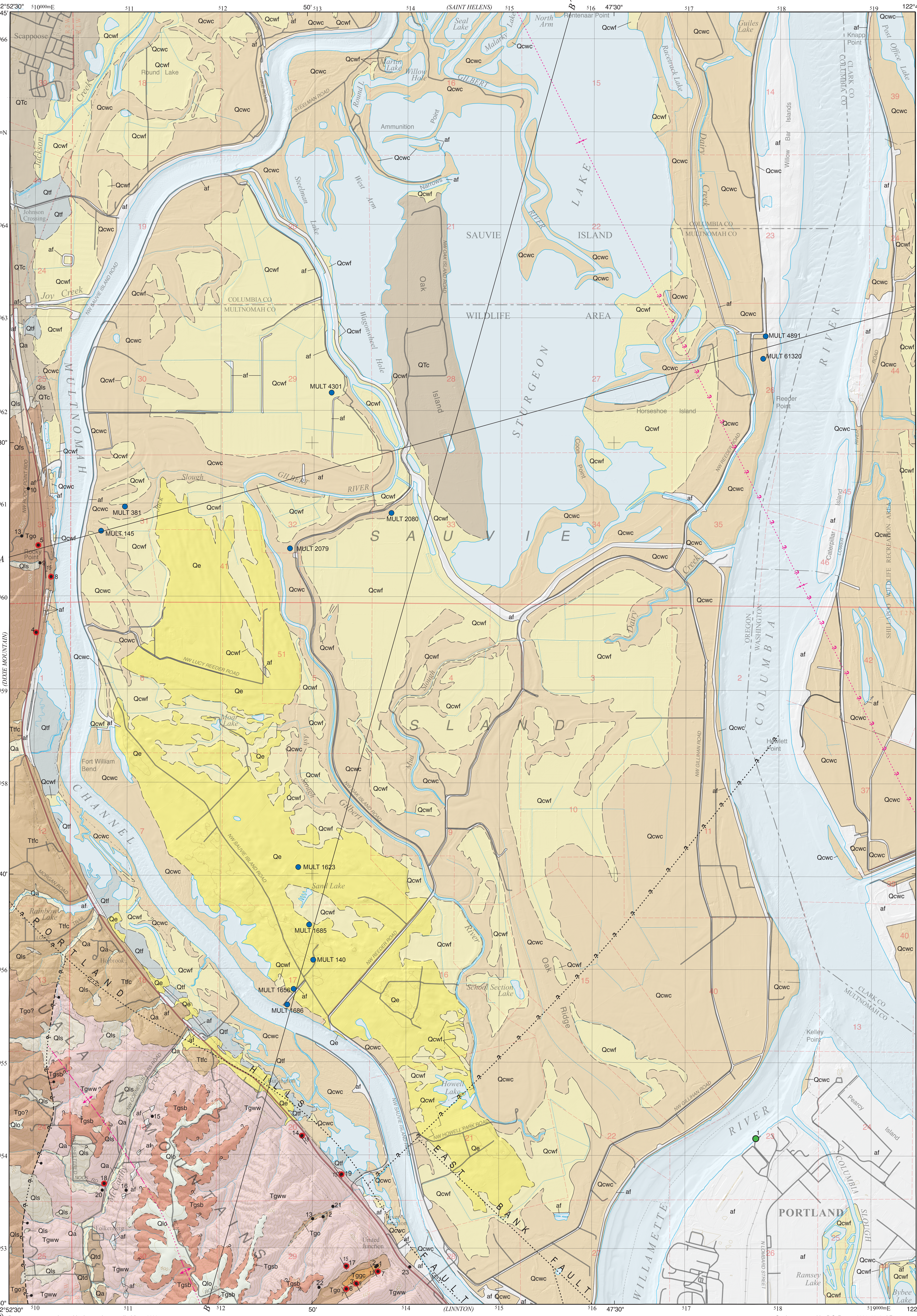
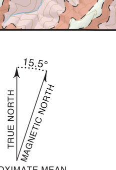


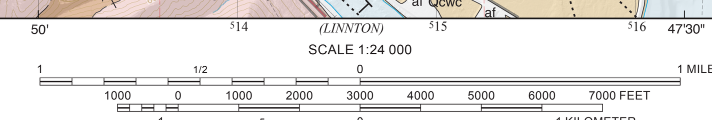
Base map topography and hydrography compiled from 2009 National Agriculture Imagery Program orthoimagery and from lidar surveys acquired in 2005 and 2009 by U.S. Army Corps of Engineers and in 2007 by Clark County, Washington

Cultural data derived from U.S. Census Bureau TIGER files and political boundaries from U.S. Geological Survey 2011 Sauvie Island digital topographic quadrangle

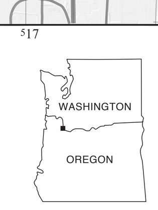
Data frame projection and 1000-meter grid: Universal Transverse Mercator, Zone 10, North American Datum 1983 (NAD83). Corner ticks for 7.5' quadrangle NAD83 shown in blue

Geologic data compiled to NAD27 quadrangle boundaries





CONTOUR INTERVAL 50 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1988



MAP LOCATION

Geology mapped by R.C. Evarts, 2004–2012; J.E. O'Connor, 2008–2012; C.M. Cannon, 2010–2012; and I.P. Madin, 2008; assisted by P.A. Dinterman, 2004

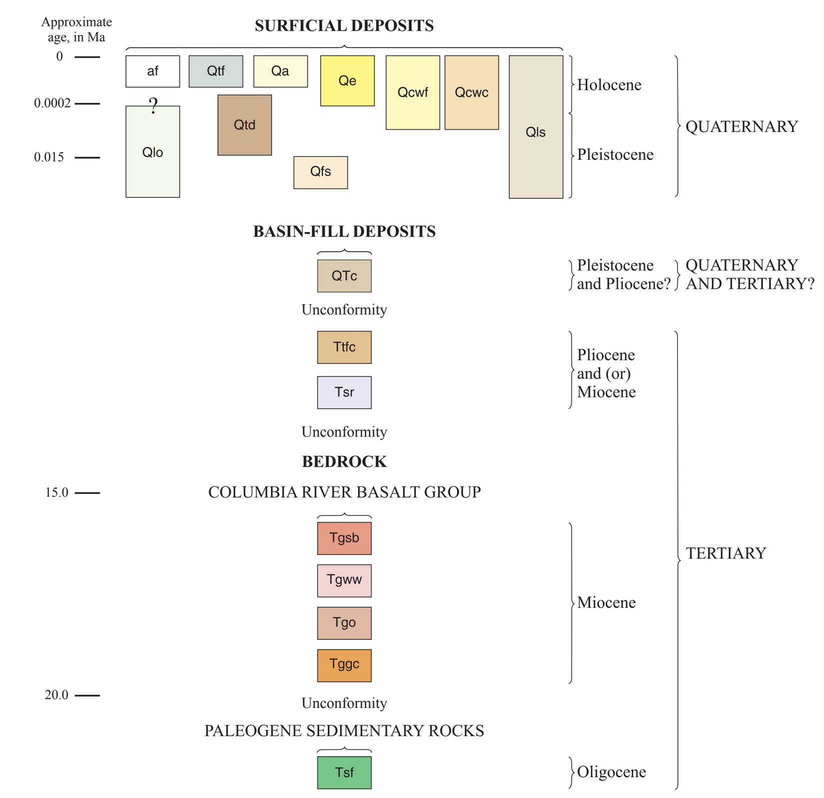
Digital cartography by C.M. Cannon, J.F. Mangano, and K.L. Wheeler

Edited by Kate Jacques and Taryn A. Lindquist

Manuscript approved for publication December 16, 2015

CORRELATION OF MAP UNITS

[Age of epoch boundaries from GTS2012 (Gradstein and others, 2012)]



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

af **Artificial fill (Holocene)**—Unconsolidated soil, sand, and gravel that underlie industrialized floodplain areas of northern Portland, Oreg., and Vancouver, Wash.; mounds of sand and minor gravel from channel dredging that flank Columbia River; and earth and crushed rock for highway and railroad beds, levees, and small dams

Qff **Fan deposits from tributaries (Holocene and Pleistocene)**—Unconsolidated silt, sand, and gravel in small fan-shaped accumulations from steep drainages in Tualatin Mountains. Most fans are younger than 2,000 years, inferred from relation with the Columbia River and Willamette River floodplain deposits (Qcwc and Qcwf). Poorly exposed, but likely composed of silt, sand, and gravel diamicts deposited by debris flow and stratified sediment deposited by streamflow

Qa **Alluvium of tributay floodplains (Holocene and Pleistocene)**—Unconsolidated sand, gravel, and organic-rich mud along rivers and creeks within Tualatin Mountains. Locally upstream of landslides, indicating deposition in landslide-dammed valley bottoms

Qe **Eolian deposits (Holocene)**—Unconsolidated, massive fine sand and silt forming dunes and benches cresting Unconsolidated, massive fine sand and silt forming dunes and benches that crest as much as 24 m (79 ft) above sea level. Mostly quartzofeldspathic sand that contains muscovite and minor lithic fragments. Forms undulating, apparently wind-fluted topography of southwestern Sauvie Island; locally mantles low benches at base of Tualatin Mountains, where mapped bodies may include the (compositionally similar) cataclysmic-flood deposits, sand and silt facies (Qfs). No evidence of modern sand accumulation or dune activity exists. Oxidized surface soils are as thick as 2 m on Sauvie Island dunes, indicating stability for hundreds or thousands of years. Well logs indicate that dune sand generally extends to depths of 10 to 20 m (33–67 ft) below sea level, locally to 30 m (100 ft) below sea level, suggesting that they began forming as long as 9,000 years ago according to elevations of dated Holocene floodplain deposits along lower Willamette River (Peterson and others, 2011). Likely formed by easterly winds that entrained Columbia and Willamette River beach and bar sands during periods of low water

Columbia River and Willamette River floodplain deposits (Holocene and Pleistocene)—Unconsolidated sediment of floodplain, islands, and bars of Columbia and Willamette Rivers at elevations mostly less than 10 m (30 ft) above sea level; largely composed of quartz, feldspar, and conspicuous muscovite, indicating Columbia River provenance. Upper elevation of deposits approaches limits of historical flooding before 20th-century river regulation and floodplain diking. Most deposits above modern low-water river level (about 5 ft [(1.5 m)] above sea level in map area) are younger than 2 ka. Deposits at depth likely to be as old as 16 ka (Baker and others, 2010). Well logs and seismic-reflection profiles show that fine-grained valley fill beneath historic floodplain locally extends to 65 to 70 m (210–230 ft) below sea level in and near map area (Gates, 1994; Pratt and others, 2001; Peterson and others, 2011). These deposits resulted from river aggradation since last-glacial sea-level lowstand of about 16 ka

Qcwf **Silt and clay facies**—Silt, clay, and fine sand deposited in low-lying areas of Columbia River floodplain at elevations below 3 m (10 ft). Includes areas of drained lake beds on Sauvie Island. Bank exposures, auger holes, and trenches show silt, clay, and organic materials in horizontal laminae typically 1 to 20 mm thick

Qcwc **Sand facies**—Sand and silt of ridge and swale topography and natural levees flanking floodplain chSand and silt of ridge-and-swale topography and natural levees that flank floodplain channels, commonly as much as 9 m (30 ft) above sea level. Ridges and swales consist of en echelon point bars or natural levees, indicating migration of Columbia River and secondary channels like Multnomah Channel. Exposed stratigraphy outside map area shows stratified fine to medium sand, in layers as thick as 30 cm, alternating with silty sand. Subhorizontal and inclined beds indicate deposition by both vertical and lateral accretion. Higher sandy deposits that flank meandering floodplain channels are natural levees and crevasse splays from overbank flooding

Qls **Landslide deposits (Holocene and Pleistocene)**—Diamicts of angular bedrock and surficial debris transported downslope en masse by semicoherent slumps, rockslides, earthflows, and debris flows. Many mapped landslides head at arcuate scars and exhibit subhorizontal tops, bulbous toes, and hummocky surfaces. Large landslide complexes are present along McCarthy Creek

Qtd **Terrace deposits (Holocene and Pleistocene)**—Unconsolidated silt, sand, and gravel that form benches along McCarthy Creek in Tualatin Mountains. Not exposed at surface but mapped by morphology. Likely consists of stratified deposits of streams and diamicts of debris flows

Qlo **Loess (Holocene? and Pleistocene)**—Massive unconsolidated deposits of light-gray to buff, micaceous, quartzofeldspathic eolian clay, silt, and fine sand on upland areas of Tualatin Mountains; contains granules and small pebbles; locally capped by strongly developed red soils. Forms mantle as much as 12 m thick along ridgetop southwest of Multnomah Channel that overlies the Sentinel Bluffs Member of the Grand Ronde Basalt (Tgsb). Probably deposited during several episodes throughout late Quaternary time; luminescence ages from similar loess deposits outside map area range from greater than 79 ka to 39 ka. Radiocarbon ages on eolian silt on upland areas near Ridgefield, east of map area, indicate episodic deposition throughout Holocene (Punke and others, 2011). Equivalent to the loess of Trimble (1963) and the Portland Hills Silt of Lentz (1981)

Qfs **Cataclysmic-flood deposits, sand and silt facies (Pleistocene)**—Unconsolidated, light-brown to light-gray silt, clay, and fine to medium sand. Mappable accumulations are sparse in map area, but thin deposits likely discontinuously mantle surfaces as high as 120 m (400 ft) elevation in Tualatin Mountains. Difficult to map because of similar appearance and composition to loess that covers most upland surfaces. Fresh exposures regionally show many 0.25- to 1.5-m thick, fining-upward sequences of ripple cross-stratified very fine sand grading up to massive, bioturbated clayey silt, locally as thick as 30 m. Sand is composed of quartz, feldspar, basalt fragments, and mica, showing Columbia River provenance. Interpreted as slack-water sediment that settled from temporarily ponded floodwaters during colossal outburst floods caused by repeated failure of ice dam at Clark Fork River that formed Pleistocene Glacial Lake Missoula in western Montana (Bretz, 1925, 1959; Bretz and others, 1956; Trimble, 1963; Allison, 1978; O'Connor and Baker, 1992; Benito and O'Connor, 2003). Regionally correlates with Trimble's (1963) Quaternary lacustrine deposits. Radiocarbon and tephrochronologic data outside map area indicate depositional ages of 20 to 15 ka (Waitt, 1985, 1994; Atwater, 1986; Benito and O'Connor, 2003; Clague and others, 2003; O'Connor and Benito, 2009). Regionally, coarse bedload deposits and fine slack-water deposits mapped separately (Evarts and O'Connor, 2008, 2013), but only fine facies is present in map area

BASIN-FILL DEPOSITS

QTc **Unnamed conglomerate (Pleistocene and Pliocene?)**—Unconsolidated to semiconsolidated pebble conglomerate. Underlies Oak Island and benches as high as 15 m (50 ft) elevation in northwestern part of map area. Oak Island exposure apparently correlates with subsurface gravel surface that separates deeper fine-grained fill beneath Multnomah Channel and Columbia River, and it is probably contiguous in subsurface with benches in northwestern part of map area that extend north as broad gravel terrace that underlies Scappoose (Gates, 1994; Evarts, 2004a; see also, fig. 4, cross section A–A'). Sparse well-log data show that gravel is locally thicker than 41 m. Poorly exposed in map area, but better exposures in gravel quarries near Scappoose to north show subhorizontal layers 0.5 to 2 m thick of clast-supported, round-cobble gravel that has sandy matrix. Cobbles are diverse lithologies that include quartzite and granitic rocks of upper Columbia River provenance. Layers are locally defined by sets of north-dipping foresets, and they are in places separated by horizontal lenses of micaceous quartzofeldspathic sand as thick as 30 cm. Many fine-grained volcanic clasts in surficial oxidized zone have weathering rinds as thick as 2 to 6 mm, and rare clasts have rinds as thick as 1 cm. No age data from within map area, but ages of clast weathering, of overlying cataclysmic-flood deposits, and of luminescence from quarries near Scappoose indicate late Quaternary age of 80 to 15 ka for upper 8 m of this gravel; deeper gravel may be much older

Ttfc **Troutdale Formation, conglomerate member (Pliocene and(or) Miocene?)**—Consolidated, well-sorted, clast-supported pebble and cobble conglomerate. Largely composed of well-rounded clasts from rocks of the Columbia River Basalt Group, as well as minor, but persistent, clasts of quartzite and also granitic and felsic metamorphic rocks. Sparse interbeds of volcanic-lithic and micaceous quartzofeldspathic sandstone. Poorly exposed in map area; mapped on flanks of Tualatin Mountains where well logs indicate cemented gravel and sand overlie the Columbia River Basalt Group and where temporary construction exposures show sand and gravel intensely weathered to depths of several meters. Equivalent in part to upper member of the Troutdale Formation of Mundorff (1964) and lower member of the Troutdale Formation of Tolan and Beeson (1984). Early Pliocene to late Miocene age inferred from stratigraphic relations outside quadrangle (Trimble, 1963; Tolan and Beeson, 1984)

Tsr **Sandy River Mudstone (Pliocene and (or) Miocene)**—Semiconsolidated, well-bedded sandstone, siltstone, claystone, and minor quartzite-bearing conglomerate, pumice-lapilli tuff, and lignite. Planar and trough crossbeds and cut-and-fill structures within sandy horizons indicate fluvial deposition. Age is poorly known but probably is late Pliocene to middle Miocene on basis of relations elsewhere in Portland Basin (Evarts, 2004c; Evarts and O'Connor, 2008; Evarts and others, 2009a). Shown in cross section only

BEDROCK

COLUMBIA RIVER BASALT GROUP

Grande Ronde Basalt (Miocene)—Light-gray to black flows of tholeiitic basaltic andesite; vesicular to microvesicular, aphyric to microphyric to very sparsely plagioclase-phyric; exhibit relatively low-TiO_2 contents that are characteristic of the Grande Ronde Basalt of the Columbia River Basalt Group (Swanson and others, 1979; Mangan and others, 1986; Beeson and others, 1989; Reidel and others, 1989; Reidel and Tolan, 2013). Flows in this quadrangle are deeply weathered; where exposed in roadcuts and quarries, flows display hackly (entablature) to blocky to columnar-jointed patterns and vesicular flow tops; pillow lava locally present at base. Typical samples are intergranular to intersertal, containing lathlike plagioclase, granular clinopyroxene, and Fe-Ti oxide crystals in sparse to abundant dark glass; some flows contain rare plagioclase phenocrysts and glomerocrysts as long as 5 mm. Textures resemble those described by Long and Wood (1986) for correlative flows in Columbia Basin. Basalt issued from vents in eastern Columbia Basin and entered northwestern Oregon and southwestern Washington through wide gap in Cascade Range (Tolan and others, 1989; Wells and others, 1989; Beeson and Tolan, 1990). $^{40}Ar/^{39}Ar$ age determinations (Barry and others, 2010, 2013; Baksi, 2013) indicate emplacement of Grande Ronde flows at about 16 Ma. Nomenclature is from Reidel (2005) and Reidel and Tolan (2013)

Tgsb **Sentinel Bluffs Member—**Aphyric to sparsely phyric basaltic andesite flows that form uppermost member of the Grande Ronde Basalt, within N_2 magnetostratigraphic unit of Swanson and others (1979). Flows are distinguished from all other Grande Ronde Basalt flows in the N_2 magnetostratigraphic unit by their relatively high MgO and Cr contents and their normal magnetic polarity (Reidel and others, 1989; Reidel, 2005). Owing to deep weathering and extensive loess cover, unit not exposed at surface in map area; distribution inferred from relations in adjacent quadrangles (Evarts, 2004a; Madin and Niewendorp, 2008; Madin and others, 2008)

Tgww **Winter Water Member**—Sparsely plagioclase-phyric to glomerophyric basaltic andesite flows that have relatively low MgO contents (3.4–3.9 weight percent) and moderate TiO_2 contents (2.0–2.2 weight percent). Contains scattered plagioclase phenocrysts and glomerocrysts 1 to 3 mm across in aphyric to sparsely microphyric groundmass. Exhibits normal magnetic polarities with low inclinations (<35°; J.T. Hagstrum, written commun., 2010). Stratigraphic position and petrographic, chemical, and paleomagnetic characteristics indicate equivalence to Winter Water Member of Reidel and Tolan (2013), within N2 magnetostratigraphic unit of Swanson and others (1979). At least 30 m thick where exposed in Angell quarry near south edge of map area. Most analyzed samples from map area are highly weathered (denoted by low totals and (or) anomalously low iron contents of <11 weight percent FeO*). Data from fresher samples indicate that two chemically distinguishable flows are present in map area. One has MgO content of about 3.9 weight percent; TiO_2, about 2.05 weight percent; and Ba, <600 ppm. Other has MgO content of ≤3.6 weight percent; TiO_2, >2.10 weight percent; and Ba, >600 ppm. Distribution in map area, especially north and west of McCarthy Creek, is extremely uncertain owing to poor exposure, and part of that area may be underlain by the informal Ortley member (Tgo) of Reidel and Tolan (2013) (Madin and others, 2008)

Tgo **Ortley member of Reidel and Tolan (2013)**—Flows of aphyric, intersertal to intergranular basaltic andesite that has relatively low MgO (3.5–3.6 weight percent) and TiO_2 (1.95 weight percent) contents and normal magnetic polarity (J.T. Hagstrum, written commun., 2010). Stratigraphic position and petrographic, chemical, and paleomagnetic characteristics indicate equivalence to the informal Ortley member of Reidel and Tolan (2013), within N_2 magnetostratigraphic unit of Swanson and others (1979). Four flow units totaling about 65 m thick are exposed in Angell quarry; base of uppermost flow is pillow lava. Most analyzed samples from map area, even those from quarry, are highly weathered (denoted by low analytical totals and (or) iron contents of <11 weight percent FeO*)

Tggc **Grouse Creek member of Reidel and Tolan (2103)**—Flows of aphyric basaltic andesite exposed only in Angell quarry where total thickness of three flows is 50 m. Uppermost flow is about 40 m thick and reversely magnetized; overlies columnar-jointed flow about 6 m thick, which, in turn, overlies about 3 m of hackly jointed lowest flow. Chemical analyses show that only lower two flows are relatively fresh; their compositions resemble those of Grouse Creek flows member mapped elsewhere in western Oregon (R.E. Wells, oral commun., 2014; R.C. Evarts, unpub. data)

PALEOGENE SEDIMENTARY ROCKS

Tsf **Scappoose Formation (Oligocene)**—Shallow-marine, tuffaceous, micaceous, arkosic sandstone; underlies the Grande Ronde Basalt to west and northwest of map area (Madin and Niewendorp, 2008; M.G. Sawlan, oral commun., 2013). Abundant molluscan fauna indicate late Oligocene age (Warren and Norbisrath, 1946). Shown in cross section only

EXPLANATION OF MAP SYMBOLS

Contact—Solid where location is accurate; long-dashed where location is approximate; short-dashed where location is inferred; queried where existence or extent is uncertain

Fault—Long-dashed where location is approximate; short-dashed where location is inferred; dotted where location is concealed; queried where existence or extent uncertain. Ball and bar on downthrown side. Arrows show relative horizontal movement; A, away from observer; T, toward observer (in cross section)

Anticline—Trace of axial plane; long-dashed where location is approximate; dotted where location is concealed

Syncline—Trace of axial plane; dotted where location is concealed; queried where existence or extent are uncertain

25 **Strike and dip of beds**

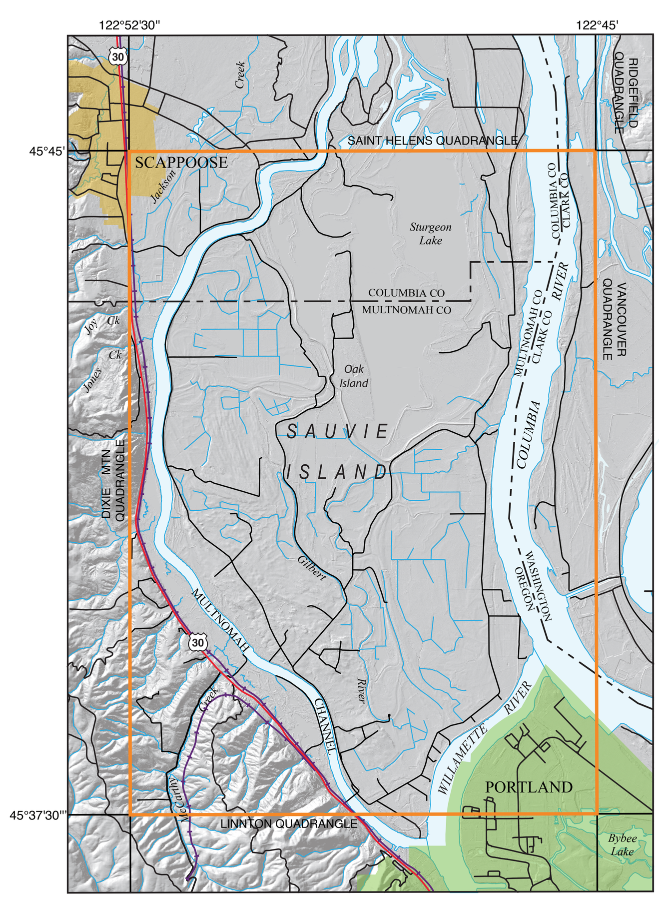
SAMPLE LOCALITIES

Chemical analysis—Showing map number; see table 1 for analyses

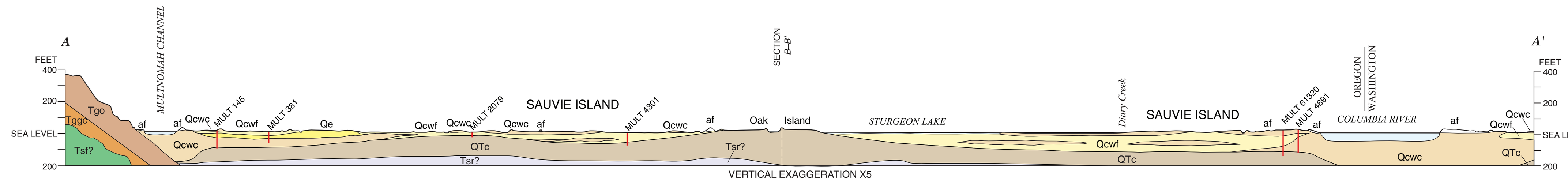
Paleomagnetic analysis

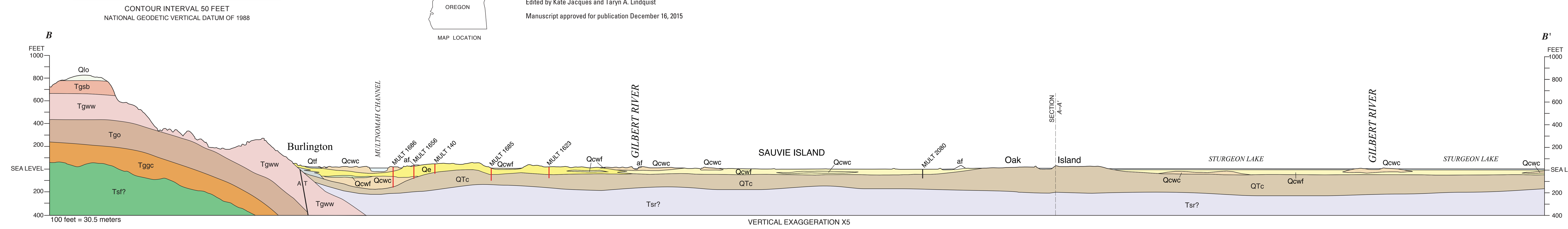
Radiocarbon age—Showing map number; see table 4 for analyses

MULT 145 **Approximate location of water wells used to construct cross sections**—Marked by red vertical lines in cross sections, showing Oregon Department of Water Resources identifier number



INDEX MAP SHOWING GEOGRAPHIC AND CULTURAL FEATURES OF SAUVIE ISLAND QUADRANGLE (ORANGE OUTLINE) AND VICINITY ON HILLSHADE IMAGE DERIVED FROM LIDAR DATA. ALSO SHOWN ARE NEIGHBORING QUADRANGLES MENTIONED IN TEXT





Geologic Map of the Sauvie Island Quadrangle, Multnomah and Columbia Counties, Oregon, and Clark County, Washington

By

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