service	NW	SE	14	21	9	E	King	rock	volcanic rock	Teg									19.6								
14270020	15		FS-295		City of Seattle?	NE	NW	15	21	9	E	King	crushed rock	andesite	Tf	>	25		0.003													

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14270004	15		FS-296		Burlington Northern	NE	SW	20	21	9	E	King	crushed rock	andesite	Tf			0.03	0.048	0.4				17		2.64						
14270003	15		FS-297		Burlington Northern	SW	NW	20	21	9	E	King	rock	andesite	To			0.01	0.013	0.5				16	68	2.52						
14270007	15		FS-300			SW	SE	22	21	9	E	King	crushed rock	andesite	Tf	>	25	0.01	0.019	0.3		4	0.16									
14270005	15		FS-298			SE	NW	22	21	9	E	King	rock	volcanic rock	Tf									76.4								
14270006	15		FS-299			NE	SW	22	21	9	E	King	rock	volcanic rock	Tf									39.8								
14270012	15		FS-301			NW	SW	23	21	9	E	King	rock	volcanic rock	Tf									22								
14270011	15		FS-304		U.S. Forest Service	NE	NW	26	21	9	E	King	pit run	breccia	Tf	>	40	0.01	0.016			2	0.05	39	14.9	1.66						
14280011	15		FS-302		U.S. Forest Service	NE	SE	26	21	9	E	King	rock	andesite	Tf							0		28.1		2.5						
14270010	15		FS-303	Cougar Mtn./ Rocky Point pit		NW	SW	26	21	9	E	King	rock	volcanic rock	Tf									18.6						92	8	
14270009	15		FS-306	Switchback pit	Northern Pacific Railroad	NE	SE	27	21	9	E	King	pit run	volcanic rock	Tf									33.8						90	10	
14270008	15		FS-305		Burlington Northern	NE	NE	27	21	9	E	King	rock	diorite	Tf			0.01	0.014					26.6	38	2.6				91	9	
14270002	15		FS-307		U.S. Forest Service	SE	NE	30	21	9	E	King	rock	andesite	To									22.2		2.42				90	10	
14270001	15		FS-308		Weyerhaeuser	NE	SE	32	21	9	E	King	pit run	andesite	Tf				0.008													
14290040	15		FS-310		City of Seattle	SE	SW	1	21	10	E	King	crushed rock	andesite	To		30		0.002			4	0.13									
14290041	15		FS-309		City of Seattle	SE	SW	1	21	10	E	King	gravel		To (OB)	>	20		0.003	0.03		0	0.00									
14280037	15		FS-314		City of Seattle	NE	NW	3	21	10	E	King	crushed rock	grano-diorite	Tsgs				0.008	0.1												
14280038	15		FS-312	Cedar River Spur pit	City of Seattle	NW	NW	3	21	10	E	King	crushed rock	grano-diorite	Tsgs	>	50	0.02	0.032	0.5		0	0.00						97	3	
14280035	15		FS-313		City of Seattle	SE	NE	5	21	10	E	King	crushed rock	andesite	To		30		0.006	0.7		0	0.00									
14280034	15		FS-311		City of Seattle	NW	NW	9	21	10	E	King	crushed rock	andesite	To	>	45	0.01	0.016			1	0.02									
14290037	15		FS-315		Weyerhaeuser	NW	SE	11	21	10	E	King	crushed rock	dacite	To	>	40		0.008	0.7		0	0.00									
14280036	15		FS-316		City of Seattle	NW	NW	11	21	10	E	King	pit run	collu-vium	To	>	20		0.002	0.1		0	0.00									
14280029	15		FS-317		U.S. Forest Service	SW	SW	14	21	10	E	King	crushed rock	dacite	To			0.01	0.016	0.2				18.3		2.61						

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14280028	15		FS-318		Weyerhaeuser	SE	SW	15	21	10	E	King	crushed rock	grano-diorite	Teg	>	45	0.02	0.024			2	0.04	17.9	29	2.48						
14280026	15		FS-319			SE	SW	15	21	10	E	King	rock	volcanic rock	Teg																	
14280027	15		FS-320		U.S. Forest Service	SE	SE	16	21	10	E	King	crushed rock	rock	Teg	>	5					1	0.20									
14280033	15		FS-321			NE	NW	16	21	10	E	King	pit run	collu-vium	Tidp									20	66	2.43						
14280025	15		FS-323		City of Seattle	NE	SE	17	21	10	E	King	crushed rock	andesite	Teg	>	180	0.50	0.800	0.8		2	0.01	34.9	25	2.44						
14280024	15		FS-322	West Small Creek pit		S/2	SW	17	21	10	E	King	rock	volcanic rock	Teg									30.3	24							
14280021	15		FS-324	West Smay Creek pit	City of Seattle	W/2	NE	19	21	10	E	King	pit run	grano-diorite	Qag (BR)	>	25		0.002	0.1		1	0.04	31.5								
14280015	15		FS-325			SE	SE	19	21	10	E	King	rock	basalt?	Tf									22.6								
14280018	15		FS-326		U.S. Forest Service	NW	SE	22	21	10	E	King	crushed rock	volcanic rock	Tiap?				0.006			0										
14280020	15		FS-329		City of Seattle	NE	SW	23	21	10	E	King	crushed rock	andesite	Qu (BR)	>	30		0.005	0.1		1	0.03	22.2								
14290025	15		FS-328		City of Seattle	NE	SE	23	21	10	E	King	crushed rock	dacite	Qu (BR)	>	30	0.10	0.160	0.4		2	0.07	18.8		2.44						
14280019	15		FS-327		City of Seattle	NW	SW	23	21	10	E	King	crushed rock	grano-diorite	To	>	40	0.02	0.040	0.1		0	0.00	19.1	30	2.44						
14290026	15		FS-331		City of Seattle	SE	SE	24	21	10	E	King	rock	volcanic rock	To																	
14290033	15		FS-330		City of Seattle	NW	NW	24	21	10	E	King	rock	volcanic rock	To									27.3	30	2.32						
14280016	15		FS-333		U.S. Forest Service	NW	NW	26	21	10	E	King	grid roll	volcanic rock	To		15			0.2		0.5	0.03	19.3		2.3						
14280017	15		FS-332		U.S. Forest Service	NE	NW	26	21	10	E	King	rock	andesite	To	>	90	0.02	0.024	0.3		6	0.07	21.5								
14280010	15		FS-334		Weyerhaeuser	SE	SW	29	21	10	E	King	pit run	landslide	Ql	>	140			0.3		3	0.02									
14280009	15		FS-335	West Smay Prime quarry	Weyerhaeuser	SW	SE	30	21	10	E	King	crushed rock	andesite	Teg	>	30							33.2	19	2.41						
14280014	15		FS-336		Weyerhaeuser	NW	NE	30	21	10	E	King	crushed rock	andesite	Tf			0.02	0.032			3		35.1	23	2.32						
14280001	15		FS-337			SW	SE	31	21	10	E	King	crushed rock	grano-diorite	Tip	>	90	0.05	0.080			2	0.02									
14280005	15		FS-339			SE	NE	31	21	10	E	King	crushed rock	grano-diorite	Tip	>	30			0.3		2	0.07									
14280003	15		FS-338		Weyerhaeuser	NW	SE	31	21	10	E	King	rock	diorite	Tip	>	75	0.10	0.160	1.8		0	0.00									
14280002	15		FS-341		Weyerhaeuser	SE	SW	32	21	10	E	King	crushed rock	grano-diorite	Tip	>	300	0.50	0.800	6.9		0	0.00									
14280004	15		FS-340			SW	SW	32	21	10	E	King	crushed rock	grano-diorite	Tip	>	60	0.20	0.320	0.2		3	0.05									

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14290006	15		FS-343		U.S. Forest Service	NW	SE	36	21	10	E	King	crushed rock	andesite	To?	>	60	0.50	0.800	0.1		2	0.03									
14290009	15		FS-342	Divide Tie quarry	U.S. Forest Service	SW	NW	36	21	10	E	King	crushed rock	andesite	To			0.10	0.160	0.6				22.2	24	2.5				65	26	9.3
14300035	13		S-148			SE	SE	1	21	11	E	Kittitas	gravel		Tns (OB)																	
14290046	15		FS-382		U.S. Forest Service	NW	SW	2	21	11	E	Kittitas	crushed rock	tuff	To			0.03	0.053	1.4		0										
14300036	16		FS-381		U.S. Forest Service	SE	NW	2	21	11	E	Kittitas	crushed rock	tuff	Tolk			0.02	0.024	0.5	100	0										
14290045	15		FS-380	Power pit	U.S. Forest Service	SW	SW	2	21	11	E	Kittitas	crushed rock	volcanic rock	To			0.10	0.160	1.4		0										
14300037	13		S-149	WSDOT		NE	NE	2	21	11	E	Kittitas	rock	dacite	Tolk							3		18	13	2.58						
14290047	15		FS-383		Burlington Northern	SE	NE	3	21	11	E	Kittitas	gravel		To (OB)			0.02	0.024	0.7		0										
14290048	15		FS-384	Lost pit	U.S. Forest Service	NW	NE	4	21	11	E	Kittitas	crushed rock	tuff	To			0.10	0.160	8.3		2										
14290044	15		FS-344		Burlington Northern	SW	SE	5	21	11	E	King/ Kittitas	crushed rock	rhyolite	To			0.01	0.018	1.4		1										
14290049	15		FS-345		U.S. Forest Service	NW	NE	6	21	11	E	King	crushed rock	andesite	To																	
14290038	15		FS-348		City of Seattle	NE	SE	7	21	11	E	King	pit run	collu-vium	To (OB)		20		0.008	0.5		0	0.00									
14290042	15		FS-346		City of Seattle	NE	NW	7	21	11	E	King	pit run	andesite	To	>	20		0.002	0.05		4	0.20									
14290043	15		FS-347		City of Seattle	NE	NE	7	21	11	E	King	rock	andesite	To		15		0.002	0.09		2	0.13									
14290039	15		FS-385		U.S. Forest Service	NW	SW	10	21	11	E	Kittitas	crushed rock	volcanic rock	To			0.02	0.032	0.25		1										
14300028	15		FS-386		Burlington Northern	SW	NW	13	21	11	E	Kittitas	gravel		Tn (OB)				0.005	0.5		45		16.9								
14290035	15		FS-349		U.S. Forest Service	SW	SW	16	21	11	E	Kittitas	crushed rock	andesite	Tiap			0.08	0.136	1.7		1		16.4	19							
14290034	15		FS-388	Meadow Mountain pit		SE	SE	17	21	11	E	Kittitas	rip rap	andesite	Tiap			0.02	0.024	2		0										
14290036	15		FS-387		Burlington Northern	SE	NE	17	21	11	E	Kittitas	rip rap	andesite	Tiap		6		0.006	0.3		0	0.00									
14290029	15		FS-350		Burlington Northern	SW	NE	19	21	11	E	King	crushed rock	grano-diorite	To	>	40	0.10	0.160	0.25		3	0.08									
14290027	15		FS-351	Upper Snow pit		SE	SW	20	21	11	E	King	crushed rock	andesite	To	>	35	0.03	0.048	0.09		2	0.06	28.4	19.9	2.41						
14290030	15		FS-389	Meadow Mtn. pit	U.S. Forest Service	SW	NW	20	21	11	E	King	crushed rock	andesite	To			0.10	0.160	2		0										
14290031	15		FS-352			NW	SE	20	21	11	E	King	rock	volcanic rock	To									43.6								
14290032	15		FS-354		Burlington Northern	NW	SW	21	21	11	E	Kittitas	pit run	collu-vium	To (OB)				0.008	0.2		0										

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14290028	15		FS-353		Burlington Northern	SE	SE	21	21	11	E	King	crushed rock	volcani-clastic rock	To	>	20	0.01	0.010	0.05		3	0.15								
14300016	15		FS-392		U.S. Forest Service	SW	SE	24	21	11	E	Kittitas	crushed rock	basalt	To		150	0.01	0.013	0.5		0	0.00								
14300020	15		FS-391	Gnat Skyline rock pit	U.S. Forest Service	SW	NE	24	21	11	E	Kittitas	crushed rock	basalt	To			0.01	0.011	2		3		45	27		53				
14300022	15		FS-390		U.S. Forest Service	NW	NW	24	21	11	E	Kittitas	crushed rock	basalt	To		60	0.08	0.128	1		0	0.00	22	80		73				
14300015	15		FS-393		U.S. Forest Service	SE	SW	24	21	11	E	Kittitas	rock	tuff	To					0.03				25.3	22						
14300013	15		FS-356		Burlington Northern	SE	NW	25	21	11	E	King	rock	volcani-clastic rock	To									29.6							
14300014	15		FS-355		Burlington Northern	NE	NW	25	21	11	E	King	rock	volcani-clastic rock	To					0.05				26.8						74	26	
14300010	15		FS-357	Dandy Ridge pit	U.S. Forest Service	SE	SW	26	21	11	E	King	crushed rock	breccia	To	>	20		0.003			0	0.00	18	48	2.31						
14300011	15		FS-358		U.S. Forest Service	SW	SE	26	21	11	E	King	crushed rock	breccia	To	>	15	0.05	0.080			1	0.07	24					2	42	50	6
14290019	15		FS-359		Burlington Northern	S/2	SW	27	21	11	E	King	grid roll	volcani-clastic rock	To	>	35	0.04	0.056			1	0.03									
14290021	15		FS-360		Burlington Northern	SW	SE	27	21	11	E	King	pit run	breccia	To					0.05												
14290023	15		FS-361		Burlington Northern	SW	NE	27	21	11	E	King	pit run	breccia	To	>	25		0.002	0.07		2	0.08									
14290020	15		FS-362		U.S. Forest Service	NE	SE	28	21	11	E	King	crushed rock	andesite	To	>	65		0.002	0.09		1	0.02									
14290018	15		FS-363		U.S. Forest Service	SW	SE	28	21	11	E	King	riprap	granitic rock	To																	
14290022	15		FS-364	Forgotten pit	Burlington Northern	SE	NW	29	21	11	E	King	crushed rock	breccia	To	>	35	0.50	0.800	0.3		2	0.06									
14290017	15		FS-367	Upper Snow Creek pit	Burlington Northern	SE	SE	29	21	11	E	King	rock	andesite	To	>	110	0.50	0.800	0.6		3	0.03									
14290016	15		FS-365		Burlington Northern	SE	SE	29	21	11	E	King	rock	volcani-clastic	To																	
14290015	15		FS-366		Burlington Northern	SE	SE	29	21	11	E	King	pit run	landslide	Ql	>	100	0.06	0.096	0.3		3	0.03									
14290014	15		FS-369		U.S. Forest Service	SE	SE	30	21	11	E	King	gravel	alpine drift	Qag	>	20		0.002	0.2		2	0.10									
14290024	15		FS-368		U.S. Forest Service	NE	NW	30	21	11	E	King	gravel		To (OB)	>	30	0.05	0.080	0.2		2	0.07									
14290010	15		FS-372			NW	NE	31	21	11	E	King	crushed rock	breccia	To	>	25		0.002	0.2		8	0.32									

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14290011	15		FS-371		Burlington Northern	NW	NE	31	21	11	E	King	rock	breccia	To	>	20		0.002			3	0.15									
14290007	15		FS-370		Burlington Northern	NE	SE	31	21	11	E	King	soil		To (OB)		15		0.002	0.05		0	0.00	22.8	29	2.44						
14290058	15		FS-374	Sunday pit	U.S. Forest Service	SE	SE	32	21	11	E	King	crushed rock	basalt	To			0.02	0.029	0.3		5		18.5	30	2.41						
14290012	15		FS-373		U.S. Forest Service	NE	NW	32	21	11	E	King	crushed rock	gravel	To (OB)	>	25		0.002	0.08												
14290008	15		FS-375		Burlington Northern	SW	SW	33	21	11	E	King	rock	volcani-clastic rock	To					0.05												
14290013	15		FS-376	Last Chance pit	U.S. Forest Service	NW	NE	34	21	11	E	King	pit run	gravel	To (OB)	>	50	0.10	0.160	0.08		1	0.02	27.7							97	3
14300009	15		FS-377		Burlington Northern	NE	NW	35	21	11	E	King	crushed rock	breccia	To	>	60	0.01	0.016	0.2		2	0.03									
14300001	15		FS-379		U.S. Forest Service	SW	NW	36	21	11	E	King	crushed rock	andesite	Tia	>	40	0.01	0.013	0.5		0	0.00	23								
14300039	15		FS-395	Thetis Creek pit	Burlington Northern	W	E/2	1	21	12	E	Kittitas	crushed rock	andesite	Tnbg			0.03	0.044	0.3		0		18.1	31							
14300034	15		FS-548	Keechelus Dam pit	U.S. Forest Service	W/2	SW	10	21	12	E	Kittitas	gravel	alpine drift	Qag		30			1		3	0.10									
14300033	21		S-116	Price Creek/ Keechelus Dam pit	U.S. Forest Service	SE	SW	10	21	12	E	Kittitas	gravel	alpine drift	Qag	>	12			47.7		1.5	0.12	12.2		2.68			1	61	38	0.1
14300029	21	11362		Sultan Crystal Springs pit	Burlington Northern	SE	SE	15	21	12	E	Kittitas	gravel	alpine drift	Qag	<	35			34		3	0.09	12.2	32		66					
14300030	18		S-113	Crystal Springs pit	WSDOT	SE	SE	15	21	12	E	Kittitas	gravel	alpine drift	Qag		20			11		2	0.10	16.3	29	2.72			0	72	28	0.9
14300031	13		S-54	Waste dump pit		NE	NW	15	21	12	E	Kittitas	gravel	alpine drift	Qag														12	48	40	0
14300032	13		S-55			SE	NE	15	21	12	E	Kittitas	gravel	alluvium	Qa											2.62			12	55	32	0.1
14300008	18		FS-396	Crystal Springs pit	U.S. Forest Service	NE	NE	22	21	12	E	Kittitas	crushed rock	alpine drift	Qag		10	0.08	0.120	7.6		1	0.10	21	34		31					
14300024	15		FS-397		U.S. Forest Service	SW	NW	22	21	12	E	Kittitas	crushed rock	tuff	To			0.04	0.056	0.9												
14300025	15		FS-398		U.S. Forest Service	NE	NE	22	21	12	E	Kittitas	crushed rock	andesite	Qag (BR)			0.02	0.040													
14300023	15		FS-519			NE	SE	22	21	12	E	Kittitas	rock	volcani-clastic rock	Tnr									41	29							
14300021	13		S-52			SE	SE	23	21	12	E	Kittitas	quarried rock	basalt	Tn																	
14300026	15		S-140			NW	NE	24	21	12	E	Kittitas	gravel	alpine drift	Qag																	

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14300027	15		FS-399		U.S. Forest Service	NE	NE	24	21	12	E	Kittitas	rock	volcani-clastic rock	Tn				0.002	0.2				19.8								
14300019	15		FS-400		U.S. Forest Service	NW	NW	26	21	12	E	Kittitas	rock	andesite	Tnr		200	0.10	0.160	0.5				41.3	9.4							
14300017	15		FS-394		Burlington Northern	NW	SW	27	21	12	E	Kittitas	crushed rock	basalt	To			0.03	0.048	2.5				33.6								
14300002	15		FS-401		U.S. Forest Service	SE	SE	34	21	12	E	Kittitas	rock	basalt	To			0.01	0.022	2.3												
14300012	15		FS-402		U.S. Forest Service	NE	NW	34	21	12	E	Kittitas	rock	tuff, basalt	To			0.03	0.048	1.4				16.9	31							
14290053	15		FS-531			SW	NE	34	21	12	E	Kittitas	rock	volcani-clastic rock	Tolk									38								
14300006	15		FS-403		U.S. Forest Service	NW	NE	36	21	12	E	Kittitas	gravel	alluvium	Qa			0.08	0.120	1.8				15	39							
14300007	15		FS-520	Sky Swamp Cat pit		NW	NE	36	21	12	E	Kittitas	gravel	alluvium	Qa									15	39							
14300005	18		S-134		Boise Cascade Logging Co.	SW	NE	36	21	12	E	Kittitas	gravel	alluvium	Qa		13			40.2		2	0.15	14.5	59	2.67			0	60	40	5
14300057	18	12833		Ellson Pit	Ellensburg Cement Products	SW	NE	36	21	12	E	Kittitas	gravel	outwash	Qag		30	0.40	0.640	17		2	0.07									
14300041	15		FS-530	Upper Big Wolf pit		NW	SE	36	21	12	E	Kittitas	rock	andesite	Tngb					1.3												
14300042	15		FS-529	Lower Big Wolf pit		SE	NW	36	21	12	E	Kittitas	rock	andesite	Tngb									23	56							
14300004	13		S-299	Ellensburg Cement Products			E/2	36	21	12	E	Kittitas	gravel	alluvium	Qa		15					5	0.33	16	47	2.64						
14310016	15		FS-409		U.S. Forest Service	SW	SW	2	21	13	E	Kittitas	rock	dikes	Kes																	
14310014	15		FS-408			SW	NE	9	21	13	E	Kittitas	rock	basalt, tuff	Tssp																	
14310015	15		FS-407			SE	NE	9	21	13	E	Kittitas	rock	volcani-clastic rock	Tssp		12	0.01	0.019	0.6												
14300018	15		FS-406		U.S. Forest Service	NE	SW	30	21	13	E	Kittitas	rock	basalt	Tn			0.02	0.032	0.5				10.8								
14310008	15					SE	SE	32	21	13	E	Kittitas	gravel		Tn (OB)														9	32	59	20
14310009	15		S-53			NE	SE	32	21	13	E	Kittitas	quarried rock	rhyolite	Tnr																	
14310011	15		FS-405		U.S. Forest Service	SE	SE	34	21	13	E	Kittitas	gravel	alluvium	Qa	>	50	0.08	0.136	5.7												
14310010	21		S-256		U.S. Bureau of Reclamation	NE	SW	34	21	13	E	Kittitas	gravel	alpine drift	Qag		60				100			16	61	2.71			0	11	89	25

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14310012	15		FS-404		Burlington Northern	SW	SW	35	21	13	E	Kittitas	gravel	alluvium	Qa	>	50	0.10	0.160	69												
14320002	16		FS-525	Lake Cle Elum pit		NE	NE	5	21	14	E	Kittitas	gravel	alpine drift	Qag			0.15	0.240		100											
14320001	15		FS-526	Corral Creek pit	U.S. Forest Service	SW	NE	24	21	14	E	Kittitas	rock	basalt?	Tt																	
13250018	13		A-287	Walsh		SE	NE	2	22	6	E	King	gravel	outwash	Qvr		12					2	0.17						4	57	39	1
14250010	18					SW	SW	23	22	7	E	King	quarried rock	basalt	Tdg																	
13260067	17			Lingley notes: WSL12-99-5		NW	SW	24	22	7	E	King	gravel	Vashon outwash	Qvr_3		45	25.00	40.00										5	15	75	5
13260066	17			Lingley notes: WSL12-99-6		NE	NE	24	22	7	E	King	gravel	Vashon outwash	Qvr_2		151												2	19	77	2
14250013	18	12675		Kangley pit	Stoneway Rock			27	22	7	E	King	gravel	Vashon outwash	Qvr_5		100			610												
14250015	18		A-512	Kangley pit	Gary Merlino (Stoneway)			27	22	7	E	King	gravel	Vashon outwash	Qvr_5		60		38.00					16	67	2.67						
14250012	13		A-355	George Litras, Ravensdale		NE	NW	32	22	7	E	King	gravel	Vashon outwash	Qvr_6		20							10.9	73	2.64			10	52	38	2
13260051	15		FS-410		City of Seattle	SE	SE	3	22	8	E	King	pit run	Vashon outwash	Qvr_1	>	50	0.10	0.160	2		0	0.00			2.54			0	57	44	9
13260054	17			Lingley notes: WSL12-99-9		SW	SE	8	22	8	E	King	gravel	Vashon outwash	Qvr_1		260												20	87	10	3
13270005	15		FS-411		City of Seattle	NE	SW	11	22	8	E	King	pit run	andesite	To	>	130	0.04	0.056	0.3		4	0.03	21.8		2.38						
13270004	15		FS-412		City of Seattle	NE	NW	13	22	8	E	King	crushed rock	volcani-clastic rock	To	>	35		0.002	0.1		4	0.11	22								
13270002	15		FS-413		City of Seattle	SE	NW	13	22	8	E	King	pit run	volcanic rock	To	>	40		0.008	0.2		1	0.02	39.5	18	2.26						
13260064	15		FS-414		City of Seattle	SE	NW	14	22	8	E	King	crushed rock	andesite	To			0.01	0.013													
13260065	15		FS-415		City of Seattle	NW	SW	14	22	8	E	King	crushed rock	tuff	To	>	30	0.02	0.032	0.5												
13260061	14			Lingley notes: WSL12-99-10		NW	SW	17	22	8	E	King	gravel	Vashon outwash	Qvr_1		32												20	65	15	3
13260062	14			Lingley notes: WSL12-99-7		SW	SW	18	22	8	E	King	gravel	Vashon outwash	Qvr_2	>	11												0	0	97	3
13260060	14			Lingley notes: WSL12-99-8		NW	NE	18	22	8	E	King	gravel	Vashon outwash	Qvr_1	>	25												3	72	20	3
14270027	15		FS-417		City of Seattle	SW	NW	25	22	8	E	King	crushed rock	andesite	Teg	>	20		0.008			2	0.10									
14270030	15		FS-419	211.2 No. 1 quarry	City of Seattle	NE	SW	25	22	8	E	King	crushed rock	andesite	Tf	>	60	0.01	0.019	0.2		2	0.03	28		2.32						

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14270029	15		FS-416		City of Seattle	NW	SE	25	22	8	E	King	crushed rock	volcani-clastic rock	Teg	>	50	0.01	0.016	0.2		1	0.02	37.6								
14270028	15		FS-418		City of Seattle	SW	NW	25	22	8	E	King	pit run	andesite	Teg	>	50	0.01	0.013	0.2		3	0.06									
14260021	15		FS-420		City of Seattle	NE	SW	27	22	8	E	King	crushed rock	andesite	Tf		25		0.002			0	0.00									
14260020	15		FS-421		City of Seattle	SE	SW	29	22	8	E	King	crushed rock	Vashon outwash	Qvr_1	>	50			0.1		0	0.00	17.9	70	2.67				67	31.6	1.4
14260018	15		FS-422		City of Seattle	NE	NE	34	22	8	E	King	crushed rock	andesite	Tf	>	200	0.01	0.016			10	0.05									
14270031	15		FS-423		City of Seattle	NW	NE	36	22	8	E	King	crushed rock	andesite	Tf	>	75	0.50	0.800			3	0.04									
13280023	15		FS-424		Weyerhaeuser	SW	SW	1	22	9	E	King	crushed rock	andesite	To		15	0.01	0.019	0.3		1	0.07									
13280027	13		A-349	Weyerhaeuser		NW	SW	1	22	9	E	King	gravel	Vashon outwash	Qvr_1	>	25					3	0.12	18		2.66			9	43	48	1.5
13270011	15		FS-425		Weyerhaeuser	N/2	SW	2	22	9	E	King	crushed rock	andesite	To	>	30		0.008	0.01		2	0.07									
13270012	15		FS-427		U.S. Forest Service	W/2	NW	2	22	9	E	King	crushed rock	andesite	To	>	15	0.10	0.160	4.8		0	0.00									
13280028	15		FS-426		Weyerhaeuser	SE	NW	2	22	9	E	King	rock	andesite	To	>	20	0.01	0.016	0.07		1	0.05									
13280033	13		A-348			NE	NE	2	22	9	E	King	gravel	Vashon outwash	Qvr_1																	
13270010	15		FS-429		Weyerhaeuser	NW	SE	3	22	9	E	King	crushed rock	andesite	To		25		0.008	0.2		2	0.08									
13270014	15		FS-428		Weyerhaeuser	N/2	NW	3	22	9	E	King	crushed rock	andesite	To	>	30	0.04	0.064	0.3		0	0.00									
13270009	15		FS-430		Weyerhaeuser	NW	SE	3	22	9	E	King	crushed rock	grano-diorite	Tsgf		30		0.008	0.1		1	0.03									
13270013	15		FS-431		Weyerhaeuser	SE	NE	3	22	9	E	King	crushed rock	grano-diorite	Tsgf		30	0.01	0.016	0.07		1	0.03									
13270007	15		FS-433		City of Seattle	NW	NW	8	22	9	E	King	crushed rock	andesite	To	>	30	0.01	0.020	0.1		2	0.07									
13270006	15		FS-432		City of Seattle	NE	SW	8	22	9	E	King	crushed rock	volcani-clastic rock	To	>	30	0.01	0.014	0.08		2	0.07	14.1								
13280024	15		FS-434		U.S. Forest Service	NE	NW	12	22	9	E	King	pit run	landslide	Qmw (BR)	>	20		0.005			2	0.10									
13270003	15		FS-435		City of Seattle	NW	NW	14	22	9	E	King	crushed rock	andesite	To	>	3	0.03	0.048	2.8		0	0.00									
13270001	15		FS-436		City of Seattle	NW	NW	22	22	9	E	King	gravel	alluvium	Qa	>	100	0.50	0.800	0.4		2	0.02	22.3								
14270032	15		FS-437	Little Mountain pit	City of Seattle	NE	NE	28	22	9	E	King	crushed rock	andesite	To	>	100	0.10	0.160	0.2		4	0.04									
14270022	15		FS-438		City of Seattle	NW	SW	31	22	9	E	King	crushed rock	andesite	Tf	>	50	0.10	0.160	0.2		1	0.02									

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14270023	15		FS-439		City of Seattle	SW	NE	31	22	9	E	King	crushed rock	andesite	Tf	>	60	0.02	0.032	0.4		1	0.02									
14270024	15		FS-440		City of Seattle	NE	SW	33	22	9	E	King	crushed rock	volcani-clastic rock	Tf	>	25	0.02	0.032	0.03		1	0.04									
14280025	15		FS-441		City of Seattle	SE	SW	33	22	9	E	King	crushed rock	volcani-clastic rock	Tf	>	65	0.06	0.104	0.2		2	0.03									
14280042	15		FS-442		City of Seattle	NE	NE	35	22	9	E	King	rock	rockslide	Teg									13.3	28	2.51						
14280041	15		FS-443		City of Seattle	NE	SE	35	22	9	E	King	rock	volcanic rock	Teg									19.2	52	2.55						
13280026	21		A-219		Russell Creighton, North Bend	SW	SW	6	22	10	E	King	gravel	Vashon outwash	Qvr_1		12			2.7	100			11.2		2.74			2	51	47	1
13280031	15		FS-445		IT&T Rainier	NE	NW	6	22	10	E	King	rock	granitic rock	Tsgs		15	0.05	0.080	0.2		1	0.07									
13280032	15		FS-444		Lewis Co. Timber Co.	NE	NW	6	22	10	E	King	rock	granitic rock	Tsgs	>	20	0.05	0.080	0.3		1	0.05	30.4	78	2.55						
13280010	15		FS-446		Weyerhaeuser	SW	SW	7	22	10	E	King	crushed rock	andesite	To	>	50	0.10	0.160	0.4		1	0.02									
13280011	15		FS-447		Weyerhaeuser	SW	SW	7	22	10	E	King	crushed rock	andesite	To		30	0.05	0.080	0.25		1	0.03									
13280012	15		FS-507	public rock collection area	U.S. Forest Service		SE	7	22	10	E	King	gravel	alluvium	Qa																	
13280018	15		FS-508	public rock collection area	U.S. Forest Service	SW	NE	7	22	10	E	King	gravel	alluvium	Qa																	
13280017	21		A-301		Forestry	SE	NE	7	22	10	E	King	gravel	alluvium	Qa		10			0.3	100	0	0.00						7	62	31	2
13280025	13		A-255	U.S. Forest Service		NE	NW	7	22	10	E	King	gravel	Vashon outwash	Qvr_1	>	12					0	0.00						17	51	32	3
13280020	15		FS-451		U.S. Forest Service	NW	NW	8	22	10	E	King	crushed rock	grano-diorite	Tsgs		50	0.05	0.080	17		0	0.00									
13280022	15		FS-449		IT&T Rainier	NW	SW	8	22	10	E	King	crushed rock	grano-diorite	Tsgs	>	40	0.10	0.160	0.5		0	0.00									
13280013	21		A-26		U.S. Forest Service	SW	SE	8	22	10	E	King	gravel	alluvium	Qa		6			20.6	100	0	0.00			22.7			24	47	29	3
13280021	15		FS-450		U.S. Forest Service	SE	NW	8	22	10	E	King	riprap	grano-diorite	Tsgs	>	15	0.02	0.032	0.05		0	0.00									
13290013	15		FS-452		U.S. Forest Service	SE	NW	13	22	10	E	King	crushed rock	andesite	Qa (BR)	>	15	0.03	0.048	0.3		1	0.07	24.4		2.7						
13290012	15		FS-453		U.S. Forest Service	N/2	NE	14	22	10	E	King	crushed rock	soil, sand	Qa			0.02	0.024													
13280004	15		FS-455		Weyerhaeuser	SE	SW	15	22	10	E	King	riprap	grano-diorite	Tsgs	>	100			0.07												
13280003	15		FS-454		Weyerhaeuser	SW	SE	15	22	10	E	King	rock	granitic rock	Tsgs		20	0.01	0.016	0.2		1	0.05									

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13280015	21		A-201		U.S. Forest Service	NW	NW	16	22	10	E	King	gravel	alluvium	Qa					0	100	10		17.4	44	2.75			9	59	32	0
13280036	21		A-233		U.S. Forest Service	SE	NE	16	22	10	E	King	gravel	alluvium	Qa	>	10			5.5	100	1	0.10	27	73	2.81			39	39	22	6
13280007	15		FS-457		Weyerhaeuser	S/2	NW	17	22	10	E	King	crushed rock	andesite	Tsgs	>	15	0.10	0.160	0.3		0	0.00									
13280014	16		FS-458		U.S. Forest Service	NE	NE	17	22	10	E	King	crushed rock	andesite	Qa (BR)		10	0.05	0.080		100	1	0.10									
13280005	15		FS-459		Weyerhaeuser	NW	SW	17	22	10	E	King	crushed rock	grano-diorite	Tsgs			0.02	0.035	0.4		0		22.7	70	2.62				53	39.6	7.4
13280006	15		FS-460		Weyerhaeuser	NW	SW	17	22	10	E	King	crushed rock	grano-diorite	Tsgs		43			0.05		0	0.00									
13280008	15		FS-462		Lewis Co. Timber Co.	NE	NE	18	22	10	E	King	crushed rock	andesite	Tsgs	>	30	0.05	0.080	0.2		0	0.00	24	75	2.64						
13280009	15		FS-461		Milwaukee Land Co.	NE	NE	18	22	10	E	King	crushed rock	andesite	To	>	30	0.06	0.096	0.08		2	0.07									
14280061	15		FS-463		Weyerhaeuser	SW	SE	21	22	10	E	King	pit run	granitic rock	Tsgs	>	40	0.05	0.080	0.1		2	0.05									
13280001	15		FS-464		Weyerhaeuser	SW	NE	21	22	10	E	King	rip rap	grano-diorite	Tsgs	<	20	0.05	0.080	0.2		0	0.00									
13280002	15		FS-465		U.S. Forest Service	NW	NE	22	22	10	E	King	rock	grano-diorite	Tsgs		20		0.008	0.03		1	0.05									
14280053	15		FS-471		City of Seattle	W/2	SE	27	22	10	E	King	crushed rock	grano-diorite	Tsgs		25	0.03	0.048	0.03		1	0.04	27	35	2.52						
14280060	15		FS-468		Weyerhaeuser	NE	NW	27	22	10	E	King	crushed rock	grano-diorite	Tsgs		20	0.04	0.061	0.1		2	0.10									
14280058	15		FS-466		Weyerhaeuser	S/2	NE	27	22	10	E	King	gravel	alpine drift	Qag	>	20	0.02	0.024	0.3		1	0.05									
14280052	15		FS-470		Weyerhaeuser	NW	SW	27	22	10	E	King	rock	granitic rock	Tsgs		25	0.05	0.080	0.1		0	0.00									
14280057	15		FS-469		Weyerhaeuser	SW	NW	27	22	10	E	King	rock	grano-diorite	Tsgs		20	0.01	0.016	0.1		1	0.05									
14280059	15		FS-467		Weyerhaeuser	NE	NW	27	22	10	E	King	rock	grano-diorite	Tsgs		25	0.01	0.016	0.3		1	0.04									
14280050	15		FS-472	Hansen Saddle pit	U.S. Forest Service?	S/2	SW	28	22	10	E	King	crushed rock	granitic rock	Tsgs		30	0.10	0.160	1.1		0	0.00	39.3		2.71						
14280056	15		FS-473		U.S. Forest Service	SW	NE	28	22	10	E	King	rock	granitic rock	Tsgs	>	30	0.05	0.080	1.4		1	0.03	44.4								
14280049	15		FS-476		City of Seattle	SE	SW	29	22	10	E	King	crushed rock	grano-diorite	Tsgs	>	45		0.005	0.1		0	0.00									
14280051	15		FS-474		City of Seattle	NE	SW	29	22	10	E	King	crushed rock	grano-diorite	Tsgs	>	50		0.005	0.1		2	0.04									
14280055	15		FS-475		City of Seattle	SW	NW	29	22	10	E	King	crushed rock	grano-diorite	Tsgs	>	150	0.10	0.160	2.3		0	0.00	25.3								

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14280046	15		FS-477		U.S. Forest Service	SW	SE	30	22	10	E	King	crushed rock	grano-diorite	Tsgs	>	50	0.10	0.160	0.2		0	0.00									
14280047	15		FS-478		U.S. Forest Service	NW	SE	30	22	10	E	King	crushed rock	grano-diorite	Tsgs					0.1		0										
14280054	15		FS-479		U.S. Forest Service	SW	NE	30	22	10	E	King	rock	grano-diorite	Tsgs	>	25		0.008	0.1		0	0.00									
14280043	15		FS-480		City of Seattle	SE	NW	31	22	10	E	King	crushed rock	grano-diorite	Qa (BR)	>	10	0.10	0.160	0.6		0	0.00									
14280044	15		FS-481		City of Seattle	NW	NE	31	22	10	E	King	pit run	landslide	Ql	>	30	0.10	0.160	0.2		0	0.00	35		2.64						
14280048	15		FS-482		City of Seattle	NE	NW	31	22	10	E	King	pit run	landslide	Ql	>	20		0.002	0.02		0	0.00									
14280039	15		FS-483		City of Seattle	SE	SE	33	22	10	E	King	grid roll	grano-diorite	Tsgs	>	30		0.005	0.07		1	0.03									
14280040	15		FS-484		U.S. Forest Service	S/2	SE	34	22	10	E	King	crushed rock	talus	Tsgs																	
13300008	21		S-237		U.S. Forest Service	SE	SW	2	22	11	E	Kittitas	gravel	alpine drift	Qag		12			12.4	100	5	0.42	13.7	60	2.87			44	33	33	9
13290019	16		A-432		King County?	NE	NW	4	22	11	E	King	quarried rock	phyllite?	Tng					4	100											
13290017	16		FS-485		Burlington Northern	NW	SE	5	22	11	E	King	riprap	andesite	Tng		10		0.003		100	0	0.00									
13290018	21		A-54	I-90 snowshed	Burlington Northern Railroad	NW	SE	5	22	11	E	King	talus	andesite	Tng		30			4.8	100	0	0.00	13.1	62	2.78						9
13290015	16		FS-486		U.S. Forest Service	SW	NW	8	22	11	E	King	crushed rock	andesite	Tng	>	45		0.002	0.06	100	0	0.00									
13290010	21		S-156	Gold Creek pit	Northern Pacific Railroad	SW	SW	11	22	11	E	Kittitas	gravel	alluvium	Qa		10			15.1	100	0	0.00	12.19	61	2.71			17	57	26	2.3
13290016	18		S-243		Northern Pacific Railroad	SW	NW	11	22	11	E	Kittitas	gravel	alpine drift	Qag		13			7.9		6	0.46	26.1	24	2.63						0
13290009	15		FS-549	Gold Creek pit	U.S. Forest Service?	SW	NW	14	22	11	E	Kittitas	gravel	alluvium	Qa		25	0.10	0.160	4.1		1	0.04									
13300004	21		S-156	Gold Creek pit	Northern Pacific Railroad	NW	NW	14	22	11	E	Kittitas	gravel	alluvium	Qa						100											
13290007	21		S-57		WSDOT	NE	SE	15	22	11	E	Kittitas	gravel	alluvium	Qa		20			3.4	100	3	0.15	12.4		2.68			33	46	21	3
13290011	18		S205	S300	Real Estate Co. of America	NW	NE	15	22	11	E	Kittitas	gravel	alpine drift	Qag		12			17.9		4	0.33	17.2	40	2.62			0	60	40	10
13290006	21		S-112		Bureau of Reclamation	SE	SE	15	22	11	E	Kittitas	gravel	alpine drift	Qag	>	2			6.2	100	1	0.50	10.2	66	2.79			16	54	30	2
13290008	21		S-204			NW	SE	15	22	11	E	Kittitas	gravel	alpine drift	Qag		9			16.5	100	2	0.22	14.9	52	2.75			30	55	15	6
13290014	15		A-55			SE	NE	18	22	11	E	King	quarried rock	basalt	Tnmc																	1.5
13290001	15		FS-487		Plum Creek Timber Co.	SW	NW	19	22	11	E	King	rock blanket	granitic rock	Tng	>	30			0.09		0	0.00									
13290003	21		S-271		U.S. Forest Service	SW	NE	22	22	11	E	Kittitas	gravel	alpine drift	Qag		12			11	100	1	0.08	17.6	17	2.64			4	47	49	9.5

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13290005	15		FS-489		U.S. Forest Service	NW	NW	22	22	11	E	Kittitas	rip rap	tuff	Tnmc				0.005	0.7		0										
13290002	13			U.S. Forest Service		NW	SE	22	22	11	E	Kittitas	gravel	alpine drift	Qag							0							2	37	61	2
14290057	16		FS-490	Rocky Run pit	U.S. Bureau of Reclamation	SW	SW	23	22	11	E	Kittitas	gravel	alluvium	Qa			0.03	0.053	6.9	100	0										
14300049	15		FS-527	Rocky Run pit		SW	SW	23	22	11	E	Kittitas	gravel		Tngb (OB)		15	0.10	0.160	4.1		0	0.00	14	48	2.7			8	44	48	7
13300001	21		S-255		U.S. Bureau of Reclamation	SW	NW	23	22	11	E	Kittitas	gravel	alluvium	Qa		11.5			6.9	100	1	0.09	13.5	48	2.7			26	43	31	10
13300002	15		FS-491	Rocky Run Bridge pit	U.S. Forest Service	NW	SE	24	22	11	E	Kittitas	riprap	basalt	Tnbg				0.002													
14300044	15		FS-492		Burlington Northern	SW	SE	25	22	11	E	Kittitas	rock	tuff	Tngb			0.05	0.075	0.6		0										
14300050	15		FS-528	Big Wolf pit	Burlington Northern	NE	NE	25	22	11	E	Kittitas	rock	tuff	Tngb																	
14290056	21		S-272		U.S. Forest Service	N/2	NW	26	22	11	E	Kittitas	gravel	alpine drift	Qag		12			12	100	1	0.08	14	53	2.67			4	46	50	11.5
14300047	21		S-272		U.S. Forest Service	N/2	NW	26	22	11	E	Kittitas	gravel	alpine drift	Qag		12			12	100	1	0.08	14	53	2.67			4	46	50	11.5
14300048	13		S-56	U.S. Forest Service		NE	NW	26	22	11	E	Kittitas	gravel	alpine drift	Qag														0	47	53	3.5
14290055	15		FS-493	Keechelus rock pit	Bureau of Reclamation	NE	NW	27	22	11	E	Kittitas	gravel	alpine drift	Qag			0.05	0.080	4.1		0		22	49	2.52	72					
14290054	15		FS-488	Chilly Waster pit	U.S. Forest Service	NE	NE	28	22	11	E	Kittitas	gravel	till	Qag		6	0.01	0.021	1.3		0	0.00	14			75					
14290050	15		FS-494		Burlington Northern	NE	SE	33	22	11	E	Kittitas	crushed rock	volcanic rock	To			0.02	0.040	0.7		0										
14290051	15		FS-496		U.S. Forest Service	NE	SW	34	22	11	E	Kittitas	crushed rock	volcanic rock	To		21	0.04	0.056	1		0	0.00									
14290052	15		FS-495		U.S. Forest Service	NW	SE	34	22	11	E	Kittitas	crushed rock	volcanic rock	Tolk			0.04	0.056	1		0										
14300040	15		FS-498		U.S. Forest Service	NW	SE	36	22	11	E	Kittitas	crushed rock	andesite	Tolk			0.02	0.035	0.5		0										
14300043	15		FS-497		U.S. Forest Service	SW	NE	36	22	11	E	Kittitas	crushed rock	tuff	Tngb			0.02	0.024	2.3												
14300038	15		FS-499		U.S. Forest Service	SE	SE	36	22	11	E	Kittitas	rock	basalt	Tnbg		9	0.01	0.013	0.2		0	0.00									
13300007	15		FS-550		U.S. Forest Service	SW	NE	13	22	12	E	Kittitas	gravel	alpine drift	Qag		6	0.01	0.016	1		1	0.17									
13300003	15		FS-551		U.S. Forest Service	SE	SE	24	22	12	E	Kittitas	gravel	alluvium	Tnbg (OB)		6	0.02	0.024	1.5		0	0.00									
14300051	15		FS-552	Gale Creek borrow pit	U.S. Forest Service	NW	SE	26	22	12	E	Kittitas	gravel	alluvium	Tngb (OB)		10		0.002	0.7		0	0.00									

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14300052	15		FS-553		U.S. Forest Service	SW	NE	26	22	12	E	Kittitas	gravel	alluvium	Tngb (OB)		3	0.02	0.032	6.8		3	1.00									
14300045	15		FS-554		U.S. Forest Service	NW	NE	34	22	12	E	Kittitas	crushed rock	andesite	Tngb			0.02	0.029	1.1				36								
13310004	15		FS-532			SW	SW	4	22	13	E	Kittitas	rock	volcani-clastic rock	Tcp			0.08	0.128	1.4		0		19	78	2.65				53	41	6
13310005	15		FS-533		Burlington Northern	NW	SE	5	22	13	E	Kittitas	gravel	alluvium	Ked (OB)			0.02	0.027	0.5		0		19	80	2.63				53	41	6
13310002	15		FS-534	Upper Kachess rock pit	U.S. Forest Service	NW	SE	8	22	13	E	Kittitas	gravel	alluvium	Qa		15	0.20	0.320	14.9		1.5	0.10	22	27	2.89	14			53	41	6
13310003	15		FS-555		U.S. Forest Service		NW	12	22	13	E	Kittitas	rock	sand-stone	Tss		10	0.01	0.017	0.6		0	0.00	19								
13300006	15		FS-535	Box Canyon pit	U.S. Forest Service	SE	SW	18	22	13	E	Kittitas	rock	andesite	Tnbg			0.02	0.040	0.5		0										
13300005	15		FS-557		U.S. Forest Service	W/2	NE	19	22	13	E	Kittitas	rock	basalt	Tnbg			0.04	0.064	1		0		19	58							
14300053	15		FS-560		U.S. Forest Service	SE	NW	30	22	13	E	Kittitas	rock	basalt	Tngb		100	0.01	0.016	6.2		0	0.00									
14300054	15		FS-558		U.S. Forest Service	NE	NE	30	22	13	E	Kittitas	rock	basalt	Tngb		6		0.008	2		0	0.00									
14300046	15		FS-559		U.S. Forest Service	SE	SW	30	22	13	E	Kittitas	rock	volcanic rock	Tns		6	0.02	0.040	2.75		1	0.17									
13320004	15		FS-523	Lulu pit (Cooper River pit)	U.S. Forest Service	NE	SW	8	22	14	E	Kittitas	rock	sand-stone	Tss			0.20	0.320	2.75		0		23	75							
13310001	15		FS-556		U.S. Forest Service	SW	NE	14	22	14	E	Kittitas	gravel	alpine drift	Qag		5		0.008	0.3		0	0.00	17	25	2.64	57					
13320003	15		FS-561	Garbage pit	U.S. Forest Service	SW	SE	16	22	14	E	Kittitas	gravel	alluvium	Qa		20	0.01	0.014	28.7		0	0.00	22		2.65	56					
13320001	15		FS-562		Burlington Northern	W/2	SW	21	22	14	E	Kittitas	gravel	alluvium	Qa		9	0.12	0.192	8.25		1.5	0.17									
13320002	15		FS-563	Little Salmon La Sac pit	Burlington Northern	SE	SW	21	22	14	E	Kittitas	gravel	alluvium	Qa		30	0.20	0.320	10.2		1.5	0.05									
14320006	15		FS-524	Lower Thorp pit	U.S. Forest Service	SE	SE	29	22	14	E	Kittitas	rock	volcani-clastic rock	Qag (BR)		50	0.25	0.400	8.2		1.5	0.03	16		2.68						
14320003	15		FS-565		U.S. Forest Service	SE	SE	30	22	14	E	Kittitas	rock	sand-stone	Tss			0.04	0.064	1.4		1										
13310018	15		FS-564		U.S. Forest Service	NW	SW	30	22	14	E	Kittitas	rock	sand-stone	Tss			0.03	0.048	1.9		0		20								
13310013	15		FS-566		Burlington Northern	SW	NE	31	22	14	E	Kittitas	rock	basalt	Tss				0.008	0.9		0										
13310017	15		FS-567			NW	NW	31	22	14	E	Kittitas	rock	volcani-clastic rock	Qag (BR)																	

IDENTIFIER						LOCATION							RESERVES										QUALITY										
WADNR unique number	WADNR data type code	WADNR permit number	WSDOT/USFS site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2½ inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
14320004	16		FS-568		U.S. Forest Service	NW	SE	32	22	14	E	Kittitas	gravel	alluvium	Qa			0.10	0.160	5.7	100	0										
14320005	13		S-130	U.S. Forest Service		SE	SE	32	22	14	E	Kittitas	gravel	alpine drift	Qag		20					0.2	0.01	17		2.64			24	48	28	3
13250019	13		A-302	WSDOT		SE	NE	36	23	6	E	King	gravel	Vashon outwash	Qvr		20					1	0.05	11.4		2.71			6	46	48	8
13250033	13		A-286	WSDOT		SW	SE	10	23	7	E	King	gravel	Vashon outwash	Qvr_5	>	25					2	0.08	11.4		2.64			7	57	36	15
13250034	13		A-136	G. E. Erickson		NE	NW	11	23	7	E	King	sand	Vashon outwash	Qvr_5	>	30					2	0.07						0	0	100	5.6
13250029	13		A-358	Weyerhaeuser		SW	SW	15	23	7	E	King	gravel	till	Qvt		30					4	0.13						0	18	82	13
13250026	18		A-288			NE	SE	20	23	7	E	King	gravel	till	Qvt														3	29	68	5
13250028	13			WSDOT		NE	NW	21	23	7	E	King	gravel	till	Qvt									14.1	71	2.73			3	46	51	2
13250021	21	10857	A-271		Meridian Minerals	W/2	NE	31	23	7	E	King	gravel	Vashon outwash	Qvr		105			10.25	100											
13250020	21		A-271			NE	SW	31	23	7	E	King	gravel	Vashon outwash	Qvr	>	20			16.5	100	1.5	0.08						4	41	55	2.7
13260006	21		A-131		State Bank of Snoqualmie	SW	NW	5	23	8	E	King	crushed rock	andesite?	Tkwb		32			4.6	100	3	0.09						8	44	36	12
13260002	13		A-17			NW	NE	9	23	8	E	King	gravel	alluvium	Qa														16	46	38	0.5
13270069	21	10039	A-224	Johnson pit	WSDOT	SW	NW	13	23	8	E	King	gravel	alluvium	Qa		45			35	100	1	0.02	14.7	60	2.67			2	43	53	2
13270042	21	11435	A-475		M. A. Segale	SW	NW	13	23	8	E	King	gravel	alluvium	Qa						100			13.6	32	2.7			7	57	36	2
13270040	21	10873	A-224	PS-A-224	WSDOT	NE	SE	14	23	8	E	King	gravel	alluvium	Qa		11			13.6	100	1.5	0.14									
13260011	15		FS-501			NE	NE	16	23	8	E	King	gravel	alluvium	Qa		4	0.05	0.080	1.4		0	0.00	14		2.65						
13260016	21	11417	A-433	Keller pit	M. A. Segale	SE	SE	16	23	8	E	King	gravel	ice contact	Qvi_3		55			5	100	3	0.05						0	60	40	2
13260029	13		A-87			NE	NW	23	23	8	E	King	gravel	alluvium	Qa		10					0	0.00	12.2		2.69			11	60	29	2
13270037	18		A-222		Lavern Brister	NW	SE	24	23	8	E	King	gravel	alluvium	Qa					2.6									0	62	38	1
13270024	13		A-333			NW	SE	25	23	8	E	King	gravel	Vashon outwash	Qvr_1																	
13270035	13		A-43a	West Ragnar pit		NE	NE	25	23	8	E	King	gravel	ice contact	Qvi_3		100					0	0.00						7	55	38	0.1
13270036	13		A-59			NE	NE	25	23	8	E	King	gravel	alluvium	Qa														30	70		6
13260041	18		A-209		W. T. Bachellor, Seattle	SE	SE	27	23	8	E	King	gravel	ice contact	Qvi_3	>	30			20.9		1	0.03						0	34	66	6
13260032	18	10869	A-462		WSDOT	NE	NW	27	23	8	E	King	sand	ice contact	Qvi_3		75	0.67	1.072	17		1.5	0.02	26	25	2.77			0	2.3	97.7	10
13260031	13		A-340	Richard Zemp		NE	NE	27	23	8	E	King	gravel	ice contact	Qvi_3														0	80	20	10
13270022	13		A-43b	East Ragnar pit		NW	NE	36	23	8	E	King	gravel	Vashon outwash	Qvr_1														2	36	62	0.2
13270070	15		FS-502		State of Washington	NW	NW	11	23	9	E	King	gravel	alluvium	Qa															89.1	10.9	

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit number	WSDOT/USFS site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridan	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2½ inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
13270044	15		FS-503		King County?	W/2	SW	18	23	9	E	Kittitas	gravel	alluvium	Qa																	
13270045	21		A-225		King County	SE	SW	18	23	9	E	King	gravel	alluvium	Qa		20				100	2	0.10	12.3		2.7			16	42	42	5
13270038	21	10622			J. J. Welcome & Sons	NE	NW	19	23	9	E	King	gravel	alluvium	Qa		13				100	2	0.15									
13270039	21		A-460	old Weyer-haeuser site	Cadman Sand & Gravel	NW	NE	19	23	9	E	King	gravel	alluvium	Qa		15				100	3	0.20	15	59	2.71			5	54	41	9
13270032	21	11945			WSDOT	SE	SW	21	23	9	E	King	gravel	Vashon outwash	Qvr_1					40	100	0										7
13270073	16		A-461		Weyerhaeuser	NW	NE	28	23	9	E	King	gravel, rock	grano-diorite	Qvr_1		21			76	100	1.5	0.07									
13270031	21		A-236		Weyerhaeuser	NW	SW	28	23	9	E	King	gravel	Vashon outwash	Qvr_1		300			30.3	100	6	0.02						0	45	55	2
13270033	21		A-456	Grouse Ridge	WSDOT		N/2	28	23	9	E	King	gravel	Vashon outwash	Qvr_1						100			14	35	2.69			0	65	35	5
13270034	13		A-461	King County (10771)		NE	NE	28	23	9	E	King	gravel	Vashon outwash	Qvr_1							10										
13270030	18	12684	A-214	Scott pit	Fiorito Brothers	NE	SE	29	23	9	E	King	gravel	Vashon outwash	Qvr_1		150					2	0.01	17.6	46	2.7			10	54	36	8.9
13270029	21	12684		Homestead Valley	Fiorito Brothers, Inc.	N/2	SE	29	23	9	E	King	gravel	Vashon outwash	Qvr_1		300			80	100	1	0.00									
13270028	21		A-58		WSDOT	NE	SW	29	23	9	E	King	gravel	Vashon outwash	Qvr_1		150				100	0	0.00						0	46	54	22.5
13270027	21		A-58	Second Site		SE	NE	30	23	9	E	King	gravel	Vashon outwash	Qvr_1						100											
13270025	13		A-362			NW	SW	30	23	9	E	King	gravel	Vashon outwash	Qvr_1																	
13270026	13		A-43c	Site 3		NE	SE	30	23	9	E	King	gravel	Vashon outwash	Qvr_1																	
13270021	13		A-57			SE	NE	33	23	9	E	King	gravel	Vashon outwash	Qvr_1																	2
13270015	13		A-56			SW	SE	34	23	9	E	King	quarried rock	granitic rock	Tsgf																	4
13270016	13		A-470	King County		SE	SE	34	23	9	E	King	quarried rock	diorite	Qvr_3 (BR)											2.75						
13270018	13		A-215	Weyerhaeuser		NW	SE	34	23	9	E	King	gravel	alluvium	Qa		4					0	0.00	12.8					13	58	29	4
13270017	21		A-217		Weyerhaeuser	SW	SW	35	23	9	E	King	gravel	Vashon outwash	Qvr_1		10			3	100	1.5	0.15						20	52	28	6
13280029	16		FS-505		Weyerhaeuser	SE	SE	35	23	9	E	King	rock	grano-diorite	Qvr_1 (BR)		40	0.01	0.016	0.9	100	0	0.00									
13270019	13		A-216			NW	SW	35	23	9	E	King	quarried rock	diorite	Tkwg							0										
13270020	13		A-351			NW	SW	35	23	9	E	King	gravel	Vashon outwash	Qvr_1							2							8	68	26	7
13280030	13		A-297			SW	SW	36	23	9	E	King	gravel	Vashon outwash	Qvr_1																	

IDENTIFIER						LOCATION							RESERVES									QUALITY										
WADNR unique number	WADNR data type code	WADNR permit number	WSDOT/USFS site number	Mine name	Operator or permit holder	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridan	County	Product	Rock type	Geologic unit	Qualifier	Resource thickness (feet)	Million cubic yards	Million tons	Acres	Percent depletion	Overburden thickness (feet)	Stripping ratio	Los Angeles Abrasion	Degradation	Specific Gravity	Sand Equivalent	Stabilometer R Value	Percent >2½ inches	Percent ¼–2½ inches	Percent <¼ inch	Percent <U.S. No. 200 sieve
13270020	21		A-212			SE	NW	33	23	11	E	King	quarried rock	argillite	Tgn		35			4.1	100	0	0.00	10.5								
13310007	16		FS-570	Tired pit	U.S. Forest Service	NE	SW	27	23	13	E	Kittitas	gravel	alluvium	Tss (OB)			0.10	0.160	1.3	100	0										
13310006	16		FS-571	Cooper Pass pit	U.S. Forest Service	SW	SE	34	23	13	E	Kittitas	gravel	alluvium	Qa			0.02	0.040	0.5	100	0										
13320008	15		FS-521	Hawkeye/Silver Creek pit	Plum Creek Timber Co.	SW	SE	11	23	14	E	Kittitas	gravel	alluvium	Qa			0.01	0.016	1												
13320010	15		FS-572			NE	SW	11	23	14	E	Kittitas	gravel	alluvium	Qa		10		0.002	0.2		0	0.00									
13320007	15		FS-574		U.S. Forest Service	NW	NE	14	23	14	E	Kittitas	gravel	alluvium	Qa		9	0.02	0.032	2		1	0.11									
13320005	15		FS-575		U.S. Forest Service	SE	SE	26	23	14	E	Kittitas	gravel	alluvium	Qa		9	0.02	0.032	2		1	0.11									
13320006	15		FS-522	Camp Creek pit		N/2	SE	26	23	14	E	Kittitas	gravel	alluvium	Qa																	

Appendix 4. Well database

This database contains information about all water wells and geotechnical bores that are plotted on Plate 1. The information contained herein is available digitally as part of the geographic information system (GIS) files for the Snoqualmie Pass 1:100,000 quadrangle. The columns that are not self-explanatory are defined as follows:

WADNR unique number – The Washington Department of Natural Resources (WADNR) unique number is used by the geographic information system (GIS) to relate a feature on Plate 1 to a row in the database. The first four digits of the number identify the 7.5-minute quadrangle map in which the well is located. The last four digits are a unique number on each 7.5-minute quadrangle.

WADNR data type code – The code number that indicates the type of drill hole, as follows: 11 = water well (point); 12 = geotechnical or other bore (point).

WADOE well number – One of a variety of numbers found on the Washington Department of Ecology (WADOE) water-well report forms. The possible types include start card, application, or permit numbers.

Data verified? – Relates to the quality of data. 'Y' indicates that the drill log is from a geotechnical bore or has been verified by a consulting firm; otherwise, the field is blank.

Well location – Gives the street address of the well or the nearest geographical feature. Washington State Department of Transportation bores are referenced to the bridge, intersection, or street location where the bore is drilled.

¼ ¼ section, ¼ section, Section, Township, Range, Meridian – Legal description of the well with reference to the Government Land Office grid. Townships and ranges are shown on Plate 1.

Geologic unit – The short label that identifies a particular unit on a geologic map. This field indicates the unit in which the well is located on the surface. See Appendix 5 for some geologic unit descriptions; descriptions of geologic units not in Appendix 5 can be found in Tabor and others (2000).

Qualifier – Applies only to the deepest gravel thickness reported (see following columns) and indicates that either the thickness is exact because the whole layer is penetrated by the well (blank) or that the actual gravel thickness is greater than the thickness reported because the bottom of the gravel was not identified in the well log (>).

Overburden thickness (feet) – The thickness, in feet, of soil, clay, or non-commercial aggregate that must be removed in order to reach the aggregate resource.

1st gravel thickness (feet), 1st interbed thickness (feet), 2nd gravel thickness (feet), 2nd interbed thickness (feet), 3rd gravel thickness (feet) – These fields refer to the interpretation of the well log by the authors, starting at the ground surface. 'Gravel thickness' refers to the thickness of a likely aggregate resource, whereas 'interbeds' are non-commercial materials such as silt and clay.

Depth to water-bearing zone (feet) – Gives depth, in feet, to top of the first water-bearing unit encountered during drilling.

Bedrock penetrated? – This column contains either a Y (yes), N (no), or blank (unknown) indicating whether the well was drilled to the depth of bedrock.

Reference – The source of data for the well log, if other than the Washington Department of Ecology water-well log archives.

IDENTIFIER						LOCATION								WELL LOG											
WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well *total* depth (feet)	Bedrock penetrated?	Reference
15320083	11	36740	N		Dale Lloyd		SE	NW	1	19	14	E	Kittitas	Qa		32	22	158				140	262	N	
15320084	11	80929	N		John Smith		NW	NW	1	19	14	E	Kittitas	Qag	>	44	38					65	82	N	
15320086	11	28690	N		Monty Cline		NE	NW	1	19	14	E	Kittitas	Qag		20	80					75	120	Y	
15320087	11	46412	N		Roger Pearson		NW	NE	1	19	14	E	Kittitas	Qag	>	118						0	118	N	
15320196	11	46406	N		Donald Sutton		NW	NE	1	19	14	E	Kittitas	Qag	>	117						87	117	N	
15320088	11	46407	N		Alex Strnard		NW	NE	1	19	14	E	Kittitas	Qag	>	80	9					77	89	N	
15320089	11	W047084	N		Cal Cleveland		NE	NE	1	19	14	E	Kittitas	Qa		5	18	23	48	54	26	149	500	Y	
15320194	11	46408	N		Dale Lloyd		NW	NE	1	19	14	E	Kittitas	Qag		100						0	100	N	
15320195	11		N		John Smith		NW	NE	1	19	14	E	Kittitas	Qag		13	72	35				0	129	Y	
15320094	11	13545	N		John Williams		SE	NE	1	19	14	E	Kittitas	Qag		52	6	14	29	1		72	78	N	
15320096	11	87868	N		John Smith		NE	NW	1	19	14	E	Kittitas	Qag	>	80						65	80	N	
15320102	11	W34111	N		Don Sutton		NE	NE	1	19	14	E	Kittitas	Qa		7	49	39	5	1		95	100	N	
15320103	11	W36977	N		Jeff Entrop		NE	NE	1	19	14	E	Kittitas	Qa		18	60	42				100	105	N	
15320104	11	W050362	N		Herb Sorenson		NE	NE	1	19	14	E	Kittitas	Qa		2	110	8				109	120	N	
15320105	11	W34110	N		Joseph Henry		NE	NE	1	19	14	E	Kittitas	Qa		8	94	2				96	100	N	
15320199	11	87869	N		John Smith		NW	NW	1	19	14	E	Kittitas	Qa		30						153	172	Y	
15320053	11	52411	N		Dan Sturgill		SE	SE	2	19	14	E	Kittitas	Qa		10	20					180	402	Y	
15320054	11	A32903	N		Mike Hoban		NE	SW	2	19	14	E	Kittitas	Ked		35							170	Y	
15320055	11	W037302	N		Mike Hoban		NE	SW	2	19	14	E	Kittitas	Ked		30							100	Y	
15320056	11	A32903	N		Mike Hoban		NE	SW	2	19	14	E	Kittitas	Ked		35							170	Y	
15320082	11	36439	N		Larry Navarre		NE	NW	2	19	14	E	Kittitas	Ked		10						0	62	Y	
15320049	11	28718	N		Gordon Campbell		SW	SW	3	19	14	E	Kittitas	Qa		55						20	100	Y	
15320050	11		N		William Jones		SW	SW	3	19	14	E	Kittitas	Qa	>	32	25					36	57	N	
15320051	11	28719	N		Gary Perna		NW	SW	3	19	14	E	Kittitas	Qa		55						200	500	Y	
15320052	11		N		Dick Bowman		NE	SE	3	19	14	E	Kittitas	Ked		20						30	300	Y	
15320076	11		N		Patrick Peterson		SE	NW	3	19	14	E	Kittitas	Qa	>	20	18					2	38	N	
15320077	11		N		Richard & Shelly Day		SE	NW	3	19	14	E	Kittitas	Qa	>	31	19					7	50	N	
15320078	11	W50913	N		Pat Deneen		SE	NW	3	19	14	E	Kittitas	Qa		47	12	21				8	80	Y	
15320079	11		N		Duane Jolliffe		SE	NW	3	19	14	E	Kittitas	Qa	>	50	6					18	56	N	
15320080	11	36375	N		Gary Perna		NW	NW	3	19	14	E	Kittitas	Qa	>	75							75	N	
15320081	11		N		Tom Whitaker		NE	NW	3	19	14	E	Kittitas	Qa		26							350	Y	
15320070	11	W048974	N		Roth E-1&F-3		SW	SW	5	19	15	E	Kittitas	Qag		32	52	27	15	34		56	220	Y	
15320071	11	W48980	N		Roth G-2		SW	SW	5	19	15	E	Kittitas	Qag		28	57	71				46	240	Y	
15320072	11	W48979	N		Roth A-2		SW	SW	5	19	15	E	Kittitas	Qag	>	18	82	12	48			73	160	N	
15320073	11	W048976	N		Roth H-2		SW	SW	5	19	15	E	Kittitas	Qag		17	53	28	24	22		69	240	Y	
15320074	11	10435	N		Joseph Moreau		NE	SW	5	19	15	E	Kittitas	Qag		5	23	42				70	160	Y	
15320115	11	43091	N		Tom Roth		SW	NW	5	19	15	E	Kittitas	Qag		35	35	330				98	400	Y	
15320116	11	43097	N		Roth		SW	NW	5	19	15	E	Kittitas	Qag		20	30	10	18	32		98	240	Y	
15320063	11	86972	N		Lynda Montgomery		SW	SW	6	19	15	E	Kittitas	Ked		6							1060	Y	

IDENTIFIER						LOCATION								WELL LOG										
WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
15320064	11	79595	N		R. McCuen & M. Morgavi		SW	SW	6	19	15	E	Kittitas	Ked		6						198	300	Y	
15320065	11	W06336	N		Mike Terry		SW	SW	6	19	15	E	Kittitas	Qag		33						60	100	Y	
15320066	11	W048172	N		Ted Vigil		SW	SW	6	19	15	E	Kittitas	Qag		32						0	100	Y	
15320090	11	W45134	N		Don Madsen		SW	SW	6	19	15	E	Kittitas	Qag		7	65					62	72	Y	
15320091	11	A33451	N		Don Madsen		SW	SW	6	19	15	E	Kittitas	Qag		7	67					0	422	Y	
15320092	11		N		Robert Paul		NW	SW	6	19	15	E	Kittitas	Ked		7	65	38				40	125	Y	
15320093	11	83019	N		Rodney Dunn		NW	SW	6	19	15	E	Kittitas	Ked		5						18	220	Y	
15320098	11		N		Larsh Rothert		SW	NW	6	19	15	E	Kittitas	Qag		8	95	42				200	665	Y	
15320099	11	W61183	N		Gary Sherrel		SE	NW	6	19	15	E	Kittitas	Qag		5						100	200	Y	
15320100	11	10466	N		Squirrel-Youngblood		NE	NW	6	19	15	E	Kittitas	Qag		95						5	180	Y	
15320101	11	10476	N		Don Wilson		NE	NW	6	19	15	E	Kittitas	Qag		0	15	185					200	N	
15320106	11		N		George Fraser		NW	NE	6	19	15	E	Kittitas	Qa	>	27	116					70	143	N	
15320107	11	W047097	N		Glen Parker		NW	NE	6	19	15	E	Kittitas	Qa	>	97	19					84	116	N	
15320108	11	22570	N		Wayne Newberger		SW	NE	6	19	15	E	Kittitas	Qag		0	57	75					360	Y	
15320109	11	A21162	N		James Fuller		NE	NE	6	19	15	E	Kittitas	Qa		12	52					0	70	Y	
15320110	11	A27163	N		James Fuller		NE	NE	6	19	15	E	Kittitas	Qa		14	36					0	120	Y	
15320111	11	43171	N		Harvie Choat		SE	NE	6	19	15	E	Kittitas	Qag	>	38	57					76	95	N	
15320112	11	W41452	N		Harvey Ho		SE	NW	6	19	15	E	Kittitas	Qag	>	77	23					32	100	N	
15320113	11	34148	N		Herb Kile		SE	NE	6	19	15	E	Kittitas	Qag	>	72	66					48	138	N	
15320117	11	W48158	N		Marilee Kiene		N/2	SE	6	19	15	E	Kittitas	Qag		1	22	62	22			0	250	Y	
15320118	11	W48158	N		Marilee Kiene		N/2	SE	6	19	15	E	Kittitas	Qag		72	3					0	105	Y	
15320119	11	W64316	N		George Kukuk		SW	NE	6	19	15	E	Kittitas	Qa		41	18	22				32	58	Y	
15320120	11	34113	N		Larry Dixon		SW	NE	6	19	15	E	Kittitas	Qa	>	22	63	27	8			31	120	N	
15320121	11	84411	N		Robert Deeds		SW	NE	6	19	15	E	Kittitas	Qa	>	10	100	90	10			190	210	N	
15320057	11	2040	N		John Ells		NW	SE	7	19	15	E	Kittitas	Qa	>	60	3					39	63	N	
15320067	11	43167	N		Phil Miller		NE	NE	7	19	15	E	Kittitas	Qa		12	38	5				61	240	Y	
15320061	11	34140	N		Don Scogings		NW	SW	8	19	15	E	Kittitas	Qa	>	75	85					25	160	N	
15320059	11	43099	N		Tom Chambers		NW	SW	8	19	15	E	Kittitas	Qa		160						110	320	Y	
15320197	11	W043172	N		Norman Skeels		NW	SW	8	19	15	E	Kittitas	Qa		235						220	487	Y	
15320060	11	87860	N		Norman Rowley		NW	SW	8	19	15	E	Kittitas	Qa		217						195	245	Y	
15320198	11	W48964	N		Norman Skeels		NW	SW	8	19	15	E	Kittitas	Qa		0	40	195				220	487	Y	
15320062	11		N		George Connors		SW	NW	8	19	15	E	Kittitas	Qa	>	125						50	125	N	
15320068	11	87236	N		Richard Roll		NW	NW	8	19	15	E	Kittitas	Qa	>	2	9	172	2			163	185	N	
15250143	11	20-6E-1M	N	43	Ryan Terhune		NW	SW	1	20	6	E	King	Qvr_4	>	0	12	18	26			23	56	N	
15250142	11	20/7E/33J	N	44	Bill Sweeney		SE	SE	2	20	6	E	King	Qvt	>	0	29					14	29	N	
15250126	11	ACV761	N	46	Knut Harjo		SW	NE	11	20	6	E	King	Qvr_4	>	3	5	72	18			68	98	N	
15250132	11	20/06-11A	N	45	Vern Edwards		NE	NE	11	20	6	E	King	Qvt		2	36	12				20	50	N	
15250127	11	20/06-12K	N	49	Frank Wasicek		NW	SE	12	20	6	E	King	Qvr_4	>	26	44					38	60	N	
15250128	11	31-23246	N	48	Jim Flint		SW	NE	12	20	6	E	King	Qlh	>	80	9					60	89	N	

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WADNR unique number	WADNR data type code	WADOE well number	Data verified?	Well name	Original well owner	Well location	¼ ¼ section	¼ section	Section	Township (N)	Range	Meridian	County	Geologic unit	Qualifier	Overburden thickness (feet)	1st gravel thickness (feet)	1st interbed thickness (feet)	2nd gravel thickness (feet)	2nd interbed thickness (feet)	3rd gravel thickness (feet)	Depth to water-bearing zone (feet)	Well total depth (feet)	Bedrock penetrated?	Reference
15250133	11	65389	N	40	Brian Bashaw		NW	NW	12	20	6	E	King	Qvr_4	>	30	25	3	10			15	68	N	
15250134	11	20/06-12C	N	47	Howard Johnson		NE	NW	12	20	6	E	King	Qlh	>	23	17					18	40	N	
15250052	11	20/06-35Q	N	50	GeoEngineers Inc.		SW	SE	35	20	6	E	King	Qa		2	3	6	16	110		1	185	Y	
15250053	11	20/06-35R	N	51A	Puget Power		SE	SE	35	20	6	E	King	Qa		0	20	38				7	58	N	
15250054	11	20/06-35R	N	51B	Puget Power		SE	SE	35	20	6	E	King	Qa		4	48	4				9	56	N	
15250070	11	ACK093	N	39A	Pete Lockwood		NE	NE	36	20	6	E	King	Qlh	>	0	198					170	198	N	
15250071	11	20-6E/36A	N	39B	Dave Warren		NE	NE	36	20	6	E	King	Qlh	>	2	34	5	18			17	59	N	
14250112	11	21/4-4J	N	99	L. J. Public Water System		NE	SE	4	20	7	E	King	Qvt		25						80	260	Y	
15250154	11	20-07-05M	N	60	Neil McKee		NW	SW	5	20	7	E	King	Qvr_3	>	0	59					42	59	N	
15250148	11	56655	N	57	Gary Skinner		SW	SE	5	20	7	E	King	Qvr_3		29	19	2				23	50	N	
15250118	11	20/07-01K	N	66	Richard Zarbock		SE	SE	7	20	7	E	King	Qvr_3		16	22	21				4	59	N	
15250129	11	20/7-7/J	N	65	Jim Curtiss		NE	SE	7	20	7	E	King	Qvr_3		2	52	35	7					Y	
15250130	11	20-7-7J	N	64	Wayne Nachtsheim		SE	NE	7	20	7	E	King	Qlh	>	41	4	38	17			32	98	N	
15250135	11	12396	N	63	Roger Martin		NW	NW	7	20	7	E	King	Qvr_4		34	24	6				51	68	Y	
15250136	11		N	62A	George Nicolai		N/2	NE	7	20	7	E	King	Qlh	>	96						0	96	N	
15250137	11	14466	N	62B	R.A. Martin		NE	NE	7	20	7	E	King	Qlh		15	30	15	12			65	140	Y	
15250119	11	75508	N	72	Tom Farabee		SW	SW	8	20	7	E	King	Qvr_3	>	128	7					40	135	N	
15250120	11	ACG876	N	69	J&J		SW	SE	8	20	7	E	King	Qvi_1	>	87	29					20	116	N	
15250121	11	ABZ077	N		Gany Gilara		SE	SE	8	20	7	E	King	Qvi_1	>	3	6	16	15			15	40	N	
15250124	11	20/07E/08-J	N	70	C Mtn. Ranch		NE	SE	8	20	7	E	King	Qvi_1	>	34	6					27	40	N	
15250131	11	20/07-08L	N	71	Lyle Jorgensen		NE	SW	8	20	7	E	King	Qvr_3	>	34	6					19	40	N	
15250139	11	20/07-08C	N	68	Ed Welch		NE	NW	8	20	7	E	King	Qvr_3	>	32	28					27	60	N	
15250141	11		N	67B	Bob Bracken		NE	NE	8	20	7	E	King	Qvr_3	>	74	5					30	79	N	
15250152	11	75502	N	67A	Mike Runland		NE	NE	8	20	7	E	King	Qvr_3	>	0	4	26	15	40	10	20	95	N	
15250123	11		N	73	Dallas Barkubein		SW	SW	9	20	7	E	King	Qvr_1		9	9	37	8			1	80	Y	
15250151	11	20/01/10B	N	74	Robert Guariwo		NW	NE	10	20	7	E	King	To	>	91						64	89	N	
15250107	11	64755	N	77	John Graham		SE	NW	16	20	7	E	King	Qvi		2	78					18	200	Y	
15250108	11	20/7E/16D	N	75	Bob Bryant		NW	NW	16	20	7	E	King	Qvr_1		98						110	265	Y	
15250106	11	20-7-17G	N	78	Don Young		SW	NE	17	20	7	E	King	Qvi_1	>	7	31	10	11	9	7	24	75	N	
15250116	11		N	76	Thomas Willi		NW	NW	17	20	7	E	King	Qvr_3	>	22	18					6	40	N	
15250103	11	20/07-18H	N	80C	Bruce Stewert		SE	NE	18	20	7	E	King	Qvr_3	>	32	8					10	40	N	
15250104	11	20-7E-18H	N	80B	Don Kessler		SE	NE	18	20	7	E	King	Qvr_3	>	20	5					8	40	N	
15250105	11	66249	N	80A	Brent Horton		SE	NE	18	20	7	E	King	Qvr_3	>	80	22					47	102	N	
15250115	11	ACG886	N	79	Alan Haywood		NE	NE	18	20	7	E	King	Qvr_3		40	30					26	100	Y	
15250097	11	12119	N	84C	Enumclaw Landfill		NW	SE	19	20	7	E	King	Qvr_3		0	22	33				55	58	N	
15250098	11	12119	N	84A	Enumclaw Landfill		NW	SE	19	20	7	E	King	Qvr_3	>	0	10	2	17			29	38	N	
15250065	11	20/07-33J	N	83B	John Heath		NE	SE	33	20	7	E	King	Qvr_6	>	3	45	15	27	255	15	335	360	N	
15250153	11	20/7E/33J	N	83A	Jeff Hansen		NE	SE	33	20	7	E	King	Qvr_6		40						245	494	Y	
15250067	11	46483	N	83C	Gary Holmvig		NE	SE	33	20	7	E	King	Qvr_6		5	85	5	34	146	5	340	380	Y	

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15320173	11	W089703	N		Ken Mikkelson		SW	SW	2	20	14	E	Kittitas	Qag		10	7					84	405	Y	
15320171	11	36378	N		James Steckline		SW	SE	10	20	14	E	Kittitas	Qag		3	42	37				120	260	Y	
15320178	11		N		LeRoy Crow		NW	NW	12	20	14	E	Kittitas	Tru		80							100	Y	
15320179	11		N		Arthur VanMeter		NW	NW	12	20	14	E	Kittitas	Tru		10						0	325	Y	
15320180	11	34150	N		Jerry Mills		SW	NW	12	20	14	E	Kittitas	Qag		2	62	18				48	175	Y	
15320181	11	W048359	N		John Thornberry		NW	SW	12	20	14	E	Kittitas	Qag		16	153	1				130	170	N	
15320182	11	3531	N		Matt Chambers		SE	NW	12	20	14	E	Kittitas	Qa		24						144	194	Y	
15320183	11	G3-21798P	N		Lycol Veneer Inc.		SE	NW	12	20	14	E	Kittitas	Qa		38						155	500	Y	
15320184	11	28742	N		Lester Engelhart		NE	NW	12	20	14	E	Kittitas	Tru		45						50	200	Y	
15320185	11	W39181	N		Mark Brandt		NE	SW	12	20	14	E	Kittitas	Qa		0	103	8				85	260	Y	
15320186	11	10467	N		Al Simpson		SE	SW	12	20	14	E	Kittitas	Qag		0	84	11				80	160	Y	
15320187	11	7907	N		J. R. Ford		SW	SW	12	20	14	E	Kittitas	Qag		65							120	Y	
15320188	11	7912	N		John Nock		SW	SW	12	20	14	E	Kittitas	Qag	>	95						15	95	N	
15320189	11	7910	N		Bob Durham		SW	SW	12	20	14	E	Kittitas	Qag		61						100	149	Y	
15320190	11		N		Ron Gerrard		NW	SE	12	20	14	E	Kittitas	Qa		42	18						62	Y	
15320191	11	W06343	N		J. T. Gourney		SE	SE	12	20	14	E	Kittitas	Qa		20						130	160	Y	
15320192	11	W092871	N		Dave Alfred		NE	NE	12	20	14	E	Kittitas	Tru		5	90					50	120	Y	
15320168	11	213564	N		Plum Creek		NE	NE	14	20	14	E	Kittitas	Qa	>	0	56					8	57	N	
15320169	11	213564	N		Plum Creek		NE	NE	14	20	14	E	Kittitas	Qa		0	57	189	62	12			320	N	
15320160	11	21015	N		Bob McKenzie		SW	SE	17	20	14	E	Kittitas	Qa	>	30						5	30	N	
15320161	11	W045294	N		Charles Barnes		SW	SE	17	20	14	E	Kittitas	Qa	>	4	24					4	28	N	
15320162	11	W047160	N		Dave Anderson		SE	SE	17	20	14	E	Kittitas	Qa	>	1	35					5	36	N	
15320163	11	W47756	N		Wayne Panter		NW	SE	17	20	14	E	Kittitas	Qa	>	2	30					4	32	N	
15320122	11	10230	N		Eugene Ikola		NW	SW	27	20	14	E	Kittitas	Qa	>	65	5					20	70	N	
15320124	11	205685	N		Edward Bogachas		W/2	SW	27	20	14	E	Kittitas	Qa	>	4	76					24	80	N	
15320125	11		N		Ed Williams		NE	SW	27	20	14	E	Kittitas	Qa	>	55	30					7	85	N	
15320126	11	16265	N		Eugene Mingo		E/2	W/2	27	20	14	E	Kittitas	Qa		4	11	48	18	14	25	8	120	Y	
15320127	11	W087472	N		Rob Hawk		NW	NW	27	20	14	E	Kittitas	Qa	>	1	15	279	5			2	300	N	
15320128	11	80514	N		C. W. Christie		NW	NW	27	20	14	E	Kittitas	Qa	>	27	5	6	10	35	5	13	88	N	
15320129	11		N		Howard Cooper		SW	SE	27	20	14	E	Kittitas	Qa		295						1	300	Y	
15320130	11	W48131	N		Winton Hungerford		W/2	SE	27	20	14	E	Kittitas	Qa	>	2	10	2	12	2	30	18	60	N	
15320131	11		N		A.C. Mills, Sr.		W/2	SE	27	20	14	E	Kittitas	Qa	>	8	8	3	24			11	43	N	
15320132	11	W047096	N		Glen Parker		NE	SE	27	20	14	E	Kittitas	Qa	>	7	21	6	20	18	6	14	78	N	
15320133	11	W39175	N		Lammers		NE	SE	27	20	14	E	Kittitas	Qa	>	400	17					0	417	N	
15320134	11	W062860	N		Noel Barlament		SE	SE	27	20	14	E	Kittitas	Qa	>	2	16	342	20			120	380	N	
15320135	11	W45099	N		Noel Barlament		SE	SE	27	20	14	E	Kittitas	Qa		2	14	328					344	N	
15320150	11	G4-28804	N		Don Stepper		SE	NE	27	20	14	E	Kittitas	Qa	>	8	21	2	49	74	50		338	N	
15320151	11	W050320	N		Glen Parker		NE	NE	27	20	14	E	Kittitas	Qa	>	3	21	4	24			9	52	N	
15320152	11	W087957	N		Glen Parker		NE	NE	27	20	14	E	Kittitas	Qa	>	12	12	11	13			12	48	N	

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15320153	11	36431	N		Dan Arnett		NW	NE	27	20	14	E	Kittitas	Qa	>	80						20	80	N	
15320154	11	36431	N		Dan Arnett		NW	NE	27	20	14	E	Kittitas	Qa	>	80							80	N	
15320166	11	84402	N		Rawligh Parks		NE	NW	19	20	15	E	Kittitas	Qag		5						160	320	Y	
15320165	11	W087421	N		Trendwest		SW	NW	29	20	15	E	Kittitas	Qag		0	210	26				165	236	N	
14250017	11	21/6/36Q	N	95A	Len Bondy		SW	SE	36	21	6	E	King	Qvr_4	>	2	12	11	29	7	39	18	100	N	
14250018	11	G1-21691	N	95B	E. J. Ramolif		SW	SE	36	21	6	E	King	Qvr_4		40	23	3				51	66	N	
14250019	11	21-6-36R	N	96A	David Rauschenberg		SE	SE	36	21	6	E	King	Qvr_4	>	1	41	48	10			23	100	N	
14250020	11	21/D6-36R	N	96B	Jack LeGrande		SE	SE	36	21	6	E	King	Qvr_4		16	5					40	180	Y	
14250113	11	21-7E-3L	N	97	Edd Butler		NE	SW	3	21	7	E	King	Qvr_3	>	2	98					70	100	N	
14250092	11	21/07-4R	N	98	Dave Sihto		SE	SE	4	21	7	E	King	Qvt	>	3	30					15	33	N	
14250108	11	121/7E-4M	N	101	Carl Clifton		NW	SW	4	21	7	E	King	Qvr_4		4	46	82				74	132	N	
14250109	11		N	102	Dayle Wyatt		SE	SW	4	21	7	E	King	Qvt		53						70	330	Y	
14250117	11		N	100A	Ed Whitmore		NE	SW	4	21	7	E	King	Qvr_4		105						60	130	Y	
14250204	11	/7E-4L	N	100	Roger Lemieux		NE	SW	4	21	7	E	King	Qvr_4		30						71	480	Y	
14250118	11	21-7E-4E	N	104A	Weyerhaeuser Real Estate		SW	NW	4	21	7	E	King	Qvr_4		0	40	14	36	8		43	105	Y	
14250203	11	18693	N	104C	Walter Chambers		SW	NW	4	21	7	E	King	Qvr_4		5						65	168	Y	
14250119	11	21/7-4/E	N	104B	Ronald Spencer		SW	NW	4	21	7	E	King	Qvr_4		21						60	140	Y	
14250199	11	21/7E/4	N	103	Tom & Lisa Bunce		NW	NW	4	21	7	E	King	Qvr_4		0	42					40	137	Y	
14250107	11	11805	N	105	CWD - Sugarloaf		SE	NE	5	21	7	E	King	Qvr_4	>	95	10	30	21	4		57	160	N	
14250195	11		N	BDCH 1	Duncan Oil Company (oil and gas well)		SE	NE	5	21	7	E	King	Qvi	>		50								
14250090	11	21/07-06K	N	107	Bill Shimmel		SE	SE	6	21	7	E	King	Qvt	>	55	5						60	N	
14250106	11	W108317	N	106	Jeff Kirkland		SE	NW	6	21	7	E	King	Qvt		54						20	180	Y	
14250080	11	W42306	N	109A	Dale Curtis		SW	SW	8	21	7	E	King	Qvr		2	139					147	340	Y	
14250081	11	205399	N	109B	Chris Clegg		SW	SW	8	21	7	E	King	Qvr		26	73					135	340	Y	
14250206	11	W064770	N	109C	Russell Trossell		SW	SW	8	21	7	E	King	Qvr		5	9	9	29			82	280	Y	
14250082	11	21/07-8	N	108	Doug Walthers		S/2	SW	8	21	7	E	King	Qvr		128						140	379	Y	
14250083	11	19998	N	110A	Richard Ostrowski		NW	SW	8	21	7	E	King	Qvr	>	0	19	27	9	13	2	56	72	N	
14250084	11	67249	N	110B	Terry Kasberger		NW	SW	8	21	7	E	King	Qvr		2	16	5	12	43	29	79	222	Y	
14250085	11	21/07-10Q	N	116	WA St Parks & Rec. Comm.		SW	SE	10	21	7	E	King	Qvr_3	>	10	48					13	58	N	
14250086	11	W053797	N	117	Matthew Hawley		SE	SE	10	21	7	E	King	Qvr_3		3	3	20	42	5		100	185	Y	
14250093	11	21/07-10D	N	113B	Pietro Gotti		NW	NW	10	21	7	E	King	Qvr_3		31						43	160	Y	
14250205	11	W098825	N	113A	Dani Gatti		NW	NW	10	21	7	E	King	Qvr_3		22						40	180	Y	
14250094	11	43446	N	114B	Rainbow Trout Club		SE	NW	10	21	7	E	King	Qvr_3		51						8	56	Y	
14250095	11	W094353	N	114A	David Prator		SE	NW	10	21	7	E	King	Qvr_3		0	13					0	107	Y	
14250096	11		N	111A	R. Robertson/Grn R Tavern		N/2	SE	10	21	7	E	King	Qvr_3		38						85	220	Y	
14250097	11	21/07-10J	N	111B	Fred Rice		NE	SE	10	21	7	E	King	Qvr_3	>	3	97					52	100	N	
14250098	11	21/07-10J	N	111C	Larry Barrow		NE	SE	10	21	7	E	King	Qvr_3	>	1	16	18	5			13	40	N	
14250115	11	21/07-10G	N	115	Jon Shoemaker		SW	NE	10	21	7	E	King	Qvr_3	>	49	6	3				37	58	N	
14250116	11	21/07-10A	N	112	Kevin Higgins?		NE	NE	10	21	7	E	King	Qvr_3	>	55	5					45	60	N	

IDENTIFIER						LOCATION								WELL LOG											
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14250099	11	21/7/11M	N	118B	Don Winson		NW	SW	11	21	7	E	King	Qa	>	57	34					57	91	N	
14250100	11		N	118A	Joe Hodgson		SW	SW	11	21	7	E	King	Qa	>	35	47					72	82	N	
14250074	11	21/07-14N	N	127	MC Maresh		SW	SW	14	21	7	E	King	Tp		56						31	140	Y	
14250087	11	W056671	N	123	Jack Kay		NE	SW	14	21	7	E	King	Qvi_1		5						35	250	Y	
14250088	11		N	125	Leroy Schueller		SE	NW	14	21	7	E	King	Qvi_1		6	19	7				21	80	Y	
14250078	11	W058819	N	128	Daryl Harper		SW	NW	17	21	7	E	King	Qvr		0	135					111	140	Y	
14250079	11	W058820	N	128B	Daryl Harper		SW	NW	17	21	7	E	King	Qvr		0	95					61	100	Y	
14250063	11	21/07-20Q	N	129B	Mike Cunningham		SW	SE	20	21	7	E	King	Qvi_3		0	95					82	96	Y	
14250064	11	21/7/20Q	N	129A	George Walker		SW	SE	20	21	7	E	King	Qvi_3		37	49	9				80	100	Y	
14250066	11		N				SW	SW	21	21	7	E	King	Qvr_3	>		8								
14250067	11	21/07-21M	N	133A	Scott Paper Company		NW	SW	21	21	7	E	King	Qvr_2		0	82					76	125	Y	
14250068	11		N	133B			NW	SW	21	21	7	E	King	Qvr_2	>		11								
14250069	11		N				NE	SW	21	21	7	E	King	Qvi_1	>		27								
14250070	11		N				NE	SW	21	21	7	E	King	Qvi_1			0								
14250073	11	W065380	N	134C	Gary Palmer		NE	NW	23	21	7	E	King	Qvi_1		8						12	140	Y	
14250044	11	21/07-28N	N	137	Clifford Harmon		SW	SW	28	21	7	E	King	Qvr_3	>	81	29					92	110	N	
14250048	11	21/07-28M	N	136	Gary Barquist		NW	SW	28	21	7	E	King	Qvr_3	>	1	83	30	14			90	128	N	
14250050	11	21/07-28L	N	135	Robert Ross		NE	SW	28	21	7	E	King	Qvr_3		31						21	160	Y	
14250042	11	ACB318	N	144	Palmer Coking Coal Co.		SW	SW	29	21	7	E	King	Qvi_3	>	80	22					90	102	N	
14250043	11	21/07-29Q	N	141	Bob Gunderson		SW	SE	29	21	7	E	King	Qvi_3		56	4					41	60	Y	
14250057	11	ACB347	N	143	Palmer Coking Coal Co.		SW	NW	29	21	7	E	King	Qvi_3	>	0	8	82	27			90	117	N	
14250058	11	21-7E-29C	N	142	Palmer Coking Coal Co.		NE	NW	29	21	7	E	King	Qvi_3		0	8	84	23			92	135	Y	
14250059	11	ACB341	N	138	Palmer Coking Coal Co.		NW	NE	29	21	7	E	King	Qvi_3		7						40	240	Y	
14250060	11	W060282	N	139	Palmer Coking Coal Co.		SE	NE	29	21	7	E	King	Qvi_3		0	9	13				70	300	Y	
14250061	11	21/07-29A	N	140A	Greg Elmendorf		NE	NE	29	21	7	E	King	Qvi_3		80						50	80	N	
14250062	11	21/07-29A	N	140B	R. L. Rogers		NE	NE	29	21	7	E	King	Qvi_3	>	76	6					48	82	N	
14250041	11	44280	N	145	Arthur Hansen		SW	SE	30	21	7	E	King	Qvr_4	>	0	80					52	80	N	
14250028	11	21/7/31A	N	146	Tye Jones		NE	NE	31	21	7	E	King	Qvi_3	>	0	10	33	40			50	83	N	
14250021	11	21/07-32Q	N	151	James Heigaard		SW	SE	32	21	7	E	King	Qvr_3		103	15					71	118	Y	
14250025	11	21/07-32J	N	150	Bruce Burris		NE	SE	32	21	7	E	King	Qvi_3	>	0	98					79	98	N	
14250026	11	21/7/32-E	N	148A	Dana Egbert		SW	NW	32	21	7	E	King	Qvi_3		3	5	75	5			38	88	N	
14250027	11	21/7E/32	N	148B	Cumberland Manor		SW	NW	32	21	7	E	King	Qvi_3	>	3	8	39	10			20	60	N	
14250029	11	21/7E/32D	N	149A	Eric Kruse		NW	NW	32	21	7	E	King	Qvi_3	>	23	36					41	60	N	
14250030	11	21/7E/32D	N	149B	B&P Public Water System		NW	NW	32	21	7	E	King	Qvi_3	>	27	33	28	29			78	120	N	
14250031	11	21/7/32-C	N	147A	Peter McCowin		NE	NW	32	21	7	E	King	Qvi_3	>	2	33	16	21			50	72	N	
14250032	11	21/07-32C	N	147B	Richard Metzler		NE	NW	32	21	7	E	King	Qvi_3	>	60	20					50	80	N	
14250022	11	21/7E/33N	N	156	Gannon–Morris Water Supply		SW	SW	33	21	7	E	King	Qvr_3		110	6					70	116	Y	
14250023	11	ACB321	N	155	Tim Johnson		SE	SW	33	21	7	E	King	Qvr_3	>	3	6	23	19			26	51	N	
14250024	11	64821	N	154	Mark Toner		SE	SE	33	21	7	E	King	Qvr_1		5	5	2				5	12	N	

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14250035	11	21/07-33G	N	153	Warren Thompson		SW	NE	33	21	7	E	King	Qvr_3	>	3	62	15	2	12	5	50	99	N	
14250045	11		N	152B	Earl Knickerbocker		NW	NE	33	21	7	E	King	Qvr_3	>	23	76					62	99	N	
14250046	11	21/7E/33B	N	152A	Ken Hall		NW	NE	33	21	7	E	King	Qvr_3		2	6	6	24	3		4	171	Y	
14250036	11	41440	N	159	Ken Stowman		SW	NW	34	21	7	E	King	Qvr_1	>	5	51					32	56	N	
14250038	11	219433	N	157	Marco Davis		NW	SW	34	21	7	E	King	Qvr_1		12						70	260	Y	
14250039	11	21/07-34D	N	158B	Mark Warrender		NW	NW	34	21	7	E	King	Qvr_1	>	6	41					39	47	N	
14250040	11	21/07-34D	N	158A	Chas Becken		NW	NW	34	21	7	E	King	Qvr_1	>	73	8					67	81	N	
14250149	11		N	194	Walter Chambers		SW	SW	25	22	6	E	King	Qvr_6	>	56						6	59	Y	
14250150	11		N	193	Ron Davis		NW	SW	25	22	6	E	King	Qvr_6	>	18	22					9	40	N	
14250151	11	28177	N	191B	John Johnson		NE	SW	25	22	6	E	King	Qvr_6		3	4	7	6			6	40	Y	
14250192	11		N				SE	SE	25	22	6	E	King	Qvr_6	>		37								
14250125	11	14581	N	197	L-Bar Products Inc.		SW	SW	36	22	6	E	King	Qvt		0	9	27				27	36	N	
14250147	11	22/6-36F	N	195	Evor Morgan		SE	NW	36	22	6	E	King	Qvr_6		22	15						37	Y	
14250152	11	22/6-36A	N	196A	King Co. Water Dist. 105		NE	NE	36	22	6	E	King	Qvr_6	>	0	40	3				22	43	N	
14250201	11		N	196B	Fire District No. 43		NE	NE	36	22	6	E	King	Qvr_6	>	18	22					10	40	N	
14250178	11	AAJ366	N	218	King Co. CDBG		NE	NW	26	22	7	E	King	Qvr_3	>	3	219					96	222	N	
14250179	11		N				NW	NE	26	22	7	E	King	Qvr_3	>		25								
14250180	11		N				NW	NE	26	22	7	E	King	Qvr_3	>		21								
14250181	11	22/07-26	N	24	Bob Brothers		SW	NE	26	22	7	E	King	Qa		65						80	160	Y	
14250194	11	22/07-26D	N	223	Steve Brunette		NW	NW	26	22	7	E	King	Qvr_3	>	118	18					119	136	N	
14250166	11	19999	N	227	Richard Stolsig		NE	SE	27	22	7	E	King	Qvr_3		14	84	8	10	2		96	118	N	
14250176	11	22/07-27K	N	228	Douglas Connolly		NW	SE	27	22	7	E	King	Qvr_3	>	0	12	200	8			100	220	N	
14250196	11	6124358F	N	226	Stoneway Concrete		SW	NW	27	22	7	E	King	Qvr_4	>	0	137	13	58	6	64	203	288	N	
14250130	11		N				SW	SE	28	22	7	E	King	Qvr_4	>		1								
14250131	11	ABB727	N	230	Danica Browning		SW	SE	28	22	7	E	King	Qvr_4		0	37					35	180	Y	
14250133	11		N				S/2	SE	28	22	7	E	King	Qvr_4	>		91								
14250134	11		N	3	James Smith		SE	SE	28	22	7	E	King	Qvr_4		43	49					92	300	Y	
14250165	11	22/07/28	N	19	Ben Olson		NW	SW	28	22	7	E	King	Qvi		0	20	64	29			78	113	Y	
14250163	11	17428	N	40	Mike Brown		SW	NE	29	22	7	E	King	Qvi_5	>	5	23	67	19			59	114	N	
14250202	11	22/07-30F	N	234	Harlon Abraham		SE	NW	30	22	7	E	King	Qvr_6		18	6	1				8	25	N	
14250156	11	22/07/30R	N	235	Don Corey		SE	SE	30	22	7	E	King	Qvr_6		23	110	2				89	135	N	
14250158	11	22/07-30C	N	233B	Loren Mitchell		NE	NW	30	22	7	E	King	Qvt		31	16	9				18	56	N	
14250159	11	22/07-30	N	233A	Jim Polley		E/2	NW	30	22	7	E	King	Qvt	>	74						0	150	Y	
14250160	11	14487	N	233C	Associated Water System 12		NE	NW	30	22	7	E	King	Qvt	>	2	23	105	20	30	6	157	186	N	
14250197	11	22/7E/30A	N	232	Sam Jones		NE	NE	30	22	7	E	King	Qvt	>	0	20	10	5	58	69	120	165	N	
14250121	11	22-7-32L	N	240	Bob Hall		NE	SW	32	22	7	E	King	Qvi	>	30	40					48	70	N	
14250122	11	22-7-32K	N	239	Ronald Anderson		NW	SE	32	22	7	E	King	Qvi		1	6	71				85	420	Y	
14250123	11	22-7-32J	N	238	Todd Hammerstrum		NE	SE	32	22	7	E	King	Qvi		22	4					4	26	N	
14250127	11	22-7-32B	N	237	Lee James		NW	NE	32	22	7	E	King	Qvi	>	36	10					30	46	N	

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14250128	11	22-7-32A	N	236	Raymond Mielde		NE	NE	32	22	7	E	King	Qvi	>	28	6	21	5			18	60	N	
14250157	11	22-7-32E	N	215B	Ronald Anderson		SW	NW	32	22	7	E	King	Qvi		12	6	31				110	360	Y	
14250135	11	22/07-34C	N	4	Patrick Michaelson		NE	NW	34	22	7	E	King	Qvr_3		11						30	259	Y	
14250136	11		N				NE	NW	34	22	7	E	King	Qvr_3	>		6								
14250137	11	22/07-34B	N	242B & 18	James Garrick		NW	NE	34	22	7	E	King	Qvr_3		38	19	16				79	285	Y	
14250138	11	22/7E/34B	N	242A	Ron Laughlin		NW	NE	34	22	7	E	King	Qvr_3	>	7	54					220	401	Y	
14250139	11		N				NW	NE	34	22	7	E	King	Qvr_3	>		18								
14250140	11	22/7E/34	N	242C	Roy Myers		NW	NE	34	22	7	E	King	Qvr_3		4	90					86	260	Y	
14250141	11	22/07-34B	N	242D	Terrance Beirne		NW	NE	34	22	7	E	King	Qvr_3		23	12	50	3	3		83	160	Y	
14250142	11	22/07-34A	N	241A	Thomas Ehlke		NE	NE	34	22	7	E	King	Qvr_3		2	31					67	225	Y	
14250143	11	22/07-34A	N	241B	Gordon Ocha		NE	NE	34	22	7	E	King	Qvr_3		5	84					84	240	Y	
14250144	11		N				NE	NE	34	22	7	E	King	Qvr_3	>		11								
14250145	11		N				NE	NE	34	22	7	E	King	Qvr_3	>		12								
14250198	11	22/07-34C	N	242E	Albert Foss		NE	NW	34	22	7	E	King	Qvr_3		2	29	24				140	240	Y	
14250146	11		N				SE	NW	35	22	7	E	King	Qvr_3			16								
13260007	11		N		Peter Hammond		NW	SE	8	23	8	E	King	Qvt		14	10	7	6	3		14	43	Y	
13260009	11		N		Grant Tolleth		SW	SE	8	23	8	E	King	Qvt	>	4	3	9				23	240	Y	
13260003	11		N				SW	NW	10	23	8	E	King	Qa	>		13								
13260004	11	23/8E/10K	N		James Westlake		SE	NW	10	23	8	E	King	Qa	>	15	5	20				12	40	N	
13260071	11	23/8E/10Ki	N		Byron Moore		SE	NW	10	23	8	E	King	Qa	>	4	6	20	10			16	40	N	
13260005	11		N		Orr Potebnya		NE	NE	10	23	8	E	King	Qa	>	6	34					12	40	N	
13260008	11	23/08-10	N		Fred Fisher		NW	SW	10	23	8	E	King	Qa	>	20	29					17	49	N	
13260012	11	23/08/14D	N		Walt Hills		NW	NW	14	23	8	E	King	Qa		2	4	38				21	44	N	
13260015	11	23/08-14L	N		Al Chicklero		NE	SW	14	23	8	E	King	Qa	>	7	5	19	6			12	37	N	
13260010	11		N		Vern Tracy		NW	NW	15	23	8	E	King	Qa	>	41	12					13	53	N	
13260072	11		N		Carl Cangie		NW	NW	15	23	8	E	King	Qa		37	3	1				9	41	N	
13260014	11	23/08-15F	N		Walter Schaefer		SE	NW	15	23	8	E	King	Qa	>	23	32					12	55	N	
13260017	11		N				SE	SE	15	23	8	E	King	Qa			0								
13260018	11		N		Cascade Golf Course		SE	SE	15	23	8	E	King	Qa		9	27	7	17	9	20		160	N	
13260013	11		N		Dennis Hyltine		SE	NW	16	23	8	E	King	Qvt	>	64						140	400	Y	
13260071	11	23/8-16/f	N		H.L. Robinson		SE	NW	16	23	8	E	King	Qvt	>	3	26					9	29	N	
13260030	11	W098958	N		Robert VanWinkle		SW	NW	23	23	8	E	King	Qa		14	2	30				6	46	N	
13260040	11		N		Telephone Utilities of WA		SE	SE	27	23	8	E	King	Qvi_3		0	2	194					196	N	
13260042	11	23/08-34B	N		City of Seattle		NW	NE	34	23	8	E	King	Qvi_3	>	0	18	21	11	38	2	37	163	N	
13260043	11		N		John Boyce		NE	NE	34	23	8	E	King	Qvi_3		18	21					10	42	Y	

Appendix 5. Aggregate-producing geologic units

This appendix describes some geologic units that have been mined for construction aggregates and (or) that have potential to produce gravel or rock meeting the threshold criteria. This list is based on a reconnaissance investigation, and therefore some important units may have been overlooked. In order to provide data for engineers and geologists, these unit descriptions incorporate geological terms too numerous to be included in the glossary. The rocks and sediments listed below are described using the unit symbols and nomenclature from the most recent geologic map of the Snoqualmie Pass quadrangle (Tabor and others, 2000). Unit symbols used in DGER's digital geologic database (Washington Division of Geology and Earth Resources, 2001) are provided in parentheses.

Quaternary Sediments

Qa (Qa) **Alluvium**—Unconsolidated gravel, boulders, and sand deposited on the flood plains of major rivers. Clasts are composed of reworked glacial sediment, much of which is hard and durable granitic or volcanic material derived from Canada or the Cascade Range. This unit also includes a variety of weaker volcanogenic clasts derived from the central Cascades. Deposits of unit Qa are generally less than 50 feet (15 m) thick and do not contain significant gravel reserves, except where the unit can be mined together with nearby glacial gravels. Generally, gravel in this unit is discontinuous and interfingers with fine sand or clay. Consequently, it is easy to overestimate the volume of gravel available in any given alluvial deposit.

Alluvium is present throughout the study area. A total of 32 small pits and 20 larger mines produce from alluvium. The average reported Los Angeles Abrasion Test result for this unit is 22 percent.

Ql (Qls) **Landslide deposits**—Heterogeneous rubble deposits resulting from down-slope movement of sediment and rock. The size of particles varies greatly from deposit to deposit, from large boulders to silts and clays. Where mined, this unit is composed largely of talus.

Landslide deposits are present in all steeper parts of the study area. In the Snoqualmie Pass quadrangle, 22 small mines and 1 large mine have produced from this unit. Meaningful test data are not available for this unit, but each landslide contains a unique mixture of rock types.

Qvr, Qvr_{1-6} (Qgo) **Ice-age (Fraser Glaciation) glacial outwash**—Sand and gravel that are moderately to well sorted, stratified, and well bedded with silty sand to silty clay. These sediments were deposited in ice-age proglacial and ice-marginal environments. These deposits are made up of hard and durable clasts derived from Canada, the north Cascade Range, and local sources. However, much of the outwash in the Cedar and Green River channels is composed of andesite clasts (Kroft, 1972).

Outwash deposits are limited to the northwestern portion of the study area. Typical outwash deposits range from 50 feet (15 m) to more than 150 feet (45 m) in thickness. The large Cedar River outwash channel includes several large deposits and may reach 150 feet (75 m) in thickness (Brown and Caldwell, 1978). However, this great thickness probably includes older units and thin intervening till layers.

For the most part, mines within the outwash lie above the water table and cause relatively little environmental impact, except where they impinge on riparian zones. Preserved ice-age outwash channels are characterized by low elevation and gentle topographic relief. Consequently, potential sites for mining outwash can also be prime farmlands or zoned for rural five-acre tracts. These land uses are generally incompatible with mining. Most of the Cedar River outwash channel lies within the municipal watershed for Seattle.

A total of 26 small pits and 31 larger mines produce from the glacial outwash. It is the main producing interval in the North Bend–Cumberland complex. Los Angeles Abrasion and Washington Degradation Test values are typically less than 20 and 25 percent respectively (Appendix 3)

Qag (Qad_e) **Alpine glacial drift**—Includes sand, gravel, clay, and other sediments derived from outwash or till that were deposited by alpine glaciers and glacial meltwater streams. Alpine glacial drift also includes deposits from alluvial fans, slope wash, talus deposits, small fans, and bogs. For the most part, these deposits are younger than the continental glacial deposits (unit Qvr).

Alpine glacial drift is present in most valleys issuing from the Cascade Range. Nineteen large and 15 small mines in the Snoqualmie Pass quadrangle have extracted aggregate from this unit. It is the main producing unit in the Bullfrog complex. Test data are unavailable for this unit.

Miocene Volcanic Rocks

Tgn, Tgr_2 (Mvg) **Grande Ronde Basalt**—Fine-grained basalt that is commonly columnar- or hackly-jointed. A few interbeds of tuffaceous fine-grained sandstone, siltstone, and mudstone are present. Some of the flows display localized pillow zones. The flows generally have vesicular or brecciated flow tops, but the interiors of the flows consist of dense basalt, which is ideal for asphalt aggregate. In general, colonnades and entablatures contain the best rock. The flows are middle Miocene in age (16.5 to 15.0 million years).

Grande Ronde Basalt crops out only in the southeastern portion of the Snoqualmie Pass quadrangle and has been quarried in only three locations. However, this unit is the most important bedrock unit in eastern Washington and along the Columbia and Cowlitz Rivers southwest of the Snoqualmie Pass quadrangle. It has been extensively quarried in many other locations, where much of the unit consists of very high quality rock. In 13 quarries in the adjacent

Yakima 1:100,000 quadrangle (Weberling and others, 2001), Los Angeles Abrasion and Washington Degradation Test values average 20 percent and 72 respectively.

Tf (Mva, Mva_{fp}) **Fifes Peak Formation volcanic flows**—Heterogeneous volcanic flows, mudflow breccias, and volcaniclastic and sedimentary rocks. Porphyritic andesites, dacites, and basalt flows, which are typically 75 to 150 feet (23 to 46 m) thick and intensely fractured. Poorly developed columns (hexagonal pillars roughly 4 feet [1.2 m] in diameter and tens of feet high) are present, and some flows exhibit platy jointing that commonly facilitates excavation. The andesite contains some glass that can be detrimental to aggregate quality. Massive to well-bedded breccias contain andesite clasts similar to the flows. The volcaniclastic sandstones, siltstones and lapilli-tuffs are generally well bedded. Most of this unit consists of weak rock. The age of the Fifes Peak Formation is mainly early Miocene, but some late Oligocene rocks have been dated (Tabor and others, 2000).

This unit also includes the volcanic rocks of Cougar Mountain of Frizzell and others (1984). Thin, well-bedded sandy to silty units are found locally in these Miocene rocks. Feldspar and mafic phenocrysts are very common, and some flows display a glassy texture. Some minerals in the andesite and basalt show alteration to clay that may weaken the rock or create alkali-reactive mixtures that could degrade portland cement concrete.

Fifes Peak Formation flows are found in the south half of the Snoqualmie Pass quadrangle. Because of their proximity to the market, they are currently the most important source of quarried bedrock in the Snoqualmie Pass quadrangle. Scenic bedrock knobs that protrude out of the flat plain of Osceola mudflow deposits surrounding the town of Enumclaw are mostly Fifes Peak Formation. These knobs are particularly well suited to top-down quarry mining. The three biggest bedrock mines in the region, the Enumclaw, White River, and 410 quarries, produce from the Fifes Peak Formation. (See Table 3 and Appendix 3.) Additionally, rock from this unit has been mined in 186 small forest quarries. Los Angeles Abrasion Test data from 23 of these quarries average 25 percent.

Tfc (Mvt_{fp}, Mvt_{fpc}, Mvt_{fps}) **Fifes Peak Formation tuffs**—Mainly rhyodacite ash-flow tuff and well-bedded volcaniclastic sedimentary rocks. Alteration of this unit is locally so pervasive that original grain types and textures are not discernable. Tuffs are locally welded and exhibit crude columns. The rock in these units has been dated at about early Miocene.

These units are found in the south-central and southwestern part of the Snoqualmie Pass quadrangle. Despite the unfavorable lithologic characteristics, 23 quarries have used rock from these units. Most of the rock is used for forest road construction and maintenance. Data from 12 quarries give Los Angeles Abrasion Test results averaging 22 percent.

Miocene Intrusive Rocks

Tip, Tidp (Mian) **Aphanitic intrusive andesite, undifferentiated**—Gray to green hypersthene and clinopyroxene intrusive andesite with glass and clay alteration, and minor gray hornblende dacite or rhyodacite porphyry, granodiorite, and tonalite. The age is early to middle Miocene.

This unit occurs as small, localized outcrops in the central part of the Snoqualmie Pass quadrangle. This unit has been used for three large quarries and 11 smaller mines. Rock from this unit may be locally of high quality, but in some areas it has been adversely altered by weathering. Only one site had a reported Los Angeles Abrasion Test value, which is 33 percent.

Tsgg, Tsgs ($Migd_s$) **Granodiorite of the Snoqualmie batholith**—Granitic rock (granodiorite and tonalite) that crops out in the north-central part of the Snoqualmie Pass quadrangle. This batholith is probably several miles thick in many locations and of relatively uniform composition. For these reasons, this unit is probably among the largest construction aggregate resources in the state. The age of the unit is middle Miocene.

At least 27 quarries have used rock from this unit, but mostly for forestry applications or building Interstate Highway 90. Units Tsgg and Tsgs exceed several thousand feet in thickness and cover a large surface area. Los Angeles Abrasion Test results reported from five quarries average 21 percent. Aggregate is mined from talus in this unit, where Los Angeles Abrasion Test values do not meet the threshold criteria.

Tsgf (Mim_s) **Monzonite of the Snoqualmie batholith**—Fine-grained, highly-altered granitic rock (monzonite). The age of this unit is middle Miocene.

Three quarries have used rock from this unit; however, no test data are available.

Tiap (Mim_s) **Intrusive dacite**—Dacite porphyry, which includes some highly altered quartz-bearing volcanic rock and some porphyritic rhyolite that grades into medium-grained tonalite. The age of this unit is early Miocene.

Unit Tiap is exposed as small outcrops in the central part of the Snoqualmie Pass quadrangle, where it is used for forestry applications. Rock from this unit has been produced in at least 10 quarries, with Los Angeles Abrasion Test data for five quarries averaging 21 percent and ranging from 17 to 27 percent. At a sixth quarry, altered andesite and volcaniclastic clastic rocks yielded a Los Angeles Abrasion Test result of 55.

Tcr ($Migd_{cr}$) **Carbon River stock granodiorite**—Massive granodiorite and granodiorite sills, locally with a tonalite border phase. The Carbon River stock is a satellite of the much larger Tatoosh pluton. Both units probably extend to great depth. This unit is middle Miocene in age.

Unit Tcr crops out in the southwestern part of the Snoqualmie Pass quadrangle, and five small quarries have used rock from this unit. Test data are unavailable for this unit.

Tstn, Tit (Mit) **Tonalite**—Granitic rock (tonalite), a minor portion of which grades into granodiorite or quartz diorite. Some bodies of unit Tstn are texturally transitional to pyroxene andesite porphyry. Many small tonalite masses may be satellites of the Snoqualmie or Tatoosh batholiths. The age of this unit is late Oligocene to early Miocene.

Unit Tstn is found in small outcrops throughout the northern Snoqualmie Pass quadrangle. Rock from this unit has been quarried in seven locations; Los Angeles Abrasion Test values from four of these average 24 percent.

Tfci, Tfce, Tfrt, Tfst, Tfcr (Mir_{fp}) **Intrusive rhyolite of Clear West Peak, Fifes Peak Formation**—Chiefly intrusive rhyolite that is mostly gray to purple. In places, the rock is highly altered. This unit is included in the Clear West Peak complex by Fischer (1970). Rocks are conspicuously banded perpendicular to columnar joints, suggesting steep and varied flow layering or multiple dikes, and are locally intruded by andesite dikes. The rhyolite may be mostly intrusive, but it includes some erupted material. The age of this unit is early Miocene.

This unit is present in the southwestern part of the Snoqualmie Pass quadrangle. Seventeen quarries have used rock from this unit, including one large mine. Los Angeles Abrasion Test data have been provided from 10 of these sites and average 17 percent.

Miocene–Oligocene Volcanic Rocks

Teg ($MΦva_{eg}$) **Volcanics of Eagle Gorge**—Dark green to black andesitic and basaltic flows and flow breccias, minor tuffs, and volcanic sedimentary rocks. Lava flows variously exhibit platy jointing and columnar jointing; some areas exhibit vesicular tops, scoria, and amygdaloidal zones. The unit is late Oligocene to early Miocene in age.

Eagle Gorge volcanic rocks crop out in the central part of the Snoqualmie Pass quadrangle. Twenty-three forest quarries and three large mines have produced from this unit. Los Angeles Abrasion Test data for 15 of these quarries average 23 percent and range from 13 to 38 percent.

Miocene–Oligocene Intrusive Rocks

Tsm (MΦian, $MΦigb_s$) **Intrusive andesite and gabbro of the Snoqualmie batholith**—Intrusive andesite (DGER unit MΦian) and gabbro (DGER unit MΦigb) and minor dacite (Frizzell and others, 1984). This unit may be the chilled margin of a high-level cupola of the Snoqualmie batholith. Mapped bodies include closely spaced dike swarms. The rock, which is commonly altered to smectite and zeolite, has been dated as late Oligocene to early Miocene.

Six small quarries have used rock from this unit, but no test data are available.

Oligocene Volcanic Rocks

To, Tolk, Tv ($Φvc_{oh}$) **Ohanapecosh Formation**—Well-bedded, multicolored, volcanic- and crystal-lithic andesitic tuff and breccia, volcaniclastic sedimentary rocks, and minor flows. These flows alternate with massive tuff-breccia and subordinate rhyolite, basalt, and andesite flows. Numerous fission-track ages from zircon indicate the rocks were erupted 28 to 36 million years ago (late Eocene to Oligocene).

Many (189) small forest quarries and one large mine have used rock from the Ohanapecosh Formation. Los Angeles Abrasion Test results reported from 69 quarries average 25 percent and range from 14 to 45 percent.

Eocene Sedimentary Rocks

Tn, Tns (Ec_{2na}, Ec_{2nas}) **Naches Formation**—Predominantly sandstone and shale, but includes minor volcanic rocks such as rhyolite, andesite, and basalt flows and tuff, as well as breccia with interbeds of feldspathic subquartzose sandstone, siltstone, and rare coal. Although these rocks are mapped as sedimentary, it is likely that many of the pits and quarries produce from volcanic intercalations. The andesites and basalts are amygdaloidal in part, commonly columnar, and have brecciated, vesicular tops. Rhyolite is found as flow-banded flows or domes and minor ash-flow tuffs. The interbedded sedimentary rocks are coarse-grained micaceous feldspathic sandstone and argillite and laminated siltstone. Both volcanic and sedimentary rocks are thermally metamorphosed adjacent to Miocene plutons.

The Naches Formation crops out in the east-central portion of the quadrangle. One large mine and 31 small quarries have used rock from this unit. Los Angeles Abrasion Test data from 5 of these average 23. The only degradation test in the unit is 67.

Eocene Volcanic Rocks

Tpt, Tmp (Evc_t, Eva_{mp}) **Tukwila and Mount Persis Formations**—Fine crystalline volcanic rocks that are mostly very dark gray aphanitic alkalic basalts in poorly defined flows. Also included are andesitic intrusives, heterogeneous volcanic flows, breccias, and sedimentary rocks. Near Tiger Mountain, unit Tpt consists partly of a columnar-jointed sill 60 feet thick (T. J. Walsh, Wash. Divn. of Geology and Earth Resources, oral commun., 1999). The age of the Tukwila and Mount Persis Formations is late Eocene.

These units crop out in the northwestern parts of the quadrangle. Although most of the Tukwila Formation consists of weak, stratified volcaniclastic rock types, it includes local basaltic flows, a few of which are hard and durable. The Tukwila Formation is mapped on Plate 1 as a possible bedrock resource where cliffs or forest borrow pits suggest higher quality deposits. These rocks have been used by the Weyerhaeuser Company and Washington Department of Natural Resources for forest road construction. Quarried bedrock products are produced from 13 small mines used for forest road maintenance. Reserves are limited to those contained in two borrow pits. Quantitative rock quality data are not available.

Tbf (Evb_{fm}, Evb_{fmb}) **Basalt of Frost Mountain**—Dense black olivine basalt that weathers red and has localized columnar jointing and brown glass. The unit has minor white siliceous alteration. Its age is late Eocene; potassium-argon ages are 32 and 47 million years. The basalt of

Frost Mountain is correlative with the Teanaway Formation, which crops out farther north.

This unit crops out in the southeastern Snoqualmie Pass quadrangle and has been used locally for logging road construction and maintenance. At least 12 quarries have developed in this unit; however no strength or durability data are available. A railroad report (Newell Campbell, consultant, Yakima, Wash., written commun., 2000) indicates good quality aggregate, but most exposures are too remote to be of value. Strength and durability are not available for the Basalt of Frost Mountain.

Tnmc (Evt_{na}) **Mount Catherine Rhyolite Member of the Naches Formation**—Flow-banded rhyolite, welded, crystal-lithic ash-flow tuff, and feldspathic sandstone and shale interbeds. The unusual hardness of the rhyolite is probably due to recrystallization during intrusion of the Snoqualmie batholith. Basalt flows and breccia are found locally, as well as interbeds of coaly shale, rare volcanic-rich pebble conglomerate, and quartz pebble grit. The age of the unit is middle to late Eocene.

This unit crops out in the east central portion of the quadrangle. Eight small quarries in this unit have provided rock for logging road construction and maintenance. No analyses are available for this unit.

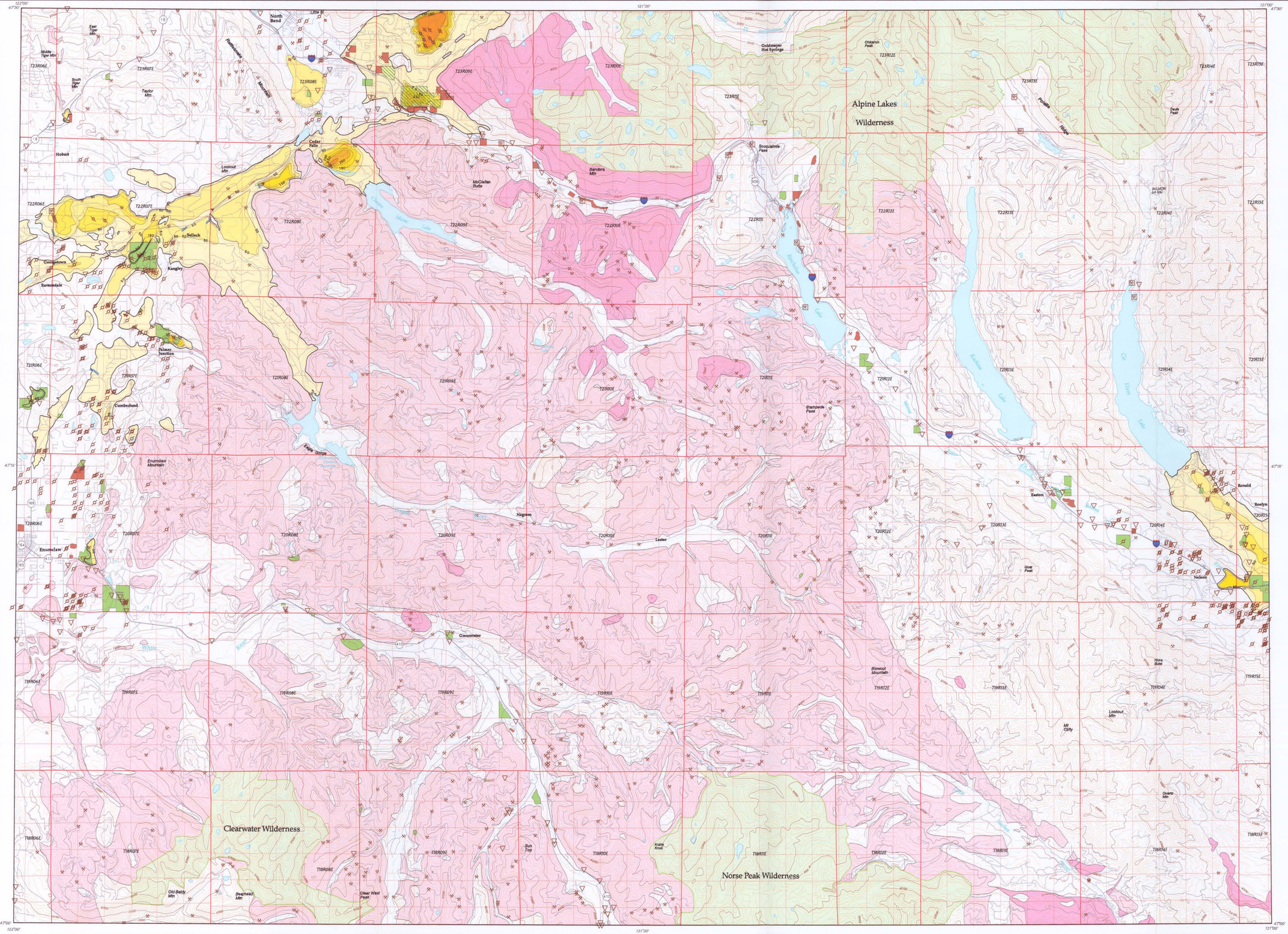
Tnr (Evr_{na}) **Rhyolite flows of Naches Formation, Cabin Creek block**—White to gray, flow-banded, platy jointed flows or domes of rhyolite from a few feet to hundreds of feet thick. Some rhyolite in this unit is probably intrusive. The unit contains minor interbeds of basaltic tuffs and flows and feldspathic sandstone. Fission track ages on zircon yield ages of 40 to 44 million years (middle Eocene).

This unit has been quarried at eight small mines for logging road construction and maintenance. Average Los Angeles abrasion and degradation analyses for four mines in unit Tnr are 29 and 22, respectively.

Tnb, Tnbg (Evb_{nap}) **Basalt of Naches Formation, Cabin Creek block**—Basalt and glomeroporphyritic basalt with interbeds of andesite and feldspathic sandstone and siltstone. The unit occurs as thick flows, in part with vesicular tops. It occupies a similar stratigraphic position to the Tukwila and Mount Persis volcanic rocks. This unit is middle Eocene to early Oligocene in age.

This unit crops out in the east-central portion of the quadrangle. Twenty small forest quarries have been developed in this unit, with Los Angeles abrasion and degradation analyses from four averaging 24 and 48, respectively.

Washington Division of Geology and Earth Resources
Ron Teissere, State Geologist
Information Circular 96
June 2002



WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

PLATE 1

LOCATION OF SOME SAND, GRAVEL, AND QUARRIED BEDROCK RESOURCES IN THE SNOQUALMIE PASS 1:100,000 QUADRANGLE, WASHINGTON

EXPLANATION

<50, 50-100, 100-150, 150-200, 200-250, 250-300, 300-350 — Potential extent of "hypothetical undiscovered" sand and gravel reserves, most of which meet threshold criteria for strength, durability, thickness, areal extent, and clast-size distribution, and are not buried under thick layers of overburden (See text for further explanation). Yellow and orange shades indicate approximate gravel thickness in feet.

50 — Contour showing possible thickness of some hypothetical gravel deposits meeting the threshold criteria (50-ft interval)

Potential extent of "speculative undiscovered" bedrock reserves, most of which meet threshold criteria for strength, durability, thickness, and areal extent, and are not buried under thick layers of overburden. (See text for further explanation)

Potential extent of "speculative undiscovered" bedrock reserves which locally meet the threshold criteria, but are composed mostly of weak lithologies that are unsuitable for construction aggregate

Large active mine. Includes intermittently operated sites and a few sites that may have been abandoned, but are not reported as such

Large depleted or abandoned mine

Large proposed mine

Small gravel pit, borrow pit, or quarry. Most of these mines are used for forest road maintenance or construction and/or do not significantly influence the market at this time

Depleted or abandoned small gravel pit, borrow pit, or quarry. Includes mines with terminated state reclamation permits, reclaimed sites, and mines that cannot be operated owing to changes in land use (for example, the site has been flooded by a reservoir)

Water well used in this study for subsurface information

Geotechnical or other borehole used in this study

Sampling site for laboratory test of strength and durability of gravel or rock. Does not include analyses from most mines (analyses from mines are described in Appendix 3)

Geologic observations used in this report

Stratigraphic section measured as part of this study

Section Grid

0 1 2 3 4 5
MILES

Scale 1:100,000

TOPOGRAPHIC CONTOUR INTERVAL 200 FEET

Lambert Conformal Conic Projection
1927 North American Datum
Washington State Plane Coordinate System, South Zone
Other base map information from the Washington Department of Natural Resources, Geographic Information System Database - 2000
Washington Division of Geology and Earth Resources

Map production by
Charles Caruthers and Phung Ho

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Plate 1