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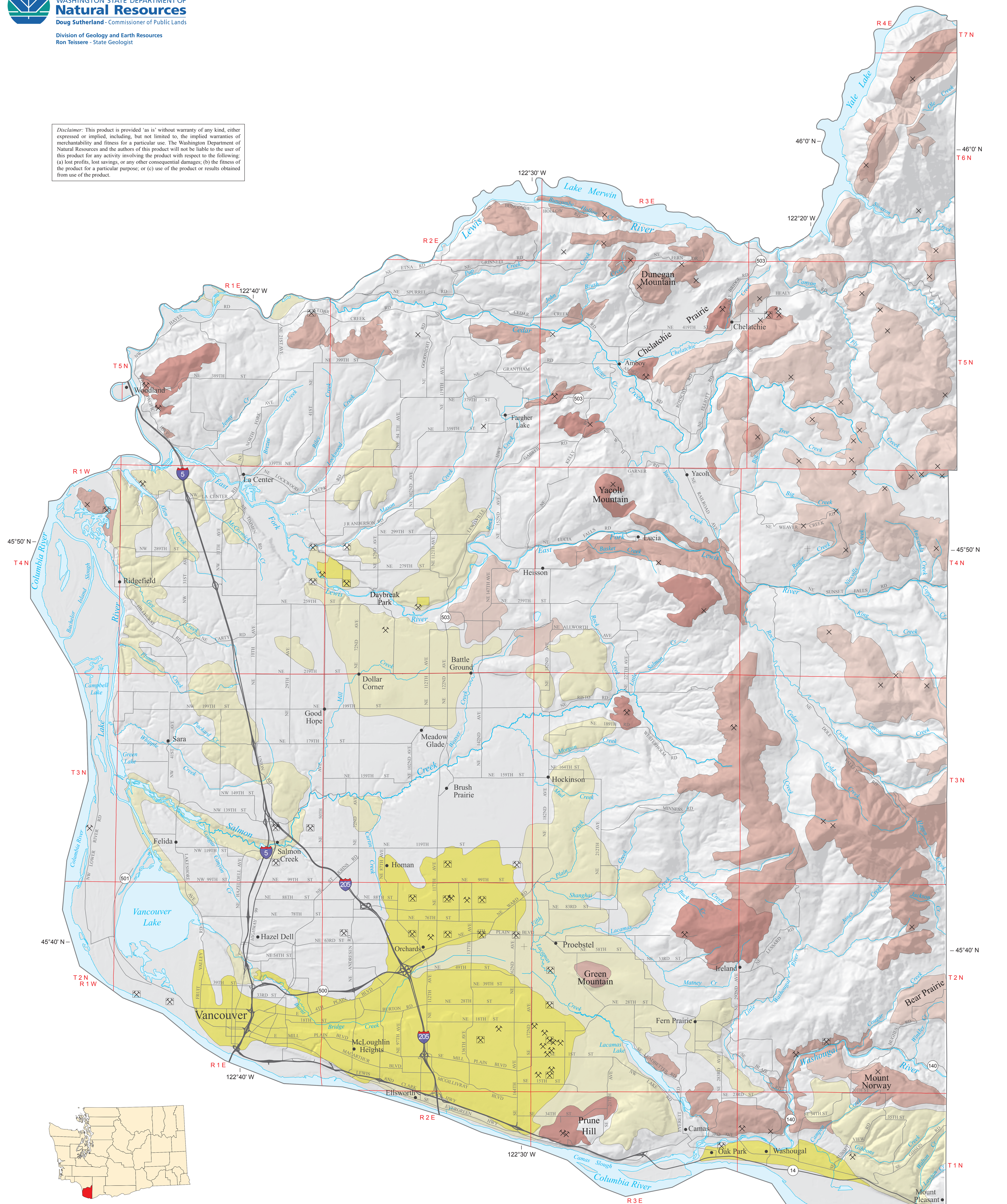

Lambert conformal conic projection
North American Datum of 1983 HARN
Shaded relief generated from U.S. Geological Survey 30-meter Digital Elevation Model, 2x vertical exaggeration
Map production by Rebecca A. Niggemann
Editing and layout by Jaretta M. Roloff

SCALE 1:100,000
MILES
KILOMETERS

Rock Aggregate Resource Lands Inventory Map for Clark County, Washington

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EXPLANATION

Resource		Definition
IDENTIFIED	Gravel, Bedrock	Identified resources are gravel or bedrock aggregate for which distribution, grade, and quality can be confidently estimated from specific geologic evidence, limited sampling, and laboratory analysis. Identified resources may include economic, marginally economic, and subeconomic components that reflect various degrees of geologic certainty. We map an identified resource where available data appear to satisfy all of the elements of our threshold criteria.
HYPOTHETICAL	Bedrock	Hypothetical resources are aggregate resources postulated to exist on the basis of general geologic information and aggregate test data and production history. We map hypothetical resources where available data appear to satisfy most but not all of the elements of our threshold criteria.
SPECULATIVE	Gravel, Bedrock	Speculative resources are aggregate resources for which geologic and production information is sparse and where rock types have not been evaluated for their aggregate potential. Nevertheless, inferences can be made from existing geologic mapping and data to suggest that these rock units may have the potential for meeting the threshold criteria established for this study and possibly contain future aggregate resources.

⚒ Bedrock or sand and gravel mine with an active surface mine reclamation permit (information current as of 2000)

⚒ Bedrock or sand and gravel mine with a terminated surface mine reclamation permit (information current as of 2000)

× Small bedrock quarry explored or used by the USDA Forest Service

Table 1. Important construction aggregate specifications established by WSDOT (2004). This investigation establishes threshold aggregate quality criteria based on laboratory test results for asphalt-treated base.

Laboratory test	Asphalt-treated base	Portland cement concrete
Los Angeles Abrasion (%) [a measure of rock strength]	<30%	<35%
Washington Degradation (%) [a measure of rock durability]	>15%	not used
Sand Equivalent (%) [a measure of the cleanness of a sample in terms of the proportion of silt and clay to sand and gravel]	>30%	not used
Percent Passing U.S. No. 200 Sieve (%) [<0.0029 in.]	2–9%	0–0.5%
Specific Gravity (g/cc)	>1.95	>1.95

Table 2. Land area covered by each rock aggregate resource category and the geologic map units included in the category. Geologic map units and symbols are from the DGER 1:100,000-scale digital geologic map coverage for Washington, which is online at http://www.dnr.wa.gov/geology/dig100k.htm.

Aggregate resource categories	Total land area (acres)	Geologic map unit	Geologic unit symbol
Identified gravel resource	27,729	Missoula flood gravel deposits	Qfg
		flood-plain alluvium	Qa
Identified bedrock resource	7,297	Skamania Volcanics, including younger diorite and quartz diorite intrusives	Φva_1 and Φva_2
		basalt at Prune Hill (Boring Volcanics)	$Q\Phi vb_{ph}$
Hypothetical bedrock resource	29,838	Goble Volcanics	ΦEvb_g
		Skamania Volcanics, including younger diorite and quartz diorite intrusives	Φva_1 and Φva_2
		Silver Star Granodiorite	$Migd_{ss}$
		intrusive andesite	Mia_{ss}
		Grande Ronde Basalt	Mv_g
		basalt at Green Mountain (Boring Volcanics)	$Q\Phi vb_{gm}$
		basalt at Bear Prairie (Boring Volcanics)	$Q\Phi vb_{bp}$
Speculative gravel resource	54,072	Troutdale Formation	ΦMc
		flood-plain alluvium	Qa
Speculative bedrock resource	25,889	Goble Volcanics	ΦEvb_g
		Skamania Volcanics	Φva_1 and Φva_2
		basalt at Mt. Norway (Boring Volcanics)	$Q\Phi vb_{mn}$
		basalt at Prune Hill (Boring Volcanics)	$Q\Phi vb_{ph}$
		basalt at Battle Ground (Boring Volcanics)	$Q\Phi vb_{bg}$

INTRODUCTION

The Growth Management Act (GMA) requires that local jurisdictions identify and classify aggregate and mineral resource lands from which the extraction of minerals occurs or can be anticipated. These lands should be classified on the basis of geologic, environmental, and economic factors, existing land uses, and land ownership. The Washington State Department of Natural Resources (WADNR), Division of Geology and Earth Resources (DGER), is preparing aggregate resource maps for selected counties using funds provided by the Legislature in the 2005 supplemental budget. These maps are primarily intended for use by local jurisdictions in implementing requirements of the GMA concerning designation of mineral resource lands. These maps may also be used by government agencies, the private sector, and the general public to identify areas where sand and gravel and bedrock might be extracted and used as concrete aggregate or asphalt-treated base.

The aggregate mapping and data presented in this publication provide local jurisdictions with information about the geologic factors used to classify mineral resource lands. In this study, rock aggregate resources are defined as naturally occurring gravel or bedrock aggregate estimated or inferred to exist on the basis of a favorable geologic setting, little or no sampling, and only general knowledge of past aggregate production (U.S. Bureau of Mines and U.S. Geological Survey, 1976). This study does not establish 'reserves', a process that requires detailed site-specific data defining quantity, overburden depth, grade, quality, and economic value determined by closely spaced drilling, sampling, and analysis. Such work is beyond the scope of this investigation and is usually performed by landowners or mine operators as they consider the potential profitability of developing a producing mine.

Our mapping shows the distribution of areas where aggregate resources are likely to be present. These areas may contain economic aggregate reserves. However, we cannot account for other factors, such as environmental conditions, road access, and existing residential density, that could affect the potential for mine development at a specific location. Our study focuses on rock resources used for concrete and asphalt aggregate purposes and does not consider building stone or industrial mineral uses. These other potential uses of rock products are currently of minor economic consequence; however, changing demand and market factors could alter this situation.

Because the primary purpose of our recent resource investigations is to assist GMA implementation, this aggregate resource map covers the entire county. Earlier aggregate resource maps published by DGER covered six 1:100,000-scale quadrangles (Loen and others, 2001; Weberling and others, 2001; Dunn, 2001; Norman and others, 2001; Lingley and others, 2002; Dunn and others, 2002). Those maps did not provide complete coverage of aggregate resources in areas under local government jurisdiction.

GEOLOGIC SETTING

The bedrock geology of Clark County is dominated by early Tertiary products of the Cascade volcanic arc, consisting primarily of intermediate to mafic lava flows, volcaniclastic rocks, and igneous intrusions (Phillips, 1987b; Evarts and Ashley, 1990; Evarts, 2002; Howard, 2002; Evarts, 2004 a,b,c,d). Following mild folding, faulting, and erosion of these bedrock units, the terrain at low elevation was inundated by voluminous lava flows of the Columbia River Basalt Group (including the Grande Ronde Basalt) between 16.5 and 15.6 million years ago (Snavely and Wells, 1996; Niem and Niem, 1985). Erosional remnants of the Grande Ronde Basalt are exposed in northwest Clark County along the Columbia River between the towns of Woodland and Ridgefield (Snavely and others, 1973; Phillips, 1987b; Evarts, 2004d).

Following emplacement of the basalt flows, the ancestral Columbia River and local tributaries transported silt, sand, and gravel into the subsiding Portland Basin—sediments that now form the Troutdale Formation (Mundorff, 1964). Clark County includes the northern part of the basin. The floor of this structural depression slopes west-southwest from central Clark County to a depth of 1800 ft at Vancouver (Tolan and Beeson, 1984; Beeson and Tolan, 1989; Swanson and others, 1993; Evarts and others, 2002).

About 100,000 years ago, basaltic eruptions produced small shield volcanoes and cinder cones between the Columbia River and the Battle Ground area (Hammond and Korosec, 1983; Fleck and others, 2002; Howard, 2002; Phillips, 1987b).

In eastern and northern Clark County, Pleistocene glacial sediments constitute overburden for much of the Tertiary bedrock. As much as 100 ft of these sediments occurs along the Chelatchie Prairie near Amboy (Mundorff, 1984; Phillips, 1987b). In latest Pleistocene time (15,300–12,700 years ago), one or more of the giant Lake Missoula floods raced down the Columbia River gorge and dispersed sediment loads northwestward across much of southwest Clark County. The resultant sand and gravel deposits are as much as 300 ft thick (Palmer and Poelstra, DGER, 2004, unpub. data; Phillips, 1987b; Waitt, 1985; Trimble, 1963). Recent fluvial sediments are deposited on the flood plains of modern rivers throughout Clark County (Mundorff, 1964; Phillips, 1987b; Trimble, 1963).

AGGREGATE RESOURCE MAPPING

Our aggregate resource evaluation is based on the most current geologic mapping available for the study area, aggregate test data obtained primarily from the Washington Department of Transportation (WSDOT), locations of historic sand and gravel or bedrock extraction provided by a variety of sources (including the WADNR, the U.S. Geological Survey (USGS), and local public works departments), interpretation of water well and geotechnical boring logs, and overlays of agricultural soils and topographic map information. However, these data are concentrated near existing population centers. Consequently, our evaluation of aggregate resources in undeveloped parts of the county is limited by a paucity of data. As more detailed geologic mapping and additional aggregate test data and water well logs become available for these areas and improved evaluations of aggregate resource potential are developed, this map will be updated.

Aggregate Resource Criteria

Our classification of aggregate resources is based on a set of criteria, modified slightly from Loen and others (2001), that addresses the potential quality, quantity, and suitability for mine development. These criteria are:

- The thickness of the sand and gravel or bedrock deposit must exceed 25 ft.
- The area of the deposit exposed at the surface must exceed 160 acres and measure at least 1500 ft across the minimum dimension of the deposit, or the reserves must exceed 10 million cubic yards. Exceptions may include unusually thick deposits, or resources of special local importance that have consistently yielded high quality aggregate.
- The 'stripping ratio' (ratio of overburden to gravel or overburden to bedrock) must be less than one to three (1:3).
- The strength and durability of the rock must meet the WSDOT minimum specifications for asphalt-treated base, a rock product used to construct some lower layers of asphalt roads (Table 1).
- Sand and gravel aggregate resources must contain the proper proportions of sand and gravel (ideally, a ratio of 40% sand to 60% gravel). Pebbles and cobbles must be clean, round, hard, durable, and chemically inert (Bates, 1969; WSDOT, 2004).

Aggregate Resource Categories

For both sand and gravel and bedrock aggregate deposits, we have mapped areas that fall within one of three resource categories: identified, hypothetical, and speculative resources. These categories reflect our level of confidence in our evaluation of the quality and quantity of these aggregate resource units.

- **Identified resources** are gravel or bedrock aggregate for which distribution, grade, and quality can be confidently estimated from specific geologic evidence, limited sampling, and laboratory analysis. Identified resources may include economic, marginally economic, and subeconomic components that reflect varying degrees of geologic certainty. We map an identified resource where available data appear to satisfy all of the elements of our threshold criteria.
- **Hypothetical resources** are aggregate resources postulated to exist on the basis of general geologic information and aggregate test data and production history. We map hypothetical resources where available data appear to satisfy most, but not all, of the elements of our threshold criteria.
- **Speculative resources** are aggregate resources for which geologic and production information is sparse and where rock types have not been evaluated for their aggregate potential. Nevertheless, inferences can be made from existing geologic mapping and data to suggest that these rock units may have the potential for meeting the threshold criteria established for this study and possibly containing future aggregate resources.

Aggregate Resource Mapping Methods

The delineation of aggregate resource areas was achieved by an objective, systematic procedure in which portions of geologic units likely to contain aggregate resources were selected, evaluated, and either accepted or rejected based the standard criteria established for this inventory. Sand and gravel resources and bedrock resources were mapped separately.

Sand and gravel resources were identified using geologic and National Soil Conservation Service soils maps (McGee, 1972; Fiksdal, 1975), water well logs (available online from the Washington State Department of Ecology at http://apps.ecy.wa.gov/welllog/), and thickness models from Palmer and Poelstra (unpub. data, 2004). In total, about 1400 water wells and 140 geotechnical borings were reviewed in the process of creating the source gravel and overburden thickness models and developing the resource map.

Bedrock units with potential for high strength and durability were identified from geologic maps and unit descriptions produced by DGER and the USGS; the geomorphic position of resistant bedrock as determined from lidar, DEMs, and aerial photographs; the location of aggregate mines (McKay and others, 2001), and the location of good quality test samples. (Rock strength and durability data are published online by WSDOT at http://www.wsdot.wa.gov/biz/mats/ASA/.) We field checked larger prospective bedrock areas to verify that resource targets would meet the resource criteria. Bedrock resource areas were then mapped on the basis of lithology, number of resistant rock units in contact, and their attitude, geometry, geomorphic expression, and structural discontinuities.

Polygons were digitized and attributed using ESRI ArcGIS. This allowed us to evaluate aggregate potential on a polygon-by-polygon basis and to perform spatial data queries. GIS analysis was used to select polygons larger than 160 acres having minimum widths of 1500 ft or more. Final polygons were individually evaluated and classified as identified, hypothetical, or speculative resources.

Overburden

Intense chemical weathering of geologic units in the western Pacific Northwest has developed saprolitic soil horizons locally as much 30 ft thick over both bedrock and basin-fill sediments. Weathered units are best exposed in steep cliff faces, landslide scarps, and streambeds (Evarts, 2002).

Alpine glacial sediments constitute overburden for much of the Tertiary volcanic bedrock in east and north Clark County. The thickest (>100 ft thick) and most extensive of these glacial sediments are present along Chelatchie Valley near Amboy (Mundorff, 1984; Phillips, 1987b). Although a few small aggregate mines have been developed in Pleistocene glacial outwash deposits in north and east Clark County, the product does not meet WSDOT specifications for asphalt-treated base because clasts are weathered and coated with iron oxide (Dethier and Bethel, 1981).

Summary of Results

The geology of Clark County is favorable for large sand and gravel resources and bedrock aggregate resources. The largest bedrock resources are hosted in Tertiary lava flows and intrusive rocks exposed along canyon walls and in the uplands of eastern and northern Clark County. The best sand and gravel aggregate resource is hosted in the Missoula outburst flood deposits of south central and southwest Clark County and in flood-plain alluvium in the vicinity of Daybreak Park on the East Fork Lewis River. Aggregate resources in Clark County are primarily hosted in 14 geologic map units. The total land area assigned to each resource category and a list of included geologic map units and their symbols is provided in Table 2. All geologic map unit symbols used below (unit Qa, for example) are from the DGER 1:100,000-scale digital geologic map coverage for Washington, which is available online at http://www.dnr.wa.gov/geology/dig100k.htm. Information describing these geologic units and the contacts between geologic units is from both the DGER 1:100,000-scale digital geologic map coverage and the USGS 1:24,000-scale geologic maps cited in this report.

INCLUDED GEOLOGIC MAP UNITS AND THEIR AGGREGATE POTENTIAL

The aggregate resource polygons generated for this map are subsets of larger geologic map units or combinations of geologic map units and represent rock types have desirable aggregate potential. For example, a bedrock polygon might contain basalt and andesite lava flows and a diorite intrusive, all of which are in contact and have high strength and durability.

Quaternary Sand and Gravel Units

Alluvial gravels of the East Fork Lewis River and Lewis River flood plains (unit Qa)—These deposits generally meet WSDOT specifications for asphalt-treated base. For 22 samples tested, the average Los Angeles (LA) Abrasion was 22.2%, Washington Degradation was 63.6%, and specific gravity was 2.7 g/cc. Identified gravel resources near Daybreak Park on the East Fork Lewis River flood plain are largely basalt and andesite clasts derived from upland Tertiary volcanic rocks and subordinate amounts of quartzite clasts eroded from the Troutdale Formation. Sand and gravel deposits form bars, channels, and terraced deposits that are typically less than 45 ft thick and locally up to 160 ft thick (Mundorff, 1964; Phillips, 1987b; Trimble, 1963).

Missoula flood gravel deposits (unit Qfg)—Missoula flood deposits yield high-quality aggregate that meets all WSDOT specifications for asphalt-treated base and Portland cement concrete. For 22 samples tested, the average LA Abrasion was 17.6%, Washington Degradation was 54.8%, and specific gravity was 2.4. The Missoula gravel deposit is an identified resource meeting minimum specifications for thickness, stripping ratio, and strength and durability. This resource is part of the greater upper Pleistocene Missoula flood deposit hosting large sand and gravel deposits in southwest Clark County between the cities of Camas and Vancouver. The Missoula gravels consist of well-rounded, well-sorted, foreset-stratified cobbles and boulders. The gravel is clast-supported and has a sandy matrix composed mostly of basalt, pebbles and cobbles, and smaller amounts of quartzite and granitic pebbles and cobbles. Missoula flood gravel deposits in Clark County are up to 300 ft thick (Palmer and Poelstra, unpub. data, 2004; Phillips, 1987b; Trimble, 1963).

Troutdale Formation (unit ΦMc)—A few mines have produced from a conglomerate unit deposited at the top of the Troutdale Formation. Sand and gravel clasts commonly retain a coating of iron oxide and clay after washing, and generally do not meet WSDOT specifications for asphalt-treated base and/or Portland cement concrete. However, oversize cobbles and boulders, when crushed, may meet WSDOT specifications for asphalt-treated base. Out of 14 samples tested, the average LA Abrasion was 18.4%, Washington Degradation was 44.8%, and specific gravity was 2.7. This conglomerate represents an upper member of the extensive alluvial deposits of the ancestral Columbia River system and adjacent Cascade highlands. The conglomerate is typically 90 to 150 ft thick and is made up mostly of basalt pebbles and cobbles, with lesser quartzite, granite, and schistose metamorphic clasts, in a fine-grained matrix of arkosic and vitric sand. The conglomerate is well sorted, with lenticular bedding, and is indurated to weakly consolidated. Gravel clasts are characteristically smooth, well rounded, and iron oxide stained (Mundorff, 1964; Phillips, 1987b; Trimble, 1963; Tolan and Beeson, 1984; Evarts, 2002).

Quaternary Bedrock Units

Boring Volcanics (basalt flows at Bear Prairie [unit $Q\Phi vb_{bp}$], Prune Hill [unit $Q\Phi vb_{ph}$], Green Mountain [unit $Q\Phi vb_{gm}$], Mount Norway [unit $Q\Phi vb_{mn}$], and the Battle Ground area [unit $Q\Phi vb_{bg}$])—The tops of these Quaternary lava flows commonly contain abundant vesicles, flow breccias, cinders, ash, and tuff and do not yield rock that meets WSDOT specifications for asphalt-treated base. However the interiors of the flows may be favorable for aggregate resources. For example, the basalt flow at Prune Hill (host for the Fisher Quarry, just west of the town of Camas) meets WSDOT specifications for asphalt-treated base. Out of four Prune Hill samples tested, the average LA Abrasion was 22.2%, Washington Degradation was 63.6%, and specific gravity was 2.7. The Boring Volcanics form small shield volcanoes, cinder cones, and lava flows, typically 50 to 100 ft thick. Composition ranges from basalt to basaltic andesite. Flow jointing ranges from platy to blocky, depending on silica content and individual flow characteristics (Hammond and Korosec, 1983; Fleck and others, 2002; Howard, 2002; Phillips, 1987b; Evarts, USGS, unpub. data, 2005).

Tertiary Bedrock Units

Grande Ronde Basalt (unit Mv_g) (Miocene)—No strength or durability data is available for unit Mv_g in Clark County. However, small quarries have been developed in dissected remnants of Grande Ronde Basalt along the Columbia River between the towns of Woodland and Ridgefield (Beeson and others, 1979; Phillips, 1987b; Wells and Niem, 1987; Evarts, 2004d). These rocks generally have very desirable engineering properties for most construction uses, and large quarries have been developed in the Grande Ronde Basalt across the Columbia River near Columbia City, Oregon (Gray and others, 1978). Grande Ronde (member of the Columbia River Basalt Group) is made up of dark gray to black basaltic andesite (Phillips, 1987b). Total thickness in Clark County may be as much as 100 ft but varies locally (Wells and Niem, 1987; Tolan, 1982; Evarts, 2004d).

Silver Star Granodiorite (unit $Migd_{ss}$)—No strength and durability data is available for the Silver Star Granodiorite in Clark County, and little aggregate mining has occurred in this unit to date. This granodiorite is typically light gray and porphyritic to equigranular. It is part of a northeast-trending belt of Miocene intermediate intrusions that extends from southeast Clark County into Skamania County (Korosec, 1987; Phillips, 1987b; Power and others, 1981; Felts, 1939).

Intrusive andesite (unit Mia_{ss})—There is no production history or strength and durability data available for unit Mia_{ss}. This andesite is light to medium gray with locally abundant visible pyroxene and plagioclase grains in a fine matrix (porphyry). It forms the chilled border zone of the Silver Star pluton and numerous other smaller shallow intrusive bodies of similar composition and texture in the eastern third of Clark County (Phillips, 1987b).

Miscellaneous diorite and quartz diorite intrusive bodies (lumped for convenience with unit Φva_2)—Diorite and quartz diorite intrusive bodies have a history of crushed aggregate production in northeast Clark County. Two samples of quartz diorite from Yacolt Mountain yielded LA Abrasion test results of 22.8% and 27.2%, and Oregon Degradation test results of 17.7% and 18.4% (Rotschy Inc. of Yacolt, Wash., unpub. data, 2005). Evarts (2005) mapped Tertiary diorite and quartz diorite in northeast Clark County at Buncombe Hollow Creek, Chelatchie Prairie, Dunegan Mountain, and Yacolt Mountain. These intrusive rocks had not been mapped when the original DGER 1:100,000-scale digital geologic map coverage was compiled, hence their inclusion in unit Φva_2. Recent mapping by Evarts (USGS, unpub. data, 2005) shows that they are younger than the Skamania volcanic rocks. These rocks are typically porphyritic to equigranular and form erosion resistant knobs and ridges.

Volcanic rocks locally known as the Skamania Volcanics (unit Φva_2) (upper Oligocene)—Lavas and sills within unit Φva_2 have a history of aggregate production (currently mined at the Finn and Chelatchie Prairie quarries and numerous small forestland quarries). Lava flows and sills meet all WSDOT specifications for asphalt-treated base, where they are not intensely weathered. Out of 22 samples tested, the average LA Abrasion was 22.2%, Washington Degradation was 63.6%, and specific gravity was 2.7. The unit includes dark gray basaltic andesite that commonly has visible plagioclase grains in a very fine matrix and forms massive, dense, blocky to platy jointed lava flows or sills. Lava flows are locally interlayered with mechanically weak volcaniclastic rocks (Phillips, 1987b; Howard, 2002; Evarts, 2004a,b,c,d; Evarts, USGS, unpub. data, 2005). These weak rocks may locally constitute overburden to aggregate resources.

Volcanic rocks locally known as the Skamania Volcanics (unit Φva_1) (lower Oligocene)—Out of 22 samples tested, the average LA Abrasion was 22.2%, Washington Degradation was 63.6%, and specific gravity was 2.7. Unit Φva_1 is made up of dark gray andesite and basaltic andesite lava flows and sills that have a very fine matrix with occasional visible pyroxene and plagioclase grains. Flows are typically massive and blocky to platy jointed and interlayered with mechanically weak rocks consisting of massive flow breccias and volcaniclastic rocks. These weak rocks may locally constitute overburden to aggregate resources (Phillips, 1987a,b; Evarts, 2004 a,b,c,d).

Goble Volcanics (unit ΦEvb_g)—Although no test data is available for Clark County, flow centers in the Goble Volcanics have been mined in adjacent Cowlitz County, and may locally meet WSDOT specifications for asphalt-treated base. Local zeolite and chlorite alteration may render portions of flows unsuitable for use as asphalt-treated base aggregate (Wise, 1970; Tschernich, 1986; Evarts and others, 1987; Evarts and Swanson, 1994). The Goble Volcanics (upper Eocene to lower Oligocene) are comprised of a thick sequence of basalt, andesite, and dacite flows and flow breccias and thin interbeds of red-brown siltstone, sandstone, conglomerate, and tuff throughout northern Clark County. Lava flows have abundant gas bubble voids at their tops, and flow breccias commonly develop dense lenticular flow centers. Prospective bedrock aggregate resources occur locally within dense flow centers, which are typically blocky to platy jointed and have well-developed columnar jointing or colonnade-entablature structure. Individual flow units are typically 15 to 30 ft thick; however, some flows may be as much as 80 ft thick (Phillips, 1987b; Evarts and Swanson, 1994; Evarts and Ashley, 1990; Evarts, 2004a,b,c,d).

USING THIS MAP FOR LAND-USE PLANNING

Areas that we classified as identified resources have sufficient data to indicate that all of the aggregate resource criteria are satisfied. Generally these areas contain a large proportion of the commercial aggregate mines within the area of our investigation. Areas delineated as hypothetical resources cannot be confirmed to meet all of our established criteria based on the available data, although commercial aggregate mines may be operating within these resource areas. There is sufficient data to indicate that most, but not all, of our threshold criteria are satisfied, and that there is a strong likelihood that these areas contain a significant aggregate resource.

Areas identified as speculative resources have evidence of historic use as an aggregate source (that is, locations of small pits or quarries) and a favorable geologic setting. These factors indicate that there may be some potential for aggregate resource that cannot be disregarded. However, there is not sufficient data in these areas to evaluate the criteria used in our resource classification scheme. We must emphasize that areas delineated as speculative may contain a significant aggregate resource.

If our resource map is used in the delineation of mineral resource lands as part of GMA implementation, we recommend that the areas shown as identified and hypothetical resources be considered for the designated resource areas. We also recommend that landowners be allowed to initiate designation of mineral resource lands based on information specific to a particular parcel or area of ownership. This would allow the inclusion of areas that we have classified as speculative resources because of a lack of data. This procedure would require that the landowner provide data indicating that the areas proposed for inclusion as mineral resource lands do satisfy our classification criteria. For more information on implementation of the GMA for mineral resource lands, see Lingley and Jazdzewski (1994) in the growth management issue of *Washington Geology* [http://www.dnr.wa.gov/geology/pubs/washgeol/2news94.pdf]. They have reviewed Washington's aggregate resources and offer helpful suggestions to local jurisdictions.

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